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Vertical and Horizontal Intra Industry Trade in Some Asian and Latin American Less Developed Countries

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Abstract

A casual look at the intra industry trade (IIT) data of eighteen Asian and Latin American less developed countries show that for them (a) vertical IIT overwhelmingly dominates horizontal IIT and (b) manufactured goods (SITC 6) is one of the two commodity categories (the other being machine and transport equipments (SITC 7)) for which IIT is relatively high. A theoretical model consistent which these observation is constructed and suggests the hypothesis that the level of economic development is a determining character for such kind of trade. Returning to the raw data set we find that such a relationship can indeed be established . Though the overall relationship clearly holds, there are major fluctuations with in the sample and the overall growth rate of IIT falls with increasing levels of economic development.

• **JEL Classifications:** F1

• **Key Words:** intra industry trade, vertical product differentiation

I. Introduction

The aim of this paper is to highlight two rather neglected areas in the empirical literature on intra-industry trade (*IIT*).First, the paper targets the less developed countries (LDCs) for a comprehensive analysis of their *IIT*. Secondly, it clearly distinguishes between *IIT* in vertically and horizontally differentiated products and singles out the former for a theoretical as well as empirical analysis in the context of the LDCs. This is done primarily because, of the two types of *IIT*, vertical *IIT*

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is seen to dominate horizontal *IIT* for the countries in the sample.

The need for the distinction between the two types of *IIT* arises from the fact that they require different types of theoretical structure for their analysis. Standard papers on *IIT* use models on horizontal *IIT* in developed countries (DCs) as the theoretical backdrop for testing hypotheses on *IIT* which are of the mixed (horizontal as well as vertical) variety[1]. The result is that many important determinants of *IIT* latent in the chosen theoretical structure do not find empirical support. As an example we can consider one of the most important variables considered by the traditional *IIT* models (see Helpman (1987) for a survey), viz, economies of scale. Loerstcher and Wolter (1980), Caves (1981) and Finger and De Rosa (1979) found negative signs for the economies of scale variable in their regression thus proving that, contrary to the wisdom of the models, the variable does not affect *IIT* positively. In a comparatively recent paper Trotsenson (1996) tested the robustness of the variables suggested by the traditional models for Sweden (arguably the most studied country in the world as far as determinants of *IIT* are concerned) and found that most of them (including economies of scale) failed the effective bounds analysis (EBA) devised by Leamer. There are numerous other examples (see Leamer and Levinson (1995) for some other cases) of the traditional variables not finding support in empirical exercises. One of the major reasons for the failures is that *IIT* can be generated by a host of economic structures all of which do not embrace the variables suggested by the theories that were well known initially. Falvey and Kierkowski (1987), Flam and Helpman (1989) and more recently Davis (1997)have suggested alternative scenarios for *IIT* that do not require increasing returns to scale to explain it. As Jones *et al.* (1998) point out, certain varieties of *IIT* can easily be accommodated into the traditional Heckscher-Ohlin framework of international trade by using the concept of factor endowments more broadly than what is implied in the original theory.If these authorrs are right then it is not unusual to find ‘economies of scale’ to be a redundant variable in explaining *IIT*.

It is therefore necessary to take a more careful look at the *IIT* data of different countries before we can form our opinion regarding the appropriate structure to be used in modeling *IIT* of these countries. In this paper we first take a casual look at the *IIT* figures of thirteen LDCs and then suggest a theoretical model on *IIT* based on the observations thus made. The model is used to derive a simple proposition regarding *IIT* of this variety. The proposition is then tested in the form

[1]See Leamer and Levinson (1995)for a critical survey.

of a hypothesis with the data of the thirteen countries that we have.

The classification of *IIT* into vertical and horizontal components was first accomplished by Greenaway *et al.* (1994,1995). The methodology they follow is the following: *IIT* is horizontal if unit value of export relative to import is within 15%. If the unit value of export relative to import is greater than 15% then *IIT* is classified as vertical. We have followed this methodology in this paper. All industries where trade occurs is first classified into ones which take part in horizontal trade and vertical trade by using the above criteria. Since the criteria compares unit values of import and export, obviously all industries for which either import or export is zero has to be first eliminated[2]. After the classification is made, average *IIT* is calculated over all the industries in the particular category.

The standard index used for calculating *IIT* for a group of industries is the Grubel-Lloyd (uncorrected)index first suggested by Grubel and Lloyd(1975). The index is defined as follows:

$$I_{GL(U)} = 1 - \frac{\sum |X_i - M_i|}{\sum (X_i - M_i)}$$

Where the summation runs over industries. Given the nature of the data here and our objective of dividing *IIT* into two different categories, we need to slightly modify the index for our purpose. Note that given our objective, (1) we have to first eliminate all zero *IIT* industries and (2) the division of industries into vertical and horizontal components leaves an unequal number of industries in each group. The former problem leads to the elimination of a large number of industries, leaving very few in each category, especially in the horizontal *IIT* category[3]. If these industries happen to have a high *IIT* then the average *IIT* calculated from them is correspondingly high[4], irrespective of whether these industries account for a very large or very small proportion of total trade. The second fact aggravates this problem by over (under) reporting the value of the index for either the vertical or horizontal category. To take care of this problem we have modified *GL*(*U*) as follows:

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[2]This has important implications as far as the magnitude of average *IIT* over all industries is concerned. The elimination of zero export(or import) industries and hence all industries with zero *IIT* gives the *IIT* figures calculated an upward bias.

[3]Because very few industries have horizontal trade in *LDCs*.

[4]Thus, for example, if for a certain country, there is only one industry in the horizontal category with positive *IIT*, and if *IIT* for it is .95 but there are ten industries in the vertical category with highest *IIT* .98 but lowest *IIT* .02 then average *IIT* calculated by using *GL*(*U*) is obviously much lower for the vertical component than for the horizontal component.

$$NIIT_{VER} = \left[\frac{M_{VER} + X_{VER}}{M_{TOT} + X_{TOT}}\right] \times GL(U)_{VER}$$

$$NIIT_{HOR} = \left[\frac{M_{HOR} + X_{HOR}}{M_{TOT} + X_{TOT}}\right] \times GL(U)_{HOR}$$

where M_{VER} (M_{HOR}) and X_{VER} (X_{HOR}) are the total import and export of all nonzero *IIT* industries falling in the vertical (horizontal) category. M_{TOT} and X_{TOT} are defined as:

$$M_{TOT} = M_{VER} + M_{HOR}$$

$$X_{TOT} = X_{VER} + X_{HOR}$$

and $NIIT_{VER}$ ($NIIT_{HOR}$) is the new *IIT* index for the vertical (horizontal) category.

These indices have the attribute that their value increases (decreases) as the proportion of trade accounted for by the particular category (vertical and horizontal)increases(decreases). The index is thus a better indicator of the actual importance of *IIT* within a particular category of trade.

Though the above indices serve our purpose better we none the less sometimes report the *GL*(*U*) index alongside the above indices for purposes of comparison.

Given the above objectives and the methodology of the work, we divide the rest of the paper into the following sections: section 2 presents the basic data regarding the thirteen LDCs and chooses an appropriate model on *IIT* in LDCs. Section 3 presents an international duopoly model on vertical *IIT* in between LDCs and DCs and derives a simple proposition regarding the positive relationship between vertical *IIT* and the level of economic development. Sections 4 and 5 test this proposition in the form of a hypothesis by using the data on the thirteen LDCs. While section 4 tests the hypothesis directly, section 5 determines the growth rate of vertical *IIT* with respect to *GNP* and *GDP* and compares it to the growth rate of total trade volume. Section 6 concludes the paper.

II. Vertical And Horizontal *IIT* In *LDCs*: The Data

Table 1 reports the break up of *IIT* between vertical and horizontal components in the sample countries. First and foremost, it is clear from the table that (1) the division of industries into vertical and horizontal components is extremely unequal and hence (2) the new index gives us a more reliable estimate of the actual

Table 1. Breakup of *IIT* between vertical and horizontal components in the sample countries (3 digit SITC, 15% level)

Country	1990				1991				1992			
	GL(U)[1]		*NIIT*[2]		*GL*(*U*)[1]		*NIIT*[2]		GL(U)[1]		NIIT[2]	
	VER	HOR	VER	HOR	VER	HOR	VER	HOR	VER	HOR	VER	HOR
Lower and lower middle income countries												
INDIA	0.68 (5)	0(0)	0.03	0	0.74 (4)	0.88(1)	0.03	0.007	0.58 (7)	0.858(1)	0.04	0.006
PAKISTAN	0.19 (3)	0(0)	0.03	0	0.18 (3)	0 (0)	0.03	0	0.27 (2)	0 (0)	.009	0
INDONESIA	0.65 (6)	0.382(5)	0.05	0.003	0.53(13)	0.52 (4)	0.08	0.040	0.54(11)	0.587(5)	0.10	0.030
PHILIP-PINES	0.45 (8)	0.596(1)	0.07	0.008	0.66(12)	0.93(1)	0.14	0.210	0.67(14)	0.190(1)	0.25	0.003
COLUMBIA	0.59 (8)	0.374(2)	0.08	0.006	0.69 (9)	0 (0)	0.10	0	0.75 (5)	0.461(2)	0.06	0.040
THAILAND	0.67 (9)	0.347(1)	0.10	0.007	0.67 (8)	0 (0)	0.09	0	.79 (7)	0 (0)	0.10	0
CHILE	0.62 (3)	0(0)	0.02	0	0.74 (5)	0 (0)	0.04	0	0.45 (7)	0.846(1)	0.05	0.006
Mean	**0.55**	**0.24**	**0.05**	**0.003**	**0.60**	**0.33**	**0.07**	**0.04**	**0.58**	**0.42**	**0.09**	**0.01**
CV[4]	**29.75**	**92.00**	**51.03**	**95.92**	**30.60**	**120.9**	**52.76**	**196.18**	**28.90**	**80.90**	**83.90**	**122.5**
Upper middle and high income LDCs												
ARGENTINA	0.52 (24)	0.848(4)	0.28	0.07	0.59(24)	0.450(2)	0.29	0.01	0.38 (20)	0.529(5)	0.12	0.064
URUGUAY	0.39 (16)	0.600(5)	0.17	0.06	0.40(14)	0.609(6)	0.13	0.11	0.45 (16)	0.686(4)	0.16	0.035
BRAZIL	0.50 (28)	0.563(2)	0.23	0.03	0.57(32)	0.528(1)	0.32	0.01	0.53 (32)	0.964(1)	0.28	0.014
KOREA	0.60 (5)	0.562(1)	0.83	0.15	0.64 (8)	0.598(1)	0.70	0.05	0.69 (8)	0.535(2)	0.90	0.122
SINGAPORE	0.74 (9)	0.76 (3)	0.68	0.07	0.57(12)	0.860(2)	0.50	0.10	0.54 (11)	0.786(2)	0.48	0.084
HONG KONG	0.68 (9)	0.813(8)	0.43	0.30	0.71(12)	0.829(7)	0.45	0.30	0.78 (8)	0.841(7)	0.48	0.326
Mean	**0.57**	**0.69**	**0.44**	**0.11**	**0.58**	**0.64**	**0.40**	**0.097**	**0.56**	**0.72**	**0.40**	**0.11**
CV	**2041**	**17.37**	**55.50**	**82.07**	**16.23**	**23.26**	**45.10**	**103.30**	**24.20**	**21.88**	**65.06**	**96.37**

Notes: 1. The Grubel- lloyd (uncorrected) index (see text for definition) 2. See text for definition. 3. Figures in brackets are the number of industries in each category, 4. Coefficient of variation.

Source: Calculated from The International Trade Statistics Yearbook (various issues).

Table 2. Vertical *IIT* in the Sample Countries Arranged According to Their Mean Values Over 1990-1992 New index[1], (SITC 3 digit 15%)

Country	*NIIT*	Country	*NIIT*
KOREA	0.81	THAILAND	0.10
SINGAPORE	0.55	COLUMBIA	0.08
HONGKONG	0.45	INDONESIA	0.08
BRAZIL	0.28	CHILE	0.04
ARGENTINA	0.23	INDIA	0.03
URUGUAY	0.15	PAKISTAN	0.02
PHILIPPINES	0.15		

Notes 1: See text for definition.
Source: Calculated from The International Trade Statistics Yearbook, (various issues).

Table 3. Responsiveness of Vertical *IIT* to Differences in Classification Level.(average 1990 to 1992, New index)[1]

Country	3 DIGIT	4 DIGIT	5 DIGIT
INDIA	0.033	0.013	0
PAKISTAN	0.023	0.010	0
INDONESIA	0.077	0.023	0.041
PHILIPPINES	0.153	0.113	0.032
COLUMBIA	0.080	0.023	0.023
THAILAND	0.097	0.147	0.055
CHILE	0.037	0.010	0
ARGENTINA	0.230	0.173	0.016
URUGUAY	0.153	0.567	0.124
BRAZIL	0.277	0.150	0.018
KOREA	0.810	0.117	0.015
SINGAPORE	0.553	0.167	0.158
HONG KONG	0.453	0.183	0.173

Notes: 1 See text for definition.
Source: Calculated from The International Trade Statistics Yearbook, (various issues).

importance of *IIT* in the sample countries. Going therefore, by the new index it is clear that vertical *IIT* (*VIIT*) dominates horizontal *IIT* (*HIIT*) for the sample countries and over the sample period so much, so that average *VIIT* is well higher than average *HIIT* (.23 vs .06). The gap also clearly increases with the level of economic development of the countries. The proportion of *VIIT* in total trade also rises with the level of income of the countries (Table 2). Finally, though *VIIT* falls with disaggregation of SITC categories it does not tend to vanish except when the initial level of *IIT* at the broadest classification level (SITC 3 digit level) is very small (Table 3).

Table 4. Responsiveness of Vertical and Horizontal *NIIT* to Differance in Import Price and Export Price (average of 1990 to 1992, 3 digit)

Country	15%		25%		40%		50%	
	Ver	Hor	Ver	Hor	Ver	Hor	Ver	Hor
INDIA	.031 (16)	.004 (2)	.029 (15)	.006 (3)	.028 (14)	.008 (4)	.023 (11)	.013 (7)
PAKISTAN	.024 (8)	0 (0)	.243 (8)	0 (0)	.009 (6)	.016 (2)	.009 (6)	.016 (2)
INDONESIA	.076 (30)	.034 (14)	.061 (25)	.050 (19)	.051 (20)	.059 (24)	.044 (17)	.066 (27)
PHILIPPINES	.151 (34)	.074 (5)	.125 (29)	.101 (10)	.064 (22)	.161 (17)	.043 (21)	.162 (18)
COLUMBIA	.080 (22)	.015 (6)	.078 (21)	.017 (7)	.029 (13)	.066 (15)	.025 (11)	.070 (17)
THAILAND	.098 (24)	.002 (1)	.070 (18)	.030 (7)	.044 (12)	.057 (13)	.039 (10)	.062 (15)
CHILE	.030 (15)	.002 (1)	.023 (9)	.015 (7)	.018 (8)	.020 (8)	.018 (8)	.020 (8)
ARGENTINA	.227 (68)	.047 (11)	.185 (56)	.059 (23)	.124 (37)	.150 (42)	.087 (27)	.187 (52)
URUGUAY	.155 (46)	.065 (15)	.140 (38)	.078 (22)	.095 (26)	.122 (35)	.085 (22)	.132 (39)
BRAZIL	.277 (92)	.018 (4)	.264 (87)	.031 (9)	.231 (77)	.062 (19)	.178 (60)	.118 (36)
KOREA	.810 (21)	.109 (4)	.481 (18)	.149 (7)	.383 (12)	.291 (13)	.249 (9)	.381 (16)
SINGAPORE	.554 (32)	.085 (7)	.415 (25)	.224 (14)	.315 (17)	.323 (22)	.253 (14)	.385 (25)
HONGKONG	.454 (29)	.310 (22)	.298 (20)	.465 (31)	.226 (14)	.538 (37)	.205 (12)	.559 (39)

Source: Calculated from The International Trade Statistics Yearbook, (various issues).

Table 5. Breakup of Industries with Vertical *IIT* into $P_M>P_X$ and $P_M<P_X$ Categories (3 digit, 1990 to 1992 total, 15% level)

Country	$P_M>P_X$	$P_M<P_X$	Total
INDIA	9	7	16
PAKISTAN	5	3	8
INDONESIA	22	8	30
PHILIPPINES	15	19	34
COLUMBIA	13	9	22
THAILAND	17	7	24
CHILE	11	4	15
ARGENTINA	46	21	67
URUGUAY	13	33	46
BRAZIL	75	17	92
KOREA	11	10	21
SINGAPORE	15	17	32
HONGKONG	7	22	29

Source: Calculated from The International Trade Statistics Yearbook, (various issues).

Table 4 and 5 bring out two important characteristic of *VIIT*. First, though the level of *VIIT* falls and *HIIT* rises as we increase the dispersion between import and export unit value it does not tend to vanish. This implies that a large number of industries categorised within *VIIT* have a large amount of difference between their import and export values (Table 4). Further, for most countries in the sample the import unit value is higher than export unit value implying that the countries tend

Table 6. Breakup of Vertical *IIT* in the Sample Countries at the Industry Level

Aggregation level	SITC5			SITC6			SITC7			SITC8		
	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
Vertical intra-industry trade												
0-50%												
3 digit	12[1]	10	9	16	15	20	14	18	19	5	4	3
4 digit	9	5	6	15	8	14	13	11	13	4	1	1
5 digit	3	2	1	7	3	6	3	3	4	6	2	2
Total	**24**	**17**	**16**	**38**	**26**	**40**	**30**	**32**	**36**	**15**	**7**	**6**
50-90%												
3 digit	19	21	18	17	21	21	22	26	27	6	10	6
4 digit	9	10	9	15	14	12	32	36	31	9	13	10
5 digit	1	2	1	10	6	4	3	4	5	8	13	3
Total	**29**	**33**	**28**	**52**	**41**	**37**	**57**	**66**	**63**	**23**	**36**	**19**
90-100%												
3 digit	4	9	10	8	9	6	7	10	6	2	2	3
4 digit	2	2	3	4	6	4	6	9	9	1	1	0
5 digit	0	0	2	2	3	1	3	3	2	2	2	2
Total	**6**	**11**	**15**	**14**	**18**	**11**	**16**	**22**	**17**	**5**	**5**	**5**

Notes: 1. Number of industry. 2. The squared numbers are the model values in each level of IIT.
Source: Calculated from The International Trade Statistic Yearbook, (various issues).

to export cheaper varieties of a product for which it imports the costlier varieties (Table 5). Since the sample countries are all LDCs, the findings are consistent with a North-South theoretical model where the North produces high quality versions of a product which it export to the South in return for which it imports cheaper Southern varieties of the same product. These observation along with the observation (made in Table 1) regarding the overwhelming dominance of *VIIT* over *HIIT* is the main rational behind the actual model that we choose to underpin *IIT* in LDCs.

Table 6 shows the dispersion of the *VIIT* industries over commodity categories. It is clear from the table that *VIIT* industries are mostly clustered around SITC 6(manufactured goods) and SITC 7(Machinery and transport equipment). The model that we present is however more consistent with SITC 6 commodities. It is for this reason that we refer only to this group of commodities while empirically testing the propositions of the model in section 4.

III. A Theoretical Model

The model we use is a version of a model that has a long tradition in economics.

It was first suggested by Gabszewiez and Thisse (1978, 1979, 1982) and subsequently applied to international trade by Shaked and Sutton (1989), Flam and Helpman (1987) and more recently by, Stokey (1991), Copeland and Kotwal (1996) and others[5]. There is a vertically differentiated good which is produced under monopoly in autarky and under differentiated product duopoly in free trade. There are two countries A and B one of which is a developed and the other an underdeveloped country. Let A be the developed country. Consumers are assumed to be uniformly distributed along a line in both countries. We assume that there is no R&D expenditure in B but product quality can be improved through R&D in A. the equilibrium for the DC firm has two stages[6]. In the first stage it chooses quality by maximizing profits given its R&D expenditure. Since there is no R&D in B there is no decision variable for B and consequently there is no game at this stage. In the second stage the firms play a quantity game given a constant marginal cost of producing quantity. Given the structure of the model, at the final stage there are only two ways in which the countries (and their monopolist firms under autarky) can differ from the production side[7], viz., quality and the constant marginal cost. Of the two, quality is more fundamental to the model in the sense that trade is not meaningful with uniform quality and non uniform marginal costs. On the other hand it can be checked that allowing for a difference in quality as well as marginal cost gives no new results though it makes the algebra significantly complicated.

One variety of a vertically differentiated good X is produced in each country. Let the quality of X produced in A be denoted by q_A and the quality produced in B by q_B. Let us initially begin by analysing the second stage of the game, that is, for the moment we assume that the quality levels of the two firms have somehow been chosen and that, since A is the developed country, $q_A > q_B$, so that A produces a higher quality of the product[8].

[5]Though most of these papers model *IIT* between developed and underdeveloped countries none of them addresses the issues that we address here. While Flam and Helpman and Stokey analyze North-South trade and highlights the impact of technology, endowments and income distribution on product cycles that change over time, Copeland and Kotwal looks at North-South trade from the perspective of developed countries and tries to find reasons why its magnitude will be smaller (or even be zero) when it is with underdeveloped countries.

[6]Motta (1993) has discussed this model in the context of a closed economy.

[7]Not given the structure, of course, (dis)similarity can be defined in many other ways such as preferences, incomes etc.

[8]The assumption therefore implies that the country doing R&D activity (the developed country has a better quality. This is of course requires an appropriate assumption on the cost function for producing quality for the developed country. Below we show, with the help of an example, the type of restriction on the cost function that guarantees this.

In the pre-trade situation each producer of X is a monopolist in his own country. The net utility function of a typical consumer consuming the i-th variety of X in any country is given by:

$$U_i = q_i - (1/\gamma)P_i$$

where price of the i-th product is P_i and γ is a reservation value for the consumer depending on his income. In particular, γ can be interpreted as the inverse of the marginal rate of substitution between income and quality (see Tirole, 1988) formally, $\gamma = 1/U'(I)$ where I is the level of income. We assume U to be concave so that γ rises with the level of income.

Both countries have a population with varying income levels distributed uniformly between income levels $[\underline{I}, \bar{I}]$. Assuming that the reservation value of the person with the highest $(\bar{I})$ and lowest $(\underline{I})$ incomes are $\bar{\gamma}$ and $\underline{\gamma}$ respectively, we have a continuum of consumers in each country with reservation values that are distributed uniformly in the interval $(\underline{\gamma}, \bar{\gamma})$.

The preference structure of the consumers is given as follows. There is a marginal consumer with reservation value γ^*, for whom, the net utility from consuming the i-th variety is just equal to zero. Putting $\gamma = \gamma^*$ and $U_i = 0$ in the utility function we get $\gamma_I^* = P_i/q_i$. This is the quality adjusted price of the product i whose money price is P_i.

Consumers whose reservation values exceed γ_i^* purchase one unit of the i-th product, while other consumers purchase none. Since the distribution is uniform, the total demand for the i-th variety in any country equals the number of people with reservation values exceeding γ_i^*, that is in the interval $(\gamma_i^*, \bar{\gamma})$. Since the number of such people is[9] $(\bar{\gamma} - \gamma_i^*)$, that is $(\bar{\gamma} - P_i/q_i)$, the demand function for the i-th variety in any country is:

$$P_i = (\bar{\gamma} - X_i)q_i \qquad (1)$$

X is produced in both countries with a constant marginal cost ‘a’ which is the same for all varieties and a fixed cost F_i, the cost of producing quality[10]. The monopolist producing the i-th variety thus has the following profit function:

$$\Pi_i = (\bar{\gamma} - X_i)q_iX_i - aX_i - F_i$$

Profit maximization (given quality) leads to the following price, quantity and

[9]We assume without any loss of generality $\bar{\gamma} - \underline{\gamma} = 1$

[10]The fixed cost, of course, has no role to play until when quality in A is endogenised. Also note that F_B is equal to zero as the firm in B does not have any R&D expenditure.

profit solutions:

$$X_i^A = \frac{1}{2}(\bar{\gamma} - a/q_i)$$

$$P_i^A = \frac{1}{2}(\bar{\gamma} + a)$$

$$\Pi_i^A = \frac{1}{4}(\bar{\gamma}q_i - a)\left(\bar{\gamma} - \frac{a}{q_i}\right) - F_i$$

Where the superscript "A" stands for autarky. Since $\delta^2\Pi/\delta X_i^2 = -2q_i < 0$, the second order condition is satisfied.

The following points should be noted about the autarky equilibrium specified above. First, as quality of a product rises its money price also rises. Thus in the pre trade situation, $P_A > P_B$. Second, the restrictions on quality and hence price automatically defines a restriction on γ^*. Recall that $\gamma^* = P_i/q_i$. Thus, in autarky, $\gamma^* = 1/2(\bar{\gamma} + a/q_i)$. Since $q_A > q_B$ therefore necessarily $\gamma_A^* > \gamma_B^*$.

After trade opens up the variety of X produced in A (X_A) becomes available in B and the variety produced in B (X_B) becomes available in A. the market structure thus now becomes that of a differentiated product duopolist.

In the post trade situation we have two quality adjusted prices γ_A^* and γ_B^*. Let, $\gamma_A^* > \gamma_B^*$. Given the structure of demand, this cannot be an equilibrium unless there are some consumers with reservation values greater than γ_B^* but money incomes in the interval (P_A, P_B). In such an equilibrium, poor people in both countries purchase the low quality good and get less consumer surplus than they would if they could afford the higher quality good. Consumers with reservation values greater than γ_B^* whose incomes exceed P_A will purchase one unit of the high quality good. Combining the two inequalities $\gamma_B^* > \gamma_A^*$ and $P_A > P_B$ gives a necessary condition for such an equilibrium:

$$P_B/P_A < q_B/q_A < 1 \tag{3}$$

Given the autarky prices, the only way in which the B firm can have positive sales under free trade is for it to lower its relative price to satisfy this inequality. If it does, it will sell cheap low quality goods in both markets, and the A firm will sell expensive high quality goods in both markets.

Since we have assumed consumers to be distributed directly according to their reservation values rather than incomes, we must determine a critical reservation value (γ^C, say) up to which all consumers consume X_B and after which consumers consumes X_A. This can easily be done by equating U_A and U_B and solving the resultant equation for $\gamma\,(=\gamma^C)$. Thus,

$$\gamma^C = (P_A - P_B)/(q_A - q_B)$$

Note that, if inequality (3) holds then, $\gamma^C > \gamma_A^{*}$[11] $(> \gamma_B^{*})$. Thus there are indeed consumers in both countries who choose X_B even though X_B is available. Given γ^C, the total demand for X_B in any country is the number of consumers between (γ_B^*, γ^C) and the demand for X_A is the number of consumers in the interval $(\gamma^C, \bar{\gamma})$. Consumers in the interval $(\underline{\gamma}, \gamma_B')$ do not consume X, that is, choose to retain their income[12].

Given inequality (3)[13] the total demand for X_A and X_B in the post trade situation is given by[14]:

$$X_A = 2\{\bar{\gamma} - (P_A - P_B)/(q_A - q_B)\}$$

$$X_B = 2\{(P_A - P_B)/(q_A - q_B) - (P_B/q_B)\}$$

For clarity, the above discussion can be summed up in the following lemma:

LEMMA I: If $q_A > q_B$ and firms in A and B both have positive demand for their products (*IIT* is possible) then (a) $P_A > P_B$ and (b) $(P_A/P_B) > (q_A/q_B)$, that is, inequality (3) must be satisfied and (c) the demand function for A and B are given by the above two equations.

PROOF: The proof follows from the above discussion.

Solving the above two equations the inverse demand functions for X_A and X_B are:

$$P_A = (q_A - q_B)(\bar{\gamma} - 1/2X_A) + 1/2q_B(2\bar{\gamma} - X_A - X_B) \quad (4)$$

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[11]Note that this means $\{(P_A - P_B)/(q_A - q_B)\} > P_A/q_A$ or, $(P_B/P_A) < (q_B/q_A)$.

[12]A condition required for this specification to yield positive demand for both X_A and X_B is: $\bar{\gamma} > \gamma^C > \gamma_A^* > \gamma_B^*$. It can be checked that this inequality is guaranteed by (3) which we assume to be true.

[13]Of course, two other cases are possible:
I. If $\gamma_B^* > \gamma_A^*$ then $\gamma_B^* > \gamma_A^* > \gamma^C$ and $1 > (P_B/P_A) > (q_B/q_A)$. Under such circumstances B will not have a market at all and we have a homogeneous product monopolist (belonging to A) serving the entire of the market, both in the LDC as well as the DC. There will only be one way trade, with products flowing from the DC to the LDC in this industry.
II. If $\gamma_B^* = \gamma_A^*$ then $\gamma_B^* = \gamma_A^* = \gamma^C$ and $1 = (P_B/P_A) = (q_B/q_A)$. which violates our basic assumption that $q_A > q_B$.
Since our primary concern is trade in differentiated products we do not consider these cases here.

[14]$X_A = \int_{\underline{\gamma}}^{\gamma} d\gamma$ and similarly for *XB*

$$P_B = 1/2q_B(2\bar{\gamma} - X_A - X_B) \tag{5}$$

Since our primary concern in this section and the next two sections is with the difference in quality between X_A and X_B rather than their absolute magnitudes, we assume, without loss of generality, that $q_A = 1$ and $q_B = \beta(\beta < 1)$. Under the circumstances (4) reduces to:

$$P_A = (1-\beta)(\bar{\gamma} - 1/2X_A) + 1/2\beta(2\bar{\gamma} - X_A - X_B) \tag{6}$$

The profit functions of the two firms are:

$$\Pi_A = (1-\beta)(\bar{\gamma}X_A - 1/2X_A^2) + 1/2\beta X_A(2\bar{\gamma} - X_A - X_B) - aX_A - F_i$$

$$\Pi_B = 1/2\beta(2\bar{\gamma} - X_A - X_B)X_B - aX_B - F_i$$

the profit maximizing duopolist, equate their respective marginal revenues to their marginal costs. We assume that firms choose quantities. The resultant Cournot - Nash equilibrium is given by the following two reaction functions:

$$X_A + 2X_B = 2(\bar{\gamma} - a/\beta)$$

$$2X_A + \beta X_B = 2(\bar{\gamma} - a)$$

Solving these the post trade equilibrium price quantity and profits are given by:

$$X_A^T = \frac{2}{4-\beta}[\bar{\gamma}(2-\beta) - a] \tag{7}$$

$$X_B^T = \frac{2}{4-\beta}\left[\bar{\gamma} + a\left(1 - \frac{2}{\beta}\right)\right] \tag{8}$$

$$P_A^T = \frac{1}{4-\beta}[2\bar{\gamma}(1-\beta) + a(3-\beta)] \tag{9}$$

$$P_B^T = \frac{\beta}{4-\beta}\left[\bar{\gamma}(\beta - 2) + \frac{2a}{\beta}\right] \tag{10}$$

$$\Pi_A^T = \frac{1}{(4-\beta)^2}[2\bar{\gamma}(1-\beta) + a(3-\beta) - a(4-\beta)][2\bar{\gamma}(2-\beta) - 2a] \tag{11}$$

$$\Pi_B^T = \frac{1}{(4-\beta)^2}[2\bar{\gamma}(1-\beta) + a(3-\beta) - a(4-\beta)][2\bar{\gamma}(2-\beta) - 2a] \tag{12}$$

Where the superscript "*T*" stands for solution in the post trade situation. For (7) to (12) to be a trading equilibrium, X_A^T and X_B^T must be positive and inequality (3) should be satisfied. For the former we require (from (7) and (8)) ($\bar{\gamma}/a > (2/\beta) -$

1. Putting (9) and (10) in (3) we find that, for the later we require ($\bar{\gamma}/a > (2 + \beta^2 - 3\beta)/(4\beta - 3\beta^2)$). Of the two $\gamma/a > (2\beta) - 1$ is binding as it is greater of the two. Thus:

LEMMA II: For the existence of a differentiated product duopoly equilibrium consisting of (7) to (12) in the post trade situation the following condition must be satisfied:

$$\gamma/a > (2/\beta) - 1$$

PROOF: This follows directly from equations (7)-(10) and inequality (3). Further, Since:

$$\Pi_{AB} = -(1/2\beta) = \Pi_{BA}$$

therefore own marginal revenue declines when the other firm increases its output. Thus the reaction functions are negatively sloping and the equilibrium is stable.

Since consumers in both countries have the same preferences and both countries have the same income distribution exactly half of each firm's output is sold at home and the other half is exported. Thus total trade in similar products or *IIT* for any country is equal to $(X_A^T + X_B^T)/2$ where X_A^T and X_B^T are given by equations (7) and (8).

Now let $\bar{I}$ (and hence $\bar{\gamma}$) increase. Since people added at the upper end of the income spectrum, therefore per capita income of the population increase in both the countries. We can then note the following observation:

OBSERVATION 1: An increase in per capita income in the trading partners increase *IIT*.

Proof: This follows directly from the definition of *IIT* in this model and equations (7) and (8).

An Example

Let us now consider the process by which the firm in A chooses quality by R&D in the post trade situation[15]. Let us assume that i) a=0 and ii) $\bar{\gamma}$=1 and γ=0. Under the circumstances the profit functions of the two firms are:

$$\Pi_A = (q_A - q_B)\{X_A - (1/2)X_A^2\} + (1/2)X_A q_B(2 - X_A - X_B) - F$$
$$\Pi_B = q_B X_B - (1/2)q_B X_A X_B - (1/2)q_B X_B^2$$

Where F is A's R&D expenditure which is a fixed cost at this stage.

The equilibrium price and quantity solutions are:

[15] The firm in *B* cannot choose quality as it has no R&D expenditure.

$$X_A = 2(2q_A - q_B)/(4q_A - q_B);\ X_B = 2q_A/(4q_A - q_B) \tag{13}$$

$$P_A = q_A(2q_A - q_B)/(4q_A - q_B);\ P_B = q_A q_B/(4q_A - q_B) \tag{14}$$

Since there is no R&D expenditure in the firm in B therefore q_B is exogenous $q_B = \bar{q}_B$. Let the cost function for producing quality in A be represented by $C(b, q_A, q_B)$. Where b is a parameter. We assume

$$\frac{\delta C}{\delta q_A} < 0 \text{ and } \frac{\delta C}{\delta \overline{q}_B} < 0.$$[16]

The first stage profit function for A is:

$$\Pi_A = \frac{2(2q_A - \overline{q}_B)^2}{(4q_A - \bar{q}_B)^2} < C(q_A, \bar{q}_B)$$

Let the equilibrium q_A available from maximizing profit be:

$$q_A = f(\bar{q}_B, C_{qA}), f_{qB} > 0, f_{CqA} < 0 \tag{15}$$[17]

Where $C_{qA}(= \delta C/\delta q_A)$ is the marginal cost of producing q_A. As it has been shown in the example considered below an appropriate assumption on C_{qA} can guarantee a higher quality for A than B.

From (13) and (14) the total amount of IIT is:

$$IIT = \frac{1}{2}(X_A + X_B) = \frac{3f(\overline{q}_B, C_{qA}) - \overline{q}_B}{4f(\overline{q}_B, C_{qA}) - q_B} \tag{16}$$

Differentiating (16) w.r.t. C_{qA} and $\bar{q}_B$ we get:

$$\frac{\delta IIT}{\delta C_{qA}} = \frac{f_{CqA}\bar{q}_B}{(4q_A - \bar{q}_B)^2}$$

$$\frac{\delta IIT}{\delta \bar{q}_B} = \frac{f_{qB}\bar{q}_B - f(\bullet)}{(4q_A - \bar{q}_B)^2}$$

Where $f_{CqA} = \delta f(\bullet)/\delta C_{qA}$. Using (16) we have proved the following proposition:

OBSERVATION 2: (a) Intra industry trade increases with technical progress in the developed

[16] To increase quality the firm has to incur higher cost but there is a spill over effect of a rise in the quality of the competitor.

[17] As marginal cost of producing quality increase quality produced falls.

country.
(b) If $f_{qB} > q_A/\bar{q}_B$ [18] then *IIT* increases with economic development of the underdeveloped country[19].

The two observations mentioned above establishes a positive relationship between *IIT* and economic development of the trading partners[20]. In the rest of the paper we will test for this relationship with the data on vertical *IIT* presented in the previous section[21].

IV. Results

In what follows we drop one country considered in the previous section viz., Chile from the analysis as for it data regarding the percentage share of industry in *GDP* (the variable *IND*) is not available for all the sample years. The simple regression results of *VIIT* with *GNP* and *IND* are[22]:

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[18]As q_B increases q_A increases faster than q_B(as $q_A/q_B > 1$), that is, as dissimilarity between the countries increase.

[19]Note that these are sufficiency conditions not necessary conditions.

[20]Let the cost function be: $C(b, q_A, q_B) = b(q_A - \bar{q}_B)/(4q_A - \bar{q}_B)$. Note that $\delta C/\delta q_A > 0$ and $\delta C/\delta \bar{q}_B < 0$. Equilibrium $q_A = \{\bar{q}_B\ (8 - 3b)\}/\{4\ (4 - 3b)\}$ so that $f_{qB} = (8 - 3b)/\{4\ (4 - 3b)\} > 0$, $f_{CqA} = -\{(4q_A - \bar{q}_B/ 24b\bar{q}_B\} < 0$ and, $q_A > q_B$ for $b > 8/9$. Finally, $IIT = (8-3b)/4$ so that $\delta IIT/\delta b = -3/4 < 0$. Since $\delta C_{qA}/ \delta b = 3q_B/(4q_A - \bar{q}_B) > 0$ therefore $\delta IIT/\delta C_{qA} < 0$. However *IIT* is free of q_B.

[21]Some writers have tested this hypothesis (see, for example, Havrylyschin and Civan (1983), Helpaman and Krugman (1985), chapter 8) using the horizontal *IIT* model as the theoretical backdrop for such tests. The hypothesis has not been tested for vertical *IIT* as this paper intends to do.

[22]Since *IIT* is a positive fraction some statistical problems are expected if we run an OLS regression with it as the dependent variable. For example, it has been pointed out by several writers (see, for example, Bergstrand, 1983) that since the explanatory variables are assumed to be non-stochastic, the only source of randomness in IIT_i is the random error term, say, ui. However the latter, in turn, is assured to have a standard normal distribution, defined over a range $(-\propto, +\propto)$. The net impact of this is therefore that while ui can take any value on the real number plane, *IIT*, its linear combination in the regression equation, can only take values in a limited range.

To overcome this problem Bergstrand (1983) suggests a logit transformation:

$IIT_i = [\{\exp(x_i'\beta)\}/\{1 + \exp(x_i'\beta)\}] \cdot u_i$

where u_i's are homoscedastic disturbance terms. This implies that:

$$ln\{IIT_i/(1 - IIT_i)\} = x_i'\beta + ln\{u_i/(1 - u_i)\}$$

$$= x_i'\beta + \varepsilon_i(say)$$

assuming $Z_i^1 = ln\{IIT_i/(1 - IIT_i)\}$ we regress Z_i^1 on the independent variables. However, for the transformed regression the random error term $\varepsilon_i = f(u_i) \sim N(\theta, f'\delta_u^2)$. Thus, $V(\varepsilon_i) = \sigma_u^2/\{IIT_i/(1 - IIT_i)\}$ and the transformed model has heteroscedastic disturbances. Application of OLS will obviously lead to unbiased but inefficient estimates. So, while running the regression we will have to apply WLS with $\{IIT.(1 - IIT)\}^{1/2}$ as weights. However, we continue to denote the adjusted dependent and the independent variables by their original titles. Thus, in what follows, *IIT*, *GNP* and *IND* are not the original variables, but the variables with the above adjustments.

Table 7. The Estimated Model with *GNP* Dummies

Variable	Coefficient	T ratio	Variable	Coefficient	T ratio
GD1	–.0074	1.01	GD9		2.41
GD2	–.0063	0.69	GD10	0.0003	–6.15
GD3	–.0030	–2.48	GD11	0.00007	–2.16
GD4	–.0017	–4.69	GD12	–0.00006	–1.65
GD5	–.0016	–1.47	GD14	0.00012	5.46
GD6	–-.0013	–3.99	GD15	0.0002	8.47
GD7	–.0005	–1.62	*GNP*	–0.00002	–0.86
GD8	–-.0007	–2.04	CONS	–.1890	–10.14

Notes: 1. R^2 =.95 and ($\bar{R}^2$ =.94 2. Heteroscadasticity consistent covariance matrix used.

Table 8. The Estimated Model with Industry Dummies

Variable	Coefficient	T ratio	Variable	Coefficient	T ratio
ID_1	–.0951	–2.369	ID8	–.0717	–5.240
ID_2	–.0952	–1.923	ID9	–.0546	–4.781
ID_3	–.0770	–5.268	ID11	–.0262	–1.978
ID_4	–.0681	–4.620	ID12	–.0284	–2.170
ID_5	–.0814	–4.658	IND	– 0.015	– 3.08
ID_6	–.0757	–5.623	CONS	–.393	–1.544
ID_7	–.0574	–4.902			

Notes: 1. R^2 =.95 and ($\bar{R}^2$ =.94 2. Heteroscadasticity consistent covariance matrix used.

Table 9. *IIT* and Economic Development: Income Group Based Classification[1,3,5]

Group	Cons.	*GNP*	*IND*	$\bar{R}^2$	*COR*[4]
Low and Lower Miiddle	–0.58 (–23.4*)	–0.0002 (–2.1)		0.12	0.77 (5.3*)[2]
	–0.55 (–10.1*)		–0.007 (–1.06)	0.09	
Upper middle and High	–1.10 (–2.9*)	0.00006 (2.37)	.04 (2.11*)	0.17	0.06 (.16)

Notes: 1. Figures in brackets are t values. 2. t values for the correlation coefficient is calculated by using the following formula: $t=r\sqrt{(n-2)}/\sqrt{(1-r^2)}$. A significant *t* value is assumed to be a conclusive proof for multicollinearity in the model. The explanatory variables are estimated separately in such cases. 3. *Implies accepted at 5% level and **Implies accepted at 10% level. 4. Correlation between *GNP* and IND. 5. Chow's test for stability of coefficients between (1) Low and Lower middle is 25.39* for regression with *GNP* and 12.45* for regression with IND, (2) Lower middle and Upper middle: 2.63 and 1.92 and (3) Upper middle and high: 35.64* for regression with *GNP* and *IND* together.

The above equation[23] shows a strongly positive relationship between vertical *IIT* and the level of economic development. Coming now to the country effects[24], the estimated results are presented in Tables 7 and 8. Since we have taken a relatively developed country (Korea) as the base country the negative signs in front of the differential coefficients are expected[25] and they reinforce our contention regarding the positive relationship between economic development and *IIT.*

Finally we report the above relationship at the sub-group level. There are two sub-groups in our case. First the subgroup consisting of lower and lower-middle income countries and second, the subgroup consisting of upper-middle and high income LDCs[26]. The results for these groups are presented in Table 9. It is clear

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[23]The regressions are run seperately as the correlation between the *GNP* and *IND* is a significant .65. The value of the chi-square varite in the *OLS* regression on the entire data set involving all the twelve countries (and with *GNP* and *IND* as the explanatory variables respectively) turns out to be 3.63 and 4.25 which clearly rejects the null hypothesis of homoscedasticity at the one percent level of significance. A correction for heteroscedasticity is done by using the degrees of freedom adjusted version of White's (1980, 1982) heteroscedasticity consistent estimates of the variance - covariance matrix.

[24]For the fixed effects model we can use the following general dummy variable specification:

$$y_{it} = \sum_i D_{jt}\beta_{0j} + \sum_i D_{jt}x_{ljt}\beta_{lj} + \sum_i D_{jt}x_{2jt}\beta_{2j} + \varepsilon_i$$

where i,j = 1,2,..,15, t = 1,2,..,6 and x_1 and x_2 are the explanatory variables (*GNP* and *IND*). D_{ij} is defined as:

D_{jt} = 1 for country j

=0 otherwise

Two problems are to be noted about the above specification. First, the specification will involve the introduction of forty five new variables within the model which would severly affect the degrees of freedom and would have its consequent adverse effect on the robustness of the estimators. A better alternative might be to use one set of dummies at a time and hence to estimate three separate equations from the above generalized formulation. Secondly, a slight reparameterization of the model involving a constant term and with one less dummy variable from each set would be useful in assessing the differential effects. This estimate with a constant term is also required by several computer packages. The country without dummy is called the "base" country.

Reparameterizing the model with the above observations in mind and taking *Korea* (country no. 13) as the base the regression with intercept dummy becomes:

$$y_{it} = \beta_{0,13} + \sum_{j \neq 13} D_{jt}\beta_{0,j} + \beta_1 x_{1,jt} + \beta_2 x_{2,jt} + \varepsilon_{it}; j = 1 \ldots 15, t = 1 \ldots 6$$

We can similarly write down the relevant regression equations for the slope dummy on *GNP* and IND respectively as:

$$y_{it} = \beta_{0,13} + \sum_{j \neq 13} D_{jt}\beta_{0,j} + \beta_1 x_{1,jt} + \beta_2 x_{2,jt} + \varepsilon_{it}; j = 1 \ldots 15, t = 1 \ldots 6$$

$$y_{it} = \beta_0 + \beta_{1,13}x_{1,13t} + \sum_{j \neq 13} D_{jt}\beta_{1,j}x_{1,jt} + \beta_2 x_{2,jt} + \varepsilon_{it}; j = 1 \ldots 15, t = 1 \ldots 6$$

and

$$y_{it} = \beta_0 + \beta_1 x_{1,jt} + \beta_{2,13}x_{2,13t} + \sum_{j \neq 13} D_{jt}\beta_{2,j}x_{2,jt} + \varepsilon_{it}; j = 1 \ldots 15, t = 1 \ldots 6$$

[25]All countries which are economically less developed than the base country should have a negative slope and all countries which are more developed should have a *positive* slope.

[26]The χ^2 value for the Chow test for the stability of the regression coefficients across groups (1) for *GNP* is 4.9 and (2) for IND is 9.03 both of which are significant at the 10% level.

from the table that no meaningful relationship exists between economic development and vertical *IIT* for the first group but the relationship holds strongly for the second group. Thus the relationship between economic development and vertical *IIT* depends on the absolute *level of economic development* of the trading countries.

V. Analysis of the Pattern of Data Fluctuations

Now that we know that there is a positive relationship between economic development and vertical *IIT*, given our data set, can we infer something about the pace at which vertical *IIT* responds to economic development? The sub-group level analysis seems to suggest that, *IIT* initially does not respond to economic development at all, however, after it crosses a threshold value of economic development, it begins to do so and after that the relationship is stable. Does this mean that as economic development progresses the rate of response of *VIIT* to economic development progressively rises?[27] Let us first note that we have adjusted the data set for our analysis. That is, the basic model that we work with in the pooled sample is:

$$ln(IIT/(1-IIT)) = a + b_1 GNP + b_2 IND$$

That is, $IIT = e^r/(1+e^r)$ where $r = a + b_1\ GNP + b_2$ IND. First note that as $r \rightarrow 0$ $IIT \rightarrow .5$ and as r becomes large $IIT \rightarrow 1$ (which is its maximum value and which it achieves at a finite *GNP*). Also as $r \rightarrow -\mu$, $IIT \rightarrow 0$. Secondly, differentiating the above equation partially with respect to r we have:

$$\frac{\delta IIT}{\delta P} = \frac{e^{\rho}}{(1 + e^{\rho})} > 0$$

Now as $r \rightarrow 0$, $e^r/(1+e^r)^2 \rightarrow .25$, as r $\rightarrow \mu$, $e^r/(1+e^r)^2 \rightarrow 0$ and as $r \rightarrow -\mu$, $e^r/(1+e^r)^2 \rightarrow 0$. Now since $dIIT/dGNP = b_1\ e^r/(1- e^r)$ and $dIIT/dIND = b_2\ e^r/(1-e^r)$, assuming b_1 and b_2 to be both positive, the maximum value that $dIIT/dGNP$ and $dIIT/dIND$ can achieve is $b_1/4$ and $b_2/4$. This they achieve at very low levels of

[27]Note that this is not an unreasonable presentation as economic growth itself demonstrates Kaldor's (1963) contention that per capita output grows over time, and its growth rate does not tend to diminish. Barro and Sala-i-Martin (1995) points out that Kaldor's statement "Seems to fit reasonably well with the long term data of currently developed countries" (p. - 5).

GNP and IND respectively. With higher *GNP* and *IND* the growth rate falls and asymptotically approaches zero as the variables become very large. Finally,

$$\frac{\delta^2 IIT}{\delta P^2} = \frac{e^{\rho}(1 - 2^{\rho})}{(1 + e^{\rho})^4}$$

which is negative for $r > -\ln 2$ (corresponding to $IIT > (-\ln 2/(1-\ln 2)=).33$) but positive for $r < -\ln 2$ (IIT<.33).

Assuming for the moment that the first order differentiation of *IIT* with respect to a variable is a measure of the 'growth' rate of *IIT* with respect to these variables we can say that the structure of our model suggests that *IIT* increases at a decreasing rate with respect to *r* (which we have assumed to be a positive function of *GNP* and IND) in the interval [.5,1] with a maximum 'growth' rate of 0.25 with respect to *r* which it achieves at $r = 0$. This in turn implies that the maximum growth rate of *GNP* and IND is $b_1/4$ and $b_2/4$ respectively achieved at very low levels of the variables-the rate continuously falling as these variables rise.

The rate of fluctuation of *IIT* that we have considered above is rigidly given by the structure of the model with which we are working. The only thing that we could estimate were the maximum values of the partial derivatives of *IIT* with respect to *GNP* and *IND*[28]. This seems to be unsatisfactory to the extent that we could not test the validity of the 'increasing at a decreasing rate' hypothesis that the model imposes upon us. Below we re-analyse the data independently of the model to arrive at a conclusion regarding it. To make the analysis more general we also calculate the growth rate of the total trade volume in manufacturing and compare it with the growth rate of *IIT* both with respect to *GNP* and *GDP* to determine which has increased at a faster rate. For this we estimate the following equation:

$$\ln IIT = a + b \ln GNP$$

where *b* is the elasticity of *IIT* with respect to *GNP* and $b > 1$ implies that the relationship between *IIT* and *GNP* is as follows: as *GNP* grows *IIT* grows at a faster rate ($dIIT/dGNP$, $d^2IIT/dGNP^2 > 0$) (this is because, say, $g = IIT/GNP$ and $q = dIIT/dGNP$ so that $b = q/g$. Obviously the above hypothesis implies that $q > g$ implying that $b > 1$. On the other hand $b < 1$ implies the opposite).

[28]Given the estimated equation in section 4 this implies that the maximum growth rates of *GNP* and *IND* are respectively.0005 and.175 (in percentages).

Table 10. Estimates for Growth Rates of Total Trade Volume in Manufacturing and *IIT* over *GNP* per Capita and Gross Domestic Product (*GDP*)[1]

Group	*IIT*'s growth w.r.t.			*TOT*'s growth w.r.t.		
	GNP[3,5]	*GDP*[5]	R^{2}[4,5]	*GNP*[3,5]	*GDP*[5]	R^{2}[4]
1. Low+Low-Mid	.13(1.12)	.24(1.77)	.062(.14)	–.10(–.52)	.62(3.10)	.014(.33)
2. Up-Mid+High	.21 (3.84)	.07(1.85)	.53(.20)	1.75(4.26)	.71(2.59)	.58(.34)
Total	.09(1.9)	.11(1.95)	.10(.11)	.51(3.29)	.67(3.67)	.24(.28)

Notes: 1. Estimates of intercepts not reported. 2. Total trade volume. 3. *GNP* per capita. 4. Figures outside brackets are the R^2 for the regression on *GNP*. Figures within brackets are R^2 for *GDP*. 5. Figures in brackets are t values.6. Observations 1-21 is group 1, observations 22-36 is group 2.

Table 10 reports the results for the above growth rate. There is no relationship between the rates of fluctuation between *GNP* and *IIT* for the two lower groups the first of which do not have any statistically significant relationship between these variables at the level as well. However, the rates of fluctuation support the 'increasing at a decreasing hypothesis' for the upper two groups as well as the entire sample implying that our assumption regarding a falling growth rate of *IIT* with respect to *GNP* and *IND* which was implied by the choice of our model is not a bad one. Thus as per capita gross national product of equivalently the purchasing power of the masses increase *IIT* increases at a slower rate than the increase in the purchasing power.

It is well known that for *OECD* countries trade in manufacturing has increased faster than *GDP*. For the pooled data with which we are working here table 10 however shows that this is not true for *LDCs*. It has "grown"[29] at a slower rate than both *GDP* and *GNP* per capita like in case of *IIT* (except for the high income countries where the growth rate, which is still lower but not significant). Also note that total *volume of trade has always grown at a faster rate than IIT* both over *GNP* and *GDP* and the R^2's are always high for equations with total trade volume (TOT) as the dependent variable.

VI. Conclusion

This paper suggests that for *LDCs* vertical *IIT* dominates horizontal *IIT*. A theoretical model consistent with this finding suggests that, unlike what

[29]Strictly speaking we should not be using the word "growth" as it is usually a word reserved for fluctuation over time alone not over a pooled data set. However in this paper we use the word broadly and not in the usual sense in which it is used in economics.

Loertscher and Wolter (1980) suggested for *IIT* of the mixed variety, vertical *IIT* has a strong positive relationship with the extent of economic development of the trading countries. a rigorous look at the data set confirms that there is indeed a positive relationship between economic development and *IIT* for the *LDCs*. At the aggregate level the growth rate of *IIT* falls as we move to countries with increasing levels of development. This is partly due to the fact that there is an upper bound to the *IIT* index and partly due to the reason that as *IIT* grows to very high levels the number of industries which are potentially capable of generating *IIT* but not doing so progressively falls. In other words as *IIT* increases with economic development the scope for further increase in *IIT* falls as the avenues get exhausted. Importantly however the paradigm that 'low income countries have high growth rates' cannot be taken too literally as the low income countries do not necessarily have a more significant relationship with respect to all the indicators of economic development we have considered here. The relationship with respect to per capita *GNP* is fuzzy for the countries with the lowest levels of incomes in the sample. This aberration however does not stop the result regarding growth rates from going through in the larger sense - it only suggest that the subgroups have their own special characters.Our analysis also suggests that that though *IIT* grows with economic development it does not grow as fast as total trade volume in manufacturing does implying that inter industry trade is still a large and growing segment of total trade in manufacturing in *LDCs*.

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