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Trade, Technology and Inequality in a Developing Country: Theory and Evidence from China

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TRADE, TECHNOLOGY, AND INEQUALITY IN A DEVELOPING COUNTRY: THEORY AND EVIDENCE FROM CHINA

Muqun Li[i] and Ian Coxhead[ii]

Could globalization—specifically, increased international trade and openness to foreign investment—increase inequality in developing countries? Empirical studies in many such economies show that expanding trade and FDI are associated with higher inequality in wages and regional incomes. However, there is no agreement regarding the cause of such increases. We present a theoretical model showing how interactions between factor mobility restrictions and different rates of technical progress (due to trade and FDI) in a regionally heterogeneous economy can explain the evolution of inequality. As favored regions benefit more from trade, their growing demand for skills drains skilled workers from disadvantaged areas, and average incomes in favored regions grow faster than in less favored regions. Moreover, this unbalanced regional growth may be the source of rising inequality *within* each region, and even of falling per capita incomes in the less favored region. We test our predictions with data from China's coastal and inland provinces. The results confirm that different regional growth rates have increased both interregional and intraregional inequality. In addition, growth of skills-based export industries in coastal regions, other things equal, is associated with lower incomes for the poor in inland provinces.

JEL codes: F16, O15, R1.
Key words: trade, investment, wage premium, migration, inequality, China

1 INTRODUCTION

Does foreign trade increase inequality in developing countries? Empirical studies in many developing countries show that expanding trade is associated with higher inequality in wages and in regional incomes, but there is no agreement regarding the cause of such increases. Factors acknowledged to affect economic inequality include innate ability, education, race, gender, initial wealth, labor markets, government policy and development patterns. Through one or more of these factors, opening national economies to international trade may have a significant impact on inequality.

Classical trade theory provides a convenient starting point. The usual belief is that richer countries are relatively abundant in skilled labor, while low-income countries are endowed with relatively more unskilled labor. According to the Heckscher-Ohlin model, low-income countries should specialize in the production of less skill-intensive products (for example textiles and footwear), while their wealthier trading partners specialize in skill-intensive products (for example machinery). A direct implication of this model is that greater openness to trade in a low-income economy will lower the relative price of the skilled labor-intensive imported good, and along with it the skill premium (the ratio of skilled to unskilled wages). Because the model assumes that factors of production can move across sectors, changes in prices affect factor returns economy-wide. Thus, classical theory predicts that trade liberalization should cause reductions in poverty and inequality in low-income countries.

However, empirical studies have typically failed to find evidence of such shifts. With greater trade openness, wage inequality has been observed to increase in most developed countries and to decline in some developing countries; however, with greater trade openness some developing countries have also experienced an increase in the skill premium (Hanson and Harrison 1995, Robbins 1996, Wood 1997, and Goldberg and Pavcnik 2004). These results challenge economists to explain both the widening wage gap in developed countries and the mixed effects on skill premium in developing countries.

At the same time, inequality is rarely unidimensional, and inter-regional inequality is sometimes more severe than intra-regional inequality. Abstracting from trade, neoclassical growth theory predicts faster growth of poor economies compared to rich economies, other things equal, due to the diminishing marginal productivity of capital (Barro and Sala-i-Martin 2004). An extrapolation from Heckscher-Ohlin also predicts declining regional inequality as a country improves access to international trade, so long as capital and labor are mobile across regional boundaries.

Empirical studies show clearly that the benefits of trade openness don't always spread uniformly throughout a country. Data from the EU shows that intra-national inequalities have increased as a consequence of European integration, even though international inequality has declined (Esteban 1994; Puga 2002). Among developing countries, studies of Mexico and China show that isolated regions tend to lag behind areas better positioned for trade (Hanson 2004; Hale and Long 2008; Candelaria et al. 2009). These findings suggest that international trade may affect countries in complex ways.

Understanding the links between trade and inequality is important in low-income countries. Trade openness may generate growth through many channels (such as increased specialization, economies of scale, technology transfer, improved competitiveness and increased availability of capital), but if it is accompanied by sufficiently large rises in inequality, then growth alone may not be sufficient to reduce poverty in all segments of the population.

Trade liberalization can affect the welfare of the poor by changing the prices of tradable goods and improving access to new products; by changing the relative wages of skilled and unskilled labor, therefore affecting the employment and income of the poor; by reducing government revenue from tariffs and therefore lowering its ability to finance programs helping the poor; and/or by making the economy more vulnerable to negative external shocks. Rigidities in the labor market can also make it difficult for the poor to move into other occupations or locations to take full advantage of the benefits brought by trade openness, or to minimize its negative impacts. Understanding through which channel trade affects inequality helps us not only to figure out who wins and who loses when an economy globalizes, but also how to design policy to mitigate the costs borne by the poor.

This paper models links between trade and inequality in developing countries and tests its implications using province-level data from China. Our model has two countries, North and South. South is composed of two regions, Coast and Inland; thus we have three regional economies. These are heterogeneous both in their skilled and unskilled labor endowments and in production technology. There is a continuum of goods differentiated by skill-intensity. For each good, production takes place in the region that is most efficient at producing it, and the rest of the world imports this good from that region.[iii] Given each region's endowment and technology level, the developed country (North) produces the most skill-intensive goods; intermediate skill-intensive goods production takes place in the relatively skill-intensive and relatively high technology region in the South (Coast), while the skill-scarce Southern region (Inland), with the lowest technology level, supplies unskilled labor-intensive goods. The Coast's catch-up in technology with North shifts less skill-intensive production from North to South and therefore demands more skilled than unskilled labor in the Coast region. This process leads firms in this region to offer skilled labor a higher skill premium. On the other hand, Inland may experience slower or no technological progress and therefore may lose its most skill-intensive operations to the Coast. If labor is not mobile between regions of the South, Inland may thus experience a falling skill premium. Less obviously, when skilled labor can move freely within the South but unskilled labor cannot, different rates of technological progress between the Southern regions may induce even more dramatic changes in the spatial distribution of economic activity, and in inequality both within and between regions. The empirical part of this paper uses Chinese data to test these predictions of the impact of trade on inequality both within and between regions.

The theoretical model is an extension of one by Zhu and Trefler (2005). Our model is special in a number of ways. First, we add heterogeneity into the developing economy. Second, we investigate the effect of labor market segmentation on both wage disparities and spatial inequality. Our model differs from the literature studying the relationship between foreign trade and regional inequality in three important ways. First, we assume countries don't share the same technology. Second, different regions within a country may have different skill intensities in their labor endowments. Third, we are able to study both wage inequality and regional income inequality. To the best of our knowledge, these features mark this paper as the first to study the relationship between trade and *multidimensional* inequality in a developing country.

The remainder of the paper is constructed as follows: In section 2 we present some background for studying inequality. In section 3 we develop our analytical model and link our theoretical predictions to empirical work. In section 4 we describe data, model specification and empirical results. In section 5, we draw conclusions.

2 BACKGROUND

With rapidly growing foreign trade, China has had the fastest economic growth of any nation in the past three decades: fast enough to reduce poverty, by the World Bank's $1.25/day measure, from 835m to 208m between 1981 and 2005 (Chen and Ravallion 2008). However, China has also experienced one of the largest increases in inequality during this period (World Bank, 2005). Knight and Song (2003) find that from 1988 to 1995 the Gini coefficient of earnings in China rose by eight percentage points. The mean wage increased by 52 percent, but wage of the 10th percentile rose by only 6% while that of the 90th percentile rose by 75%. More recently, Wang and Shi (2006) use 1981-2002 data to show that income inequality in urban China has increased significantly since the early 1980s, and especially since the early 1990s. Using urban wage data in six provinces, Parker et al. (2003) show that the wages of the median worker with at least some college education grew by 6.3 percent from 1988 to 1999, 1.6 percentage points higher than those of the median junior high school graduate. They also find that technicians gained more relative to manual workers, and that inequality increased significantly within each occupation group. These trends are a reminder that rapid growth does not guarantee that the gains be equally distributed, and if the benefits from trade accrue disproportionately to high-income groups or regions, the trickle-down effect of growth on poverty reduction may be slow (Bhanumurthy and Mitra 2004).

Regional incomes in China have also diverged significantly, and in particular, the widening gap between coastal and interior provinces has been very prominent in explanations of trends in overall inequality during the open door era (e.g., Jian et al 1996). The difference in growth rates between coastal and inland regions has been as high as three percent during the past two decades (Zhang and Zhang, 2003). Rural incomes are generally higher in the relatively developed east. Most provinces in central China have per capita rural incomes close to the national average. All those with per capita income below 2,000 yuan are located in the west (Wan and Zhou 2004). Park et al. (2003) find that wage growth in Guangdong province is greater than in other province at every percentile; Zhejiang is the second fastest, followed by Beijing. All three are coastal provinces. On the other hand, the median growth rate of real wages in Shaanxi, the slowest-growing province, was 3.7%—nearly 6 percentage points lower than Guangdong. It seems that China is now on a dual track, with a prosperous and fast-growing coastal region, and a poor interior growing at a considerably lower rate.

Why do spatial disparities arise? As China's economy integrates with global markets, the comparative advantage of its regions needs to be evaluated in a global context. Coastal regions enjoy a comparative advantage in proximity to the international market and in access to a large pool of well-educated labor. As a result, coastal provinces have attracted far more foreign direct investment and generated more trade volume than have inland provinces. In 2000, three coastal provinces (Guangdong, Jiangsu, and Shanghai) contributed more than 60 percent of total foreign trade, while three inland provinces (Guizhou, Inner Mongolia, and Jilin), were the worst performers in terms of attracting FDI. Together with institutional barriers to internal labor mobility, these differences lead to different regional paces of globalization, despite a uniform national policy of opening to trade.[iv]

Different initial conditions also influence trends in regional inequality. For instance, faster growth in richer regions may diminish growth prospects in poorer regions by attracting capital and skilled labor. From a poverty reduction point of view, it is important to understand this pattern in China, as despite its success in economic growth, it still accounts for some 15% of the world's poor, and those poor are located mainly in slower-growing areas.

Despite the theoretical and practical importance of the subject, to our knowledge there is still no study dealing with the question of how trade simultaneously affects both wages and regional inequality. Some New Economic Geography theorists, relying heavily on a Dixit-Stigliz-Krugman or Ottaviano type of monopolistic competition, study the impact of falling international trade costs and national transport costs on development and disparity in economies involved in an integration process (Fujita et al. 1999; Krugman and Venables 1995; Montfort and Nicolini 2000; Paluzie 2001; Monfort and van Ypersele 2003; Behrens et al. 2003). IN these studies each country is composed of two regions; labor is mobile between these but not internationally. Goods can be traded both nationally and internationally, though not costlessly. Some regions within a country may benefit from their initial conditions. For instance, having an advantage in geographic location for international trade, the coast becomes the initial location for industrial agglomeration, so people from the inland are mainly involved in agriculture while coastal workers participate in manufacturing. The coast's leadership in manufacturing is reinforced by increasing returns to scale, which implies a potential linkage between foreign trade and regional inequality. Models of this kind show that lower internal transport costs foster regional divergence when international trade costs are high enough, whereas lower international trade costs promote regional convergence when domestic transport costs are high enough. However, several characteristics of these models make them inappropriate for studying our problem. All abstract from comparative advantage of either the Ricardian or Heckscher-Ohlin type, by assuming that each region has equal access to the same technology and has identical labor endowments. These assumptions are arguably appropriate for explaining integration between similar countries, such as member states of the EU, but are unsuitable for explaining North-South inequality or that within a relatively heterogeneous economy such as China.

The model we use builds upon Zhu and Trefler (2005) (hereafter ZT). Inspired by Feenstra and Hanson (1996) (hereafter FH), they develop a model in which skilled and unskilled labor are inputs in production of a continuum of goods. Both technology and endowment differences determine that North produces and exports high skill intensive goods, while South exports low skill-intensive goods. Southern technology catch-up induces North to transfer production of its least skill-intensive goods to the South. This product relocation raises the relative demand for skilled workers, and thus wage inequality, within both regions.

Although both FH and ZT go beyond the limitations of Heckscher-Ohlin, two aspects relevant to our work are still underrepresented. First, the North-South framework cannot encompass different sub-national responses of the skill premium and of economic structure to trade openness; therefore, it makes no prediction about regional inequality *within* the South economy. Second, a meaningful exploration of trade-wage linkages within developing countries requires a clear understanding and treatment both of general equilibrium mechanisms and of the operation of the labor market, neither of which are trivial problems in such countries.

Our goal in this paper is to model mechanisms linking trade and technology to wages and economic structure in different regions of the South, both in general terms and also in the presence of labor-market frictions. In section 3, we extend the ZT model to the case of two countries incorporating three regions. Countries and regions are distinguished by differences in factor endowments and technology (rather than by shipping costs, which are emphasized in the new economic geography models). By adding features absent from the ZT framework, our model allows for regional differences in both factor endowments and productivity growth within the developing country. These differences can lead to asymmetric responses of economic structure and inequality to a trade shock. We are also able to study the influence of factor market segmentation on this process.

3 MODEL

Model setup

There are two factors of production, unskilled labor (*L*) and skilled labor (*H*). These are used to produce a continuum of goods indexed by *z*, with larger *z* representing greater skill intensity. Production functions are neoclassical, displaying strict quasi-concavity, constant returns to scale, and continuous derivatives. There are no factor intensity reversals. Goods markets are perfectly competitive, and thus in equilibrium profit is zero.

We assume that production takes place in two countries, North (*N*), a skilled-labor-abundant country, and South (*S*), a skilled-labor-scarce country. Within South there are two regions: a skilled-labor-scarce Inland and a skilled-labor-abundant Coast. We have thus assumed that labor markets are integrated in North but not in South. Internal labor mobility in developing countries is subject to many more restrictions compared to interstate mobility in the U.S. or other developed countries. In China specifically, evidence suggests that substantial barriers to labor mobility persist in spite of three decades of economic reforms. These barriers include legal impediments based on the *hukou* (household registration certificate) system as well as less formal discrimination against migrants (especially unskilled workers) from inland provinces.

These restrictions have a noticeable effect on rates of migration. For the five-year period 1985-1990, the rate of interstate migration in the U.S. was 9%, while the corresponding rate in China was only 1%. For 1995-2000 these rates were 8% in the U.S. and 3% in China (National Bureau of Statistics 2002, pp.1813-1817; U.S. Census Bureau 2003), despite far higher rates of economic growth and structural change in China. In our benchmark model we stylize this difference by assuming no labor movement between inland and coastal regions of the South economy. This assumption will subsequently be relaxed to permit certain types of labor to move.

Another reason to assume a heterogeneous South economy is that for many developing countries, regional disparities seem to be growing. At the onset of the economic reform period, average earnings in China's western regions were even higher than those in coastal regions. For instance, in 1978, the average wage was 696 yuan in the eight western provinces[v] and 666 yuan in the eight coastal provinces[vi] (National Bureau of Statistics 1999: 139). By the end of the 1980s, however, average earnings in the coastal region had risen much faster, and have been higher than in the west ever since. Even within in urban areas, earnings growth has diverged across provinces (Knight et al. 2001). A sizeable part of the observed earnings gap can be attributed to faster economic growth and greater capital inflows to the coastal region on one hand, and on the other hand, to limited labor mobility between regions. For instance, from 1995 to 2002 average earnings per worker rose by 84% in Beijing and 79% in Guangdong, but only by 3% in Gansu and 27% in Yunnan (Knight et al. 2006).

Production

Skilled and unskilled labor are the only factors of production, and $L_i(z)$ and $H_i(z)$ are the unskilled and skilled labor requirements for producing one unit of good z in region i. Let w_{jN} be the wage of factor j ($j = L, H$) in North, and w_{jS}^k be the wage of factor j ($j = L, H$) in region k (Inland, Coast) in South. Let $\omega_N = w_{HN} / w_{LN} > 1$ be the wage of skilled labor relative to that of unskilled labor in North, and let $\omega_S^j = w_{HS}^j / w_{LS}^j > 1$ be the corresponding ratio in region *j* of South. We assume that North is the most skill-abundant country, so

$$\omega_N < \omega_S^C < \omega_S^I \tag{1}$$

Furthermore, we assume that

$$w_{HS}^I \geq w_{HS}^C > w_{HN} > w_{LN} > w_{LS}^C \geq w_{LS}^I \tag{2}$$

There is a continuum of sectors in the economy. Given goods prices and factor returns, the representative firm that produces variety *z* in country *i* and region *j* faces the following maximization problem:

$$\max_{L_i^j(z), H_i^j(z)} P(z)\, f\left(L_i^j(z), H_i^j(z)\right) - \left(w_{Li}^j L_i^j(z) + w_{Hi}^j H_i^j(z)\right)$$

where $P(z)$ is the price of variety *z*. Firms choose the numbers of both unskilled workers $L_i^j(z)$ and skilled workers $H_i^j(z)$ to employ. Each firm incurs costs by paying wages to hired labor. Under constant returns to scale and assuming free entry, firms bid for workers until no firm earns a strictly positive profit. Therefore, $C_i(w_{Hi}, w_{Li}, z, t)$, the unit cost function for producing good z in region i, must be equal to $P(z)$. Finally, n stands for total varieties available, and t denotes time and captures all factors other than wage that affect unit costs—for instance technology level or infrastructure in each region. Costs are thus written

$$C_i\left(w_{Hi}, w_{Li}, z, t\right) = w_{Li} L_i\left(z\right) + w_{Hi} H_i\left(z\right).$$

Here, $L_i\left(z\right)$ and $H_i\left(z\right)$ represent the optimal quantities of unskilled and skilled labor to produce one unit of variety *z*, given the endowments and technology available in each region.

We assume (for simplicity) that goods can be costlessly shipped across countries and regions.[vii] Perfect competition exists for good *z* produced in this region, so the zero profit condition implies

$$\begin{aligned} P_N\left(z\right) &= w_{LN} L_N\left(z\right) + w_{HN} H_N\left(z\right) \\ P_S^C\left(z\right) &= w_{LS}^C L_S^C\left(z\right) + w_{HS}^C H_S^C\left(z\right) \\ P_S^I\left(z\right) &= w_{LS}^I L_S^I\left(z\right) + w_{HS}^I H_S^I\left(z\right) \end{aligned} \tag{3}$$

One drawback of the H-O model is that it assumes that both countries share the same technology, an assumption that cannot explain technological change and the related pattern of trade in some industries where technological differences seem of obvious importance. The past several decades have seen the development of several technology-oriented theories of trade, led by Posner (1961), Dornbusch et al. (1977), and Krugman (1982). International technology differences are allowed in our model (for succinctness, in what follows we usually drop t, including it only when necessary). We assume Ricardian comparative advantage, i.e.

$$\frac{\partial C_N\left(.,.,z\right)/C_S\left(.,.,z\right)}{\partial z} \le 0 \tag{4.a}$$

for all z, where $C_S\left(.,.,z\right) = \min\left[C_S^C\left(.,.,z\right), C_S^I\left(.,.,z\right)\right]$

$$\frac{\partial C_S^C\left(.,.,z\right)/C_S^I\left(.,.,z\right)}{\partial z} \le 0 \tag{4.b}$$

for all z. To be more specific, North is the technology leader in all production, especially in more skill-intensive goods. Inland lags in every field, but has comparative advantage in the least skill-intensive goods. Intermediate skill-intensive products can be the optimal choices for Coast.

<u>Lemma 1:</u> *Endowment-based comparative advantage (inequality 1) and Ricardian comparative advantage (inequality 4) together imply*

$$\frac{\partial C_N\left(w_{HN}, w_{LN}, z\right)/C_S\left(w_{Hs}, w_{LS}, z\right)}{\partial z} < 0$$

and

$$\frac{\partial C_S^C\left(w_{HS}^C, w_{LS}^C, z\right)/C_S^I\left(w_{HS}^I, w_{LS}^I, z\right)}{\partial z} < 0$$

for all ($w_{HN}, w_{LN}, w_{HS}^j, w_{LS}^j$ *), that is, the North has a comparative advantage in skill-intensive goods, and the Southern coastal region is good at intermediate skill-intensive production.*

Inequality 2, Lemma 1 and the zero profit conditions together imply that North produces and exports the most skill-intensive goods, while within South, Coast produces and exports intermediate skill-intensive goods, and the least skill-intensive goods are all produced in Inland. We define the marginal good, $z_i, i = 1, 2$ by

$$P_N\left(z_2\right) = P_S\left(z_2\right), \qquad P_S^C\left(z_1\right) = P_S^I\left(z_1\right).$$

We can think of goods produced in the North as newly developed products that require large amounts of skilled labor in their production and continuing development. The high wage of skilled labor, the lower level of technological know-how, and poor infrastructure all prevent skill-intensive good outsourcing to the South, especially to the Inland. Finally, as products mature and become standardized, the production process becomes routine and less-skilled labor can play a more important role. Together with technology diffusion into developing countries, some products can be outsourced to the South to take advantage of lower costs.

Equilibrium

<u>Goods Market</u>

Consider an economy in which all consumers supply labor inelastically and have identical preferences over a continuum of differentiated consumption goods. The utility function is assumed to have the following form:

$$U_i = \int_0^{\bar{z}} \alpha\left(z\right) \ln x_i\left(z\right) dz$$

where *x(z)* stands for the amount of variety *z* demanded by the representative consumer. Consumer utility is maximized subject to the budget constraint E_i, which is equal to the *i*th agent’s labor income, and depends on her skilled or unskilled status and also on her country or region of origin. The budget constraint of an unskilled worker in the North, for example, is:

$$\int_0^{\overline{z}} P(z)x(z)dz = w_{LN}$$

where $P(z)$ is the price of variety z. Analogous constraints exist for other types of worker.

The utility function implies that consumers have a strong preference for variety. Individual demand for variety z, $x(z)$, is obtained by maximizing utility with respect to the quantity of variety z consumed, subject to the budget constraint

$$x_i(z) = \alpha(z)\frac{E_i}{P(z)}$$

so $\alpha(z)$ is a budget share. Let Y_i be aggregate income in country *I*; then worldwide demand is

$$x(z) = \alpha(z)\frac{Y_N + Y_S^C + Y_S^I}{P(z)}. \tag{5}$$

Because we assume competitive markets and zero shipping costs, $P(z)$ is the price faced by both consumers and producers, and is denoted as follows. For a good produced in North, i.e. $z \geq z_2$:

$$P(z) = P_N(z)$$

for a good produced in Coast, i.e. $z_2 > z \geq z_1$:

$$P(z) = P_S^C(z)$$

and for a good produced in the Inland, i.e. $z < z_1$:

$$P(z) = P_S^I(z).$$

Thus we have the aggregate price index

$$P \equiv \int_0^{z_1} P_S^I(z)dz + \int_{z_1}^{z_2} P_S^C(z)dz + \int_{z_2}^{\overline{z}} P_N(z)dz.$$

<u>Labor market</u>

H_N and L_N are skilled- and unskilled-labor endowments in North. H_S^I, H_S^C, L_S^I, and L_S^C are skilled- and unskilled-labor endowments in Inland and Coast, respectively. The relative skills endowment is denoted by $h_i^j = H_i^j / L_i^j$. Labor supply is fixed, so the resource constraints for skilled and unskilled labor in the North are given by

$$\int_{z_2}^{\bar{z}} x(z) H_N(z)\, dz = H_N \text{ and } \int_{z_2}^{\bar{z}} x(z) L_N(z)\, dz = L_N ,$$

where $H_N(z)$ and $L_N(z)$ are skilled labor and unskilled labor used in production of good z in North. We define North's excess demand for skilled labor relative to unskilled labor, $N(z_2)$, by

$$N(z_2) \equiv \int_{z_2}^{\bar{z}} \left[x(z) H_N(z)/H_N \right] dz - \int_{z_2}^{\bar{z}} \left[x(z) L_N(z)/L_N \right] dz \tag{7.a}$$

In the same fashion, $S^I(z_1)$ and $S^C(z_2)$ are excess demands for Inland and Coast:

$$S^I(z_1) \equiv \int_0^{z_1} \left[x(z) H_S^I(z)/H_S^I \right] dz - \int_0^{z_1} \left[x(z) L_S^I(z)/L_S^I \right] dz \tag{7.b}$$

$$S^C(z_2) \equiv \int_{z_1}^{z_2} \left[x(z) H_S^C(z)/H_S^C \right] dz - \int_{z_1}^{z_2} \left[x(z) L_S^C(z)/L_S^C \right] dz . \tag{7.b}$$

Then we need to rewrite our relative labor demand. In Inland, consider some $z \in [0, z_1]$

from $x(z) = \alpha(z)\left(Y_N + Y_S^C + Y_S^I\right)/P_S^I(z)$, and zero profits,

$$x(z) = \alpha(z) \frac{Y_N + Y_S^C + Y_S^I}{w_{LS}^I L_S^I(z) + w_{HS}^I H_S^I(z)} = \alpha(z) \frac{Y_N + Y_S^C + Y_S^I}{w_{LS}^I} \frac{1/L_S^I(z)}{1 + \omega_S^I h_S^I(z)}$$

where $h_S^I(z)$ is the optimal amount of skilled labor relative to unskilled labor for producing z, given the labor endowment. Hence

$$\int_0^{z_1} \left[x(z) H_S^I(z)/H_S^I \right] dz = \frac{Y_N + Y_S^C + Y_S^I}{w_{LS}^I L_S^I} \int_0^{z_1} \alpha(z) \frac{h_S^I(z)}{1 + \omega_S^I h_S^I(z)} dz$$

Similarly,

$$\int_0^{z_1} \left[x(z) L_S^I(z)/L_S^I \right] dz = \frac{Y_N + Y_S^C + Y_S^I}{w_{LS}^I L_S^I} \int_0^{z_1} \alpha(z) \frac{h_S^I(z)}{1 + \omega_S^I h_S^I(z)} dz$$

$$S^I(z_1) \equiv \int_0^{z_1} \left[x(z) H_S^I(z)/H_S^I \right] dz - \int_0^{z_1} \left[x(z) L_S^I(z)/L_S^I \right] dz .$$

In equilibrium the excess demand for skilled labor relative to unskilled should be zero:

$$S^I(z_1) = \frac{Y_N + Y_S^C + Y_S^I}{w_{LS}^I L_S^I} \int_0^{z_1} \alpha(z) \frac{h_S^I(z) - h_S^I}{1 + \omega_S^I h_S^I(z)} dz = 0 .$$

In a similar fashion, for $z \in [z_1, z_2]$,

$$x(z)=\alpha(z)\frac{Y_N+Y_S^C+Y_S^I}{w_{LS}^C L_S^C(z)+w_{HS}^C H_S^C(z)}=\alpha(z)\frac{Y_N+Y_S^C+Y_S^I}{w_{LS}^C}\frac{1/L_S^C(z)}{1+\omega_S^C h_S^C(z)}$$

$$S^C(z_1)=\frac{Y_N+Y_S^C+Y_S^I}{w_{LS}^C L_S^C}\int_{z_1}^{z_2}\alpha(z)\frac{h_S^C(z)-h_S^C}{1+\omega_S^C h_S^C(z)}dz=0$$

and

$$N(z_2)=\frac{Y_N+Y_S^C+Y_S^I}{w_{LN}L_N}\int_{z_2}^{\bar{z}}\alpha(z)\frac{h_N(z)-h_N}{1+\omega_N h_N(z)}dz=0\,.$$

Trade

Under the balanced trade assumption, we assume balanced trade between each area and the rest of the world, so we have

$$TB_N=((Y_S^C+Y_S^I)\int_{z_2}^{\bar{z}}\alpha(z)dz)/\left(Y_N\int_0^{z_2}\alpha(z)dz\right)=1$$

where $\left(Y_S^C+Y_S^I\right)\int_{z_2}^{\bar{z}}\alpha(z)dz$ is demand by the rest of the world for goods produced in North,

while $Y_N\int_0^{z_2}\alpha(z)dz$ is North's import demand. Similarly, for Inland,

$$TB_I=((Y_N+Y_S^C)\int_0^{z_1}\alpha(z)dz)/\left(Y_S^I\int_{z_2}^{\bar{z}}\alpha(z)dz\right)=1$$

and when both these equalities hold, trade is automatically balanced for Coast, by Walras' Law.

With some manipulation (see Appendix A.2) the trade balance conditions can be rewritten as

$$TB_N\equiv\frac{\int_{z_2}^{\bar{z}}\alpha(z)dz}{\int_0^{z_2}\alpha(z)dz}\frac{L_S^C\left(1+\omega_S^C h_S^C\right)}{L_N\left(1+\omega_N h_N\right)}\frac{L_N(z_2)}{L_S^C(z_2)}\frac{\left(1+\omega_N h_N(z_2)\right)}{\left(1+\omega_S^C h_S^C(z_2)\right)}+$$
$$\frac{L_S^I\left(1+\omega_S^I h_S^I\right)}{L_N\left(1+\omega_N h_N\right)}\frac{L_N(z_2)}{L_S^C(z_2)}\frac{\left(1+\omega_N h_N(z_2)\right)}{\left(1+\omega_S^C h_S^C(z_2)\right)}\frac{L_S^I(z_1)}{L_S^C(z_1)}\frac{\left(1+\omega_S^C h_S^C(z_2)\right)}{\left(1+\omega_S^I h_S^I(z_2)\right)}=1$$

and

$$TB_I \equiv \frac{L_N\left(1+\omega_N h_N\right)}{L_S^I\left(1+\omega_S^I h_S^I\right)} \frac{L_S^C\left(z_2\right)\left(1+\omega_S^C h_S^C\left(z_2\right)\right)}{L_N\left(z_2\right)\left(1+\omega_N h_N\left(z_2\right)\right)} \frac{L_S^I\left(z_1\right)\left(1+\omega_S^I h_S^I\left(z_1\right)\right)}{L_S^C\left(z_1\right)\left(1+\omega_S^C h_S^C\left(z_1\right)\right)}$$

$$+ \quad \frac{L_S^C\left(z_1\right)\left(1+\omega_S^C h_S^C\left(z_1\right)\right)}{L_S^I\left(z_1\right)\left(1+\omega_S^I h_S^I\left(z_1\right)\right)} \frac{L_S^I\left(z_1\right)\left(1+\omega_S^I h_S^I\left(z_1\right)\right)}{L_S^C\left(z_1\right)\left(1+\omega_S^C h_S^C\left(z_1\right)\right)} \frac{\int_0^{z_1}\alpha\left(z\right)dz}{\int_{z_1}^{\bar{z}}\alpha\left(z\right)dz} = 1$$

The equilibrium can be fully represented by $\left(\omega_N, \omega_S^C, \omega_S^I, z_1, z_2\right)$, by solving both labor-market and trade-clearing conditions (see Dornbusch et al. 1980; Zhu and Trefler 2005).

Technological change

As discussed above, the technology level is a determinant of the structure of a region's economy. The restructuring of economies may be associated with different speeds of technological change.

The study of the impact of technology and technological change has a long tradition in the economic analysis of trade and welfare (for an overview see Dixit and Norman, 1980). While these contributions mainly address effects on trade and utility, they seldom discuss effects on relative factor prices, which are the main focus of this paper. In the spirit of modeling Southern technology catch-up, we define it as either technology spillover from developed to developing countries, or as cost-reducing process innovations. We assume that technical change is exogenous and uses no real resources. As in Vernon (1966), new products are first introduced in the North, with its large pool of skilled labor and its proximity to large and rich markets that facilitate innovation. Once a manufacturing method becomes standardized, the South can easily imitate it and take advantage of its cheaper labor to begin production.

In the age of globalization, however, barriers to the flow of technical know-how from technological leaders to followers have been greatly reduced. Trade in goods and factors provides new sources of technological progress (Grossman and Helpman 1991; Rivera-Batiz and Romer 1991).[viii] Major obstacles, such as information asymmetries and factor proportion differences between North and South, make Southern technology acquisition a complex process, and the speed of technology diffusion varies across countries and regions. Among the factors that facilitate technology adoption, human capital availability is well documented.[ix] Southern cost-reducing innovation occurs as Southern labor masters technological know-how.

We define productivity gain in the North by:

$$\phi_N(z,t) \equiv \frac{\partial \ln C_N(w_{HN}, w_{LN}, z, t)}{\partial t}$$

and similarly, for Coast we obtain $\phi_S^C(z,t)$ and Inland $\phi_S^I(z,t)$. From the definition of efficiency improvement, we know $\phi_i(.,.)$ is always non-positive. So by definition, technological catch-up in South's coastal economy is defined by $\phi_N(z,t) - \phi_S^C(z,t) > 0$; otherwise, we say that Coast lags behind North. Similarly, $\phi_S^C(z,t) - \phi_S^I(z,t) < 0$ implies that technological progress in Coast outpaces that in Inland.

Lemma 2: *As production range increases in one region, both skilled and unskilled wages* in *that region increase, for a given technology.*

Proposition 1: *When Coast catches up with North, and when Inland has a slower rate of technological progress compared to that of Coast, some skill-intensive goods production migrates into Coast from North, and Inland loses its most skill-intensive good to Coast. Wage inequality in North increases, and that of Inland decreases. Wage inequality of Coast can go either way.*

Proposition 2: *When Coast catches up with North, and Inland has slower technological progress compared to that of Coast, returns for both skilled and unskilled labor decrease in Inland, while both unskilled- and skilled-labor wages increase in Coast. Regional inequality also increases.*

Detailed proofs of Lemma 2 and these two propositions are provided in the Appendix. Intuitively, the sequence of changes in economic structure and inequality resulting from technological progress and foreign trade is as follows. Holding all wage levels fixed, coastal catch-up makes this region absolutely more productive and generates positive profits for Coast producers. Inter-firm competition for labor then raises the relative wage of Coast workers. Rising income leads South to import more, which causes Coast to develop a trade deficit with North. To eliminate the trade imbalance, Coast must increase its supply of goods and reduce its demand for Northern goods. Both changes are facilitated by a rise in z_2.

We now allow the wage level to change. A rise in z_2 eliminates the trade imbalance but creates excess demand in the South for skilled labor relative to unskilled labor. The rising skill premium eliminates this excess demand in two ways. First, it leads to a within-good substitution away from skilled labor. Second, it increases the relative price of skill-intensive goods, and this leads to a between-good reallocation toward the South's least skill-intensive goods. Together, these two mechanisms clear Southern labor markets.

Adjustment in North proceeds as follows: fixing the wage level, Northern income rises as well, but by less than that of the Coast. This leads North to import more than before but less so than Coast, which in turn results in a trade surplus. To eliminate this surplus, North has to reduce its supply of goods and increase its demand for Southern coastal products. Both changes are facilitated by a decrease in z_2. Now allow wages to change; a rise in z_2 eliminates the trade imbalance but creates excess demand for skilled-labor relative to unskilled-labor in North. The rising wage premium helps eliminate this excess demand and restore Northern labor markets.

When there is balanced technological progress within the South, we return to the ZT economy. But as long as technological progress occurs at different rates in Inland and Coast, it creates extra effects not captured in the two-country model. For instance, if Inland lags behind Coast in productivity growth, then at constant wages Inland becomes less productive relative to Coast. Therefore, slower income growth in Inland results in a trade surplus for this area with Coast. To restore trade balance requires Inland to produce less, while Coast needs to increase its variety of goods. This leads to a rise in z_2, and a decrease in z_1.

When wages are allowed to change, slower technological progress in Inland results in a skill-premium reduction, while wage inequality in Coast is reduced by that region’s expansion into less skill-intensive production. Thus faster technological progress in Coast compared to the other regions has two opposing effects on its wage inequality. Technological progress and expanded production raise both skilled and unskilled wages, and the relative wage outcome depends on which effect dominates. In Inland, by contrast, both wage changes are indeterminate in sign, so technological progress and reduced production lines have opposing effects (in the special case of a lack of technological progress, both wages decrease). But in any case, returns to both types of labor rise faster in Coast than in Inland.

Migration

In this section, we relax the restriction of labor immobility by allowing skilled labor to move freely within the South. This asymmetry in the relative mobility of labor arises because empirically, there are more restrictions on unskilled labor migration, and also because there is a shortage of skilled labor in fast-developing regions. Following Krugman (1991), "immobile labor" is usually interpreted as a proxy for all non-tradable services, amenities and factors such as land (Baldwin et al. 2003). This relative immobility of unskilled with respect to skilled workers fits well with the empirical evidence (Greenwood 1997). Apart from "pull" factors behind the mobility of skilled workers, there are several "push" factors, including unfavorable economic conditions in the home region, and lower returns to skill compared to workers of equal skill outside the home region.

Within China, most permanent migrants are skilled and educated workers such as professionals and university students. Their migration is facilitated by a local *hukou*, which in China serves as an internal passport system in many ways and gives them better access to not only jobs but also housing, education, health care, public security, and other services in the city. In addition to the *hukou* system, the "blue stamp *hukou*" was formally endorsed in 1992 and has become popular in large cities since the mid-1990s. The criteria for obtaining a blue stamp *hukou* include a large investment or home purchase, as well as age, education, and skills. Most low-skilled or rural migrants are not eligible for and/or cannot afford this type of *hukou*.

Returning to the model, we now assume free mobility of skilled labor within (but not beyond) the South economy. So $H_S^I + H_S^C = H_S$, and we define $H_S^C / H_S \equiv \eta$, i.e., the proportion of skilled labor in Coast. For its properties see appendix A.6.

With some manipulations (see appendix A.7), North’s trade balance conditions is

$$TB_N \equiv \frac{\int_{z_2}^{\bar{z}} \alpha(z)\,dz}{\int_0^{z_2} \alpha(z)\,dz} \Bigg(\frac{L_S^C\left(1+\omega_S^C \eta \dfrac{H_S}{L_S^C}\right)}{L_N\left(1+\omega_N h_N\right)} \frac{L_N(z_2)}{L_S^C(z_2)} \frac{\left(1+\omega_N h_N(z_2)\right)}{\left(1+\omega_S^C h_S^C(z_2)\right)} + \frac{L_S^I\left(1+\omega_S^I(1-\eta)\dfrac{H_S}{L_S^I}\right)}{L_N\left(1+\omega_N h_N\right)} \frac{L_N(z_2)}{L_S^C(z_2)} \frac{\left(1+\omega_N h_N(z_2)\right)}{\left(1+\omega_S^C h_S^C(z_2)\right)} \frac{L_S^I(z_1)}{L_S^C(z_1)} \frac{\left(1+\omega_S^C h_S^C(z_2)\right)}{\left(1+\omega_S^I h_S^I(z_2)\right)} \Bigg) = 1$$

and in Inland,

$$TB_I \equiv \frac{L_N\left(1+\omega_N h_N\right)}{L_S^I\left(1+\omega_S^I h_S^I\right)} \frac{L_S^C\left(z_2\right)\left(1+\omega_S^C h_S^C\left(z_2\right)\right)}{L_N\left(z_2\right)\left(1+\omega_N h_N\left(z_2\right)\right)} \frac{L_S^I\left(z_1\right)\left(1+\omega_S^I h_S^I\left(z_1\right)\right)}{L_S^C\left(z_1\right)\left(1+\omega_S^C h_S^C\left(z_1\right)\right)}$$

$$\frac{L_S^C\left(1+\omega_S^C h_S^C\right)}{L_S^I\left(1+\omega_S^I h_S^I\right)} \frac{L_S^I\left(z_1\right)\left(1+\omega_S^I h_S^I\left(z_1\right)\right)}{L_S^C\left(z_1\right)\left(1+\omega_S^C h_S^C\left(z_1\right)\right)} \frac{\int_0^{z_1} \alpha(z)\,dz}{\int_{z_1}^{\bar{z}} \alpha(z)\,dz} = 1$$

Also, the labor market clearing condition in the Southern economy becomes

$$\int_0^{z_1} \frac{Y_N + Y_S^C + Y_S^I}{w_{LS}^I} \alpha(z) \frac{1/L_S^I(z)}{1+\omega_S^I h_S^I(z)} H_S^I(z)\,dz = (1-\eta) H_S$$

And with all else constant, ω_S^I is decreasing in $1-\eta$. Thus Inland wage inequality is a decreasing function of the number of skilled workers in that region.

The relative demand for skilled labor in Inland is:[x]

$$S^I(z) \equiv \int_0^{z_1} \left[\alpha(z) \frac{Y_N + Y_S^I + Y_S^C}{w_{HS}^I H_S (1-\eta)\left(l_S^I(z)/\omega_S^I + 1\right)} \right] dz - \int_0^{z_1} \left[\alpha(z) \frac{Y_N + Y_S^I + Y_S^C}{w_{HS}^I L_S \left(l_S^I(z)/\omega_S^I + 1\right)} \right] dz = 0$$

Similarly, in Coast[xi]

$$S^C(z_1) \equiv \int_{z_1}^{z_2} \left[\alpha(z) \frac{\left(Y_N + Y_S^I + Y_S^C\right) L_S^C / \eta H_S}{w_{HS}^C \eta H_S \left(l_S^C(z)/\omega_S^C + 1\right)} \right] dz - \int_{z_1}^{z_2} \left[\alpha(z) \frac{Y_N + Y_S^I + Y_S^C}{w_{HS}^C L_S^C \left(l_S^C(z)/\omega_S^C + 1\right)} l_S^C(z) \right] dz = 0$$

Proposition 3: *As Coast catches up with North, and Inland has a lower rate of technological progress relative to Coast, some skill-intensive production migrates into Coast from North, and Inland loses its most skill-intensive goods to the Coast. Wage inequality rises in both North and Inland, while that in Coast can go either way.*

Proposition 4: *When Inland has slower technological progress relative to Coast, wages for unskilled labor in Coast increase more than those of Inland. Wages for skilled labor in the South increase, and regional inequality also increases.*

Detailed proofs of these two propositions are provided in the Appendix.

Let's use two steps to understand Propositions 3 and 4. First, holding endowment constant, the situation is exactly the same as in Proposition 1, i.e., Coast extends its production range, while that for Inland shrinks. Wage inequality in Inland decreases, and that for Coast may increase or decrease, but we know for certain that $d\omega_S^I / dt > d\omega_S^C / dt$.

Second, skilled labor moves into Coast. The rising skill premium attracts Inland skilled labor to Coast and moves the relative supply of skilled labor outward, thereby reducing relative wages in Coast. The net effect is ambiguous. In Inland, the relative demand for skilled labor decreases, and so does the relative wage. Outflows of skilled labor boost the skill premium in this region until skilled wages equalize in both Coast and Inland. So the skill premium rises in both Coast and Inland.

The analysis thus far has abstracted from the consequences of factor mobility on changes in economic structure. The inflow of skilled labor helps Coast to expand production at the expense of both Inland and North. In turn, the demand for both types of labor decreases in Inland, while the demand for labor in Coast increases even further. This second-round effect of labor mobility causes both skilled and unskilled wages to fall in Inland and to rise in Coast. In equilibrium, we know that inequality in Inland must be higher than that of Coast, and unskilled laborers in Inland certainly earn less than those in Coast.

4 EMPIRICS

In this section we test the foregoing analytical predictions using data from China. Given the strong assumption of immobility of both types of labor in propositions 1 and 2, we test only propositions 3 and 4, i.e., that a higher rate of technological progress in a region in the developing country will result in both more skill-intensity of exports and a higher skill premium, and that a faster rate of technological progress in one region may lead more inequality in a less developed region, and have adverse effects on unskilled labor returns in the lagging region. Several features of China make it relevant for our purpose. First, China is a very large country, covering 6m square miles and containing 31 administrative divisions, whose geographic features, technology levels and labor endowments differ greatly. Second, as mentioned, there is restricted labor mobility, especially for those with low or no education. Third, after opening to trade, different regions have had different access to FDI and the bundle of productivity-enhancing technologies and networks with which it is typically associated.

Labor i with skill level s_i working in province j earns wage ω_i^j:

$$\omega_i^j = m^j\left(s_i\right)$$

in which $m^j\left(.\right)$ is a provincial mapping function that maps labor skill into return of labor. This $m^j\left(.\right)$ itself is a function of export composition, relative skill stock and other provincial specific characteristics.

Our model predicts that intra-provincial inequality increases as z, its marginal good, increases: $\frac{d\omega_S^j}{dz_j} > 0,\ j = I, C$. An increase in z is associated with higher wages for both skilled unskilled workers: $\frac{d\omega_{iS}^j}{dz_j} > 0,\ i = L, H$. On the other hand, technological progress leads to higher z, and higher z is associated with higher wage inequality, so $\frac{d\omega_S^i}{dC_i} < 0,$ where $dC_i < 0,$ represents unit cost reduction.

Data and estimation method

The database used in our analysis covers 29 provinces[xii] over 1993–2005, allowing us to use panel econometric tools to analyze the questions that interest us. Given the small size of our sample, it is preferable to use annual data, so as to take into account as much as possible of the information available. However, these data may contain short-term fluctuations that may not reflect the long-term trend.

Ideally we would have data on the wages of skilled and unskilled workers (w_{LS}^{it} and w_{HS}^{it} respectively) in province i and year t. Then intra-provincial wage inequality in province i is defined as $\omega_S^{it} = w_{HS}^{it} / w_{LS}^{it}$, and interprovincial inequality at time t between provinces i and j can be represented by $w_{LS}^{it} / w_{LS}^{jt}$, as suggested by the analytical model. Unfortunately, wage data by occupation are unavailable at provincial level. Instead, we use the Gini coefficient of disposable income per worker. [xiii] However there is one issue with using the Gini as a proxy for the skill premium: there is a nonlinear relationship between these two variables, and sometimes the relationship can be non-monotonic.[xiv]

The data have other limitations that should be kept in mind. First, the NBS urban survey is restricted to households that have urban residence permits, and so does not include migrants working illegally in cities. The survey also excludes workers residing in rural areas who are engaged in wage employment. However, since most wage employment is in urban areas and most wage-workers are urban residents, the data should nonetheless capture major changes in wage inequality. Second, working hours are not reported, which precludes the possibility of constructing hourly wage rates. Third, we must treat different workers from the same household as if they had the same skill level.

For comparison of interprovincial wages we use the average wage in manufacturing for each province. We believe that a province with a higher average manufacturing wage has higher returns to both unskilled and skilled labor. However there are some problems associated with using the average manufacturing wage to represent either skilled or unskilled labor wage: the skill composition of the labor force in some regions may vary, due to the relative immobility of unskilled labor. For example, when coastal provinces experience faster technological progress than inland provinces, not only do unskilled wages in inland provinces decrease, but these regions also become more skill-scarce. As a result, our estimated effect of growth in coastal provinces on average income in the inland can be biased upward —albeit with the correct sign.

Annual data on the quintile distribution of disposable income and average manufacturing wages come from the Statistical Yearbook of each province (1995-2005). Thus we have two equations to estimate:

$$\ln G_{jt} = \beta_1 \ln z_{jt} + \beta_2 \ln\left(H_{jt} / L_{jt}\right) + \beta_3 \ln X_{jt}^1 \qquad (8.a)$$

$$\ln W_{jt} = \gamma_1 \ln z_{jt} + \gamma_2 \ln\left(H_{jt} / L_{jt}\right) + \gamma_3 \ln X_{jt}^2 \qquad (8.b)$$

where H_{jt} / L_{jt} is relative skill stock, the ratio of total skilled workers over unskilled workers at time t from province j. $X_{jt}^{\cdot}$ represents all other variables we should take into account. Following Barro and Lee (2000), we define skilled workers as those who completed at least college education and unskilled workers as all others. Data on the educational attainment composition of employment by region is from the China Labor Statistical Yearbook (1998-2005). We expect β_1, β_2, γ_1 and γ_2 to be positive.

On the other hand, z_{jt} itself is also function of technology level and other variables, such as foreign investment inflow:

$$\ln z_{jt} = \lambda_1 \ln P_{jt} + \lambda_2 \ln X_{jt}^3 \qquad (9)$$

where P_{jt} is technology level of province j at time t, and is calculated by dividing total value added by total employment (China Industry Economy Statistical Yearbook 1994-2006). X^3_{jt} includes FDI inflows as a percentage of GDP, and arable land per capita. The former variable represents technology spillover from advanced countries, while the latter can be used to control for natural resources. Natural resource abundance in a region makes it cheap to produce agricultural and other primary products; therefore, its skill intensity of exports should be low, other things equal. In regressions we lag FDI once, to allow for delays between the installation of new capital and its impact on production and exports. This also resolves a potential endogeneity problem. Data for these two variables are from provincial Statistical Yearbooks.

Provincial commodity export data are also from provincial Statistical Yearbooks (1993-2005), and the Almanac of China's Foreign Economic Relations and Trade (1992-2006).[xv] At this highly aggregated level (2-digit Harmonized System), there is no clear-cut z_{jt} above which there a province supplies no exports. Instead, we use the skill-intensity of exports as a proxy. Because an increase in z shifts the economy's export share towards more skill-intensive goods, $\hat{z}_{jt} = \int_0^1 \int_0^z x_{jt}\left(z\right) dzdx$. To compute skill-intensity, we use 1992 data on the education level of employees to classify all industries into 4 categories by skill intensity. Then the corresponding export products are classified into four groups. Table 1 reports a breakdown of China's exports into high, medium-high skill, medium-low, and low skill products. For each province, the skill intensity of its exports in a given year is defined as the value of high skill exports divided by the total value of all exports of that province. Table 2 gives summary statistics of this and other variables used in the regressions.

Previous research has revealed that the presence of a unit root in panel data can dramatically affect the asymptotic properties of regression estimates and test statistics (Levin and Lin 1992; Im et al. 2003; Levin et al. 2002; Maddala and Wu 1999). This problem may apply to our data.[xvi] So before going to estimation, we perform the Levin-Lin-Chu panel data unit root test on our dependent variable. Table 3 shows the unit root test results for the average manufacturing wage and for the bottom 20% of income. The test rejects the null hypothesis of nonstationarity for both variables when a first order lag is allowed. When no lag is included, we cannot reject the null hypothesis that the average manufacturing wage has a unit root. We will address this problem in estimation by adding a one-period lagged dependent variable.

Estimation

First, we would like to show that faster technical progress leads to an increase in the sophistication of exports. Column 1 of Table 4 displays province fixed-effect estimates of equation 9. The coefficient on the technology variable is highly significant and shows that a one percent increase in technical progress leads to a 0.204% increase in the skill intensity of exports. The elasticity of export skill intensity with respect to FDI is 0.107. Arable land per capita has a significantly negative effect on the dependent variable (-0.54), suggesting that exports from Chinese provinces follow comparative advantage. The results from the random effects model, shown in column 2, are very similar to those of the fixed effects model, which is confirmed by the Hausman test.

The learning-by-exporting argument holds that productivity in exporting firms can be improved over time, either because FDI transfers technology to firms that introduce new export products, or because the possibility of selling in export markets stimulates firms to improve their own technological capabilities (Westphal 2002). Thus the lagged skill intensity of exports may be a determinant of skill intensity in the current stage, which induces a dynamic element into our analysis. We deal with this by implementing an AR(1) specification in the disturbance terms. The results using fixed effects and random effects are reported in columns 3 and 4. The AR(1) specification makes the results from a random effects model more reliable, so even though the Hausman test rejects this model in favor of a fixed effects specification, we discuss the results of the random effects model. In this, the technology, FDI and natural resource variables retain their significance at 1% level, and their magnitudes are highly comparable with those obtained in the static model.

Another means to take care of the dynamic effect is to include a lagged dependent variable among the right hand side variables, so we have $y_{it} = \alpha y_{it-1} + x_{it}^{'}\beta + \mu_i + e_{it}$. Unfortunately, in this case, the fixed effects estimator is inconsistent.[xvii] One solution to this problem is to combine first differencing with IV, i.e., $\Delta y_{it} = \alpha \Delta y_{it-1} + \Delta x_{it}^{'}\beta + \Delta e_{it}$, using y_{it-2} as an instrument for Δy_{it-1} (Anderson and Hsiao 1981). A frequently preferred alternative is the Arellano-Bond estimator (Wooldridge 2001: 304). The Arellano-Bond estimates are shown in Table 4, column 5, while those for the pooled IV model in first differences are in column 6. These estimates differ from the AR(1) results in several ways. The natural resource variable loses significance, and the technology variable is significant only in the Arellano-Bond regression, with a smaller elasticity (0.063). The FDI variable retains a high level of significance, however, and its elasticity increases somewhat, to 0.259 in the Arellano-Bond estimates and 0.176 in the IV estimates.

We next turn to inequality, using provincial Gini coefficients, proxies for intra-province income inequality, as the dependent variable. What we want to test is whether more skill-intensity of exports is associated with a higher degree of inequality within province. Table 5 displays the estimation results. The first two columns show estimates of Eq. (8.a). The estimated coefficient on export skill intensity is positive as expected. It predicts that a 1% higher skilled export share increases the intra-provincial Gini by 0.361%. When an economy concentrates its exports and production on skill-intensive products, growth in demand for skilled labor exceeds that for unskilled labor. The skill stock variable is also positive (0.108). In the inequality regressions we also include the GDP share of government expenditure as a proxy for institutional quality. A high government expenditure share reflects potentially high taxes, which can be expected to have a negative impact on household income, especially for the poor. The government spending share has an estimated elasticity of 0.262, indicating that other things equal, government expenditure is regressive in its distributional impact.

We also address dynamics, as in the estimation of the skill-intensity model. Columns 3 and 4 of Table 5 show estimates obtained in the AR(1) specification. The results are very similar to those in columns 1 and 2. However, the estimates using first-differencing and Arellano-Bond tell a different story. In the first-differenced regression both the human capital and the public spending variables lose significance. In the Arellano-Bond estimates, human capital is weakly significant with an elasticity of 0.162. But in both cases, the skill intensity of exports remains significant, with elasticity values of 0.629 and 0.290 in the first-differenced and Arellano-Bond regressions, respectively.

Our model (and the Chinese reality) is of limited labor mobility in response to changing labor demand, and in particular, of greater mobility among skilled workers than among the unskilled. Therefore, as predicted, trade-related changes such as in the skills composition of exports could affect both intra-provincial inequality in other regions, and also inter-regional inequality. We now address both of these issues.

Does an increase in skilled labor demand in one region raise inequality in others? In Table 6, we re-estimate the inequality model on data subsets for coastal and inland provinces. From Proposition 3 we hypothesize that a rise in the skill-intensity of exports in one location will draw out relatively more skilled than unskilled workers from other regions, thereby raising the wage premium. To test for these effects we include variables for the average export skill intensity of provinces in coastal and inland regions in the inequality regressions for the inland and coastal regions, respectively. These variables are robustly positive in all specifications; accordingly we reject the hypothesis of no inter-provincial effects from inter-regional productivity changes.

Finally, we examine inter-regional inequality. The two dependent variables available for this purpose are the average manufacturing wage, a measure of the income level of the average worker in each province, and the income share of the lowest 20% of the income distribution in each province. In the first four columns of Table 7 we see that in both specifications, the skill-intensity of exports in coastal provinces has a negative effect on the average wage in the inland. The elasticity (in the Arellano-Bond model) is -0.041, meaning that a 1% increase in export skill intensity in coastal provinces leads to a 0.04 percent reduction in the average manufacturing wage in inland provinces. Conversely, higher export skill intensity in the inland has a negative impact on the coastal average wage (the elasticity is -0.013). These results support our prediction that rapid technological progress (and therefore higher skill-intensity of exports) in one region has a negative effect on average wages in other locations within the same skilled labor market.

Finally, as a proxy for the income of the poor in each province we use disposable income per worker of the bottom 20 percent of the wealth distribution. Columns 5-8 in Table 7 show first that higher skill-intensity of exports in coastal areas is associated with lower incomes of the poor in inland provinces, and second that higher skill-intensity of inland exports has a negative effect on the incomes of the poor in coastal regions. Thus a one-percent increase in the skill intensity of exports from an average coastal province is associated with a 0.56 percent decrease in the incomes of the poor in interior provinces. On the other hand, higher export skill intensity in inland provinces lowers the incomes of the poor in coastal areas, with an elasticity of -0.693. These results imply a rather elastic response of incomes of the poor to a rise in the sophistication of exports from other regions. In the presence of restrictions on the interprovincial mobility of low-skill workers, growth in one part of the country may actually impose welfare costs on others.

To summarize, the estimation results confirm our theoretical prediction that technical progress shifts export shares towards more skill-intensive goods. In turn, the shift in export shares increases intra-province inequality and the provincial average wage. These results mean that the developing country's technological progress contributes to rising inequality. Also, as our model predicts, there are interactions between the dynamic region (the coast) and the lagging region (the inland) that may also affect both intra- and inter-province inequality and the income of the poor in each region.

5 CONCLUSION

Many economists now maintain that greater openness to trade is associated with rising wage inequality in developing and transitional economies, a view that is sharply at odds with Heckscher-Ohlin. Analysis of this issue is complicated by market imperfections, specifically those that inhibit factor mobility and introduce differential rates of technical progress, since these are also sources of spatial inequality. Our theoretical and econometric analyses both show how interactions between factor mobility restrictions and different regional rates of technological progress can explain the evolution of inequality in response to trade and FDI. As favored regions benefit more from international trade, their growing demand for skills drains skilled workers from disadvantaged areas. In a dynamic sense, the latter regions lag further behind. Therefore, average income growth in the favored regions is faster than in less favored regions. Moreover, this unbalanced regional growth may also exert downward pressure on the incomes of unskilled workers in disadvantaged areas. In sum, the scarcity of human capital in some regions retards regional technological progress, and this—together with a lack of the infrastructure that facilitates international trade—keeps economic growth from occurring and slows the rate of poverty reduction.

It is frequently verified that exports are positively correlated with economic growth. However, the long-run growth effects of exports of resource-based, or low-skill labor-intensive commodities is expected to differ from those of exports of highly sophisticated technology and knowledge intensive goods. Hausmann et al. (2007) show empirically that specialization in higher skill-intensity exports can lead to faster economic growth. They argue that policies which foster skills upgrading in exports have a positive effect on economic growth. In this paper, we show that when labor market segmentation exists, high-skill exports may have adverse effects on both interregional and intraregional inequality. Therefore, the aggregate growth effect may be a net gain consisting of expansion in one region of the economy that is partially offset by contractions in others.

It is important to keep in mind that actions taken by the government can also contribute to rising regional inequality. In order to maximize aggregate growth possibilities, government may allocate public investments mainly in rapidly developing regions, an action which further favors the already rich region at the expense of poorer areas. China, in recent years, has begun redirecting public investments in both human capital and infrastructure to inland provinces, in a belated attempt to equalize rates of output and employment growth and thus to close the development gap. Given the geography of the country, however, these measures are likely to be second-best relative to policies that liberalize internal labor migration from inland to coastal provinces.

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Table 1: Products used in calculating skill-intensity of exports

Product by Skill Intensity	
High Skill Intensive Products	Aircraft and spacecraft Pharmaceuticals Office, accounting and computing machinery Radio, TV and communications equipment Medical, precision and optical instruments
Medium-High Skill Intensive Products	Other electrical machinery and apparatus Motor vehicles, trailers and semi-trailers Chemicals excl. pharmaceuticals Railroad equipment and other transport equip. Other machinery and equipment
Medium-High Skill Intensive Products	Coke, refined petroleum product and nuclear fuel Rubber and plastics products Other non-metallic mineral products Building and repairing of ships and boats Basic metals Fabricated metal products, excl. machinery
Low Skill Intensive Products	Other manufacturing and recycling Wood, pulp, paper and printed products Food products, beverages and tobacco Textiles, textile products, leather and footwear

Source: UN 2007

Table 2: Summary statistics of key variables

Variable	Unit	Mean	Median	Std. Dev	Min	Max	Obs
FDI	% of GDP	7.800	3.070	11.7925	0.326	77.100	275
Public Spending	share of GDP	0.15643	0.14662	0.052557	0.07436	0.49978	339
Skill intensity of exports		0.09319	0.06011	0.089649	0.00439	0.53252	339
Human capital	% of labor force	6.004	5.070	4.7037	0.000	30.940	309
Arable land	ha /person	0.101	0.075	0.0688	0.015	0.321	355
Gini Coefficient		0.225	0.218	0.0375	0.144	0.360	208
Income of the poor	RMB yuan	7522.33	6668.7	2760.10	3775.15	18428.78	207
Manufacturing wage	RMB yuan	9238.49	8364.50	4188.111	3611.00	29743.00	330
Value added per worker	RMB yuan	58426.98	47651.02	38127.44	9864.00	243447.00	271

Table 3: Unit root test

Variable	Average manufacturing wage		Bottom 20% income	
	1*	2**	1*	2**
Coefficient	-0.072	-0.212	-0.581	-0.916
t-value	-2.756	-7.032	-7.681	-9.024
t-star	0.105	-3.858	-4.180	-5.362
P-value	0.5419	0.0001	0.0000	0.0000
Obs	319	319	203	203
Groups	29	29	29	29

* no lag is allowed

** 1 order lag is allowed

Table 4: Estimation results: skill intensity of exports

Dependent variable	Skill Intensity of Exports					
Method			AR(1)		Arellano-	First
	FE	RE	FE	RE	Bond	differencing
Lagged skill					0.132**	0.889
intensity of export					(0.0669)	(0.7566)
Technology level	0.204***	0.187***	0.104*	0.192***	0.063*	0.106
	(0.0442)	(0.0404)	(0.0595)	(0.0465)	(0.0360)	(0.0798)
FDI	0.107**	0.138***	0.128*	0.144***	0.259***	0.176***
	(0.0494)	(0.0452)	(0.0725)	(0.0472)	(0.0595)	(0.0605)
Arable land	-0.544**	-0.783***	-0.014	-0.780***	0.159	-0.152
per capita	(0.2772)	(0.1519)	(0.3695)	(0.1456)	(0.3291)	(0.3533)
Hausman test						
Chi-square	2.40		28.45			
Observations	290	290	261	290	254	254
Groups	29	29	29	29	29	
Adj R-square:						0.0459
within	0.1878	0.1849	0.0381	0.1850		
between	0.6002	0.5969	0.4660	0.5982		
overall	0.5611	0.5636	0.4131	0.5652		

Standard error in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Estimation results: Gini Coefficient (whole sample)

Dependent variable	Gini Coefficient					
Method			AR(1)		First	Arellano-
	FE	RE	FE	RE	difference	Bond
Public spending	0.262***	0.146**	0.270***	0.140**	0.166	0.162
	(0.0772)	(0.0573)	(0.0975)	(0.0567)	(0.1319)	(0.1931)
Skill stock	0.108***	0.084***	0.089**	0.080***	0.004	0.097*
	(0.0339)	(0.0245)	(0.0403)	(0.0243)	(0.0398)	(0.0506)
Lagged Gini					0.378	-0.352***
coefficient					(0.0803)	(0.1359)
Skill intensity	0.361***	0.057	0.362***	0.055	0.629***	0.290*
of export	(0.0938)	(0.0353)	(0.1155)	(0.0346)	(0.1937)	(0.1531)
Hausman test						
Chi-square	89.93		25.65			
Observations	213	213	184	213	153	153
Groups	29	29	29	29		28
Adj R-square:					0.1473	
within	0.3560	0.3298	0.2659	3297		
between	0.0099	0.0417	0.0243	0.0418		
overall	0.0251	0.038	0.0084	0.038		

Standard error in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6 Estimation results: Gini Coefficient (by region)

Dependent variable	Gini Coefficient							
Method	FE	FE	FE AR(1)		First differencing		Arellano-Bond	
	Inland	Coast	Inland	Coast	Inland	Coast	Inland	Coast
Public spending	0.193**	0.062	0.199	0.080	-0.139	-0.741***	0.352	-0.083
	(0.0893)	(0.1347)	(0.1257)	(0.1404)	(0.1562)	(0.1804)	(0.2925)	(0.2069)
Skill stock	0.039	0.089*	-0.034	0.099***	-0.284	0.075	1.350**	0.208
	(0.0464)	(0.0454)	(0.0466)	(0.0461)	(0.3301)	(0.0673)	(0.4437)	(0.0991)
Coastal skill	0.504***		0.555***		1.433*		1.682**	
intensity of export	(0.1373)		(0.2116)		(0.7332)		(0.7574)	
Inland skill		0.767***		0.848***		0.346**		1.016***
intensity of export		(0.1460)		(0.1572)		(0.1721)		(0.2331)
Lagged Gini					-0.112	0.050	-0.303**	-0.728***
coefficient					(0.1216	(0.1245)	(0.1275)	(0.1233)
Skill intensity	-0.040	0.132	0.026	0.238***	0.172	0.467	-0.110	0.486*
of export	(0.0315)	(0.1058)	(0.0370)	(0.1156)	(0.1914)	(0.5075)	(0.3300)	(0.2638)
Observations	125	88	108	76	90	63	90	63
Groups	17	12	17	12			16	12
Adj R-square:					0.0686	0.2157		
within	0.3363	0.6126	0.1616	0.6060				
between	0.0429	0.0005	0.0418	0.0033				
overall	0.0813	0.1725	0.0207	0.0778				

Standard error in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7 Estimation results: wages and poverty

Dependent Variable	Manufacturing wage				Bottom 20% income			
Method	First differencing		Arellano-Bond		First differencing		Arellano-Bond	
	Inland	Coast	Inland	Coast	Inland	Coast	Inland	Coast
Public spending	-0.014	0.080	-0.008	0.002	-0.385**	0.104	-0.347*	0.203
	(0.0591)	(0.0634)	(0.0424)	(0.0455)	(0.1825)	(0.2088)	(0.1453)	(0.1440)
Skill stock	0.022	0.587***	0.018*	0.023	-0.120	-0.080	0.022	0.005
	(0.0185)	(0.1430)	(0.0107)	(0.0199)	(0.3401)	(0.0764)	(0.0543)	(0.0602)
Coast skill intensity of export	-0.387**		-0.041**		0.512		-0.559*	
	(0.1561)		(0.0191)		(0.6003)		(0.2961)	
Inland skill intensity of export		-0.025*		-0.013*		-0.811***		-0.693***
		(0.0127)		(0.0067)		(0.1967)		(0.1612)
Lagged dependent variable	0.548***	0.943***	-0.309***	-0.359***	0.876***	0.895***	0.037	0.291***
	(0.0917)	(0.1634)	(0.0785)	(0.0959)	(0.1047)	(0.0665)	(0.2339)	(0.1030)
Skill intensity of export	0.300***	0.587***	0.042*	0.014*	-0.120	0.451	0.300	0.397***
	(0.1033)	(0.1430)	(0.0235)	(0.0059)	(0.3401)	(0.5757)	(0.2367)	(0.1070)
Observations	153	108	153	108	90	63	90	63
Group			16	12			16	12
Adjusted R^2	0.7527	0.7691			0.4883	0.7733		

Standard error in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

NOTES

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[iii] For simplicity, we ignore trade costs, so there is complete specialization by region.

[iv] Development economists often emphasize the growth impact of exports, especially exports of high-tech goods. Export sectors, it is argued have higher factor productivity, and their growth generates positive externalities for related sectors in the form of knowledge spillovers, process and product innovation, technological change, etc.; and that the scope for positive externalities is increasing in the technology and skill content of the exported goods (Hausmann et al. 2007; Blalock and Gertler 2004; Takii 2004). However, effect of high-tech exports on inequality and economic growth in one region on other regions within a developing economy has not been thoroughly researched.

[v] Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

[vi] Tianjin, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong.

[vii] Otherwise, the cutoff point of exporting good will be different for international and intra-national trade, which makes our analysis unnecessarily complicated and beyond our main focus.

[viii] Coe and Helpman (1995) find that R&D abroad benefits domestic productivity, possibly through the transfer of technological know-how via trade.

[ix] Welch (1975), Bartel and Lichtenberg (1987) and Foster and Rosenzweig (1995), Benhabib and Spiegel (1994), Basu and Weil (1998).

[x] For goods produced in Inland, i.e., z (0,z_1)

$$x(z)=\alpha(z)\frac{Y_N+Y_S^C+Y_S^I}{w_{LS}^I L_S^I(z)+w_{HS}^I H_S^I(z)}=\alpha(z)\frac{Y_N+Y_S^C+Y_S^I}{w_{LS}^I L_S^I(z)\left(1+\omega_S^I h_S^I(z)\right)}$$

For goods produced in Coast, z (z_1,z_2)

$$x(z)=\alpha(z)\frac{Y_N+Y_S^C+Y_S^I}{w_{LS}^C L_S^C(z)+w_{HS}^C H_S^C(z)}=\alpha(z)\frac{Y_N+Y_S^C+Y_S^I}{w_{LS}^C L_S^C(z)\left(1+\omega_S^C h_S^C(z)\right)}$$

[xii] Data for Tibet and Chongqing are not available.

[xiii] For several provinces, we do have wage income, and in most the cases, wage income accounts for 70 percent or more of disposable income.

[xiv] For example, when Inland has slower technological progress compared to Coast, skilled labor chooses to emigrate from Inland, therefore the skill premium increases there. On the other hand, this skill outflow results in rich households becoming richer in Inland but there are fewer such households left. As a result, we could observe a lower Gini coefficient if there is huge drop in skill endowment. However, after reviewing the annual change rate of each province's human capital stock, we find that the change in this variable over time was relatively smooth for each province, therefore non-monotonicity issues should not greatly affect this dataset.

[xv] After 2002, the title became *Yearbook of China's Foreign Economic Relations and Trade*.

[xvi] The manufacturing wage series and that for the bottom 20% of income may have unit roots. Export skill intensity and the Gini coefficient lie in the interval [0, 1], so they are automatically stationary.

[xvii] This is because the sample mean of y_{it-1} is correlated with that of e_{it}.