Trade Liberalization, Wages, and Specialization in China*

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Abstract

This paper studies the evolution of regional specialization in China in response to trade liberalization. Using a panel of Chinese export data at the detailed commodity level over the period of 1988-2006, we show that China's regional specialization follows a U-shaped pattern: both the interior and coastal regions diversify from 1988 to 1994 but specialize afterwards. A theory of tariff reductions is proposed by constructing the Dornbusch-Fischer-Samuelson (1977) continuum of goods Ricardian model in a setup of two countries and three regions. The U-shaped pattern of specialization can be obtained from foreign tariff reductions followed by Chinese tariff reductions. The model finding is supported with empirical evidence.

Keywords: Trade liberalization, Nontraded goods, Wage inequality, Specialization, Ricardian model.

JEL Classification: F11; F13; F14; F16

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1. Introduction

It is widely believed that economic opening will lead to regional specialization and strengthen comparative advantage. Once trade barriers are removed from economic development, a country's market becomes more integrated. Thus, products and resources are free to move inside the nation and be reallocated to gain more economic efficiency. For a country as a whole, it is good to be self-sufficient and produce a full range of products. However, to maximize efficiency gain, resources within a country have to be allocated strategically. Hence, different regions have their own specialty and exchange with the rest of the nation for whatever they do not produce. China, as the world's largest developing economy, has experienced rapid economic growth and global integration since it adopted the open-door policy in 1978. On one hand, we observe its remarkable export performance in the world market. On the other hand, we would expect that internally, for such a huge country comparable to EU or the US in size, thirty years of opening to trade has led to a pattern of regional specialization.

Surprisingly, no consensus has been reached on how globalization impacts China's economic structure. Alwyn Young (2000) initiates the puzzle by finding that China's production composition across provinces became more similar from 1978 to 1997. This means that provinces are repetitively producing overlapping products instead of forming their representative industries. However, in another study, Barry Naughton (2003) constructs China's inter-provincial trade from the Input-Output tables of 1987 and 1992 and shows that inter-provincial trade is substantial and growing between the two years. Since huge domestic trade flow indicates market integration, this suggests that Chinese provinces are more specialized over time.

The studies of Young (2000) and Naughton (2003) stimulated further research. Using the Input-Output tables of 1987, 1992, and 1997, Poncet (2001, 2003, 2005) finds that the intensity ratio of inter-provincial trade to GDP decreased significantly between 1987 and 1997, especially after 1992. Furthermore, barriers to trade across Chinese provinces are estimated to be much larger than those within a single country such as Canada or the USA, with the magnitude being comparable to those within the EU or OECD countries. Holz (2009) reexamines Young's (2000) arguments one by one but concludes that the evidence provided on internal fragmentation is rather weak. Bai et al. (2004) construct industry concentration measurements using industry output data over the period of 1985 – 1997. They find that Chinese industries diversified from 1985 to 1988, but then specialized from 1989 to 1997. The World Bank (2005) also finds that China's product market was highly diversified in the 1980s, but has specialized substantially since the early 1990s. Interestingly, the U-shaped pattern of specialization is found more generally by Imbs and Wacziarg (2003) over a panel of countries and sectors. They estimate the relationship between industry diversification and per capita GDP using employment and value-added data and find that sector concentration follows a U-shaped pattern. The concentration of industries first falls but then increases as the countries grow richer, with the turning point per capita GDP being around $5800. Imbs and Wacziarg (2000) explain this U-shape pattern to be a result of the interactions of a country's aggregate productivity increase and trading cost reduction.

The novelty of our paper is that we study China's regional specialization pattern using a panel of Chinese export data over nineteen years. To the best of our knowledge, no direct measurement of comparative advantage has been studied using such a detailed Chinese trade dataset at the commodity level. We observe that the Chinese inland has become more specialized than its coastal counterpart over time. Furthermore, both the Chinese inland and coastal regions underwent two stages of specialization: they diversified from 1988 to 1994 but then specialized after 1994.

To explain the observed U-shape evolution pattern, we propose a simple theoretical model that relies *only* on reductions in trade costs. We confirm the seminal Dornbusch-Fischer-

Samuelson (1977) result that every country as a whole benefits from a move to freer trade. However, internally, how sub-regions inside a country gain comparative advantage depends on timing. We rely on the timing of tariff reductions in China and her trading partners; partner countries such as the US lowered their tariffs facing China before China lowered its own tariffs (just prior to entering the WTO). We demonstrate theoretically that this pattern of tariff reductions generates a U-shaped movement in the regional specialization indexes for China. We also develop new insight showing that the specialization patterns of the coast and inland regions are inversely related with their relative wage ratio. Furthermore, we provide sufficient evidence to support our model.

To provide some intuition for our results, we begin with a fall in foreign tariffs facing China. This action benefits the coastal region more than the inland because the coast is competing most directly with foreign countries. The tariff reduction therefore raises coastal wages relative to those inland. The wage gap between the regions leads to an expanded range of non-traded goods produced in both areas.[1] For this reason, the coastal and interior regions are producing a range of goods with greater overlap, so there is less geographic specialization. This is the pattern that we observe in the early part of our sample (1988 – 1994). Next, suppose that China lowers its own tariffs. Then the economic effects we have just described are reversed: coastal wages fall relative to those in the interior; there is greater competition between the regions, with fewer non-traded goods. Hence, there is less overlap in the range of goods produced and greater geographic specialization.

To place our contribution in the context of the existing literature, instead of using interactions of technology and transport cost as in Imbs and Wacziarg (2000), we show that trade liberalization can generate the U-shaped regional specialization pattern on its own. Our model

[1] The non-traded goods arise due to transportation costs between the regions.

connects closely to Eaton and Kortum (2002), which allows probabilistic technology heterogeneity and geographic barriers to determine specialization. Our findings on the coastal-interior relative wage ratio and tariffs contribute to the rich body of literature on trade and wage inequality, such as from Feenstra and Hanson (1996) and Xu (2003). The non-traded product range in our Ricardian continuum of goods model closely relates to the product variety and extensive margin study completed by Feenstra (1994), Hummels and Klenow (2005), Kohoe and Ruhl (2002), and Bergin, Glick and Taylor (2004).

In the next section, we study the regional specialization pattern in China. Section 3 presents the model. Section 4 examines the comparative static impacts of lowering tariffs on the non-traded product range and the specialization indexes. Section 5 provides supporting evidence, and Section 6 concludes.

2. Regional Specialization Pattern in China

To track the path of regional specialization, we use Chinese export data over the period of 1988-2006, which are available at the detailed commodity level, broken down by destination, city of origin, customs regime (including both ordinary and processing trade), and firm ownership.[2] They are classified in a 5-digit Standard International Trade Classification (SITC) system for 1988-1991, a 6-digit Harmonized System (HS) classification for 1992-1996, and an 8-digit HS system for 1997-2006. For consistency, the data on trade flows is converted to the 4-digit SITC revision 2 classification using a HS6-SITC4 concordance. We focus on the ordinary exports by manufacturing sectors to study the overall comparative advantage pattern.[3] While it

[2] Data source: China Customs General Administration, Statistics Department. See Feenstra et al. (1999) and Feenstra and Hanson (2005) for more detail.

[3] There are two trade regimes in China: processing trade and ordinary trade. Under the processing trade regime, foreign parts and components are brought in, assembled in China, and re-exported to the rest of the world. Most processing trade consists of labor-intensive goods, whereas ordinary trade is for domestic consumption and thus sensitive to domestic economy.

might be preferable to measure geographic concentration using production data from a national income table, such data are not available at the highly disaggregated product level as in export data, nor do they cover a long enough time. These limitations make the empirical findings based on production data inconclusive. As pointed out by Schott (2003), industry-level data hide substantial intra-industry heterogeneity, which violates the assumption of the Heckscher-Ohlin model. Hence, the most useful dataset used to test one country's comparative advantage is the product level trade data similar to the NBER Trade Database assembled by Feenstra (1996). Furthermore, for China's coastal provinces and many inland provinces, a large portion of manufacturing output is produced for export. Thus, we consider it appropriate to use export data to study the pattern of production specialization.

The next step is to construct a consistent measure of comparative advantage or specialization index. A number of empirical approaches have been used to measure geographic concentration and agglomeration[4]. To measure regional specialization, we compile these exports into the "Locational GINI Coefficients" as proposed by Krugman (1990), which studies the geographic distribution of production activities for U.S. manufacturing industries.[5] In trade literature, this GINI index is also known as the Hoover coefficient of localization, as in Hoover (1936). It has also been used by Kim (1995), Imbs and Wacziarg (2003), Bai et al. (2004), and Jensen and Kletzer (2005). Basically, a GINI index can be used to measure any form of uneven distribution and takes on values between 0 and 1. A zero GINI indicates a perfectly even distribution, and a unity reflects extreme unequal distribution.[6] A GINI specialization index measures a region's distribution of production/exports and maps it to the national structure.

[4] See Ellison and Glaeser (1997) and Duranton and Overman (2004) for summary review.
[5] For locational GINI coefficient construction method, please see Appendix 1.
[6] We can think of this in terms of our familiar GINI income index. A zero GINI income index means perfect income equality where everyone has the same amount of income. Whereas when GINI income index equals unity, it indicates extreme income inequality, where one person has all the income, and everyone else has no money at all.

When a GINI specialization index value is 0, then the region has an identical export composition to that of the nation; the region is fully diversified in production, and there is no specialization. On the other hand, a unity locational GINI index indicates that the region is purely concentrated in a single industry and has no production in any other industries. In summary, GINI compares the regional distribution of exports with the national export distribution. One region that has no specialization at all but simply spreads out in proportion to the national structure would have a GINI of zero. Between two regions, the one with a larger GINI is more specialized.

We compute the GINI coefficients for 30 Chinese provinces over the period of 1988-2006 and arrange them into three regional groupings: coast/inland, east/middle/west, and north/south. Table 1 presents the summary statistics of these provincial GINI coefficients. We also sort the provinces by their time average GINI from low to high, with the ranks reported in the last column. As indicated by the first row, Guangdong is the most diversified (i.e., least specialized) province in China because it has the smallest average GINI among all provinces from 1988 to 2006. At the other extreme, Qinghai and Tibet are the least diversified (i.e., most specialized) provinces. Based on their ranking, these provinces are divided into 3 groups: the first group consists of ten provinces with the smallest GINI, the next ten provinces are in the intermediate group, and the remaining ones with the largest GINI indexes fall into the third group. Correspondingly, provinces in the first group are the most diversified, and those of the third group are the least diversified. When further checking each province's macro region, interesting patterns are revealed. As column 3 indicates, eight of ten provinces in the first group lie on the coast; whereas for the most specialized group, all of the provinces are located inland. Columns 4 and 5 further categorize each province into an east/middle/west and north/south region. Over all, coastal China is less specialized than inland; the western area is more distinct than the middle and east; and southern China is more diversified than its northern counterpart. Among them, the coast/inland pair is the most revealing case.

Figure 1 further depicts the time trend of the simple averaged GINI indexes for inland and coastal China.[7] Three observations can be made. First, both inland and coastal GINI curves exhibit a U-shaped pattern, with 1994 as the turning point. From 1988 to 1994, both GINI indexes drop steadily, meaning that regional export structures are diversifying and becoming more similar to that of the nation. Later on, they both increase from 1994 to 2006, revealing the forces of regional specialization. Second, the interior GINI curve lies above the coastal GINI throughout time, indicating that the inland provinces are more specialized than their coastal counterparts. Third, the coast GINI curve is steeper in the falling stage but flatter in the rebounding stage. Thus, although the two regions are going through similar U-shaped transition process, coastal China is less responsive and much slower than inland China in forming localization.[8]

What drives these interesting observations? There are many possible explanations. First, there are significant regional imbalance in China's natural endowments, geography, and infrastructure. Being land-locked and deprived of resources, inland China is at a disadvantage in producing industrial goods. Then as China opened up, the coastal provinces were further poised to seize opportunities presented by their proximity to the world market, access to better infrastructure, educated labor force, as well as various favorable policies to stimulate trade and foreign investment. Second, as pointed out by Young (2000), local protectionism is a typical

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[7] Weighted average GINI using provincial GDP or population as weights gives a similar pattern. Provincial GDP and population data are obtained from the "*China Statistic Yearbook*" 1988-2003.

[8] To make sure that the U-shape GINI curves are not the outcome of an arbitrary sector classification or regional division, a series of robustness checks have been conducted. We calculate the GINI using east/middle/west and north/south macro region divisions. Different levels of product aggregation (SITC 2, 3, and 4 digits) and data coverage (economy wide or manufacturing in isolation) are also attempted. Besides using Chinese exports to the Rest of World (ROW), we also use the exports to the US only. The preceding results still hold under these tests.

phenomenon in China, which fragments the market and forces the sub-regions to be self-dependant and diversified. Later on, with deepening reform and the removal of local protectionism, markets are more integrated, and regions gain comparative advantage. Third, many economic factors can influence specialization as well, such as technological difference, natural endowment, and increasing returns to scale. The interactions of these factors can always lead to a U-shaped specialization pattern.

3. Model

Despite all these possible factors, we propose to explain our observations using a simple model of tariff reductions. Compared with other reasonings, our model assumption is parsimonious. Furthermore, tariff reduction is consistent with the reality that trade liberalization has been the most significant achievement in China in the past 30 years. The model setup adapts the Appleyard et al. (1989) framework, which extends the Dornbusch-Fischer-Samuelson continuum-of-goods Ricardian model (1977) to three countries. We consider two countries, home and foreign, where the home country is further divided into two regions – coastal and interior.[9] For simplification we label them as C (coast), I (inland), H (home) and F (foreign). When engaging in international trade, there is trade cost. H and F each imposes a uniform ad-valorem tariff on all of the imports from its partner, with the tariff rates denoted τ =1+t and τ*=1+t* for H and F's imports, respectively. To capture the fact that China's inland is landlocked, and the coast is the hub of goods transfer due to its geographic proximity to the world market, there is an iceberg transportation cost τ_{IC} ($\tau_{IC}>1$) between the two regions. All the goods delivered between I and F must go through C. The transport cost takes the form of an iceberg cost, meaning that a fraction $1/\tau_{IC}$ of the commodity shipped actually arrives. We

[9] We have in mind China as the home country and the United States as the foreign country.

assume that τ_{IC} is identical for all commodities and the same for shipments in either direction between I and C. This transport cost makes I's trade barrier even larger than that of C. If I imports from F, the extra margin it imposes will be $\tau \cdot \tau_{IC}$. I can import/transfer from either C or F, depending on who has the lower tariff-inclusive price of goods.

Production and Specialization

There is a continuum of goods indexed by z over the interval [0, 1]. The three economies each produce certain ranges on this interval but consumes over the full interval. Labor is the only factor of production, and each economy is endowed with labor L_i (i = I, C, F), with wage rates being w_i, and i representing inland, coast and foreign, respectively.

The production technology is summarized by an individual region's constant unit labor requirement $a_i(z)$, i = I, C, F. The relative unit labor requirement across the regions are measured relative to the interior and are denoted $A_i = a_i(z)/a_I(z)$, i = C, F. To compare the technologies among the three economies, we further make the following assumptions:

Assumption 1: $\frac{\partial A_C}{\partial z} \cdot \frac{z}{A_C} = \alpha_C < 0$, $\forall$ all z, (1)

Assumption 2: $\frac{\partial A_F}{\partial z} \cdot \frac{z}{A_F} = \alpha_F < 0$, $\forall$ all z, (2)

Assumption 3: $\alpha_C > \alpha_F$, $\forall$ all z. (3)

Assumptions 1 and 2 state that the goods are ordered by increasing comparative advantage of F and C relative to I. Assumption 3 implies that $a_C(z)/a_F(z)$ is increasing in z. The three assumptions together ensure that that if we put all the products over the interval [0, 1], I always specializes in the low end, F specializes in the high end, and C falls in the middle range. Thus, the coast is facing direct competition from above with the high-tech foreign country and from below with the low-tech inland region. This is consistent with the fact that coastal China is more advantageously located to engage in international trade and hence is more industrialized than inland China.[10] The functions of $A_C(z)$ and $A_F(z)$ are downward sloping curves, with $A_F(z)$ lying above the $A_C(z)$ curve.[11] $|\alpha_C|$ is the elasticity of A_C with respect to industry z. The smaller it is, the flatter the A_C curve is.

Given the production technology, we are ready to look at the patterns of trade. The rule is that each economy specializes in the range of products for which they have the minimum cost, with the rest of the products being imported (transferred) from the other regions. In our model, because labor is the only factor of input, the patterns of trade and production are determined by the factor price – wages. Letting the real wage rate be w_i, i =I,C,F, we define the relative real wage ratios across the three regions as:

$$\Omega_F = \frac{w_I}{w_F}, \tag{4a}$$

$$\Omega_F / \Omega_C = \frac{w_C}{w_F} \tag{4b}$$

$$\Omega_C = \frac{w_I}{w_C} \tag{4c}$$

These relative wage ratios are also known as the trade weighted terms of trade (TOT), where equations (4a) and (4b) measure the TOT between H and F, while Ω_C in equation (4c) measures the inland-coast wage gap. Notice that its inverse $1/\Omega_C = \frac{w_C}{w_I}$ represents the coastal-inland wage inequality in China. As we will show later, this domestic wage ratio plays an important role in

[10] For example, Shanghai China is far more skilled and capital abundant than the *labor abundant* inland province of Guizhou and is capable of producing a similar mix of high-end products as in foreign countries.

[11] Throughout the paper, we do not require $a_C(z)$ or $a_F(z)$ to be a constant along z, i.e., $A_F(z)$ and $A_C(z)$ need not be iso-elastic curves.

determining the national production structure. By treating C as more efficient than I, the equilibrium relative wage w_C / w_I becomes larger than unity.[12]

Under perfect competition, the price of good z in the coastal region equals $a_C w_C$ if self-produced, $\tau_{IC} a_I w_I$ if imported from the interior region, and $\tau \cdot a_F w_F$ if imported from a foreign country. Thus, the coastal area will purchase from the inland if and only if the inland's unit labor costs are adjusted for when shrinkage falls short of 1) the coastal unit labor cost, and 2) the foreign country's unit labor cost adjusted for tariffs. Thus,

a) Interior region will export to coastal region iff:

$$\tau_{IC} a_I w_I \leq a_C w_C \text{ and } \tau_{IC} a_I w_I \leq \tau \cdot a_F w_F \quad \rightarrow \quad \tau_{IC} \Omega_C = A_C(z_1) \qquad (5)$$

where the equality is derived by choosing the value of z_1 that satisfies the first expression of (5) with equality. Our assumptions (1) – (3) on the $A_i(z)$ schedule ensure that the second inequality $\tau_{IC} a_I w_I \leq \tau \cdot a_F w_F$ holds strictly at this crossover value. From this requirement, we can get a boundary point z_1, which divides the production between the inland and coast. By the same reasoning, the conditions for export by each region are further given below by two inequalities in each case.

b) Interior region will export to foreign iff

$$\tau_{IC} \tau^* a_I w_I \leq \tau^* a_C w_C \text{ and } \tau_{IC} \tau^* a_I w_I \leq a_F w_F \quad \rightarrow \quad \tau_{IC} \Omega_C = A_C(z_1) \qquad (6)$$

c) Coastal region will export to interior iff

$$\tau_{IC} a_C w_C \leq a_I w_I \text{ and } \tau_{IC} a_C w_C \leq \tau_{IC} \tau a_F w_F \quad \rightarrow \quad \Omega_C = \tau_{IC} A_C(z_2) \qquad (7)$$

d) Coastal region will export to foreign country iff

[12] If $a_C(z) < a_I(z)$ and $w_C < w_I$, then region I will not produce at all, unless there is a prohibitively high transport cost that shifts C's comparative advantage to I.

$$\tau^* a_C w_C \le a_F w_F \text{ and } \tau^* a_C w_C \le \tau_{IC}\tau^* a_I w_I \qquad \rightarrow \qquad \tau^* \frac{A_C(z_3)}{A_F(z_3)} = \frac{\Omega_C}{\Omega_F} \qquad (8)$$

e) Foreign country will export to interior region iff

$$\tau_{IC}\tau \cdot a_F w_F \le \tau_{IC} a_C w_C \text{ and } \tau_{IC}\tau \cdot a_F w_F \le a_I w_I \qquad \rightarrow \qquad \frac{A_C(z_4)}{A_F(z_4)} = \tau \frac{\Omega_C}{\Omega_F} \qquad (9)$$

f) Foreign country will export to coastal region iff

$$\tau \cdot a_F w_F \le a_C w_C \text{ and } \tau \cdot a_F w_F \le \tau_{IC} a_I w_I \qquad \rightarrow \qquad \tau \frac{\Omega_C}{\Omega_F} = \frac{A_C(z_4)}{A_F(z_4)} \qquad (10)$$

Together with assumptions (1) – (3), we can get the equalities in equations (5)-(10) specifying the boundary commodities z_1, z_2, z_3 and z_4 as a function of the relative wage ratios (Ω_i). The positions of these crossover goods thus summarize the patterns of trade. As wage ratios move in response to tariff changes, they will play important roles in the determination of the z_k. Inspecting (5)-(10), together with assumptions (1)-(3), we have:

Lemma 1: $z_1 < z_2$, $z_1 < z_3$, $z_3 < z_4$, and $z_2 < z_4$. For proofs see Appendix 2.

We further assume $z_2 < z_3$ and illustrate the patterns of trade in terms of z_k in Figure 2.[13]

Figure 2a shows the production pattern of three economies. Over all, on the [0,1] interval, I specializes at the low end from 0 to z_2, F produces in the range [z_3,1], and C focuses on the range [z_1, z_4]. Then Figure 2b elaborates on the patterns of trade in detail. Because I's comparative advantage lies at the low end of the continuum, it exports varieties [0, z_1] to both C and F, obtains varieties [z_2, z_4] from C, and imports varieties [z_4, 1] from F. Conversely, F specializes at the high end of the continuum. It exports varieties [z_4, 1] to both I and C, imports category [0, z_1] from I and [z_1, z_3] from C. Assuming that each country and region consumes

[13] $z_3 < z_2$ will not change the final results. See Appendix 2 for proofs.

all the varieties in the [0, 1] interval, there exist two ranges of non-traded goods.[14] The first range is NT1 ([z_1, z_2]) as a result of the transportation cost between C and I. Because the products within the range [z_1, z_2] are produced by both I and C at the same time and there is no trade between these two regions, this range is named the non-traded region between C and I. Similarly, the second range NT2 ([z_3, z_4]) is the tariff-driven non-traded range between H and F. Commodities within this range are produced by C and F at the same time, but do not enter international trade.

Because the non-traded product ranges are also overlapping production ranges, they reflect the degree of product similarity across the countries/regions. When economies become more specialized, trade increases, and the overlapping non-traded ranges are expected to shrink. Ultimately, they disappear with the abolishment of trade barriers. In this paper, because we are investigating patterns of China's regional specialization, we are particularly interested in the non-traded range NT1 between C and I. As national markets integrate, domestic trade increases, and NT1 becomes narrower. Thus, there is less similarity between C and I, and the two regions are more specialized with larger GINI indexes. Vice versa, when NT1 widens, there is greater overlap between C and I, so more redundant products are produced by C and I simultaneously. Then the home country is less efficient, and the two sub-regions are more diversified with smaller GINI values. Thus, our hypothesis is that the length of NT1 is negatively correlated with the GINI coefficients.

Demand and trade balance

To close the model and determine the trade equilibrium, we also consider the demand side of the market, assuming that consumers have identical Cobb-Douglas preferences across

[14] As a famous result shown in Dornbusch et al. (1977), in a continuum Ricardian model, tariffs and transport cost drive a wedge between domestic and foreign prices and thus give rise to a range of non-traded goods.

countries. Demand for each commodity is a constant share $b(z)$ of total expenditure and is identical across countries. The expenditure share profile is strictly positive, and its integral from zero to one is unity. The fraction of income spent on a subset of goods is defined as:

$$\theta(z_i) = \int_0^{z_i} b(z)dz > 0, \text{ i=1,2,3,4.} \tag{11}$$

Market clearing conditions require that a country or region's total labor income equal total spending on the goods it produces:

$$[1-\theta(z_4)](w_I L_I + w_C L_C) = \theta(z_3) w_F L_F \tag{12}$$

$$[1-\theta(z_2)] w_I L_I = \theta(z_1)(w_C L_C + w_F L_F) \tag{13}$$

Equation (12) states that at the trade balance equilibrium, a home country's imports are equal in value to its exports. Equation (13) means that I's expenditure on products from C and F equals its total sale of the two. Defining $l_i = \dfrac{L_i}{L_I}$, $i = C, F$ and using the definition of Ω_i, we can rearrange the above expressions into the following forms:

$$1-\theta(z_3) + [1-\theta(z_4)](\Omega_F l_C / \Omega_C l_F + \Omega_F / l_F) = 1 \tag{14}$$

$$\theta(z_1) \cdot (l_C / \Omega_C + l_F / \Omega_F) + \theta(z_2) = 1 \tag{15}$$

Combining the regional bilateral export conditions (5) – (10) with the normalized trade balance equations (14) and (15) on the demand side, we close the model with a general equilibrium system. The endogenous variables are the four boundary points determining the patterns of trade, and the relative wage ratios across regions/countries. The exogenous variables are the tariffs, transport cost, and labor endowment.

4. Comparative Static

To understand how the borderline products (z_k)s are affected by the exogenous variables, we differentiate and restate the equalities in equations (5) – (10) into a percentage change form. These four equations form the basis of our later analysis.

$$\hat{z}_1 = \frac{1}{\alpha_C}(\hat{\Omega}_C + \hat{\tau}_{IC}) \tag{16}$$

$$\hat{z}_2 = \frac{1}{\alpha_C}(\hat{\Omega}_C - \hat{\tau}_{IC}) \tag{17}$$

$$\hat{z}_3 = \frac{1}{\alpha}(\hat{\Omega}_C - \hat{\Omega}_F - \hat{\tau}^*) \tag{18}$$

$$\hat{z}_4 = \frac{1}{\alpha}(\hat{\Omega}_C - \hat{\Omega}_F + \hat{\tau}) \tag{19}$$

where $\alpha_C < 0$ from Assumption 1, and $\alpha = \alpha_C - \alpha_F > 0$ by Assumption 3.

Equations (16)-(19) indicate that the patterns of trade are affected by tariffs, transport costs and real wage ratios. In general equilibrium, real wage ratios will adapt as demand shifts to countries with the lowest tariff-inclusive price of goods. Hence, the effects on z_k can be decomposed into two effects: 1) a direct effect from the exogenous variables, and 2) an indirect effect from them through the terms of trade. For example, in equation (16), even though only transport cost τ_{IC} directly affects the boundary product z_1, all the other exogenous variables can indirectly influence z_1 through the wage gap Ω_C.

Non-traded Region NT1

As we are interested in how the length of the non-traded region NT1 is affected by the exogenous variable tariff rates, we totally differentiate ($z_2 - z_1$) and yield the following simple expression:

$$\frac{d(z_2 - z_1)}{(z_2 - z_1)} = \frac{1}{|\alpha_c|}(\frac{dw_c}{w_c} - \frac{dw_I}{w_I}) \tag{20}$$

Basically, equation (20) tells us that the percentage change of NT1 is proportional to the percentage change of the wage gap between the coast and inland. The model gives us another interesting result: the length of NT1 is positively correlated with the C-I wage inequality. Correspondingly, tariff rates influence NT1 through their impact on China's relative coast-to-inland wage ratio.

GINI Coefficients

From the general equilibrium model, we also derive the GINI indexes for the inland (GINI_I) and coast (GINI_C) as follows: [15]

$$GINI\_I = \frac{W_C L_C}{W_I L_I + W_C L_C} \cdot \left[1 - (z_2 - z_1)^2 (1 + \frac{W_F L_F}{W_C L_C}) \right] \tag{21}$$

$$GINI\_C = \frac{W_I L_I}{W_I L_I + W_C L_C} \cdot \left[1 - (z_2 - z_1)^2 (1 + \frac{W_F L_F}{W_C L_C}) \right] \tag{22}$$

where $W_i L_i$ stands for a region's total labor income or total expenditure. We immediately have:

$$GINI\_I + GINI\_C = \left[1 - (z_2 - z_1)^2 (1 + \frac{W_F L_F}{W_C L_C}) \right] > 0 \tag{23}$$

$$GINI\_I - GINI\_C = \frac{W_C L_C - W_I L_I}{W_I L_I + W_C L_C} \cdot \left[1 - (z_2 - z_1)^2 (1 + \frac{W_F L_F}{W_C L_C}) \right] > 0 \tag{24}$$

Notice $(z_2 - z_1)$ is exactly the length of the regional non-traded range NT1 in equations (20) and (21). Together with equation (23), this immediately proves our hypothesis that both regional GINI coefficients are negatively correlated with the length of NT1. A contracting overlapping range indicates less redundancy between C and I. Hence, the two regions exhibit patterns of specialization. From equation (23), if the two regions have a completely disjointed industry

[15] For details see Appendix 4.

structure, i.e., their non-traded region vanishes, then z_2 converges to z_1, and the two GINI indexes add up to unity, which combine to form the national composition.

More interestingly, once taking the difference between the two GINI coefficients, as in equation (24), we can always guarantee that GINI_I is larger than GINI_C based on the fact that coastal China is wealthier than the inland ($W_C L_C > W_I L_I$). This result is consistent with our empirical findings in Section 2 that the interior GINI curve lies above the coastal GINI curve. Holding the second term of equation (24) constant, when the coast contributes a larger share to national income than the inland, the difference between the two GINI indexes widens.

As a summary, Table 2 presents the qualitative impact of exogenous variable tariff rates with the mathematics presented in Appendix 3. Columns 3 and 4 report the general equilibrium results of changing τ and τ^*, respectively. Each of the rows lists the changes of the endogenous variables: domestic wage ratio, non-traded range, and GINI coefficients. We have the following lemmas.

Lemma 2 – Consequences of home country tariff reductions:

A tariff reduction in the home country will alleviate its relative coastal-interior wage disparity and contracts the range of the non-traded goods between C and I.

$$\tau \downarrow \Rightarrow (\frac{1}{\Omega_C} = \frac{w_C}{w_I}) \downarrow \Rightarrow \text{NT1} = [z_1, z_2] \downarrow$$

Consider a uniform tariff cut across all the goods that the home country imports. From equations (16) and (17), even though z_1 and z_2 are not directly affected by τ, they are indirectly so by the relative inland-coast wage ratio Ω_C. Thus, we check the effect of lowering τ on Ω_C. When z_4 shifts to the left as a result of F's export expansion, the production of high-indexed goods shifts from C to F. The direct impact is that the C-I wage ratio declines ($1/\Omega_C = w_C / w_I \downarrow$)

and C competes more with I in the remaining product range.[16] Thus $\hat{\Omega}_C>0$ in equations (16) and (17) and both z_1 and z_2 decrease by the same percentage ($\alpha_C < 0$). However, because z_2 is larger than z_1, z_2 reduces more than z_1 in level.[17] The net effect is a shrinkage of the non-traded range between the coast and the inland. As shown in Table 2, NT1 ($[z_1, z_2]\downarrow$) shrinks as the home tariff drops.

Intuitively, a country that lowers its import duties will bring in competition from abroad, particularly among its high-end products. That is why the coastal area will lose part of its comparative advantage at the high end to the foreign country and specialize in a narrower production range with less demand for labor. This attenuates the coast-inland wage gap and intensifies the competition between C and I in low-end production. As a result of the harsh competition, there will be less redundant production between the two regions, and the non-traded product range contracts. In general, external competition leads to regional specialization, market integration, and income convergence.

Lemma 3 – Effects of slashing foreign country tariffs

A reduction of foreign country tariff rates will aggravate the relative coastal-interior wage disparity in the home country and correspondingly widen the range of non-traded goods between sub-regions in the home country.

$$\tau^* \downarrow \Rightarrow \frac{w_C}{w_I} \uparrow \Rightarrow \text{NT1}=[z_1, z_2]\uparrow .$$

A falling foreign tariff generates exactly the opposite effect of cutting τ. When the home country expands its exports, the activities transferred from F to C benefit C most by upgrading

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[16] Wei and Wu (2001) also found that in China, cities that experience a greater degree of openness in trade also tend to demonstrate a greater decline in urban-rural income inequality.

[17] $\hat{z}_2 = \hat{z}_1 \Rightarrow \frac{dz_2}{z_2} = \frac{dz_1}{z_1}$ because $z_2 > z_1 \Rightarrow dz_2 > dz_1$.

C's production in the high-end product range. It follows that C's demand for labor increases, which magnifies the coastal-interior wage ratio ($1/\Omega_C = \frac{w_C}{w_I} \uparrow$). Correspondingly, the competition between C and I alleviates, and their overlapping product range widens. As demonstrated in equations (16) and (17), when the coast-inland wage gap widens, both z_1 and z_2 increase by the same percentage amount. Because $z_2 > z_1$, the net increase of z_2 exceeds that of z_1 in level. Hence, the non-traded range of products between C and I expands (NT1=[z_1, z_2]$\uparrow$). Intuitively, when a foreign country lowers its import tariff, it imports more from China. Then both coastal and inland China will try to increase their exports, not only in intensive margin but also in extensive margin. This benefits the coast most because it is directly competing with foreign products. Thus, the coast increases its exports and attracts labor from inland, which drives up the relative wage ratio of C-I. The net effect is a rise in wage inequality and a decrease in regional specialization.

Lemma 4 – GINI, NT1, and tariff rates: GINI coefficients are negatively correlated with the length of NT1. GINI falls with lower foreign tariffs, but rises when the home country dismantles trade protection.

$$\tau^* \downarrow \Rightarrow \frac{w_C}{w_I} \uparrow \Rightarrow NT1 \uparrow \Rightarrow GINI \downarrow \Rightarrow \text{Regions Diversify}$$

$$\tau \downarrow \Rightarrow \frac{w_C}{w_I} \downarrow \Rightarrow NT1 \downarrow \Rightarrow GINI \uparrow \Rightarrow \text{Regions Specialize}$$

When a foreign country lowers its tariff τ^*, it drives up the relative coast-inland wage ratio in China and expands the NT1 range. Hence, more redundant products are produced. Correspondingly, the regional GINI falls, becoming less specialized. Whereas opening up by China alleviates its coast-inland wage inequality, narrows the non-traded region NT1, and increases the regional GINI coefficients, leading to geographic concentration.

5. Supporting Evidence

From our model, the direction in which the regional GINI indexes move depends on which country liberalizes trade first. If F precedes H in removing trade barriers, then we will observe the U-shaped regional GINI curves, as shown in Section 2. In this section, we provide four pieces of evidence that support our model: numeric simulation, simple regressions, U.S.-China trade policy review, and the time trend of the coast to inland wage ratios.

5.1. Numeric Simulation

We attempt to simulate the model and solve for the numerical solution. Suppose $A_c(z) = z^{-0.24}$, $A_F(z) = z^{-2.64}$, $l_C = \frac{L_C}{L_I} = 0.94$, $l_F = \frac{L_F}{L_I} = 2$, and transport cost τ_{IC} =1.21.[18] We then obtain the following results as shown in Table 3.

The upper panel of Table 3 displays solutions to three possible equilibriums that can arise when the home country lowers its tariff rate, holding the foreign tariff constant at 1.1.[19] Suppose initially that the home country tariff is 1.3. In this equilibrium, the coast to inland wage ratio is 4.99. The home country produces in the range of [0, 0.1225], and the foreign country produces in the range of [0.1056, 1]. Due to the existence of tariffs, there is a non-traded range NT2 [0.1056, 0.1225] between the two countries. The existence of transportation costs between the coast and inland also renders an across-region non-traded range NT1 [0.0215, 0.1051]. Interior GINI and coastal GINI coefficients equal 0.71818 and 0.2004, respectively.

Then, as the home country reduces its tariff rate from 1.3 to 1.2, as shown in the second row, the inter-country non-traded range NT2 shrinks. This proves the seminal results of Dornbusch et al. (1977) that dismantling trade barriers makes more goods tradable. Furthermore,

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[18] The numbers are obtained from the previous literature. For example, see Appleyard et al. (1989) and Xu (2003).

[19] Note from the model, both τ and τ^* exceed unity.

the coast to inland wage gap enlarges, the across-region non-traded range NT1 shrinks, and both regional GINI coefficients increase. All these results are consistent with the model predictions of when the home country opens up. Then the lower panel of Table 3 presents the simulation results of when a foreign country's import tariff drops from 1.4 to 1.15, holding the home tariff constant. We can see that the non-traded range NT1 widens, accompanied by a fall in GINI_C and GINI_C.

This simulation confirms our prediction that sub-regions inside a country tend to specialize as trade opens up and they are faced with fierce competition, but diversify when its trading partner opens more. If its trading partners precede China in opening up, then we observe the U-shaped regional GINI curves.

5.2. Regression

We also conduct some simple regressions at the province level to test the negative relationship between the regional GINI coefficients and tariff rates. Using provincial-level measures of GINI coefficients, we estimate the equation:

$$GINI_{it} = \beta_1 China\_Tariff_{it} + \beta_2 US\_Tariff_{it} + \beta_3 Coast + a_i + \gamma_t + \varepsilon_{it} \qquad (25)$$

where i stands for the Chinese provinces, and t stands for year. $China\_Tariff_{it}$ is China's import tariff for province *i*, and US_Tariff_{it} is U.S. import duties at province level. The coast is a dummy variable, which equals 1 if the province lies along the coast, and 0 otherwise. In our estimation, the fixed effects are added to control any time or province invariant factors. Based on our model, our main hypotheses are: 1) β_1<0, 2) β_2>0, and 3) β_3<0.

As it takes time to form geographic concentration, we also try replacing the current year tariff rates by their one year lagged value on the right hand side. The use of the lagged value of tariffs also mitigates the potential endogeneity problem. To maintain sufficient sample size, we do not include lags of more than one year.

$$GINI_{it} = \beta_1 China\_Tariff_{i,t-1} + \beta_2 US\_Tariff_{i,t-1} + a_i + \gamma_t + \varepsilon_{it} \quad (26)$$

To obtain provincial level tariff rates, we follow Branstetter and Feenstra (2002) and compute China's import tariff rates for province i as:

$$China\_Tariff_{it} = \sum_j \frac{IMP_{ijt}}{IMP_{it}} \cdot \tau_{jt} \quad (27)$$

where τ_{jt} is China's ad-valorem Most Favored Nation (MFN) tariff rate levied on a 6-digit HS commodity j, and the weight IMP_{ijt}/IMP_{it} is China's provincial import share of matching commodity j. Similarly, tariff rates imposed by the United States on its import from Chinese province i are constructed as:

$$US\_Tariff_{it} = \sum_j \frac{EXP_{ijt}}{EXP_{it}} \cdot \tau^*_{jt} \quad (28)$$

where τ^*_{jt} is the U.S. ad-valorem MFN tariff rate, and the weight EXP_{ijt}/EXP_{it} is the percentage share of commodity j in the exports from Chinese province i to the States.

The ad-valorem MFN tariff schedule between China and USA are obtained from the TRAINS tariff database, which comes at the detailed HS 8-digit commodity level. Table 4 lists the simple average MFN tariff rates for the United States and China from 1988 to 2006. We construct an HS 6-digit MFN tariff by taking a simple average of the HS 8-digit codes within each 6-digit industry code. Then the tariff rates are matched to the Chinese import and export data at the same commodity level. The source of the Chinese trade data is the same as we construct the GINI coefficients. A panel dataset of tariff duties and GINI coefficients for 30 Chinese provinces and 15 years (1992~2006) is constructed.[20]

[20] China's tariff data is not available for 1995 and 2002 in TRAINS database. When constructing the panel for regression, we use 1994 MFN tariff schedule for 1995, and 2001 tariffs for 2002. Also, there is no tariff data for China before 1991, so our regression panel starts from 1992.

Table 5 summarizes the regression results, where robust standard errors are reported in the brackets. Each regression includes a full set of provincial and year fixed effects. Columns (1) and (2) summarize the fixed effect estimation results using current year tariffs and 1-year lagged tariffs as regressors, respectively. The coefficient of China's import tariff is exactly what we expect. They are always significantly negative whether we use current year or one-year lagged tariffs. If China's import tariff drops by 1 percent, then GINI will increase by 0.068 percent. Similarly, the coefficient of the U.S. import tariff is significantly positive. If the US cuts its import tariff by 1 percent, then China's GINI will reduce by 0.2-0.38 percent. The coastal GINI coefficient is also significantly lower than inland China by a magnitude of 0.2-0.35. In general, these results strongly support our model predictions of tariff rates and GINI coefficients.

5.3. Trade Policy

The path of the MFN tariff rates also reflects the timing of the U.S.-China trade policies. The United States has always been China's top trading partner, and it plays a leading role in determining trade policy toward China. Ever since the U.S. reestablished full diplomatic relations with China in 1979, it granted the MFN status to China every year despite heated debates in Congress over China's record on human rights and weapon proliferation.[21] This quarter-century-long debate was ended in 2001 when China joined the WTO and was granted permanent normal trade status (PNTR). As presented in Table 4, the U.S. MFN rates remain below 2 digits throughout the time, whereas China's MFN rate ranged as high as 40 percent in the early 1990s, which, according to the World Bank (1994), was the world's highest average tariff at the time. Furthermore, China also maintains a complex maze of non-tariff barriers (NTBs). By 1993, almost one half of China trade was also subject to licensing or some other form of control. However, after 1994, trade policy changes were more pronounced for China.

[21] See Janow (1998) for China's MFN renewal process over the years.

Unweighted average tariffs declined from about 36 percent in 1994 to 17 percent in 2000, just prior to China's entry to the WTO, and then to under 10 percent by 2005. Import quotas and licensing were all abolished by 2005.

These changes were triggered by the deepening reform following Deng Xiaoping's Southern Tour Speech in 1992. The market mechanism laid the ideological groundwork for a breakthrough. In November 1993 the Third Plenum of the Fourteenth Central Committee designed a comprehensive economic reform strategy. Then starting from 1994, a new round of liberalization was embarked upon, including the unification of exchange rates, a major reduction in the scope of import licensing and controls, a profound tax reform, and a substantial unilateral reduction in tariff levels.[22] This policy review indeed supports our model assumption that partner countries such as the United States lowered their tariffs facing China before China opened up.

5.4. Patterns of the Coast-Inland Wage Ratio

As summarized in Figure 3, our model predicts that NT1 is negatively correlated with the GINI coefficients but positively correlated with the coast to inland wage gap. Thus, this wage ratio should be inversely related to the GINI indexes. Figure 4 plots four series of the coastal-interior wage ratio: simple averaged wage, and weighted averaged wages using provincial GDP, population, and total exports as weights[23]. All four series show an inverse U-shape, with the peak being around 1993. While the magnitude of the fall is small, the timing of the turnaround point surprisingly coincides that of the GINI curves.

We further check the correlation between the wage ratios and GINI coefficients. As presented in Table 6, the correlation between the relative wage ratio and coastal GINI ranges around -0.8, and the correlation between the wage and inland GINI is about -0.5. Thus, China's

[22] "Decision of the Chinese Communist Party Central Committee on some issues concerning the establishment of a socialist market economic system," Beijing Review, Vol. 36, No. 37 (November 22-28, 1993), pp. 12-31.
[23] Data of provincial wage, population, and GDP at the provincial level are collected from the China Statistic Yearbook, and we use the wage rates over all the manufacturing sectors in the analysis.

coast to inland wage ratio does move in the opposite direction to the regional GINI indexes, which supports our model.

6. Conclusion

Has China experienced regional specialization with three decades of trade liberalization? We answer this question using Chinese export data at the detailed commodity level over the period of 1988-2006. We find that both China's inland and coastal regions underwent two stages of specialization: they diversified from 1988 to 1994 and then specialized from 1994 to 2006. Furthermore, inland China is more specialized than its coastal counterpart.

To explain these observations, we propose a simple theoretical model which relies only on tariff rate reduction. We set up the Dornbusch, Fischer and Samuelson (1977) continuum of goods Ricardian model with two countries and three regions and studied the effects of changing tariffs on the non-traded product range across the sub-regions within a country. The model relies on the timing of tariff reductions in China and her trading partners. Partner countries such as the U.S. lowered their tariffs facing China before China lowered its own tariffs (just prior to entering the World Trade Organization (WTO)). We demonstrate theoretically that this pattern of tariff reduction generates a U-shaped movement in China's regional specialization. We also provide convincing evidence to support our model.

More could be done from this paper. We can further discuss the effects of transport cost and labor mobility on regional specialization. It would also be interesting to check the industry specialization pattern instead of the geographic one.

Appendixes Not for Publication

Appendix 1: Calculation of Locational GINI Specialization Index

The locational GINI coefficient is built upon the "Revealed Comparative Advantage" (RCA), as proposed by Balassa (1965).[24] We define the RCA as:

$$RCA_{ij} = \frac{X_{ij} / X_j}{X_i / X_n}$$

where *i* is the industry, *j* is the region or province, *n* is the nation, and X stands for exports. So the numerator X_{ij} / X_j measures the percentage share of industry i in region j's exports, and the denominator X_i / X_n is the same sector share in national exports. When an industry i contributes a larger share to region *j* than to the whole economy ($X_{ij} / X_j > X_i / X_n$), the RCA index exceeds unity. If the RCA is less than unity, then that industry is less important to region j's economy. When region *j* does not export industry i, then RCA_{ij} equals zero,

For each region, we will end up with one RCA per industry, which makes it hard to conclude whether a region is specializing or not.[25] To better measure regional specialization, a GINI coefficient is generated as a summary index based on these RCA indices. There will be one GINI per region. The steps of the GINI index calculation are as follows:

1. For each region j, rank the sectors by their RCA_{ij} in ascending order.
2. Following that sequence of sectors, calculate the cumulative national share (X_i / X_n) for each industry, and mark them on the horizontal axis. The axis will range from 0 to 1.
3. Calculate the cumulative regional share (X_{ij} / X_j) for industry i, and mark it on the vertical axis, which also ranges from 0 to 1.

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[24] This RCA index is also known as Location Quotient, as commonly referred in economic geography literature.
[25] RCA has been applied in numerous reports as a measure of trade specialization [UNIDO (1986) and World Bank (1994)].

4. Then, each industry can be represented by a dot on the graph. Connecting all the sectors will give us a convex Lorenz curve.[26]

The GINI coefficient is defined as the area between the Lorenz curve and the 45° line divided by the entire triangle in which the Lorenz curve is contained. As shown in Figure A1, GINI=2A because the area of triangle is exactly ½. Therefore, a GINI takes on values between 0 and 1. If a region has an identical export composition and distribution with the whole country, then the RCA_{ij} index equals 1 for every sector *i* in region *j*, and the Lorenz curve will coincide with the 45° line. Correspondingly, area A disappears, and the GINI coefficient equals zero. Hence, the 45° line measures the degree of equality between an industry's regional share and national share. *If most of the industries have very low regional share but there exists one or a few industries providing most of the country's share, then the curvature of the Lorenz curve increases and the GINI coefficient is near one.*

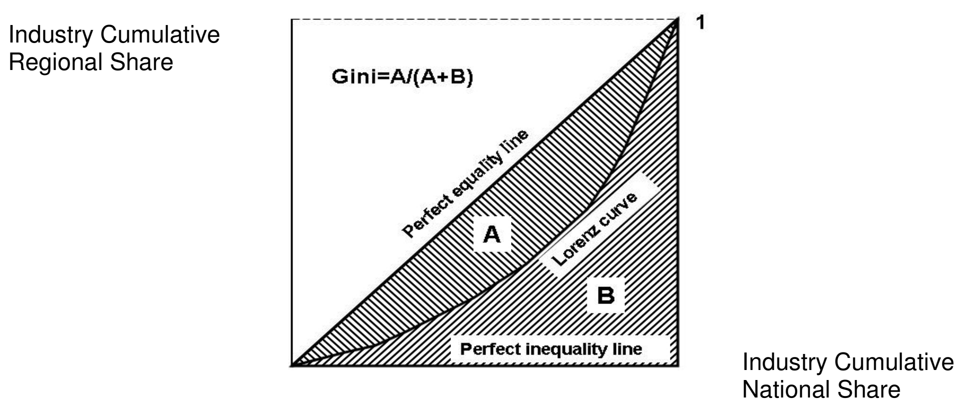


Figure A1: GINI coefficient for region j

In sum, a locational GINI index compares the regional distribution of exports with the national export distribution. If one region has no specialization at all but simply spreads out in proportion to the national export structure, it would have a GINI of zero. A region with a smaller GINI is less specialized (or more diversified).

[26] Ranking industries in ascending order of RCA guarantees that the Lorenz curve is of convex shape. If we rank the industries in descending order, then the Lorenz curve will have a concave shape.

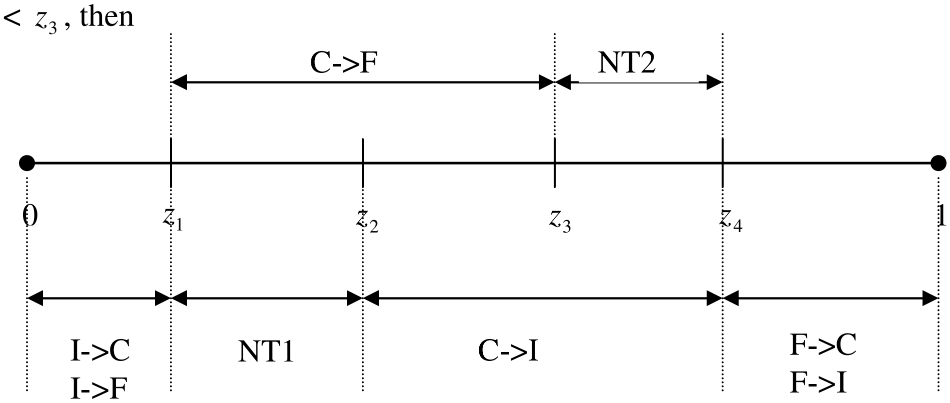
Appendix 2

Proof of Lemma 1:
Statement: $z_1 < z_2$
When in trade balance, at the equilibrium point z_1 and z_2, we have
$\Omega_C = A_C(z_1)/\tau_{IC} = A_C(z_2) \bullet \tau_{IC}$.
Because $\tau_{IC} > 1$ and $A_C(z)$ decreases with z, from the three assumptions, we have $z_1 < z_2$.

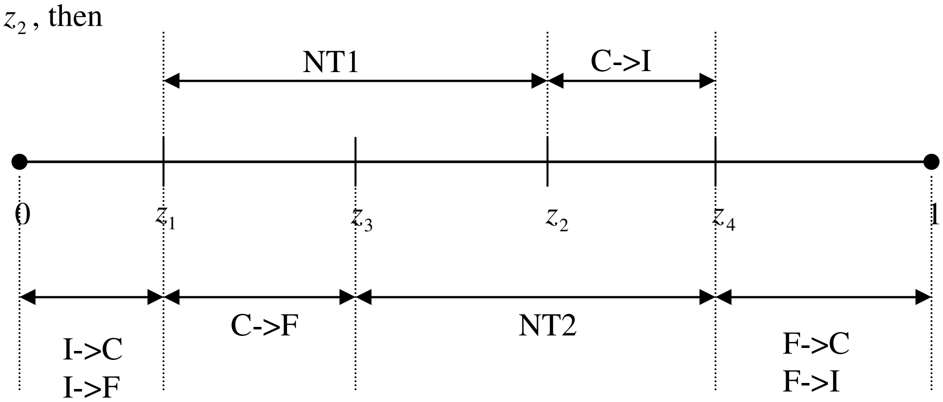
Statement: $z_3 < z_4$
When in trade balance, at the equilibrium point z_3 and z_4, we have
$\Omega_C/\Omega_F = \tau^* \bullet A_C(z_3)/A_F(z_3) = 1/\tau \bullet A_C(z_4)/A_F(z_4)$.
Because τ and τ^* are both larger than 1, and $A_C(z)/A_F(z)$ increases with z from Assumption 3, we have $z_3 < z_4$.

The coastal region transferring goods to the interior region makes $z_2 < z_4$, and coastal region exports to a foreign country make $z_1 < z_3$.

Proof: $z_2 < z_3$ **or** $z_3 < z_2$ **will not change the results**
If $z_2 < z_3$, then



If $z_3 < z_2$, then



Appendix 3: Solving for Comparative Static

We rewrite equations (16)-(17) here, which are the percentage change form of z_k.

$$\hat{z}_1 = \frac{1}{\alpha_C}(\hat{\Omega}_C + \hat{\tau}_{IC}) \tag{A1}$$

$$\hat{z}_2 = \frac{1}{\alpha_C}(\hat{\Omega}_C - \hat{\tau}_{IC}) \tag{A2}$$

$$\hat{z}_3 = \frac{1}{\alpha}(\hat{\Omega}_C - \hat{\Omega}_F - \hat{\tau}^*) \tag{A3}$$

$$\hat{z}_4 = \frac{1}{\alpha}(\hat{\Omega}_C - \hat{\Omega}_F + \hat{\tau}) \tag{A4}$$

We further differentiate the two trade balance equations (9) and (10) and re-express them in the percentage form.

$$\begin{aligned}&\left[\frac{1}{\alpha_C}\eta_1(\varepsilon_1+\varepsilon_2)+\frac{1}{\alpha_C}\eta_2(1-\varepsilon_1-\varepsilon_2)-\varepsilon_1\right]\cdot\hat{\Omega}_C-\varepsilon_2\cdot\hat{\Omega}_F+\varepsilon_1\cdot\hat{l}_C\\&+\varepsilon_2\cdot\hat{l}_F+\frac{1}{\alpha_C}[\eta_1(\varepsilon_1+\varepsilon_2)-\eta_2(1-\varepsilon_1-\varepsilon_2)]\cdot\hat{\tau}_{IC}=0\end{aligned} \tag{A5}$$

$$\begin{aligned}&\frac{1}{\alpha}(\varepsilon_3\eta_3+\varepsilon_4\eta_4+\alpha\varepsilon_5)\cdot\hat{\Omega}_C-\frac{1}{\alpha}(\varepsilon_3\eta_3+\varepsilon_4\eta_4+\alpha\varepsilon_4)\cdot\hat{\Omega}_F-\varepsilon_5\cdot\hat{l}_C\\&+\varepsilon_4\cdot\hat{l}_F-\frac{1}{\alpha}\varepsilon_3\eta_3\cdot\hat{\tau}^*+\frac{1}{\alpha}\varepsilon_4\eta_4\cdot\hat{\tau}=0\end{aligned} \tag{A6}$$

where the coefficients are defined as:

$$\alpha = \alpha_C - \alpha_F > 0$$

$$\varepsilon_1 = \theta(z_1)\cdot {l_C}/{\Omega_C} > 0 \qquad \varepsilon_2 = \theta(z_1)\cdot {l_F}/{\Omega_F} > 0$$

$$\varepsilon_3 = 1-\theta(z_3) > 0 \qquad \varepsilon_4 = [1-\theta(z_4)]\left(\frac{\Omega_F l_C}{\Omega_C l_F}+\frac{\Omega_F}{l_F}\right) > 0$$

$$\varepsilon_5 = [1-\theta(z_4)]\left(\frac{\Omega_F l_C}{\Omega_C l_F}\right) > 0$$

$$\eta_i = \frac{\partial\theta_i}{\partial z_i}\cdot\frac{z_i}{\theta_i} \qquad \text{i=1,2} \qquad \eta_i > 0$$

$$\eta_j = \frac{\partial\theta_j}{\partial z_j}\cdot\frac{z_j}{1-\theta_j} \qquad \text{j=3,4} \qquad \eta_j > 0$$

Then we write equations (A5) and (A6) in a reduced form:

$$(BC-AD)\cdot\hat{\Omega}_C=(Am_1+Bq_1)\cdot\hat{l}_C+(Am_2+Bq_2)\cdot\hat{l}_F+Am_3\cdot\hat{\tau}_{IC}+Bq_4\cdot\hat{\tau}^*+Bq_5\cdot\hat{\tau} \quad \text{(A7)}$$

$$(BC-AD)\cdot\hat{\Omega}_F=(Cm_1+Dq_1)\cdot\hat{l}_C+(Cm_2+Dq_2)\cdot\hat{l}_F+Cm_3\cdot\hat{\tau}_{IC}+Dq_4\cdot\hat{\tau}^*+Dq_5\cdot\hat{\tau} \quad \text{(A8)}$$

where

$$A=\frac{1}{\alpha}(\varepsilon_3\eta_3+\varepsilon_4\eta_4+\alpha\varepsilon_4)>0$$

$$B=\varepsilon_2>0$$

$$C=\frac{1}{\alpha}(\varepsilon_3\eta_3+\varepsilon_4\eta_4+\alpha\varepsilon_5)>0$$

$$D=\frac{1}{\alpha_C}[\eta_1(\varepsilon_1+\varepsilon_2)+\eta_2(1-\varepsilon_1-\varepsilon_2)-\alpha_C\varepsilon_1]<0$$

$$m_1=\varepsilon_1>0 \qquad q_1=\varepsilon_5>0$$

$$m_2=\varepsilon_2>0 \qquad q_2=-\varepsilon_4<0$$

$$m_3=\frac{1}{\alpha_C}[\eta_1(\varepsilon_1+\varepsilon_2)-\eta_2(1-\varepsilon_1-\varepsilon_2)] \qquad q_3=0$$

$$m_4=0 \qquad q_4=\frac{1}{\alpha}\varepsilon_3\eta_3>0$$

$$m_5=0 \qquad q_5=-\frac{1}{\alpha}\varepsilon_4\eta_4<0$$

Equations (A7) and (A8) can also be expressed in matrix form:

$$\begin{bmatrix}\hat{\Omega}_C\\ \hat{\Omega}_F\end{bmatrix}=\frac{1}{\Delta}\begin{bmatrix}A & B\\ C & D\end{bmatrix}\begin{bmatrix}m_1 & q_1\\ m_2 & q_2\\ m_3 & q_3\\ m_4 & q_4\\ m_5 & q_5\end{bmatrix}'\begin{bmatrix}\hat{l}_C\\ \hat{l}_F\\ \hat{\tau}_{IC}\\ \hat{\tau}^*\\ \hat{\tau}\end{bmatrix} \quad \text{(A9)}$$

$$\Delta=BC-AD>0$$

Then the solutions to changing terms of trade $\hat{\Omega}_C$ and $\hat{\Omega}_F$ are substituted into equations (A1) – (A4) to solve for changes in z_k.

Appendix 4: Regional GINI Derivation

Following the definition of GINI in Appendix 1, we can now derive the two regional GINI indexes theoretically. Let the total income of each region be $W_I L_I$, $W_C L_C$, and $W_F L_F$ for I, C and F, respectively. We also assume that they spend all production income on the consumption of goods. Then each region's production income from a different production range will equal the consumption expenditure on the goods:

In $[0, z_1]$, $W_I L_I(z) = b(z)*(W_I L_I + W_C L_C + W_F L_F)$ (A10)

In $[z_1, z_2]$, $W_I L_I(z) = b(z)*(W_I L_I)$ (A11)

$W_C L_C(z) = b(z)*(W_C L_C + W_F L_F)$ (A12)

In $[z_2, z_3]$, $W_C L_C(z) = b(z)*(W_I L_I + W_C L_C + W_F L_F)$ (A13)

In $[z_3, z_4]$, $W_C L_C(z) = b(z)*(W_I L_I + W_C L_C)$ (A14)

$W_F L_F(z) = b(z)*(W_F L_F)$ (A15)

This is the foundation for calculating GINI. Within each region, we first calculate RCA_{ij} for each industry and then sort them from small to large. The horizontal axis is the cumulative national share for each industry in order, and the vertical axis is the corresponding cumulative regional share of each industry.

Interior GINI index

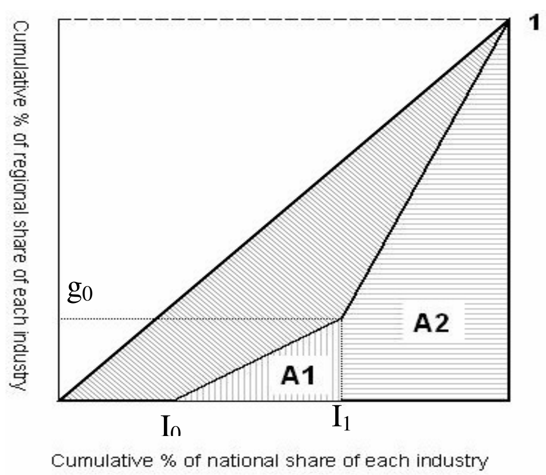
The RCA_{ij} for the interior region's production range will be:

In $[0, z_1]$, $X_i = X_{iI}$ $\Rightarrow RCA_{ij} = X_n/X_j$

In $[z_1, z_2]$, $X_i > X_{iI}$ $\Rightarrow RCA_{ij} < X_n/X_j$

In $[z_2, 1]$, $X_{ij} = 0$ $\Rightarrow RCA_{ij} = 0$

After sorting all the products by increasing ranking of RCA_{ij}, we form a polygon similar to the following (the Lorenz curve consists of three straight lines as follows).



In the figure, area A_1 corresponds to the product region [z_1, z_2], and area A_2 corresponds to region [0, z_1]. A_1 and A_2 are both triangles because in each region *j*, RCA_{ij} is independent of industry *i*, i.e., all the industries in each region have the same value of RCA_{ij}, which is the slope in the triangular shape.

Then, we calculate the X-axis as the industry accumulated national share. The Y-axis is the industry accumulated regional share.

- g_0 is the total regional share of goods [z_1, z_2] produced by the interior region. Assuming $b(z)$=1, we have
  $$g_0 = \int_{z_1}^{z_2} X_{ij} dz \Big/ X_j = z_2 - z_1$$

- ($I_1 - I_0$) is the national share of goods [z_1, z_2] produced by both the interior and coastal regions.
  $$I_1 - I_0 = \int_{z_1}^{z_2} X_i dz \Big/ X_n = (1+\lambda)*(z_2 - z_1)$$

where $\lambda = \dfrac{W_F L_F}{W_I L_I + W_C L_C} = (1 - z_4)/z_3$, and second equality if from trade balance equation (2).

- (1- I_1) is the national share of goods [0, z_1],
  $$1 - I_1 = \int_0^{z_1} X_i dz \Big/ X_n = (1+\lambda)* z_1 ,$$

Thus, the area below the Lorenz curve is:

$$\begin{aligned} 2*(A_1 + A_2) &= (1+\lambda)*(z_2 - z_1)^2 + (1+\lambda)* z_1 *(1 + z_2 - z_1) \\ &= (1+\lambda)*(z_1 + z_2{}^2 - z_1 z_2) \end{aligned}$$

We obtain the GINI index for the interior region as:

$$\begin{aligned} \text{GINI\_I} &= 1 - 2*(A_1 + A_2) \\ &= 1 - (1 + \frac{W_F L_F}{W_I L_I + W_C L_C})*(z_1 + z_2{}^2 - z_1 z_2) \\ &= \frac{W_C L_C}{W_I L_I + W_C L_C} \cdot \left[1 - (z_2 - z_1)^2 (1 + \frac{W_F L_F}{W_C L_C}) \right] \end{aligned} \qquad (A16)$$

Coastal GINI index

For the coastal region, $X_j = W_C L_C$, and the RCA_{ij} over the production ranges are:

In $[z_1, z_2]$, $RCA_{ij}=X_n/X_j*(W_C L_C+W_F L_F)/(W_I L_I+W_C L_C+W_F L_F)$
In $[z_2, z_3]$, $RCA_{ij}=X_n/X_j$
In $[z_3, z_4]$, $RCA_{ij}=X_n/X_j$
for the other production ranges, $RCA_{ij}=0$

Thus, the Lorenz curve for the coastal region can be depicted using the same figure as above, except that the values of I_0, I_1, g_0 have changed. Now area A_1 corresponds to $[z_1, z_2]$, and A_2 corresponds to $[z_2, z_4]$.

We also have:

$$g_0=\int_{z_1}^{z_2} X_{ij}dz \Big/ X_j = (1+\varphi)*(z_2 - z_1)$$

where $\varphi = W_F L_F / W_C L_C$,

$$I_1 - I_0=\int_{z_1}^{z_2} X_i dz \Big/ X_n = (1+\lambda)*(z_2 - z_1)$$

$$1 - I_1=\int_{z_2}^{z_4} X_i dz \Big/ X_n = \int_{z_2}^{z_3} X_i dz \Big/ X_n + \int_{z_3}^{z_4} X_i dz \Big/ X_n =(1+\lambda)*(z_3 - z_2)+ z_4 - z_3$$

$$2*(A_1+A_2)= 1-(1+\lambda)*z_2+(1+\varphi)*[1-(1+\lambda)*z_1]$$

The GINI index for the coastal region is:

$$\text{GINI\_C}=1-2*(A_1+A_2)=(1+\lambda)*z_2+(1+\varphi)*[(1+\lambda)*z_1-1]$$
$$=\frac{W_I L_I}{W_I L_I + W_C L_C}\left[1-\left(1+\frac{W_F L_F}{W_C L_C}\right)(z_2-z_1)^2\right] \qquad \text{(A17)}$$

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Table 1: Summary Statistics of Provincial GINI Coefficients (1988-2006)

Group	Province	Macro Region			Mean	Std. Dev	Max	Min	Rank
		Coastal / Interior	East / Middle / West	North / South					
Least Specialized (Most Diversified)	Guangdong	C	E	S	0.47	0.04	0.54	0.41	1
	Shanghai	C	E	S	0.48	0.07	0.6	0.37	2
	Jiangsu	C	E	S	0.49	0.07	0.61	0.4	3
	Zhejiang	C	E	S	0.52	0.09	0.69	0.41	4
	Shandong	C	E	N	0.56	0.02	0.61	0.53	5
	Beijing	C	E	N	0.58	0.1	0.74	0.38	6
	Tianjin	C	E	N	0.58	0.04	0.64	0.51	7
	Anhui	I	M	S	0.59	0.05	0.68	0.53	8
	Hubei	I	M	S	0.61	0.04	0.66	0.52	9
	Hainan	C	E	S	0.67	0.09	0.81	0.51	10
Intermediate Group	Jiangxi	I	M	S	0.67	0.06	0.79	0.59	11
	Heibei	I	E	N	0.68	0.02	0.71	0.64	12
	Liaoning	C	E	N	0.68	0.01	0.71	0.66	13
	Fujian	C	E	S	0.69	0.04	0.75	0.6	14
	Henan	I	M	N	0.69	0.04	0.75	0.61	15
	Shaanxi	I	W	N	0.69	0.05	0.78	0.62	16
	Sichuan	I	W	S	0.69	0.05	0.78	0.60	17
	Hunan	I	M	S	0.73	0.04	0.79	0.63	18
	Guangxi	I	E	S	0.77	0.04	0.83	0.69	19
	Heilongjiang	I	M	N	0.78	0.04	0.86	0.71	20
Most Specialized	Jilin	I	M	N	0.83	0.06	0.91	0.71	21
	Shanxi	I	M	N	0.85	0.06	0.92	0.73	22
	Gansu	I	W	N	0.85	0.05	0.91	0.77	23
	NeiMeng	I	M	N	0.87	0.05	0.93	0.75	24
	Xinjiang	I	W	N	0.88	0.05	0.94	0.78	25
	Guizhou	I	W	S	0.89	0.04	0.95	0.81	26
	Yunnan	I	W	S	0.89	0.02	0.91	0.83	27
	Ningxia	I	W	N	0.91	0.02	0.94	0.85	28
	Qinghai	I	W	N	0.92	0.04	0.97	0.82	29
	Tibet	I	W	N	0.94	0.06	0.99	0.79	30

Table 2: Comparative Static Results of Lowering Tariffs on Endogenous Variables

		Tariff Reduction	
Description	**Endogenous Variables**	τ drop	τ^* drop
Coast to Inland wage disparity	$1/\Omega_C = w_C / w_I$	↓	↑
Non-traded range between Coast and Inland	NT1= (z_1, z_2)	↓	↑
Regional GINI coefficients	*GINI_I, GINI_C*	↑	↓

Note: C, I, H and F stands for coastal, interior, home country, and foreign country, respectively.

Table 3: Numeric Simulation Result

τ	τ^*	τ_{IC}	z_1	z_2	z_3	z_4	$z_2 - z_1$ (NT1)	$z_4 - z_3$ (NT2)	$\frac{w_C}{w_I}$	GINI_I	GINI_C
1.3	1.1	1.21	0.0215	0.1051	0.1056	0.1225	0.0836	0.0170	4.9975	0.71818	0.20042
1.2	1.1	1.21	0.0214	0.1049	0.1057	0.1187	0.0835	0.0130	5.0134	0.718181	0.20053
1	1.1	1.21	0.0213	0.1044	0.1060	0.1103	0.0831	0.0043	5.0478	0.718199	0.20076
1.4	**1.4**	1.21	0.0215	0.1055	0.1059	0.1402	0.0839	0.0343	4.9619	0.72277	0.19735
1.4	**1.3**	1.21	0.0219	0.1070	0.1082	0.1389	0.0851	0.0307	4.8574	0.72273	0.19665
1.4	**1.2**	1.21	0.0222	0.1087	0.1108	0.1376	0.0865	0.0267	4.7469	0.72268	0.19591
1.4	**1.15**	1.21	0.0226	0.1105	0.1117	0.1362	0.0879	0.0245	4.6296	0.72261	0.19511

τ : Home country tariff; τ^* : Foreign country tariff

Table 4: USA - China MFN Tariff Rates

	USA MFN Tariffs		China MFN Tariffs	
year	Simple Average	Std. Dev.	Simple Average	Std. Dev.
1989	8.51	6.44		
1990	8.92	6.42		
1991	9.08	6.37		
1992	8.65	6.32	42.26	32.09
1993	8.52	6.29	39.19	29.97
1994	6.7	6.41	35.56	27.87
1995	6.25	6.79		
1996	5.86	9.92	23.73	17.38
1997	5.63	11.74	17.58	13.01
1998	4.64	10.55	17.52	12.92
1999	4.15	10.24	17.18	12.76
2000	3.8	10.81	17.02	12.64
2001	3.76	9.97	15.92	11.99
2002	3.45	8.88		
2003	3.17	8.85	11.33	8.32
2004	2.88	7.86	10.49	7.98
2005	3.01	9.5	9.78	7.05
2006	2.95	9.41	9.81	7.54

Source: TRAINS Tariff Database, Most Favored Nation (MFN) Tariff Rates

Table 5: GINI Coefficient Regression

Dependant Variable: GINI	(1) FE	(2) FE
China Import Tariff	-0.068*	
	(0.029)	
1-yr lag of China Import Tariff		-0.068**
		(0.026)
US Import Tariff	0.380*	
	(0.193)	
1-yr lag of US Import Tariff		0.220
		(0.224)
Coastal Area Dummy	-0.208**	-0.345**
	(0.019)	(0.020)
Constant	0.753**	0.885**
	(0.018)	(0.016)
Province FE	y	y
Year FE	y	y
Observations	450	420
R-squared	0.93	0.94

Note: Robust standard errors in parentheses; * significant at 5%; ** significant at 1%

Table 6: Correlation Matrix of GIN I indexes and the Wage Inequality Ratio

Coast to Inland Relative Wage Ratio	**Coastal GINI**	**Inland GINI**
Wage ratio 1: Simple average	-0.80	-0.44
Wage ratio 2: GDP weighted average	-0.79	-0.47
Wage ratio 3: Pop weighted average	-0.77	-0.50
Wage ratio 4: Export weighted average	-0.82	-0.61

Figure 1: GINI Coefficients of Inland and Coastal China, 1988-2006

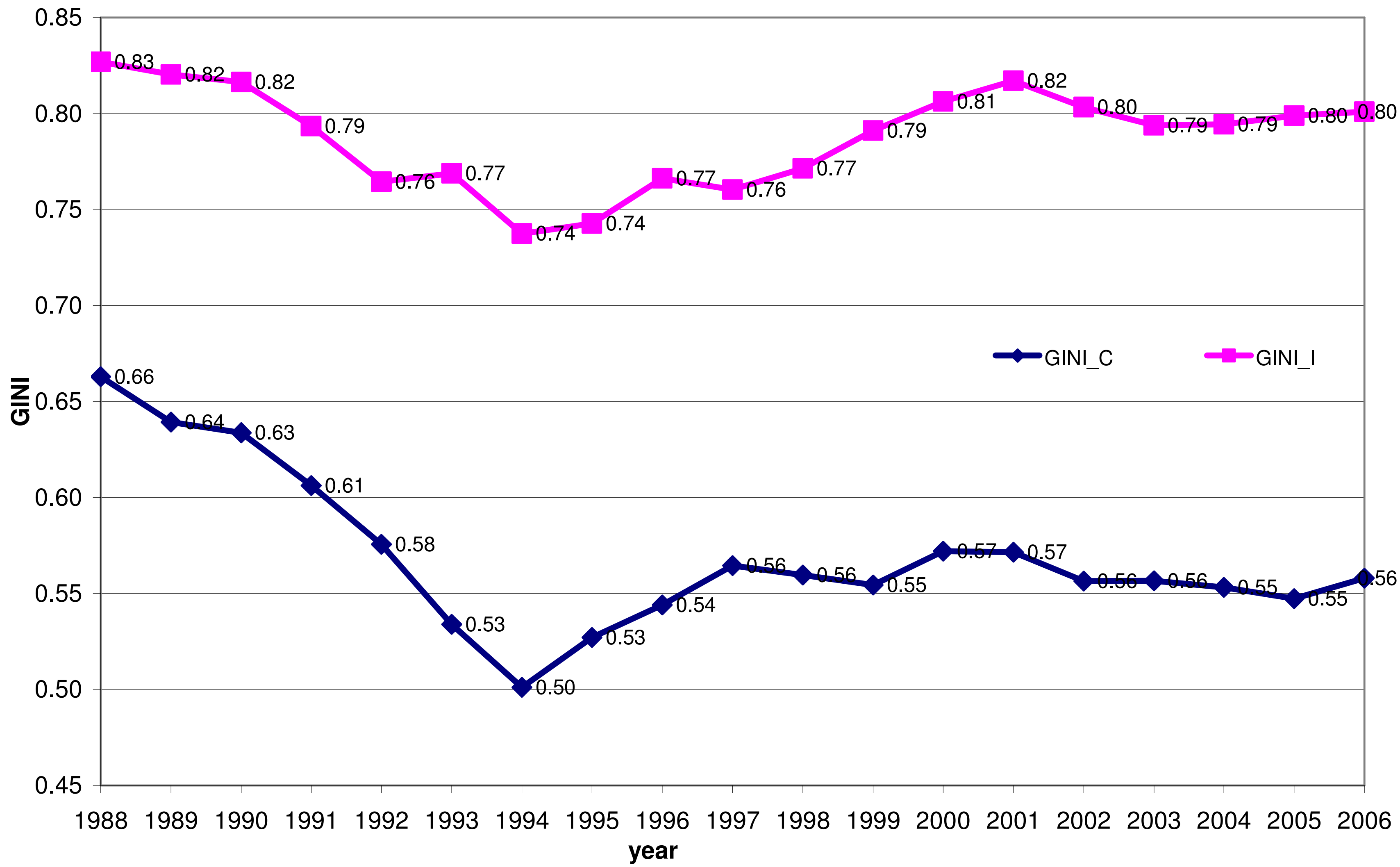


Figure 2a: Patterns of Production for C, I, and F (NT=non-traded goods)

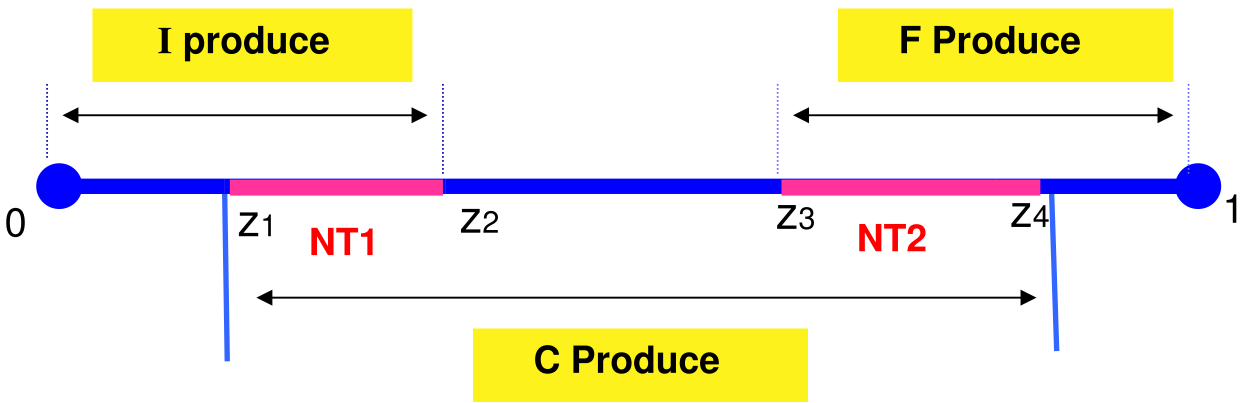
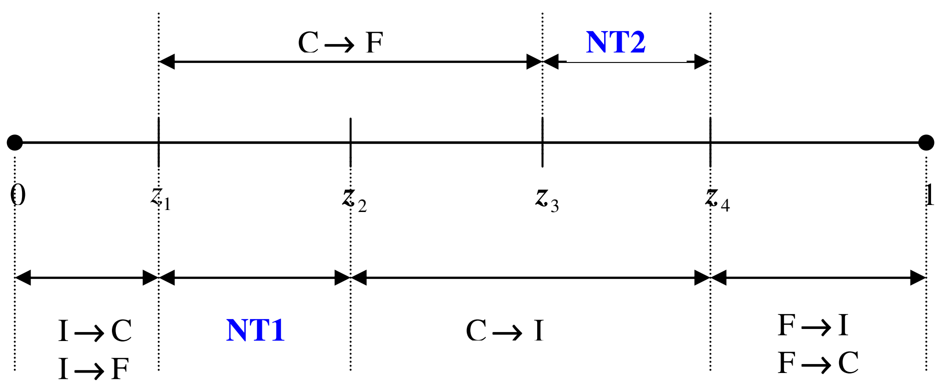


Figure 2b: Patterns of Trade with Tariffs and Transport Cost (NT=non-traded goods)



Note: C, I, H and F stand for coastal, interior, home country, and foreign country, respectively.

Figure 3: Relationship between GINI, NT1, and Wage Ratio

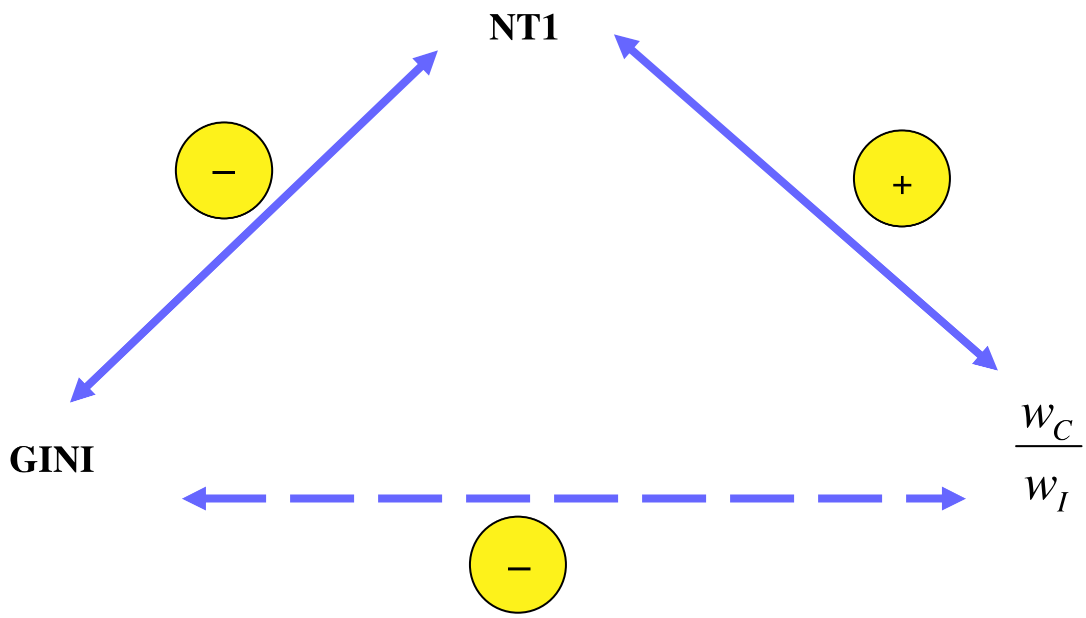


Figure 4: Time Trend of the Coast-Inland Wage Ratio in China, 1988-2006