Factor Proportions and the Growth of World Trade

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Abstract

Most of the expansion of global trade since 1980 has been of the North-South kind – between capital-abundant developed and labour-abundant developing countries. Based on this observation, I argue that the recent growth of world trade is best understood from a factor-proportions perspective. Using data on trade barriers and estimates of capital-labour ratios for a group of 45 economies between 1980 and 2008, I find that a calibrated factor-proportions model can generate significant trade growth during this period, amounting to 90% of the observed rise in North-South trade. The opening up of China alone accounts for three quarters of the predicted increase. In line with the model, I present evidence that China's liberalisation has raised the exports and imports of capital-abundant countries relative to more labour-abundant economies. Overall, my findings suggest that factor-proportions theory may be useful for interpreting several quantitative and qualitative aspects of growing world trade in a period during which the group of large, open economies has become significantly less homogenous.

JEL Classification codes: F11, F17, F62
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1 Introduction

The rapid growth of world trade has been one of the most striking developments in the global economy during the last three decades. Figure 1 shows that the traded share of world output rose by 7 percentage points between 1980 and 2008, from 12% to 19%. This surge follows a period from the mid-1970s to the late 1980s during which the growth in global trade appeared to have levelled off, and it exceeds the increase which accompanied the GATT rounds of the 1960s and 1970s.[1] Most of the recent rise in world trade has taken place between capital-abundant countries – the "North" – and capital-scarce countries – the "South" –, as Figure 2 illustrates.[2] Starting from this observation, this paper puts forward the view that factor-proportions differences are the key to explaining the expansion of global trade since 1980.

Earlier attempts, by Bergoeing and Kehoe (2003) and Yi (2003), to account for world-trade growth in the post-War era using calibrated trade models have struggled to replicate both the quantitative and qualitative features of the rise in the world trade share. The surge in trade during recent decades has proven especially difficult to explain because of the modest observed decline of average tariff rates among the world's largest economies. In this paper, I show that even relatively small reductions in tariffs can generate a large increase in the traded share of world output if they encourage classical factor-proportions trade. Using data on trade barriers and endowments of physical and human capital for a group of 45 economies between 1980 and 2008, I find that a calibrated factor-proportions model can generate significant trade growth during this period, amounting to 90% of the observed rise in North-South trade. Since the expansion of North-South trade is roughly equal to 60% of the overall rise in world trade relative to GDP, this implies that the model can explain more than half of recent world trade growth.

Classical factor-proportions models emphasise differences in countries' relative endowments of production factors as the source of gains from trade. To exploit these gains, countries export in industries which make intensive use of

[1] This remains true if the decline in global trade during the Great Recession, and its subsequent resurgence, are taken into account. Since this paper is primarily concerned with the long-run causes of world trade growth, I will focus on the period of expansion between 1980 and 2008. For studies of the collapse in world trade during the recent recession see Alessandria et al. (2010), Eaton et al. (2011), Engel and Wang (2011) and Levchenko et al. (2010), among others.

[2] Figures 1 and 2 are based on bilateral trade flows between 45 economies which accounted for 86% of global output and 70% of world trade between 1980-2008. Trade refers to one half times the sum of imports and exports. The "North" and "South" in a given year are defined as countries with ratios of capital per effective worker above and below the world's aggregate ratio, respectively. Details on data sources and construction are provided in Section 3.1 and Appendix A1.

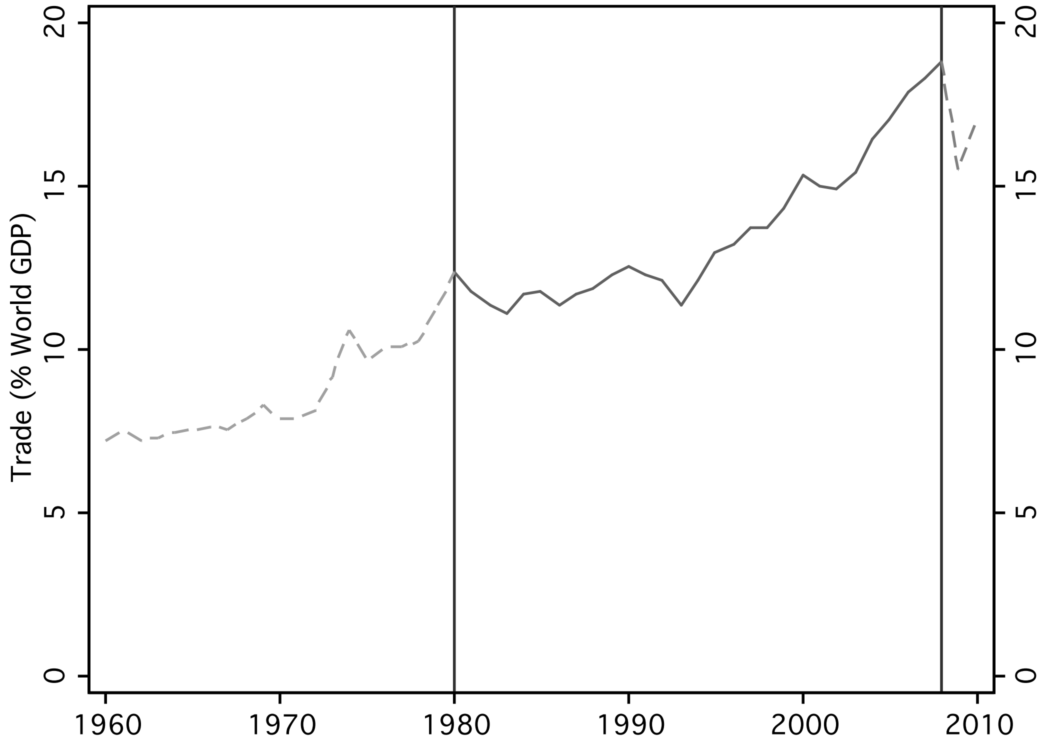

Figure 1: The Growth of World Trade, 1960-2010

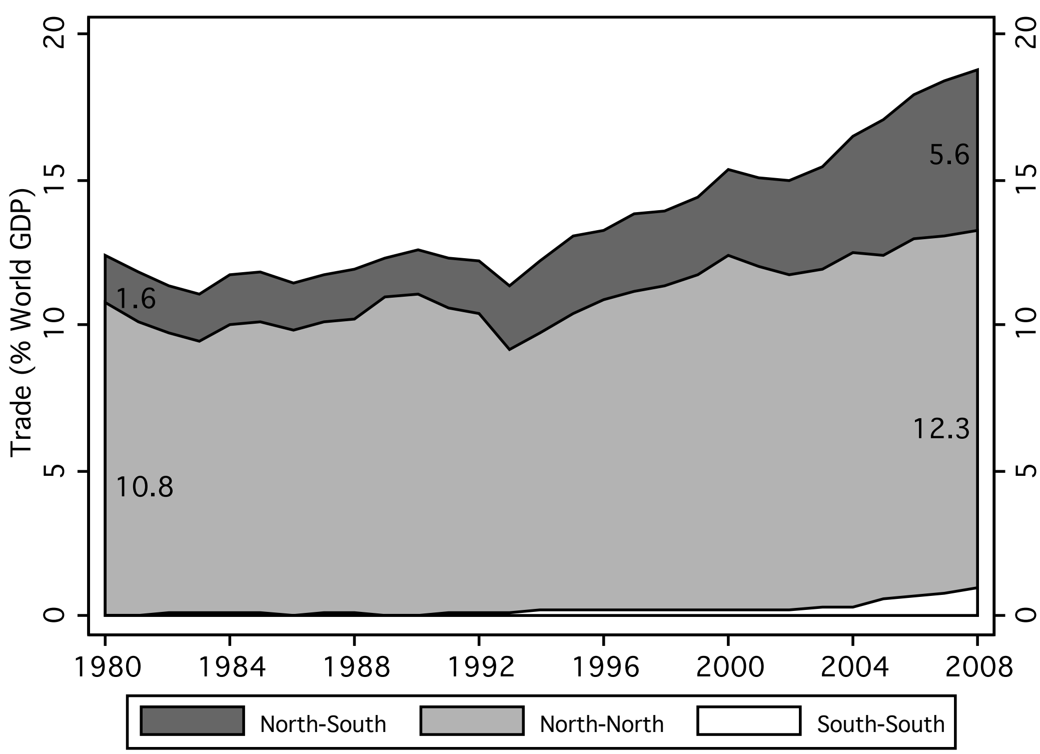

Figure 2: World Trade by Region, 1980-2008

their relatively abundant factor, and import in industries using their relatively scarce factor. In the presence of trade barriers, factor-proportions trade will take place only if these barriers are sufficiently low, or if a country's factor proportions are sufficiently different from the rest of the world's, giving rise to potentially large and non-linear effects of declines in trade frictions on international trade. The reason a factor-proportions model can easily generate significant trade growth when calibrated to fit recent data is that the largest declines in trade barriers since 1980 have taken place in countries whose ratios of capital per effective worker are dramatically different from the rest of the world's. The most notable example of this is China, whose average import tariff fell by 18 percentage points between 1980 and 2008, raising its share of world trade from 1% to nearly 10% (see Figure 3).[3] During this period, China's ratio of capital per effective worker was a mere 21% of the world's aggregate capital-labour ratio.

China's trade liberalisation − in accordance with the program of "reform and opening up" initiated by the Communist Party of China under Deng Xiaoping in 1978 − is generally viewed as an exogenous policy shock. Although the Chinese economy's comparative advantage in labour-intensive industries is widely acknowledged,[4] to the best of my knowledge I provide the first quantitative assessment of the contribution of China's opening to the growth in world trade from a factor-proportions perspective. In my calibrations, China alone is responsible for three quarters of the model-predicted growth in North-South trade. The opening up of a large, labour-abundant country like China creates new trade with capital-abundant countries, but also reduces the trade of already-open labour-abundant economies with the rest of the world. I test the latter prediction of the theoretical analysis using a model-consistent difference-in-difference estimation and find robust empirical support for it in the data. This provides additional evidence that factor-proportions theory is useful for interpreting both the quantitative and qualitative impact of China's integration into the global economy.

China's significance for any factor-proportions-based view of international goods trade derives from its sheer size and labour abundance. In line with this, most of the remainder of the rise in factor-proportions trade predicted by my calibration exercise can be traced to trade liberalisation in two other large, labour-abundant economies: Brazil and India. Previous papers which have attempted to provide an account of post-War trade growth have given little

[3]China's average tariff is measured as the value of revenue from import duties relative to total imports, based on data from Clemens and Williamson (2004), Woo and Ren (2002) and the World Development Indicators.

[4]See, for example, Rodrik (2006) and Amiti and Freund (2010).

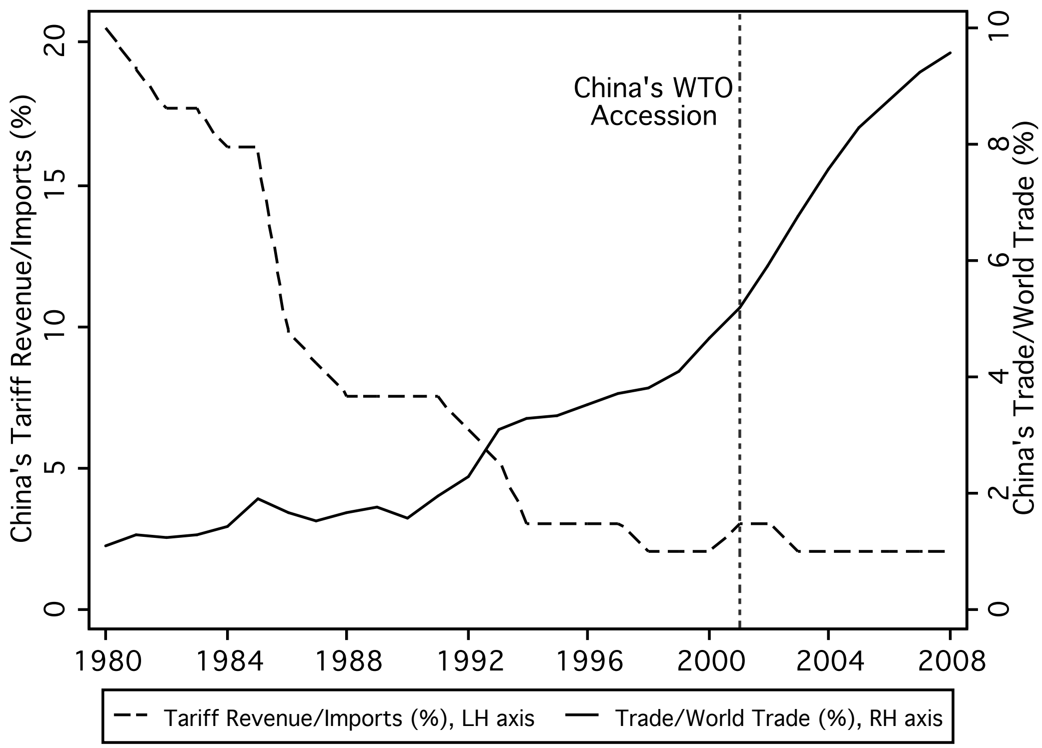

Figure 3: Opening Up of China, 1980-2008

weight in their calibrations to observed factor-proportions differences among the set of trading countries.[5] My analysis suggests that factor proportions may have become a more important determinant of international trading patterns since 1980 because the group of large open economies has become significantly less homogenous, with several labour-abundant economies emerging as key players in the global trading system.

My paper adds to a long literature on the quantitative implications of international trade models for the level and growth of world trade. The development of the so-called "new" trade theory by Krugman (1979), Lancaster (1980) and Helpman (1981) was motivated in part by the failure of traditional, comparative-advantage-based models to explain the volume of world trade and its concentration among a small group of industrialised nations. Beyond this, new trade theory has implications for trade growth, linking it to declining trade frictions or increasing income similarity across countries.[6] There is little

[5] Yi (2003) does not consider factor proportions as a motive for international trade at all. Bergoeing and Kehoe (2003) do allow for factor-proportions trade but focus on the period before 1990, and do not constrain their calibrated capital-labour ratios to equal available estimates for their sample period.

[6] See Helpman (1987) for a discussion of the second channel.

evidence that increased income similarity has played a quantitatively important part in the recent growth of world trade, causing most authors to focus on the role of declining trade frictions.[7]

Yi (2003) shows that the decline in world tariffs in the last decades of the 20th century has been too small to match the observed growth in trade using a standard Ricardian or new trade model with plausible assumptions about the elasticity of substitution between goods. He suggests that this may be due to the models' failure to account for vertical specialisation, whereby goods cross borders several times during the production process. His paper and subsequent work by Bridgman (2012) show that models which explicitly allow for input trade can explain at least half of the recent rise in trade relative to output. Both papers assume that the extent and pattern of vertical specialisation is determined by classical comparative advantage due to productivity differences. My work is complementary with theirs, insofar as I also assume a comparative-advantage motive for trade. However, I impose that comparative advantage is determined by differences in observed capital stocks per effective worker and show that, even in the absence of vertical specialisation, a calibrated model along these lines can explain a substantial part of the recent growth in world trade, given the magnitude and incidence of declines in political barriers to international trade.[8]

A recent paper by Cuñat and Maffezzoli (2007) is most closely related to the present work. The authors study the growth of U.S. trade from a dynamic factor-proportions perspective. In their setting trade integration raises the return to capital in capital-abundant countries and lowers it in capital-scarce countries, thus eliciting more capital accumulation in the former, and reducing it in the latter. They suggest that this dynamic implication of tariff reductions can explain why small tariff reductions have had a large impact on U.S. trade with the rest of the world.[9] Unlike Cuñat and Maffezzoli (2007), I study the growth in global rather than U.S. trade and, rather than letting countries' capital-labour ratios be determined freely by the model, I discipline their evolution with empirical estimates of capital stocks per effective worker in

[7]See Hummels and Levinsohn (1995), Baier and Bergstrand (2001) and Bergoeing and Kehoe (2003).

[8]In common with most of the literature, I assume below that political barriers are the main impediment to international trade. In the specific context, this seems appropriate because the recent growth in North-South trade has been driven primarily by changes in trade policy. Bridgman (2008) highlights that incorporating the evolution of global transportation costs since 1960 may make it easier to reconcile calibrated trade models with the nature and extent of post-War trade growth among developed countries. Extending his work to North-South trade would, if anything, strengthen the results of my calibration exercise.

[9]Bajona (2004) similarly develops a model in which modest declines in trade barriers can create large trade volumes because, over time, learning-by-doing magnifies pre-existing productivity differences and, hence, the extent of specialisation.

my calibration exercise. I show that, with the observed differences in capital-labour ratios across countries, a factor-proportions model can easily predict most of the rise in North-South trade – the fastest-growing portion of world trade between 1980 and 2008.

The remainder of the paper is structured as follows. Section 2 describes the theoretical model and, through three simple examples, builds an intuition for the findings of the subsequent formal calibration. Section 3 calibrates the model to real-world data, and compares model-predicted trade growth with the increase in North-South trade over the last three decades. It also tests for the model-implied differential impact of China's liberalisation on capital- and labour-abundant countries by means of a difference-in-difference estimation. Section 4 briefly summarises the main findings and concludes.

2 The Model

Below I outline a classical Heckscher-Ohlin model of international trade: differences in countries' factor proportions are a source of comparative advantage. Countries trade in goods produced with different technological factor intensities, exporting the good which uses their abundant factor intensively. The model serves to highlight the relationship between capital-labour ratios, the patterns of trade and the traded share of world output. In section 2.3.3, I use this framework to analyse the qualitative impact on world trade of the opening up of a large, labour-abundant country to build some intuition for the results of the formal calibration in Section 3.

2.1 Model Setup

2.1.1 Preferences and Endowments

Consider a world consisting of large countries, $c = 1, ..., C$. There is a representative consumer in each country with preferences represented by the Cobb-Douglas utility function

$$U_{ct} = \left(\frac{X_{cKt}}{\theta}\right)^{\theta} \left(\frac{X_{cHt}}{1-\theta}\right)^{1-\theta} \text{ with } \theta \in (0,1)\,. \tag{1}$$

In (1), X_{cKt} and X_{cHt} denote consumption of two distinct goods – the K-good and the H-good, respectively.

Physical capital (K_{ct}) and human capital (H_{ct}) are the only two factors of production. The representative consumer in each c is endowed with an exogenously determined sequence of these production factors, $\{K_{ct}, H_{ct}\}_{t=0}^{\infty}$.

For brevity, physical and human capital will occasionally be referred to simply as "capital" and "labour" in the following. Capital in c is paid a rental rate r_{ct}, and labour is paid w_{ct}. Therefore country c's GDP at time t is

$$Y_{ct} \equiv r_{ct} K_{ct} + w_{ct} H_{ct}, \tag{2}$$

and the representative consumer maximises (1) subject to the budget constraint

$$P_{cKt} X_{cKt} + P_{cHt} X_{cHt} \leq Y_{ct},$$

where P_{cKt} and P_{cHt} denote the respective prices of the K- and H-good.

2.1.2 Production

Production is carried out by profit-maximising firms in each country which produce K-goods and H-goods from capital and labour according to the production technologies

$$Q_{cKt} = \left(\frac{K_{cKt}}{\alpha_K}\right)^{\alpha_K} \left(\frac{H_{cKt}}{1-\alpha_K}\right)^{1-\alpha_K} \quad \text{with } \alpha_K \in (0,1), \tag{3}$$

$$Q_{cHt} = \left(\frac{K_{cHt}}{\alpha_H}\right)^{\alpha_H} \left(\frac{H_{cHt}}{1-\alpha_H}\right)^{1-\alpha_H} \quad \text{with } \alpha_H \in (0,1). \tag{4}$$

The technology for producing K-goods is assumed to be more capital-intensive than the technology for H-goods: $\alpha_K > \alpha_H$.

Goods and factor markets are perfectly competitive everywhere. However, while goods can be traded internationally, factor markets are strictly segmented and firms in c can only rent capital and labour from the domestic consumer. Therefore, for all c, factor market clearing requires

$$K_{cKt} + K_{cHt} = K_{ct}, \tag{5}$$

$$H_{cKt} + H_{cHt} = H_{ct}. \tag{6}$$

2.1.3 Trade Barriers

There is a government in each c which levies an import tariff τ_{ct}. This import tariff applies in an "iceberg fashion": the representative consumer only receives a fraction $1-\tau_{ct}$ of any unit of the K- or H-good imported from abroad, with the government taking the rest. The proceeds from the government tariff policy are spent on a public project which yields no utility to the consumer. Aside from government tariffs, there are no other barriers to international goods trade. International asset trade is ruled out by assumption, so exports and imports must balance for each country in every period.

2.2 Equilibrium

Section 2.1 describes a simple Heckscher-Ohlin model with iceberg trade frictions. In the equilibrium of the model, countries will exhibit different production and trading patterns depending on their relative factor endowments and the magnitude of their country-specific import tariff. Capital-abundant countries with a high ratio of physical to human capital compared to the world average, and with a sufficiently low import tariff, will export the K-good and import the H-good. Labour-abundant countries with a high ratio of human to physical capital compared to the world average, and with a sufficiently low import tariff, will export the H-good and import the K-good. Countries with "intermediate" factor proportions and high import tariffs will not trade internationally.

Among capital and labour-abundant countries whose important tariffs are low enough to induce them to trade, those with more extreme factor endowments may be fully specialised – that is, produce only the good which they export – while the rest will be diversified, producing both goods. The range of factor endowments for which trading countries are diversified in equilibrium is referred to as the "cone of diversification" in the literature, and its size is governed by the values of the parameters α_K and α_H.

Let P_{Kt}^{*} and P_{Ht}^{*} denote the equilibrium f.o.b. prices of the K- and H-good among countries which do engage in international trade. Imposing the normalisation

$$P_{Kt}^{*\theta} P_{Ht}^{*1-\theta} = 1, \tag{7}$$

countries' incomes and trading patterns can be characterised as a function of the equilibrium price of K-goods, P_{Kt}^{*}. Specifically, the value of income, $Y_{ct}(P_{Kt}^{*})$ and the value of net imports of the K-good, $M_{cKt}\left(P_{Kt}^{*}\right)$, for a country c at time t are as follows:

1. If $P_{Kt}^{*\frac{1}{1-\theta}} \leq (1-\tau_{ct}) \left(\frac{\alpha_H}{1-\alpha_H} \frac{H_{ct}}{K_{ct}}\right)^{\alpha_K - \alpha_H}$:

$$Y_{ct}\left(P_{Kt}^{*}\right) = P_{Kt}^{*-\frac{\theta}{1-\theta}} \left(\frac{K_{ct}}{\alpha_H}\right)^{\alpha_H} \left(\frac{H_{ct}}{1-\alpha_H}\right)^{1-\alpha_H}$$

$$M_{cKt}\left(P_{Kt}^{*}\right) = \theta Y_{ct}\left(P_{Kt}^{*}\right)$$

2. If $(1-\tau_{ct})\left(\frac{\alpha_H}{1-\alpha_H}\frac{H_{ct}}{K_{ct}}\right)^{\alpha_K-\alpha_H} < P_{Kt}^{*\frac{1}{1-\theta}} \leq (1-\tau_{ct})\left(\frac{\alpha}{1-\alpha}\frac{H_{ct}}{K_{ct}}\right)^{\alpha_K-\alpha_H}$:

$$Y_{ct}\left(P_{Kt}^*\right) = P_{Kt}^{*-\frac{\theta}{1-\theta}}\left[\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{1-\tau_{ct}}\right)^{\frac{1-\alpha_H}{\alpha_K-\alpha_H}}K_{ct}+\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{1-\tau_{ct}}\right)^{-\frac{\alpha_H}{\alpha_K-\alpha_H}}H_{ct}\right]$$

$$M_{cKt}\left(P_{Kt}^*\right) = \frac{P_{Kt}^{*-\frac{\theta}{1-\theta}}}{\alpha_K-\alpha_H}\left[\alpha\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{1-\tau_{ct}}\right)^{-\frac{\alpha_H}{\alpha_K-\alpha_H}}H_{ct}-(1-\alpha)\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{1-\tau_{ct}}\right)^{\frac{1-\alpha_H}{\alpha_K-\alpha_H}}K_{ct}\right]$$

3. If $(1-\tau_{ct})\left(\frac{\alpha}{1-\alpha}\frac{H_{ct}}{K_{ct}}\right)^{\alpha_K-\alpha_H} < P_{Kt}^{*\frac{1}{1-\theta}} < \frac{1}{1-\tau_{ct}}\left(\frac{\alpha}{1-\alpha}\frac{H_{ct}}{K_{ct}}\right)^{\alpha_K-\alpha_H}$:[10]

$$Y_{ct}\left(P_{Kt}^*\right) = \left(\frac{K_{ct}}{\alpha}\right)^{\alpha}\left(\frac{H_{ct}}{1-\alpha}\right)^{1-\alpha}$$

$$M_{cKt}\left(P_{Kt}^*\right) = 0$$

4. If $\frac{1}{1-\tau_{ct}}\left(\frac{\alpha}{1-\alpha}\frac{H_{ct}}{K_{ct}}\right)^{\alpha_K-\alpha_H} \leq P_{Kt}^{*\frac{1}{1-\theta}} < \frac{1}{1-\tau_{ct}}\left(\frac{\alpha_K}{1-\alpha_K}\frac{H_{ct}}{K_{ct}}\right)^{\alpha_K-\alpha_H}$:

$$Y_{ct}\left(P_{Kt}^*\right) = P_{Kt}^*\left[\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{(1-\tau_{ct})^{-1}}\right)^{\frac{1-\alpha_K}{\alpha_K-\alpha_H}}K_{ct}+\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{(1-\tau_{ct})^{-1}}\right)^{-\frac{\alpha_K}{\alpha_K-\alpha_H}}H_{ct}\right]$$

$$M_{cKt}\left(P_{Kt}^*\right) = \frac{P_{Kt}^*}{\alpha_K-\alpha_H}\left[\alpha\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{(1-\tau_{ct})^{-1}}\right)^{-\frac{\alpha_K}{\alpha_K-\alpha_H}}H_{ct}-(1-\alpha)\left(\frac{P_{Kt}^{*\frac{1}{1-\theta}}}{(1-\tau_{ct})^{-1}}\right)^{\frac{1-\alpha_K}{\alpha_K-\alpha_H}}K_{ct}\right]$$

5. If $P_{Kt}^{*\frac{1}{1-\theta}} \geq \frac{1}{1-\tau_{ct}}\left(\frac{\alpha_K}{1-\alpha_K}\frac{H_{ct}}{K_{ct}}\right)^{\alpha_K-\alpha_H}$:

$$Y_{ct}\left(P_{Kt}^*\right) = P_{Kt}^*\left(\frac{K_{ct}}{\alpha_K}\right)^{\alpha_K}\left(\frac{H_{ct}}{1-\alpha_K}\right)^{1-\alpha_K}$$

$$M_{cKt}\left(P_{Kt}^*\right) = -(1-\theta)\,Y_{ct}\left(P_{Kt}^*\right)$$

where $\alpha \equiv \alpha_K\theta + \alpha_H(1-\theta)$. The price P_{Kt}^* which achieves market clearing in the global market for K-goods at time t is then implicitly defined by:

$$\sum_c M_{cKt}\left(P_{Kt}^*\right) = 0, \tag{8}$$

and the corresponding value of P_{Ht}^*, which satisfies (7) given (8), ensures market clearing in the global market for H-goods by Walras' law.

Dropping the subscript c for "world" variables, we can now define the world trade share as

$$\frac{M_t}{Y_t} \equiv \frac{\sum_c |M_{cKt}(P_{Kt}^*)|}{\sum_c Y_{ct}}. \tag{9}$$

The next section describes three special cases of the model to show how tariff declines affect the patterns of trade and the world trade share when factor-proportions differences are the dominant motive for international trade.

[10] Here, a normalisation corresponding to (7) is imposed on the goods prices of non-trading countries.

2.3 Special Cases

For expositional convenience as well as consistency with my baseline calibration in Section 3, I impose parameter values in all three examples below which ensure that trading countries are always diversified. A sufficient condition for this is $\alpha_K = 1 - \alpha_H = 1$, which implies that K-goods are produced with capital only, while H-goods are produced with labour only. Under this assumption $\alpha = \theta$.

2.3.1 Infinitessimal Tariffs

Suppose $\tau_{ct} \to 0 \ \forall \ c$. It follows from (8) that

$$P^*_{Kt} = \left(\frac{\alpha}{1-\alpha} \frac{H_t}{K_t} \right)^{1-\alpha}, \tag{10}$$

where $K_t \equiv \sum_c K_{ct}$ and $H_t \equiv \sum_c H_{ct}$. Given (10),

$$M_{cKt} = \alpha \left(1-\alpha\right) \left(\frac{H_{ct}}{H_t} - \frac{K_{ct}}{K_t} \right) Y_t = -M_{cHt}. \tag{11}$$

So long as $H_{ct}/H_t - K_{ct}/K_t > 0$, c will be a net importer of the K-good and a net exporter of the H-good. If $H_{ct}/H_t - K_{ct}/K_t < 0$, the reverse will be the case. Countries with a larger $|H_{ct}/H_t - K_{ct}/K_t|$ produce relatively more of the good of which they are a net exporter, giving rise to larger net trade flows with the rest of the world. This is a manifestation of the classic Rybczynski theorem.

Based on (11), the traded share of world output is

$$\frac{M_t}{Y_t} = \alpha \left(1-\alpha\right) \sum_c \left| \frac{H_{ct}}{H_t} - \frac{K_{ct}}{K_t} \right|. \tag{12}$$

The larger the differences between regional shares in the world stocks of physical and human capital and, hence, the more varied the factor-content of countries' industrial production, the larger will be the overall volume of trade.[11]

2.3.2 Symmetric K- and H-Exporters

Suppose there are C_{Kt} capital-abundant countries and C_{Ht} labour-abundant countries at t, and $C_{Kt} = C_{Ht} = C$. With some abuse of notation, let C_{it} also represent the *set* of countries of type i and let us assume that $s_t/C = K_{ct}/K_t$,

[11] In the limit case in which there are no international trade costs, net trade flows are as described in equation (11) but gross trade flows are indeterminate. However, for arbitrarily small positive tariffs net and gross trade flows coincide and equation (12) describes the value of international trade relative to world income.

$(1-s_t)/C = H_{ct}/H_t \; \forall \; c \in C_{Kt}$ and $s_t/C = H_{ct}/H_t$, $(1-s_t)/C = K_{ct}/K_t$ $\forall \; c \in C_{Ht}$, with $s_t > 1/2$. Finally, impose the same tariffs for all countries: $\tau_{ct} = \tau_t \; \forall \; c$.

It is now easy to show that

$$M_{cKt} = \begin{cases} \alpha(1-\alpha)\frac{s_t(1-\tau_t)-(1-s_t)}{s(1-\tau_t)+1-s_t}\frac{Y_t}{C} & \text{if } 1-\tau_t \geq \frac{1-s_t}{s_t} \text{ and } c \in C_{Ht} \\ \alpha(1-\alpha)\frac{1-s_t-s_t(1-\tau_t)}{s_t(1-\tau_t)+1-s_t}\frac{Y_t}{C} & \text{if } 1-\tau_t \geq \frac{1-s_t}{s_t} \text{ and } c \in C_{Kt} \\ 0 & \text{otherwise} \end{cases}, \tag{13}$$

so that

$$\frac{M_t}{Y_t} = \begin{cases} \alpha(1-\alpha)\frac{s_t(1-\tau_t)-(1-s_t)}{s_t(1-\tau_t)+1-s_t} & \text{if } 1-\tau_t \geq \frac{1-s_t}{s_t} \\ 0 & \text{otherwise} \end{cases}. \tag{14}$$

As can be seen from equation (14), if diversified countries engage in factor-proportions trade, tariff declines may have a non-linear effect on the world trade share: in (14), a decline in tariffs has no effect on trade if tariffs remain above a given threshold value − which is determined by the factor-proportions differences between capital- and labour-abundant countries − , and a large but diminishing effect if tariffs fall below that value.

2.3.3 A Labour-Abundant Country Opens Up

Consider the case of three countries, $c = 1, 2, 3$, with an equal share of the effective global labour force: $H_{1t} = H_{2t} = H_{3t} = H_t/3$. Let country 1 be capital abundant at t, country 3 labour-abundant and country 2 inbetween: $K_{1t} > K_{2t} > K_{3t}$. Finally, assume that import tariffs in countries 1 and 2 are close to zero. It follows that

$$\begin{aligned} M_{1Kt} &= \begin{cases} \alpha(1-\alpha)\left(\frac{1}{3} - \frac{K_{1t}}{K_t}\frac{1-\tau_{3t}}{1-\tau_{3t}+\tau_{3t}\frac{K_{3t}}{K_t}}\right)Y_t & \text{if } \tau_{3t} \leq \frac{1-3\frac{K_{3t}}{K_t}}{1-\frac{K_{3t}}{K_t}} \\ \alpha(1-\alpha)\left(\frac{1}{3} - \frac{K_{1t}}{K_{1t}+K_{2t}}\right)(Y_{1t}+Y_{2t}) & \text{otherwise} \end{cases} \\ M_{2Kt} &= \begin{cases} \alpha(1-\alpha)\left(\frac{1}{3} - \frac{K_{2t}}{K_t}\frac{1-\tau_{3t}}{1-\tau_{3t}+\tau_{3t}\frac{K_{3t}}{K_t}}\right)Y_t & \text{if } \tau_{3t} \leq \frac{1-3\frac{K_{3t}}{K_t}}{1-\frac{K_{3t}}{K_t}} \\ \alpha(1-\alpha)\left(\frac{1}{3} - \frac{K_{2t}}{K_{1t}+K_{2t}}\right)(Y_{1t}+Y_{2t}) & \text{otherwise} \end{cases} \\ M_{3Kt} &= \begin{cases} \alpha(1-\alpha)\left(\frac{1}{3} - \frac{K_{3t}}{K_t}\frac{1}{1-\tau_{3t}+\tau_{3t}\frac{K_{3t}}{K_t}}\right)Y_t & \text{if } \tau_{3t} \leq \frac{1-3\frac{K_{3t}}{K_t}}{1-\frac{K_{3t}}{K_t}} \\ 0 & \text{otherwise} \end{cases} \end{aligned}. \tag{15}$$

Figure 4 plots the ratio of country-2, country-3 and world imports relative to world GDP for different values of τ_{3t}, assuming that country 3 is very labour-abundant.[12] We can think of this as a stylised description of

[12] The ratio of country 1's imports relative to world GDP is simply the difference between

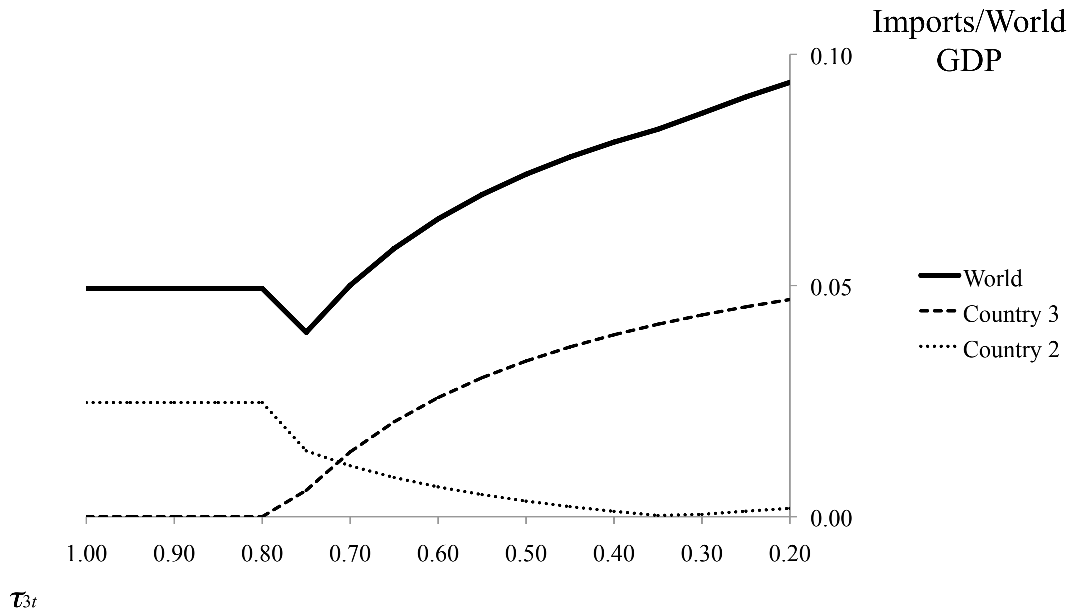

Figure 4: A Labour-Abundant Country Opens Up

China's opening up, with country 3 representing China, country 1 representing a capital-abundant country – say, Japan – and country 2 representing a country with intermediate factor proportions – say, Indonesia.

Starting from a value of Chinese tariffs equal to 1, China's liberalisation has no impact on the world trade share until tariffs fall below a certain threshold value. Figure 4 depicts the case in which the initial impact on the world trade share is negative: while China's opening creates trade between China and the rest of the world, it also reduces the incentives for trade between Indonesia and Japan and raises world GDP. At first, the latter effects dominate. Eventually the rise in trade between China and Japan is big enough to offset these two effects, and the world trade share rises. Since both Indonesia and China are initially H-good exporters, Indonesia's trade with the rest of the world is "hurt" by the terms-of-trade shock resulting from China's opening. However, if China is sufficiently labour-abundant and if its tariffs fall sufficiently far, Indonesia may begin to export the K-good and further trade liberalisation in China will eventually raise Indonesia's trade with the rest of the world again.

This simple example highlights an important point: the opening-up of a large, labour-abundant economy may raise factor proportions trade overall, but it will also alter global trading patterns by reducing the incentives to trade

the world ratio and the combined ratios of countries 2 and 3. The figure is drawn assuming $\alpha = 1/3$, $K_{1t}/K_t = 0.55$, $K_{2t}/K_t = 0.35$ and $K_{3t}/K_t = 0.1$.

of those labour-abundant economies which were already open. To determine whether a model of factor-proportions trade is useful for thinking about the growth in world trade since 1980, I will perform two tests in the next section. First, I will use data on countries' factor endowments and tariffs to show how much of the growth in North-South trade during the last 30 years a calibration of the model above can explain. Second, I will use the same data to ascertain whether China's liberalisation appears to have caused a bigger increase in the foreign trade of capital-abundant countries than of labour-abundant countries by means of a difference-in-difference estimation.

3 The Growth of North-South Trade

In this section I assess the extent to which factor-proportions differences can explain the growth in world trade between 1980 and 2008 by taking the model developed above to the data. Since it only captures trade between capital-abundant and labour-abundant countries, I compare the model's predictions with the empirical patterns of North-South trade − the fastest-growing portion of world trade during this period.

First, I investigate whether the model delivers quantitatively meaningful predictions by means of a straightforward calibration exercise: I parameterise the model to match the *volume* of North-South trade in 1980. Based on this parameterisation and taking the recent evolution of tariffs and relative factor proportions from the data, I determine the model-predicted rise in factor-proportions trade between 1980 and 2008 and compare it to the empirical expansion of North-South trade. I find that the model can easily explain most of the increase in the ratio of North-South trade to world GDP. My calibration also allows me to engage in a number of counterfactual experiments to isolate the biggest contributors to model-predicted trade growth. These experiments show that the opening up of China accounts for the largest portion, and that tariff declines in Brazil and India account for virtually all of the rest.

Second, I test whether some of the model's qualitative predictions on the evolution of trading patterns are borne out by the data. The model predicts that the opening up of a large, labour-abundant country like China should increase capital-abundant countries' trade with the rest of the world, but reduce labour-abundant countries' trade. In Section 3.3, I investigate the qualitative validity of this prediction with a difference-in-difference approach and provide evidence that the impact of China's opening on countries' trade has indeed been contingent on their respective relative factor endowments.

3.1 Basic Data and Parameterisation

3.1.1 Data

In order to calibrate the model from Section 2, I require data on countries' endowments of physical and human capital, and on their policy barriers to international trade. I use data from the Penn World Tables (version 7.1) and from Barro and Lee (2010) to construct countries' factor endowments for the years 1980, 1984, 1988, 1992, 1996, 2000, 2004 and 2008, following the methodology in Caselli (2005).[13]

To capture countries' trade policy stance, I use information on government revenue from import tariffs as a share of total imports to proxy for weighted average tariffs. The main source is Clemens and Williamson (2004), and I update it with more recent data from the World Development Indicators.[14] Figures on China's tariff revenue prior to 1980 − which are not included in Clemens and Williamson (2004) − are taken from Woo and Ren (2002). I also use countries' WTO accession dates, as described below, which are obtained from the WTO website.

In the model, differences in factor proportions are the only reason for countries to trade goods internationally. Yet, it is clear that factor-proportions trade can at best account for a fraction of global trade: Figure 2 shows that bilateral trade between capital-abundant countries − which is entirely absent from my model! − continues to account for the largest share of international trade. Therefore, I assess my model only against its ability to predict the growth in the subset of international trade flows it was designed to capture: exports and imports between the capital-abundant "North" and the labour-abundant "South". Section 3.2.5 and Appendix A2 discuss the possibility of incorporating North-North trade into my calibrations.

The empirical value of North-South trade is measured as one half times the observed value of exports and imports between capital and labour-abundant countries, where a country's factor abundance is based on the constructed human and physical capital stocks.[15] Data on aggregate trade flows and country GDP is taken from the IMF Direction of Trade Statistics and the World Development Indicators, respectively.

Overall, the requisite data on factor endowments, tariffs, GDP and trade

[13]Since physical and human capital endowments evolve only slowly over time, this should be sufficient to pick up important trends in this data. Details on the construction of physical and human capital can be found in appendix A1.

[14]I would like to thank Michael Clemens and Jeff Williamson for kindly providing me with access to their data.

[15]Unlike in the model, trade is not generally balanced in the data. For this reason, I use one half times the sum of exports and imports − instead of just imports − to represent the empirical value of trade flows.

flows is available for 45 countries which account for 86% of world GDP and 70% of world trade between 1980 and 2008 on average. Appendix A1 provides a full list of countries, as well as their shares in the total stocks of physical and human capital in 1980 and 2008.

3.1.2 Parameters

As presented in Section 2, the model has three parameters which need to be calibrated: the respective capital intensities of K-goods and H-goods, α_K and α_H, and the "average" capital intensity, α.[16] In addition, I assume that countries' policy barriers to international trade have an observed, time-varying component − which is captured by the tariff data described above − and an unobserved, constant component − which I treat as a country-specific parameter of the model, δ_c. This latter component represents fixed policy barriers to international trade, such as the well-known "border effect".[17] Therefore, the full set of parameters to be calibrated is α, α_K, α_H and $\{\delta_c\}_c$.

In line with convention, I set α so that the model matches the observed labour share in U.S. income during the period 1980-2008. This requires a value of .40 for this parameter.[18] Since there is no obvious empirical counterpart to the model's stark division of traded commodities into "K-goods" and "H-goods", α_K and α_H are more difficult to calibrate. I sidestep this issue by experimenting with different values for these parameters. In the baseline calibration, I set $\alpha_K = 1 - \alpha_H = 1$, but I present results for an alternative parameterisation in Section 3.2.3. An implication of the extreme baseline choice of values for α_K and α_H is that all countries will operate inside the cone of diversification − that is, for any distribution of factor endowments and any level of tariffs, all countries will produce both the K-good and the H-good.[19]

[16]Note that a choice of values for these three parameters implies a value for θ since, by definition, $\theta = (\alpha - \alpha_H) / (\alpha_K - \alpha_H)$.

[17]MacCallum (1995) and Anderson and van Wincoop (2003) show that the presence of national borders has an economically significant negative effect on trade which goes beyond directly measurable trade costs.

[18]Given country incomes as described in Section 2.2, the equilibrium labour share will be $1 - \alpha$ *only* for countries which *do not* engage in Heckscher-Ohlin trade. For a value of $\alpha = .40$, the average U.S. labour share for 1980-2008 implied by the calibrated model equals .57, which matches the average value for this period in the data of Karabarbounis and Neiman (2014). Reasonable variations in the choice of value for α do not have a material impact on the results presented below.

[19]The flip-side of diversification is that international trade in the model causes differences in countries' productivity-adjusted factor prices to decline down to the value of the trade wedge. There is some evidence that this prediction of conditional factor price equalisation may be borne out by the data. Trefler (1993) documents that a Heckscher-Ohlin model with conditional factor price equalisation can account for a large portion of cross-country differences in factor prices. More recently, Caselli and Feyrer (2007) show that, despite large differences in capital-labour ratios, the marginal product of capital does not appear to differ greatly across countries.

As will be discussed more formally in Section 3.2.3, this causes the baseline calibration to deliver the most conservative prediction about the likely impact of trade liberalisation on trading volumes.

The parameters capturing fixed policy barriers to trade are introduced into the model by imposing

$$\tau_{ct} = \begin{cases} \delta_c + \pi_{ct} & \text{if } c \text{ is WTO member at } t \\ 1 & \text{otherwise} \end{cases}, \tag{16}$$

where π_{ct} is country c's average tariff at time t. I use $\{\delta_c\}_c$ to ensure that the model-implied trade share in 1980 equals the empirical ratio of North-South trade to world GDP. Put differently, I assume that any difference between observed North-South trade in 1980 and model-implied factors proportions trade for that year (given values for α, α_K and α_H) is due to unobserved, time-invariant trade barriers.

Expression (16) also implies that all countries which have not yet joined the WTO are assumed to be completely closed off from international trade. The assumption that countries cannot engage in North-South trade unless they have joined the WTO is admittedly extreme. It is introduced to permit the model to make sense of the timing of China's opening, which had its biggest effect on world trading volumes around 2001 – the year of China's WTO accession.[20] Without it, for all reasonable parameterisations, the model would predict China to exert a major influence on world trade already during the 1980s, due to its extreme labour abundance and relatively low measured average tariff rate in that decade (in the range of 8-20%). In practice, China's small contribution to world trade in the 1980s was most likely due to the presence of unobserved non-tariff barriers to trade which were gradually removed over the course of the 1990s. The use of the WTO accession date in (16) is a simple – but imperfect! – way to account for the impact of these trade reforms on trading costs.[21]

For computational simplicity, I restrict δ_c to be the same for all countries within each of six geographic regions (North America, South America, Europe, Asia, Africa, Australia). This allows me to set six distinct values of δ_c, which

[20] Aside from China, seven of my sample countries were not WTO members in 1980 but have joined since: Bahrain (1993), Colombia (1981), Costa Rica (1990), Mexico (1986), Morocco (1987), Panama (1997) and Thailand (1982). Assuming that they were open to trade prior to their WTO accession (with $\tau_{ct} = \delta_c + \pi_{ct}$) has no material impact on the results of the calibration in Section 3.2.

[21] It would be ideal to incorporate a direct measure of the tariff equivalent of non-tariff barriers to trade in the calibration. Unfortunately, no comprehensive data set on the size of non-tariff barriers across countries and time exists. See Anderson and van Wincoop (2004) for a discussion of the challenges in constructing such data.

I use to match each region's North-South trade relative to world GDP in 1980 and, hence, the empirical North-South trade-GDP ratio overall. The resulting parameter values range from .14 to .63 in the baseline calibration. The tariff equivalent of the model-implied "border effect" for North America is .67 − 45% higher than the empirical estimate by Anderson and van Wincoop (2003).[22]

Table 1 provides a full overview of all data sources and parameter values.

Parameter/ Data	Value	Source
α	.40	Set to match average U.S. labour share for 1980-2008.
α_K	1.00	See text.
α_H	.00	See text.
δ_c	.14 (Africa) .51 (Asia) .49 (Australia) .63 (Europe) .40 (N. America) .11 (S. America)	Set to match region's ratio of North-South trade to world GDP in 1980.
$\{H_{ct}\}_{c,t}$	-	Size of the workforce times "quality adjustment" for the average number of years of education in the population of working age. For details, see Appendix A1.
$\{K_{ct}\}_{c,t}$	-	1980 capital stock constructed using the perpetual inventory method (first year: 1950) and investment data. For details, see Appendix A1.

Table 1: Parameter Values and Data Sources

3.2 Calibration Results

3.2.1 Baseline Results

Based on the data and parameterisation described in the previous section, I now simulate the evolution of global factor-proportions trade in the model and compare it to the observed growth in North-South trade. The results can be seen in Figure 5.

Between 1980 and 2008, actual North-South trade (solid line) rose by 4 percentage points relative to world GDP − from 1.6% to 5.6%. The model-predicted rise in factor-proportions trade relative to world GDP (rectangular markers) is 3.6 percentage points, corresponding to 90% of the former. This

[22]However, Anderson and van Wincoop (2003) obtain this estimate from an analysis of U.S.-Canadian trade flows. It does not seem to be implausible that the border effect should be somewhat larger for U.S./Canadian trade with developing countries.

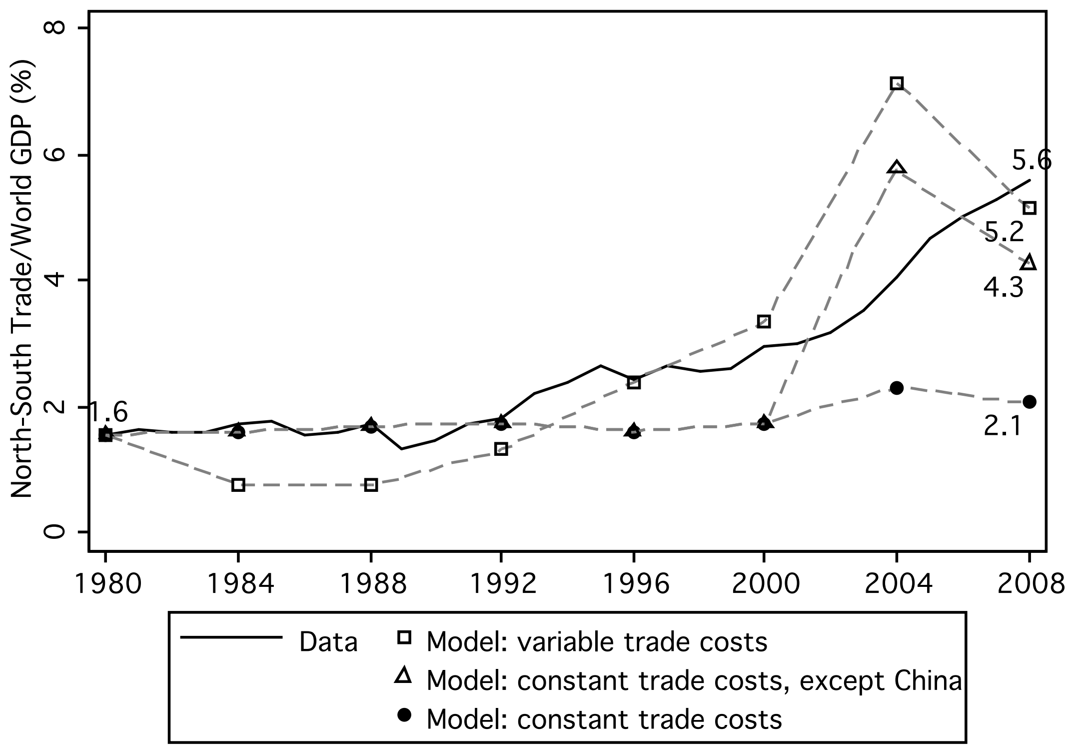

Figure 5: Calibration Results − Baseline

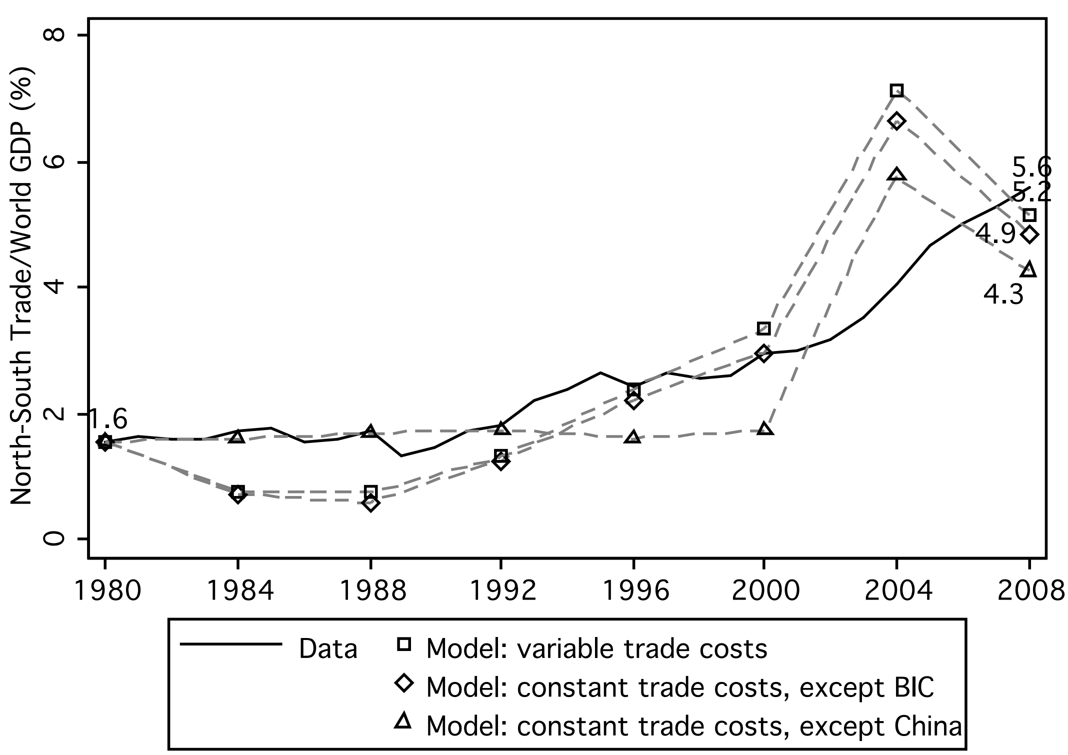

Figure 6: Calibration Results − Brazil and India

is the main result of the paper: a standard factor-proportions model can reproduce most of the observed rise in North-South trade during the last three decades. Since the expansion of North-South trade is roughly equal to 60% of the overall rise in total world trade relative to GDP, this implies that the model can account for more than half of recent world trade growth. The model also predicts the growth in North-South trade at the country level with a high degree of accuracy: for the year 2008, the correlation between Northern countries' trade with the South/Southern countries' trade with the North (relative to world GDP) in the model and in the data is .83.

An important question is what drives trade growth in the model. In principle, the model-predicted global trade share could rise either due to falling trade barriers in countries with extreme factor proportions, or due to increasing factor-proportions differences among already-open economies. To determine which channel is more important, I perform a counterfactual experiment: having calibrated $\{\delta_c\}_c$ as described in the previous section, I keep all countries' trade barriers fixed at their 1980-levels, i.e. $\pi_{ct} = \pi_{c1980} \; \forall \; c, t$. The resulting evolution of model-predicted factor proportions trade is represented by the circular markers in Figure 5. With counterfactually constant trade costs, the model only sees a modest rise in factor proportions trade relative to world GDP by 0.5 percentage points. Clearly, therefore, most of the model-predicted rise in trade is due to falling trade barriers, rather than changes in the global distribution of relative factor endowments.

As a second experiment, I explore the intermediate case in which all countries' trade barriers are constant except China's (triangular markers). The model now predicts a 2.7-percentage point rise in the global trade share. This suggests that – given data on countries' relative factor endowments – China's trade liberalisation alone is responsible for three quarters of the model's predicted rise in North-South trade. The large impact of China's liberalisation on North-South trade in the model is due to its significant labour abundance, as reflected in comparatively low values of K_{ct}/H_{ct}, combined with its large population, reflected in high values of H_{ct}.

3.2.2 Brazil and India

Since virtually all of the model-predicted rise in the world trade share is due to declining trade barriers, it is worth investigating which trade liberalisation epsiodes – aside from China's opening – are major drivers of trade growth in the calibration.

It turns out that falling average tariffs in Brazil (from 15% to 3%) and India (from 24% to 6%) are responsible for most of the non-Chinese growth in factor-proportions trade in the model. Figure 6 makes this point by introducing a further counterfactual experiment, in which only Brazilian, Chinese and Indian trade barriers are allowed to vary in line with the data, with all other trade barriers held constant at their 1980 values (diamond-shaped markers). As can be seen from the figure, the model-implied world trade share in this case closes most of the gap between the China-only simulation (triangular markers) and the baseline calibration (rectangular markers). Put differently, not only are falling trade costs responsible for most of the trade growth predicted by the baseline calibration, but almost all of the model-predicted rise in factor-proportions trade can be traced to trade liberalisation in three large economies.

The reason for the dominant impact of Brazil, China and India on the world trade share in the model is that the factor proportions of larger countries have a bigger impact on goods prices in global market equilibrium and, hence, on the overall value of world trade. This is best seen from equation (12): a very capital- or labour-abundant country will only have a large effect on the world trade share if it also holds a large share of the world's stock of physical or human capital (i.e. large K_{ct}/K_t or H_{ct}/H_t).

3.2.3 Smaller Cone of Diversification

The baseline calibration imposes $\alpha_K = 1 - \alpha_H = 1$. As highlighted in Section 3.1.2, this maximises the size of the cone of diversification. It also maximises, for given trade barriers, the range of capital-labour ratios for which countries will engage in Heckscher-Ohlin trade. In the polar opposite case – $\alpha_K = 1 - \alpha_H = 0.5$ – no country with strictly positive trade barriers will trade internationally.

In this section, I explore an alternative calibration of the capital intensities which lies between these extremes: I set $\alpha_K = 1 - \alpha_H = .75$. For ease of comparison with the results above, I keep α constant at its baseline value of .40. Note, however, that the new calibration requires a downward adjustment of the time-invariant trade-cost parameters: given the reduced incentive to engage in Heckscher-Ohlin trade due to smaller differences in factor intensities, 1980 trade costs need to be smaller to match the initial value of trade flows relative to output from the data. The new parameter values are listed in Table 2.

Figure 7 shows that model-implied North-South trade growth under the alternative parameterisation (dark rectangular markers) is nearly twice as large as in the baseline calibration (light rectangular markers), and far exceeds the growth of North-South trade in the data. The reason for this is that the opening up of China and other labour-abundant countries now affects their

Parameter/ Data	Value	Source
α	.40	Set to same value as in baseline calibration.
α_K	.75	See text.
α_H	.25	See text.
δ_c	.10 (Africa) .29 (Asia) .28 (Australia) .40 (Europe) .22 (N. America) .01 (S. America)	Set to match region's ratio of North-South trade to world GDP in 1980.

Table 2: Alternative Parameter Values

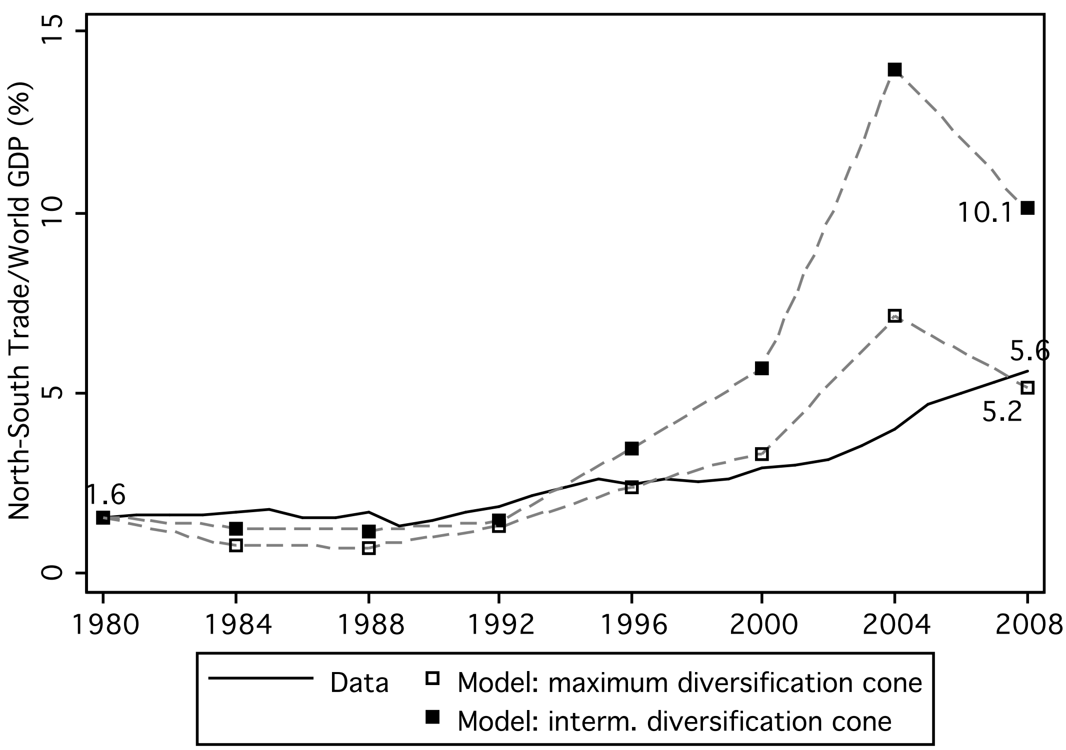

Figure 7: Calibration Results − Smaller Diversification Cone

production structures, causing them to shift production factors away from the K- and toward the H-good, possibly up to full specialisation in their export good. This, in turn, raises the value of their exports and imports. The smaller the difference in factor intensities between K- goods and H-goods, the larger the structural transformation induced by trade liberalisation, and the larger the increase in North-South trade.[23]

The parameterisation adopted for the baseline calibration thus turns out to deliver the most conservative prediction for the growth of North-South trade. This reinforces the main finding of the analysis: given observed differences in factor endowments, a simple model of factor-proportions trade would predict increases in North-South trade relative to output which are as large, or larger, than those seen in the data.

3.2.4 U.S. Comparative Advantage and the Leontief Paradox

The calibration exercise carried out in this section allows me to consider a much-debated issue − the comparative advantage of the United States in a world of Heckscher-Ohlin trade − from a different angle.

In his classic paper, Leontief (1953) showed that the United States were a net importer of capital-intensive goods in 1947 and argued that, due to high labour productivity, the U.S. economy should be viewed as labour-abundant. Leontief's finding that the capital-labour ratio embodied in U.S. imports exceeded the ratio embodied in U.S. exports has become known as the "Leontief paradox". Subsequent research has attempted to verify whether the factor content of trade and the aggregate factor endowments of the United States are indeed consistent with a comparative advantage in labour-intensive products.

I can ascertain the U.S. trading patterns implied by my model, given the data on factor endowments and trade costs used for the calibrations above. Based on the baseline calibration results, the U.S. was a net *importer* of the K-good in 1980 but had become a net *exporter* of the K-good by 2008. The reason for this finding lies in the composition of the group of open economies. In the 1980 global market equilibrium, only 17 out of my 45 sample countries engage in factor-proportions trade. By 2008, there are 26 trading countries, with the large and labour-abundant economies Brazil, India and China representing the most significant additions. As a result, the U.S. capital stock per effective worker amounts to only 83% of the average capital-labour ratio among trading countries in the calibrated 1980 equilibrium, but to 155% of the aggregate

[23] Of course, given positive tariffs, it will be impossible to match the 1980 value of North-South trade relative to output if $\alpha_K - \alpha_H$ becomes too low. As long as that is feasible, however, model-predicted trade growth rises as $\alpha_K - \alpha_H$ decreases.

in 2008.

This suggests that the United States may have been a net exporter of labour-intensive products in a world of limited North-South trade, but that trade liberalisation in the labour-abundant South during the last three decades could have altered the U.S. economy's comparative advantage in global markets.[24] A formal test of this implication of my calibration, using detailed data on the factor content of U.S. imports and exports during the last decades, goes beyond the scope of this paper but constitutes a potentially important objective for future research.

3.2.5 North-North Trade

As noted above, my model only captures trade due to differences in factor proportions and, as a result, would predict the volume of trade between countries with similar factor endowments − such as the economies of the capital-abundant North − to be zero. In practice, North-North trade still represents the largest share of international trade overall. To account for this stylised fact, it would be necessary to incorporate additional motives for goods exchange into the theoretical framework developed in Section 2.

A natural way to do so would be to introduce trade in differentiated goods which are produced under monopolistic competition in the spirit of the "new" trade theory. This begs the question whether augmenting the model accordingly would fundamentally alter the expression for the volume of North-South trade and, hence, invalidate the calibration results presented in this section. Appendix A2 shows that this need not be the case: it provides a set of plausible assumptions under which there is a positive volume of North-North trade in differentiated varieties while the volume of North-South trade continues to behave as described in Section 2. We can thus think of the calibrations here, roughly, as focusing on the North-South component of a more eclectic model of global trade.

3.2.6 The Return to Capital and International Capital Flows

Trade liberalisation, and the resulting rise in factor-proportions trade, causes factor-price convergence in my model. Figure 8 illustrates this by plotting the coefficient of variation of the model-implied return to capital among my

[24] Trefler (1993) also provides evidence that the U.S. may have been more labour-abundant in the immediate post-War period. However, Trefler's approach differs from the one employed here: he calibrates labour productivity to match the observed factor content of trade, while I infer labour productivity from observed differences in schooling, and calibrate unobserved trade costs to match the *volume* of trade at the start of my sample period.

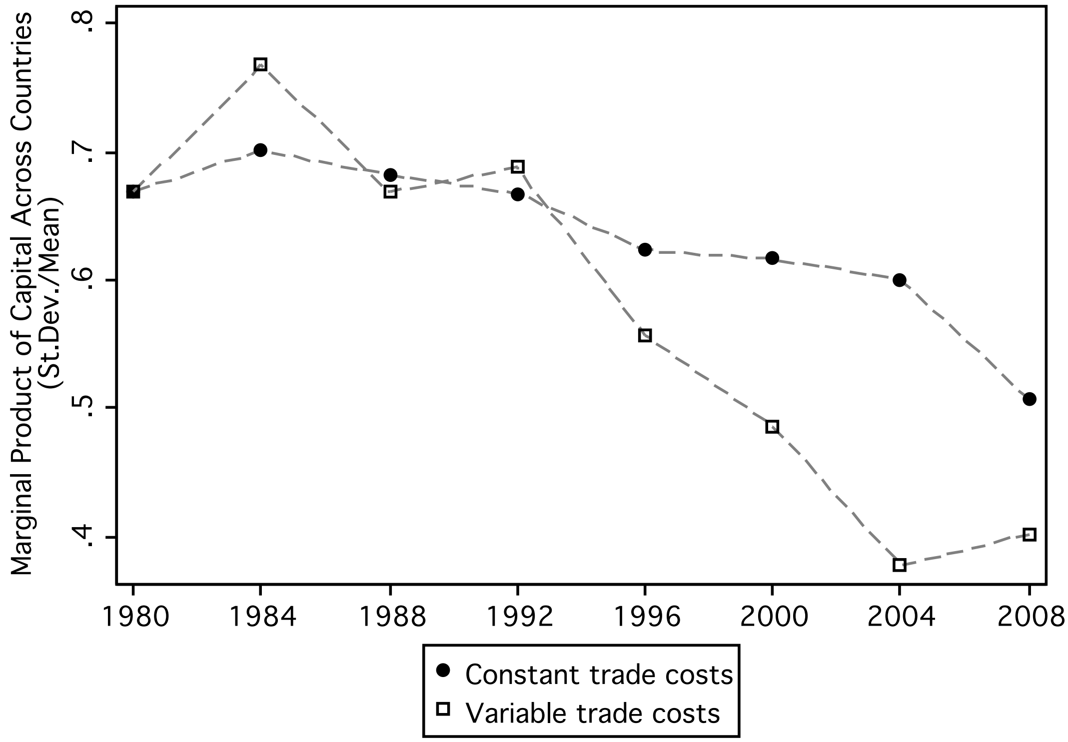

Figure 8: Calibration Results − Differences in Marginal Product of Capital

45 sample countries in the baseline calibration. Under the counterfactual assumption of constant trade barriers (circular markers), the coefficient of variation declines from .67 to .51 between 1980 and 2008, with most of the fall taking place in the last 4 years of the sample. This is due to cross-country convergence of the observed per-capita capital stocks used for the calibration. Taking account of falling trade barriers (rectangular markers), the model predicts a much larger decline − down to .40 −, starting in the mid-1990s. Therefore, allowing for an increase in factor-proportions trade due to the removal of trade barriers, leads to a more sizable, and faster, reduction in the differences between investment returns in the North and South.

International asset trade is ruled out by assumption in the model of Section 2. If I did allow for cross-border asset trade, the effect of the above would be a significant decline in the incentives for North-South capital flows during my sample period. This feature of Heckscher-Ohlin models, first discussed in Mundell (1957), is sometimes referred to as "substitutability" between international trade and international capital flows: since trade causes factor prices across countries to converge, this reduces the incentives for capital to move across borders so as to exploit returns differentials.

The timing of the decline in return differentials implied by my calibration is conspicuous: there has been a well-documented reversal of international capital flows − from modest North-South to large South-North flows −, which occurred in the mid-1990s.[25] The Heckscher-Ohlin perspective on the recent growth in North-South trade adopted in this paper suggests one explanation for this observation. Textbook one-good models of international investment have tended to emphasise locally diminishing returns to capital as the main motive for international financial flows from North to South. If growing world trade has reduced the importance of locally diminishing returns, in line with factor-proportions theory, this may have raised the relative importance of other possible drivers of international capital flows (such as risk diversification) which are more likely to result in net inflows into, rather than outflows from, developed economies.

3.3 Regression Analysis

3.3.1 Methodology

As discussed in Section 2.3.3, my model of factor-proportions trade shows that the opening of a large labour-abundant country like China should increase the exports and imports of previously capital-abundant countries relative to world GDP, but reduce the exports and imports of countries which were previously very labour-abundant. Below, I explore this qualitative implication of factor-proportions theory.

First, I regress the change in total exports and imports relative to world GDP between 1980 and 2008 of all countries *except China* on their average capital abundance among the sample countries *excluding China*. If, as assumed throughout, a large portion of trade generated by China's liberalisation has been of the factor-proportions kind, we would expect a positive coefficient, suggesting that the trade of capital-abundant countries has increased most during the period of China's opening.

A shortcoming of this first test is that it fails to tie the differential change in trade directly to Chinese liberalisation. Therefore, I also regress the change in trade on an interaction term between countries' average capital abundance without China and a measure of China's openness. My preferred measure of the latter is the average Chinese tariff rate, but I also use a dummy taking value 1 after China's WTO accession in 2001 as a robustness check. Since this difference-in-difference approach exploits cross-country variation in capital

[25] See Prasad, Rajan, and Subramanian (2006), Gourinchas and Jeanne (2013) and Caballero, Farhi and Gourinchas (2008), among others.

abundance as well as time series variation in China's openness, I can employ country and year fixed effects to control for all time-invariant heterogeneity across countries and for possible global trends. Moreover, the fact that China's liberalisation has been driven by exogenous political event should limit possible endogeneity concerns.

Dep. variable: ΔTrade$_{ct}$/WorldGDP$_{ct}$

	(1)	(2)	(3)	(4)	(5)
$(K_c/K - H_c/H)$	0.062	0.067		0.060	
	(0.008)***	(0.013)***		(0.009)***	
Tariffs$_{CHNt}$		-0.004			
		(0.002)**			
WTO$_{CHNt}$				0.001	
				(0.000)***	
$(K_c/K - H_c/H)\times$Tariffs$_{CHNt}$		-0.065	-0.065		
		(0.126)	(0.023)***		
$(K_c/K - H_c/H)\times$WTO$_{CHNt}$				0.008	0.008
				(0.019)	(0.003)**
Constant	0.003	0.003		0.003	
	(0.000)***	(0.000)***		(0.000)***	
Country F.E.	No	No	Yes	No	Yes
Year F.E.	No	No	Yes	No	Yes
Adj. R^2	0.23	0.23	0.97	0.24	0.97
Observations	1,276	1,276	1,276	1,276	1,276

Period: 1980-2008. Robust standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01
Trade$_{ct}$ is one half times the sum of country c's exports to and imports from all other sample countries.
$(K_c/K\text{-}H_c/H)$ represents country c's average capital abundance *without China* for the given period. Tariff$_{CHNt}$ is China's average tariff rate. WTO$_{CHNt}$ is a dummy equal 1 for years after China's WTO accession.

Table 3: Regression Results

3.3.2 Results

The first column of Table 3 presents the results of the regression of the change of countries' trade relative to world GDP on their capital abundance in the absence of China. As expected, the coefficient on the capital-abundance term is positive and statistically significant at the 1% level, suggesting that capital abundance was associated with faster trade growth between 1980 and 2008. The estimated constant term is also positive, but small. This implies that, on average, marginally labour-abundant countries ($0 \geq K_c/K - H_c/H > -0.048$) also experienced an increase in trade while very labour-abundant countries ($-0.048 \geq K_c/K - H_c/H$) suffered a decline. This is perfectly consistent with the discussion in Section 2.3.3.

Columns 2 and 3 record the results of the difference-in-difference estimation in which the change in countries' trade relative to world GDP is regressed on their average capital abundance without China interacted with China's average tariff. The results in Column 2 are based on an estimation without fixed effects, while Column 3 reports the findings from a regression with a full set of country and year dummies. As expected, the regression in the second column predicts lower tariffs in China to raise countries' trade both directly and via a factor-proportions channel, with more capital-abundant countries seeing a larger increase. The magnitude of the coefficient on the interaction term is unchanged if country and year fixed effects are included in the third column, and it becomes statistically significantly at the 1% level. I obtain qualitatively similar results if I use the year of China's WTO accession to capture China's opening (Columns 4 and 5).

Between 1980 and 2008, China's average tariff declined by 18 percentage points. Therefore, in terms of magnitudes, the estimated coefficients in Column 3 would suggest that the import-world GDP ratio for Japan − the second-most capital-abundant country − increased relative to Indonesia − the second-least capital-abundant country − by 0.93 percentage points. In the baseline of the calibrated model, the import-world GDP ratio for capital-abundant Japan relative to labour-abundant Indonesia rises by .63 percentage points. Therefore, the model's predictions concerning the differential impact of Southern trade liberalisation on already-open economies during the period in question appear to be both qualitatively and quantitatively plausible.

4 Summary and Conclusion

More than 60% of the growth of world trade between 1980 and 2008 has manifested itself in an increase in trade flows between developed and developing countries. I have shown that a calibrated factor-proportions model, in which differences in capital-labour ratios are the reason for countries to trade goods internationally, can easily explain most of this expansion of North-South trade and, hence, more than half of the recent growth of world trade overall. While globally the decline in political trade barriers has been small during this period, some of the most significant trade liberalisations have taken place in large economies whose capital-labour ratios are substantially lower than the world average. In my model, the opening up of China alone accounts for three quarters of the predicted growth of North-South trade, with trade liberalisation in Brazil and India responsible for almost all of the rest. Empirical evidence supports the notion that China's opening has created new trade with the world's capital-abundant countries, but reduced the trade of other labour-abundant economies with the rest of the world, in line with the predictions of my model. Overall, my findings indicate that a factor-proportions view may be useful for interpreting several quantitative and qualitative aspects of trade growth in a period during which the group of large, open economies has become significantly less homogenous.

Throughout the paper I have focused exclusively on factor-proportions differences as a motive for countries to engage in goods trade. Adopting this perspective has allowed me to highlight its relevance for understanding some important recent features of globalisation. Yet there are others which it cannot capture adequately.

Figure 2 highlights the continued concentration of a large share of international trade among a small group of relatively similar and affluent countries. By most accounts, this portion of global trade is better explained by the scale economies of new trade theory than by differences in countries' capital-labour ratios. My evidence on the importance of factor-proportions differences for the recent growth of world trade does not preclude any role for new-trade motives in explaining rises in the traded share of world output. Helpman's (1987) original argument that increased income similarity across countries should cause greater volumes of trade has had little quantitative traction because the world income distribution has remained remarkably stable during most of the post-War era. However, high growth rates in China and other developing countries may yet cause the world income distribution to narrow, opening the door to another channel through which their transition could come to affect the expansion of global trade.

Furthermore, it is clear that trade liberalisation in the South has given rise to new opportunities for vertical specialisation across countries.[26] My model abstracts from trade along the production chain by assuming, in the spirit of classical trade theory, that countries buy and sell only final goods. As more data on the structure of international production chains becomes available, it would be insightful to introduce a factor-proportions motive for trade into models of vertical specialisation – as in Dixit and Grossman (1982) – to explore the growth in trade, the rise of multi-country production and the emerging patterns of specialisation jointly.

I have attributed much of the recent growth of world trade to opportunities for factor-proportions trade created by the opening up of several large, labour-abundant countries. As their integration into global markets is far from complete, this paper is unlikely to prove the last word on its importance for the patterns of specialisation and global trade flows. Ultimately, a more

[26] See, for example, Dean et al. (2011) for an analysis of the vertical-specialisation content of Chinese trade.

electric approach may be required to do justice to the full impact of growing North-South trade on the global economy.

Appendix A1 - Factor Endowment Data

Factor endowment data is constructed in close correspondence with the methodology of the development accounting literature, surveyed in Caselli (2005).

I generate estimates of capital stocks from 1980 onwards using the perpetual inventory equation

$$K_{ct} = I_{ct} + (1 - \delta)\, K_{ct-1},$$

where I_t is gross investment in country c and year t, and δ is the constant depreciation rate. Investment data in constant, PPP-adjusted 2005 dollars is taken from the Penn World Tables (version 7.1) and, in keeping with convention, I set $\delta = .06$. I start in the year 1950 and, following standard practice, compute K_{c1950} as $\frac{I_{c1950}}{g_{I_c}+\delta}$ where g_{I_c} is the average geometric growth rate of the investment series in country c. However, the choice of K_{c1950} is immaterial since, with a depreciation rate of 6%, it has little impact on countries' estimated capital stocks from 1980 onwards.

I calculate the stock of human capital based on the size of countries' workforce, using figures from the Penn World Tables. The "quality adjustment" follows Hall and Jones (1999):

$$H_{ct} = e^{f(d_{ct})} L_{ct},$$

where L_{ct} is the number of workers and d_{ct} is its average number of years of schooling in country c and year t. The function $f()$ is piecewise linear with

$$f(d_{ct}) = \begin{cases} 0.134 \cdot d_{ct} & \text{if } d_{ct} \leq 4 \\ 0.101 \cdot (d_{ct} - 4) + 0.134 \cdot 4 & \text{if } 4 < d_{ct} \leq 8 \\ 0.068 \cdot (d_{ct} - 8) + 0.101 \cdot 4 + 0.134 \cdot 4 & \text{if } 8 < d_{ct} \end{cases},$$

and d_{ct} is based on the average years of schooling in the population above the age of 15 from Barro and Lee (2010).[27] Average years of schooling are observed quinquennially, most recently in 2010, and I interpolate all values between these quinquennial observations.

Table 4 reports shares in the total stocks of physical and human capital, based on the calculations above, for all my sample countries in the years 1980 and 2008.

[27] The paper's key findings are, if anything, strengthened if population or the size of the workforce are used to measure human capital endowments, instead of the "quality adjusted" workforce.

Country	Data			
	H_{c1980}/H_{1980}	K_{c1980}/K_{1980}	H_{c2008}/H_{2008}	K_{c2008}/K_{2008}
Argentina	.010	.014	.010	.007
Australia	.008	.021	.007	.018
Austria	.003	.010	.002	.007
Bahrain	.000	.001	.000	.001
Belgium-Lux.	.004	.013	.003	.009
Brazil	.026	.039	.046	.026
Canada	.013	.024	.011	.023
China	.350	.038	.370	.140
Colombia	.006	.005	.009	.005
Congo, Rep.	.000	.000	.001	.000
Costa Rica	.001	.001	.001	.001
Cyprus	.000	.000	.000	.000
Denmark	.003	.005	.002	.004
Finland	.002	.006	.001	.004
France	.019	.060	.016	.039
Germany	.026	.062	.026	.054
Greece	.003	.011	.003	.006
Hungary	.005	.004	.003	.003
Iceland	.000	.000	.000	.000
India	.130	.028	.158	.052
Indonesia	.036	.008	.045	.013
Ireland	.001	.003	.001	.003
Italy	.019	.063	.013	.042
Japan	.061	.133	.040	.112
Korea, Rep.	.014	.009	.015	.031
Malaysia	.004	.002	.006	.006
Malta	.000	.000	.000	.000
Mexico	.015	.030	.024	.025
Morocco	.003	.003	.004	.003
Netherlands	.006	.017	.005	.011
New Zealand	.002	.003	.001	.002
Norway	.002	.008	.002	.005
Panama	.001	.000	.001	.000
Portugal	.003	.005	.003	.005
South Africa	.006	.009	.009	.006
Spain	.011	.033	.012	.029
Sri Lanka	.005	.001	.004	.001
Sweden	.005	.009	.003	.005
Switzerland	.004	.013	.002	.007
Thailand	.016	.007	.017	.012
Tri. & Tobago	.000	.001	.000	.001
Turkey	.001	.007	.011	.010
U.K.	.026	.040	.017	.032
U.S.	.138	.253	.097	.239
Uruguay	.001	.001	.001	.001

Table 4: Shares of World Factor Endowments, 1980 and 2008

Appendix A2 - North-North Trade

Suppose the model is as described in Section 2.1 with $\alpha_K = 1 - \alpha_H = 1$, and replace equation (1) with

$$U_{ct} = \left\{ \left[\int_0^{J_t} x_{cKt}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\beta \frac{\varepsilon}{\varepsilon-1}} \frac{X_{cKt}^{1-\beta}}{\theta} \right\}^{\theta} \left(\frac{X_{cHt}}{1-\theta} \right)^{1-\theta} \quad \text{with } \theta, \beta \in (0,1) . \tag{17}$$

Agents now also consume a set of differentiated varieties of K-goods, with $\varepsilon > 1$ representing the substitution elasticity between these varieties and J_t denoting the (endogenous) mass of such goods available at time t. Differentiated goods are produced under monopolistic competition according to the production function

$$q_{cKt}(j) = \max \left\{ k_{ct}(j) - f, 0 \right\} . \tag{18}$$

For expositional simplicity, I will focus on the special case of C_K symmetric capital-abundant countries and C_H symmetric labour-abundant countries, with $C_K = C_H = C$, as introduced in section 2.3.2. If

$$(1-\alpha) \frac{s_t (1-\tau_t) - (1-s_t)}{(1-\alpha) s_t (1-\tau_t) + \alpha (1-s_t)} \geq \beta, \tag{19}$$

i.e. if the differentiated-goods sector is small (small β) or if factor proportions differences are large (large s_t) or if trade barriers are low (small τ_t), all differentiated varieties are produced in capital-abundant countries. Their producers optimally charge a price equal to a fixed mark-up over their marginal cost,

$$p_{cKt}(j) = \frac{\varepsilon}{\varepsilon - 1} P_{Kt}^*, \tag{20}$$

while free entry reduces profits to zero, yielding

$$q_{cKt}(j) = (\varepsilon - 1) f, \tag{21}$$

and

$$J_{ct} = \begin{cases} 0 & \text{if } c \in C_{Ht} \\ \frac{\beta}{\varepsilon f} \left(s_t + \frac{1-s_t}{1-\tau_t} \right) \frac{K_t}{C} & \text{if } c \in C_{Kt} \end{cases} . \tag{22}$$

There is now bilateral trade between capital-abundant countries. Denoting imports from country c by country c' at time t as $M_{cc't}$, for $c, c' \in C_K$ we have

$$M_{cc't} = \alpha\beta \frac{(1-\tau_t)^{\varepsilon-1}}{1 + (C-1)(1-\tau_t)^{\varepsilon-1}} \frac{\alpha s_t (1-\tau_t) + (1-\alpha)(1-s_t)}{s_t (1-\tau_t) + 1 - s_t} \frac{Y_t}{C}. \tag{23}$$

Given (23), we can derive a new expression for the world trade share:

$$\frac{M_t}{Y_t} = \alpha\beta \frac{(C-1)(1-\tau_t)^{\varepsilon-1}}{1+(C-1)(1-\tau_t)^{\varepsilon-1}} \frac{\alpha s_t(1-\tau_t)+(1-\alpha)(1-s_t)}{s_t(1-\tau_t)+1-s_t}$$

$$+\alpha(1-\alpha)\frac{s_t(1-\tau_t)-(1-s_t)}{s_t(1-\tau_t)+1-s_t}. \quad (24)$$

The first term represents North-North trade in differentiated K-varieties. Its size depends on the North's share in global output, trade barriers and the elasticity of substitution between differentiated goods. The second term represents North-South trade. Exactly as in Section 2.3.2, North-South trade depends on trade barriers and factor-proportions differences. As long as (19) is satisfied, equation (24) nests equation (14) from Section 2.3.2, and the volume of North-South trade in both models is identical.

Unlike in Section 2.3.2, world trade does not fall to zero if $1-\tau_t < (1-s_t)/s_t$, and equation (19) is no longer satisfied: there will still be trade in differentiated K-varieties as long as $\tau_t < 1$. However, the essential force of the non-linearity remains in place: factor-proportions differences only become a key determinant of the patterns and volume of trade once trade barriers have fallen sufficiently far.

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