

# Factor Proportions and the Growth of World Trade

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## Abstract

This paper shows that most of the growth of world trade during the last three decades can be explained by two empirical facts: i) the opening up of China and ii) the pattern of net financial flows from capital-scarce to capital-abundant countries. I present novel evidence documenting that their simultaneous occurrence has increased differences in capital-labour ratios among the group of open economies. Using a dynamic model which combines factor-proportions trade in commodities with international trade in financial assets, I illustrate the resulting impact on the patterns of specialisation and trade. I calibrate this model and find that it can account for more than 50% of the expansion of global trade between 1980 and 2007. It is also capable of predicting international investment patterns which are consistent with the data.

*JEL Classification codes: F11, F14, F21, F32, F43*

*Keywords: Heckscher-Ohlin, international trade, China, financial globalisation*

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# 1 Introduction

The rapid growth of world trade has been one of the most striking developments in the global economy over the last three decades. Figure 1.1 shows that the traded share of world output rose from 16% to 22% between 1980 and 2007 – an increase of 40%. In this paper I argue that increasing factor-proportions differences explain most of the expansion of global trade.

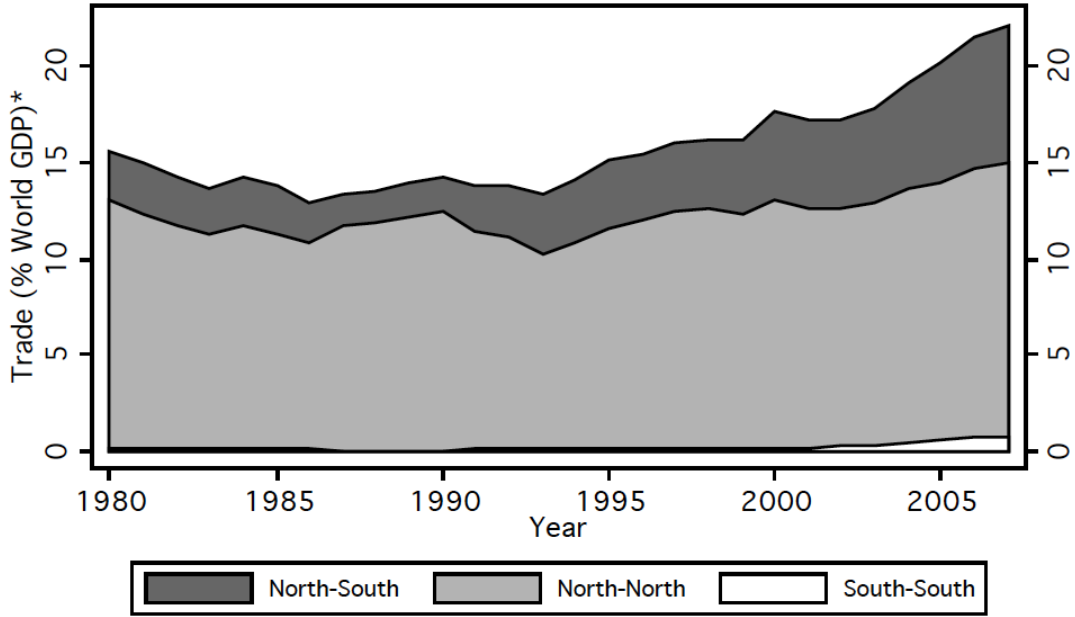
Earlier attempts to determine why world trade has increased have struggled to account for the magnitude of the phenomenon. Baier and Bergstrand (2001) show that tariff reductions are the most significant cause of trade growth between countries.<sup>1</sup> Yet, as extensively documented by Yi (2003), the modest decline in average tariff rates among the largest economies implies that standard modern trade models cannot match the nature and extent of the growth in world trade, which poses a “quantitative and qualitative puzzle” for international trade theory.

Yi’s paper appeals to the increasing vertical specialisation of international production chains, but he finds that the resulting trading patterns can account for at most 50% of the rise in global trade. Bergoeing and Kehoe (2003) also find that a calibrated new trade model fails to explain the increase in trade relative to world output, even under the assumption of non-homothetic preferences. Recently, Cuñat and Maffezzoli (2007) have shown that a model of endogenous factor accumulation and specialisation provides a better fit for the large response of U.S. trade to small tariff reductions. However, the growth of world trade remains largely unexplained.

This paper puts forward the view that world trade has increased because the group of open economies has become less homogenous. In particular, I document that differences between the capital-labour ratios of the largest trading countries have increased due to the opening up of China – a large and very labour-abundant economy – and the pattern of net financial flows from capital-scarce to capital-abundant countries, sometimes referred to as “global imbalances” or “South-North capital flows”. Classical trade theory predicts that countries specialise in industries which best suit their relative endowments of production factors, and that this specialisation gives rise to gains from international commodity trade. I calibrate such a model using estimates of countries’ endowments of human and physical capital and show that it can explain 50-80% of world trade growth between 1980 and 2007.

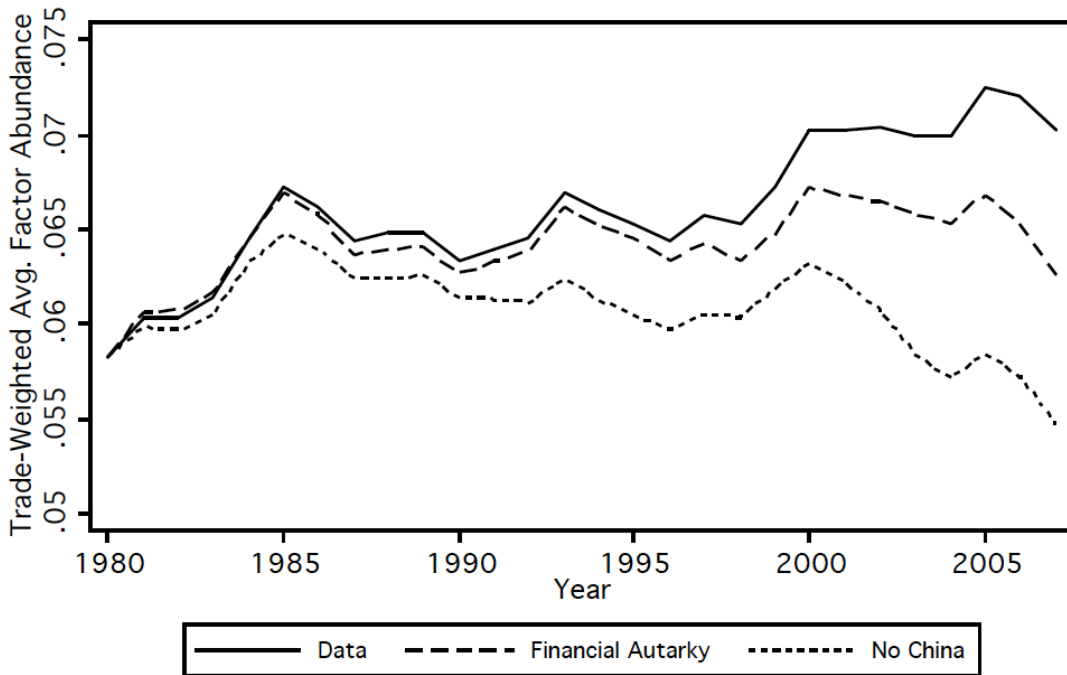
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<sup>1</sup>The authors find a significantly smaller role for transportation costs in explaining increases in trade. Moreover, Hummels (2007) notes that changes in international transportation in the second half of the twentieth century did not translate into an unambiguous trend of declining shipping costs.



Notes:  
 28 largest economies. Aggregate trade data is taken from the World Trade Organisation and bilateral trade data from the IMF's Direction of Trade Statistics (2010). The >North< and >South< are defined, respectively, as countries with capital-labour ratios above and below the world's aggregate capital-labour ratio.  
 \*Trade = (Exports + Imports)/2.

Figure 1.1.: The Growth of World Commodity Trade, 1980-2007



Notes:  
 Capital stocks are estimated using the perpetual inventory method, starting in 1950, and assuming a depreciation rate of 0.06. Details concerning the construction of physical and human capital variables are provided in Appendix A1.  
 Data for the 28 largest economies taken from Heston, Summers and Aten (2009), Barro and Lee (2010) and the World Trade Organisation.

Figure 1.2.: Dispersion of  $K/H$ -ratios Over Time

Figure 1.2 illustrates the evolution of the world distribution capital stocks per effective worker, henceforth referred to as “capital-labour ratios” or “ $K/H$ -ratios” for brevity. The solid line describes the trade-weighted average factor abundance – a measure of the dispersion of capital-labour ratios among the largest, most open economies.<sup>2</sup> It shows that the dispersion of factor proportions has increased steadily since 1980. Part of this is due to the rise in trade between capital-abundant countries (the “North”) and capital-scarce countries (the “South”) as a share of world trade. As can be seen from Figure 1.1, 70% of the overall growth in world trade since 1980 has been due to the expansion of North-South trade.

According to classical trade theory, differences in relative factor endowments are a potential cause of specialisation and, hence, trade in international goods markets. Figure 1.3 provides evidence to this effect. It correlates the average capital intensity of U.S. imports, based on sector-level trade data, with the source country’s capital-labour ratio for the years 1985, 1995, 2000 and 2005.<sup>3</sup> The graphs document that, as capital-labour ratios have diverged over time, relative factor endowments have indeed become a more significant determinant of the *type* of commodities imported by the United States from its different partner countries: since 2000 factor-proportions differences alone have accounted for approximately 30% of the differences in the average capital intensity of U.S. imports from its major trading partners.

Using my model, I find that specialisation due to increased differences in factor proportions is responsible for at least 52% of the growth in world trade since 1980. Most of the trade growth explained by my calibrations is due to the opening of China, while 10-18% are due to financial globalisation and the resulting pattern of South-North capital flows. The dashed line in Figure 1.2 highlights that the increase in factor-proportions differences since the mid-1990s would not have occurred in financial autarky.<sup>4</sup> The dotted line shows that differences between capital-labour ratios would have decreased if China had remained largely closed to foreign trade.

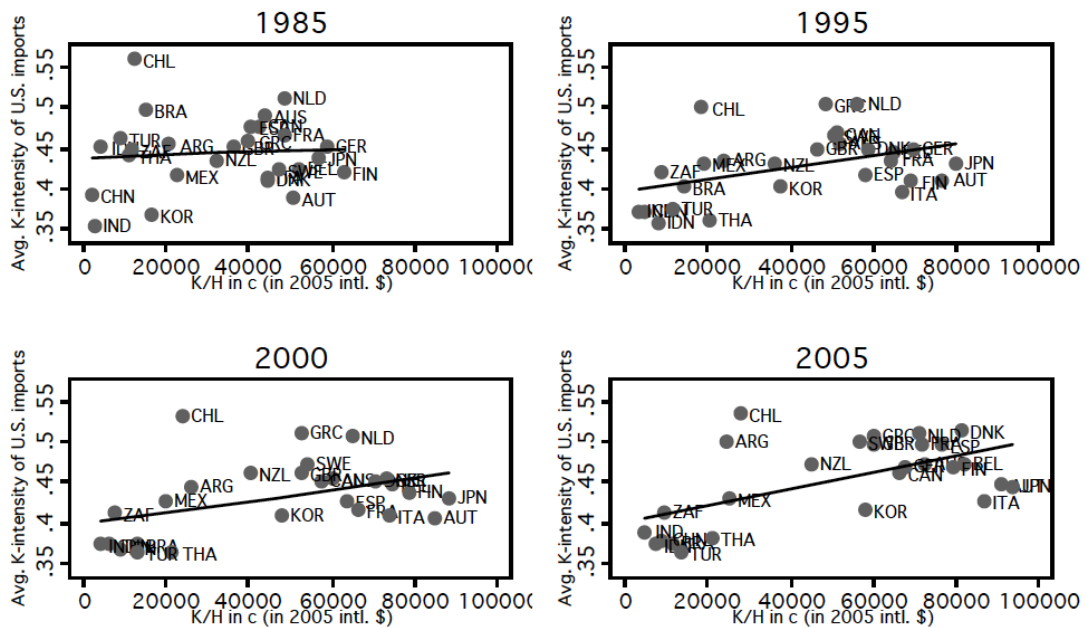
The emergence of China as a large trading economy is generally recognised

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<sup>2</sup>The trade-weighted average factor abundance is calculated as  $\sum_c \left| \frac{K_{ct}}{K_t} - \frac{H_{ct}}{H_t} \right| \frac{X_{ct} + M_{ct}}{X_t + M_t}$ , where  $K_{ct}$  is country  $c$ ’s stock of physical capital,  $H_{ct}$  its stock of human capital and  $X_{ct}$  and  $M_{ct}$  represent the value of its exports and imports, respectively. I drop the subscript  $c$  for world variables. Details on data sources and construction are provided in Appendix A1.

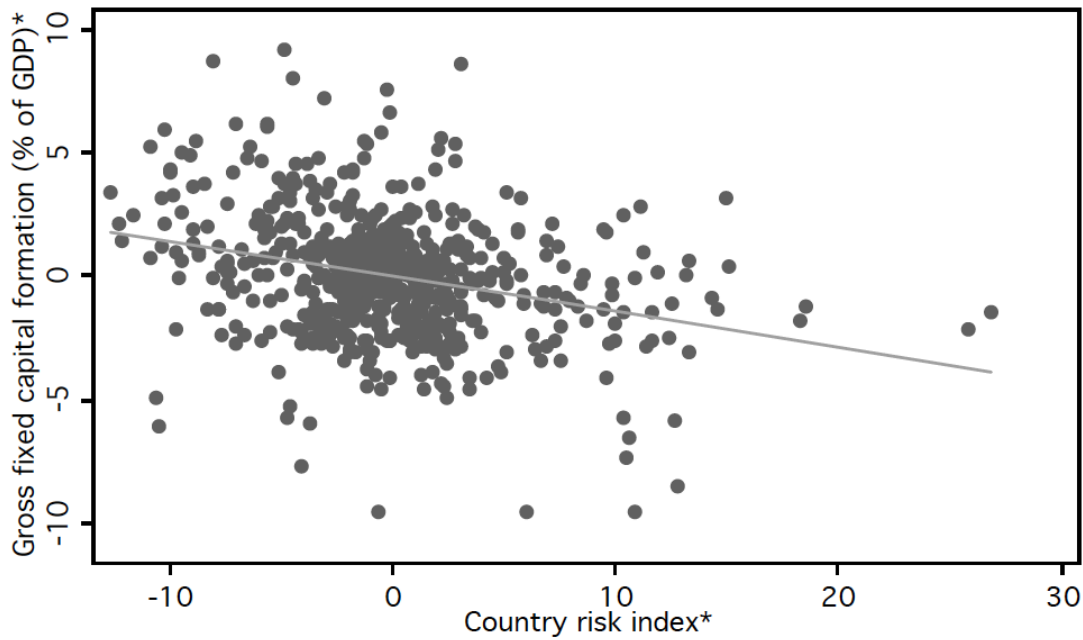
<sup>3</sup>Appendix A2 contains a more detailed regression analysis as well as a discussion of data sources and construction.

<sup>4</sup>I estimate counterfactual “financial autarky” capital stocks by cumulating countries’ gross domestic savings, rather than the usual investments, since domestic investment equals saving in financially closed economies. The construction of this data is discussed in greater detail in Appendix A1.



Notes:  
 Data on U.S. sector-level trade with the 27 largest economies taken from Feenstra (2009). Sectoral capital intensities based on the NBER-CES Manufacturing Industry Database. For data description and regression results, please refer to Appendix A2.

Figure 1.3.: Factor Proportions and Specialisation



Notes:  
 Panel of the 28 largest economies for 1980-2007. Data taken from the World Development Indicators (2010), with country risk based on PRSG surveys. For the formal regression results, please refer to Appendix A2.  
 \*Controlling for gross domestic savings, country and time fixed effects.

Figure 1.4.: Investment and Country Risk, 1980-2007

as the result of an exogenous policy shock – the program of “reform and opening up” initiated by the Communist Party of China under Deng Xiaoping in 1978. Its significance for any factor-proportions-based view of international commodity trade derives from China’s sheer size and labour-abundance. Although China’s comparative advantage in labour-intensive industries is widely acknowledged,<sup>5</sup> to the best of my knowledge this paper provides the first quantitative assessment of the China’s contribution to the growth in world trade from a factor-proportions perspective. My findings suggest that the failure of previous studies to match the growth in world trade may have been partly due to their focus on tariff declines among relatively similar countries. Allowing for the opening up of countries whose economies differ significantly from the characteristics of the North has the potential to explain a large portion of global trade growth as a result of classical comparative advantage.

The pattern of South-North capital flows – and the resulting increase in factor-proportions differences – constitutes a well-established puzzle for the theory of international finance.<sup>6</sup> Traditional one-good models of international investment have tended to emphasise locally diminishing returns to capital as the main motive for international financial flows. Barring a strong positive correlation between savings rates and total factor productivities, such models would predict capital to flow from capital-abundant to capital-scarce regions in search of higher returns, thereby reducing factor-proportions differences. I allow for international asset trade in my model and demonstrate that the increased prevalence of factor-proportions trade may explain why capital flows have increased factor-proportions differences, contrary to the conventional view.

Trade theory has established that, under well-defined conditions, trade in goods with different factor intensities may eliminate local diminishing returns to production factors, and thus the main theoretical reason for capital to flow from North to South. Suppose therefore that instead of rate-of-return differences, diversification and risk sharing are the dominant motives for international asset trade. In that case, barring a strong negative correlation between savings rates and country risk, capital should flow from risky to safe regions which may exacerbate factor proportions differences, raising specialisation and trade.

Basic empirical tests verify that country-specific investment risk has been an important determinant of international investment patterns over the last three decades. In a panel of the 28 largest economies, a measure of country

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<sup>5</sup>See, for example, Rodrik (2006) and Amiti and Freund (2010).

<sup>6</sup>See, among others, Prasad, Rajan, and Subramanian (2006), Gourinchas and Jeanne (2006) and Caballero, Farhi and Gourinchas (2008)

risk - based on historical country risk scores from the Political Risk Services Group (PRSG) - is strongly and negatively correlated with the GDP-share of investment after controlling for domestic savings and country and time fixed effects (see Figure 1.4 and the formal regressions in Appendix A2). As part of my calibration exercise, I show that a model in which factor-proportions trade eliminates local diminishing returns and agents engage in international asset trade to hedge idiosyncratic investment risk can match international investment patterns remarkably well.<sup>7</sup>

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 countries. Helpman (1987) demonstrates that, beyond this, new trade theory has implications for trade growth, linking it to the similarity of countries’ incomes. However, subsequent work by Hummels and Levinsohn (1995), Baier and Bergstrand (2001) and Bergoeing and Kehoe (2003) has uncovered little evidence that this channel has played a quantitatively important role in the recent growth of world trade, shifting attention towards declining trade frictions.

Yi (2003) argues 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 Ricardian or new trade model with plausible assumptions about the elasticity of substitution between goods. He attempts to explain this puzzle as the result of an increase in vertical specialisation, whereby goods cross borders several times during the production process, but his model leaves at least half of world trade growth unaccounted for. My paper is complimentary with Yi’s insofar as he assumes the pattern of vertical specialisation to be determined by classical comparative advantage due to productivity differences. My calibrations also assume a comparative-advantage motive for trade but show that horizontal specialisation alone, driven by factor-proportions differences, can explain a substantial part of the recent growth in world trade.

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 dy-

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<sup>7</sup>Antras and Caballero (2009) and Jin (2009) are two recent attempts to explain South-North capital flows in the context of a Heckscher-Ohlin model. My model relates more closely to the “portfolio approach” to the current account – pioneered by Kraay and Ventura (2003), Ventura (2003) and Kraay et al. (2005). I expand on their partial-equilibrium international portfolio model by embedding it in a many-good general-equilibrium framework in which local diminishing returns disappear endogenously as a result of factor-proportions trade in commodities.

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. Unlike Cuñat and Maffezzoli (2007), I use factor-proportions differences to account for the growth in global trade and I study the impact of an asymmetric increase in the trade openness of capital-scarce regions. Moreover, I dispense with their assumption of financial autarky, showing that international capital flows have played a significant part in increasing specialisation and trade.<sup>8</sup>

The inability of factor-proportions models to explain the patterns and extent of world trade has led researchers to dismiss them as a tool for quantitative studies in favour of new trade models. The main contribution of this paper is to demonstrate that, as the volume of trade between capital-scarce and capital-abundant countries has risen, factor-proportion have become crucial for understanding the growth – albeit not the level – of world trade. A secondary contribution of the paper is to highlight that a world in which factor-proportions trade is prevalent provides a natural setting in which to analyse the surprising pattern of South-North capital flows.

The remainder of the paper is structured as follows. Section 2 describes the theoretical model and shows how it can be applied to study the impact on factor proportions trade of i) the arrival of a new, labour-abundant country and ii) the occurrence of financial globalisation. Section 3 calibrates the model to real-world data in order assess how much of the growth in world trade over the last three decades it can explain. It also considers the empirical realism of the model-implied determinants of international capital flows. Section 4 concludes.

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<sup>8</sup>My estimates suggest that the U.S. capital stock would have been approximately 15% lower in 2007 in financial autarky. In fact, without sizable capital inflows the U.S. investment rate would have declined over the last 30 years – contrary to the prediction of Cuñat and Maffezzoli (2007).



## 2 The Model

Below I outline a tractable general equilibrium model to illustrate the relationship between capital-labour ratios, the patterns of specialisation and the volume of trade. The dynamic nature of the model allows me to examine the determinants of capital accumulation under different assumptions about the feasibility of cross-border asset trades.

Throughout, I emphasise the Heckscher-Ohlin view of international commodity trade: differences in regional factor proportions are a source of comparative advantage. Different regions of the world trade in  $K$ -intensive and  $H$ -intensive intermediate goods, and regions specialise in the type of good which uses their abundant factor intensively. I impose assumptions that guarantee that commodity trade equalises factor prices and derive an expression which relates the traded share of world output to the distribution of factor endowments. I then proceed to analyse two cases of interest for my subsequent calibrations: the arrival of a new country (in Section 2.3) and the impact of financial globalisation, modelled as the removal of all barriers to international asset trade (in Section 2.4).

As Mundell (1957) first showed, net financial flows across borders are indeterminate if factor-proportions trade equalises factor returns and return differentials are the only incentive for international asset trade. I show, by contrast, that net flows are *perfectly* determined if agents have an incentive to trade financial assets in order to hedge against idiosyncratic regional investment risk.<sup>9</sup> Under a general set of conditions, regions with relatively safe (low-variance) investment technologies will attract the largest share of world asset investments and, unless they also have proportionally higher savings rates, will be net recipients of international financial flows. If, in addition, these regions do not happen to be labour-abundant, such flows will exacerbate factor-proportions differences and increase specialisation and trade.

The model highlights that the stylised facts described in the previous section can be understood from the perspective of a neoclassical, frictionless world hit by two exogenous shocks. First, a labour-abundant country – China – has opened up to international goods trade. Second, financial globalisation has occurred and asset trades between small (in terms of the size of their effective workforce) but safe regions and large but risky regions have exacerbated factor-proportions differences.

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<sup>9</sup>To my knowledge, Grossman and Razin (1984) constitutes the only other paper to point out that the “substitutability” between commodity trade and capital flows in Heckscher-Ohlin models may break down if uncertainty is introduced into the model. However, their paper does not explore the dynamic macroeconomic implications of this possibility.

## 2.1 Basic Setup

### 2.1.1 Endowments and Preferences

Consider a world consisting of large regions,  $c = 1, \dots, C$ , and inhabited by two overlapping generations, the young and the old. Generations in region  $c$  have a constant size  $L_c$ . In youth, agents in  $c$  are endowed with  $h_c$  units of human capital which they supply inelastically in their regional labour market, at the given wage rate  $w_{ct}$ . A fraction  $1 - S_c$  of these agents is impatient and derives utility only from consumption in youth. A fraction  $S_c$  is patient and derives utility only from consumption in old age. At  $t$ , the region's aggregate savings,  $B_{ct}$ , and consumption,  $C_{ct}$ , are thus given by:

$$\begin{aligned} B_{ct} &= w_{ct} S_c H_c \\ C_{ct} &= w_{ct} (1 - S_c) H_c + r_{ct} B_{ct-1} \end{aligned} \quad (1)$$

where  $r_{ct}$  is the rate of return to savings in  $c$  at  $t$  and  $H_c \equiv h_c L_c$ .

### 2.1.2 Production

Final consumption and investment are identical Cobb-Douglas composites of two intermediate goods:

$$C_{ct} + I_{ct} = Q_{ct} = Q_{cKt}^\theta Q_{cHt}^{1-\theta} \text{ with } \theta \in (0, 1), \quad (2)$$

where  $I_{ct}$  denotes aggregate investment in  $c$  at  $t$ ,  $Q_{ct}$  represents aggregate industrial output and  $Q_{cjt}$  is the input of intermediate good  $j \in \{K, H\}$  used in aggregate production. Intermediate goods are assembled using two factors of production – physical capital,  $K_{ct}$ , and human capital,  $H_{ct}$  – according to

$$Q_{cjt} = K_{cjt}^{\alpha_j} H_{cjt}^{1-\alpha_j} \text{ with } \alpha_j \in [0, 1], j \in \{K, H\}. \quad (3)$$

In the following, I will assume that  $\alpha_K > \alpha_H$ . Put plainly, production of the intermediate good of the  $K$ -type uses physical capital relatively intensively, while production of the intermediate good of the  $H$ -type uses human capital relatively intensively. I also assume that final-good, intermediate-good and factor markets are perfectly competitive and that final-good and intermediate-good firms choose their inputs to maximise profits.

### 2.1.3 Savings, Investment and Capital Formation

Agents in  $c$  have exclusive access to an investment technology which allows them to turn  $I_{ct}$  units of investment in  $t$  into  $K_{ct+1}$  units of capital in  $t + 1$ ,

according to

$$K_{ct+1} = A_{ct+1}I_{ct}, \quad (4)$$

where  $A_{ct+1}$  is stochastic with

$$\begin{aligned} E_t(A_{ct+1}) &= 1 \\ \text{Var}(A_{ct+1}) &= \sigma_c^2 \\ \text{Cov}(A_{ct+1}, A_{c't+1}) &= 0 \quad \forall c' \neq c \end{aligned} \quad (5)$$

Capital depreciates fully in one period.

Since the final consumption good is assumed to be perishable, agents can only transfer consumption to the future by making risky investments in physical capital stock. Investment risk is perfectly idiosyncratic.<sup>10</sup> I shall therefore refer to  $\sigma_c$  as a measure of  $c$ 's country risk.

#### 2.1.4 Autarky Equilibrium

Suppose that region  $c$  exists in complete autarky. Defining  $P_{ct}$  as the aggregate price level, synonymous with the price of consumption and investment,

$$P_{ct} = \left( \frac{P_{cKt}}{\theta} \right)^\theta \left( \frac{P_{cHt}}{1-\theta} \right)^{1-\theta}, \quad (6)$$

where  $P_{cjt}$  is the price of intermediate good  $j$ . Perfect competition in intermediate-good markets ensures that the price of intermediate goods equals their marginal cost of production. Given perfect competition in factor markets,

$$P_{cjt} = \left( \frac{r_{ct}}{\alpha_j} \right)^{\alpha_j} \left( \frac{w_{ct}}{1-\alpha_j} \right)^{1-\alpha_j} \quad \text{for } j \in \{K, H\}, \quad (7)$$

where  $r_{ct}$  is the rental rate of capital. It is identical with the return to savings as capital investments constitute this economy's only means of postponing consumption.

Imposing the normalisation  $P_{ct} = 1$  and letting goods and factor markets clear, we obtain

$$Q_{ct}^A = K_{ct}^\alpha H_c^{1-\alpha}, \quad (8)$$

$$r_{ct} = \alpha \frac{Q_{ct}^A}{K_{ct}}, \quad w_{ct} = (1-\alpha) \frac{Q_{ct}^A}{H_c}, \quad (9)$$

$$E_t[K_{ct+1}] = I_{ct} = B_{ct} = s_c Q_{ct}^A, \quad (10)$$

where  $\alpha \equiv \theta\alpha_K + (1-\theta)\alpha_H$  and  $s_c \equiv (1-\alpha)S_c$ . As equations (8)-(10) show,  $c$ 's economy in autarky behaves like a Solow model with investment shocks.

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<sup>10</sup>This assumption is not crucial but it greatly simplifies the subsequent analysis.

## 2.2 Commodity Trade and the Patterns of Specialisation

### 2.2.1 Factor Price Equalisation and the World Economy

I introduce commodity trade between different regions by assuming that intermediate goods are perfectly tradable, while factors and final goods cannot be traded. For now – in common with most trade models – I do not allow agents in  $c$  to trade assets with residents of other regions, so that domestic capital investments remain their only means of transferring consumption to the future. One way to rationalise the absence of international asset trades could be the prevalence of transaction costs which are sufficiently large to make such trades undesirable from the agents' perspective.

The source of gains from commodity trade in the present model are differences in factor proportions. Given world prices, countries choose the production vector  $\{Q_{cKt}, Q_{cHt}\}$  which best suits their relative endowment of production factors. By the force of the Heckscher-Ohlin theorem, this leads  $K$ -abundant regions to specialise in, and export, the  $K$ -intensive intermediate and import the  $H$ -intensive intermediate, while  $H$ -abundant regions will exhibit the reverse pattern of specialisation.

It is a well-established feature of models of factor-proportions trade that trade in derivative commodities may equalise the return to production factors across regions even when factors themselves cannot move to exploit potential return differentials. This is referred to as the Factor Price Equalisation (FPE) theorem. In the present setting, FPE requires that

$$\frac{\alpha_H}{1 - \alpha_H} \frac{(1 - \alpha) K_t}{\alpha H_t} \leq \frac{K_{ct}}{H_c} \leq \frac{\alpha_K}{1 - \alpha_K} \frac{(1 - \alpha) K_t}{\alpha H_t} \quad \forall c, \quad (11)$$

where  $K_t$  and  $H_t$  denote the world stock of physical and human capital, respectively.<sup>11</sup> Condition (11) states that, given  $\alpha_K$  and  $\alpha_H$ , FPE will arise as long as regions' relative factor endowments are not too extreme compared to the world ratio of physical to human capital. I will assume, crucially, that (11) applies throughout.<sup>12</sup>

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<sup>11</sup>See Ventura (2005) for a comprehensive discussion of the necessary conditions for FPE to arise as a result of trade in commodities.

<sup>12</sup>While the possibility of trade-induced factor price equalisation is a feature of many trade models, the question whether it is also a feature of reality has not yet been answered conclusively. Treffer (1993) documents the empirical validity of a conditional version of the FPE theorem. More recently, Caselli and Feyrer (2007) show that, despite large differences in capital-labour ratios and the absence of large capital flows from capital-abundant to capital-scarce regions, the marginal product of capital does not appear to differ greatly across countries.

Assuming that (11) holds implies

$$r_{ct} = r_t, w_{ct} = w_t \forall c.$$

Moreover, since intermediate goods can be traded freely,

$$P_{cjt} = P_{jt} \forall c \text{ and } j \in \{K, H\},$$

from which

$$P_{ct} = P_t \forall c.$$

Imposing the normalisation  $P_t = 1$  and dropping the subscript  $c$  for all world variables,

$$Q_t = K_t^\alpha H^{1-\alpha}, \quad (12)$$

$$r_t = \alpha \frac{Q_t}{K_t}, w_t = (1 - \alpha) \frac{Q_t}{H}, \quad (13)$$

$$K_{t+1} = \sum_{c=1}^C A_{ct+1} I_{ct} = \sum_{c=1}^C A_{ct+1} s_c Q_{ct}. \quad (14)$$

The aggregate world economy behaves just like a larger version of the autarkic region described in Section 2.1.4, while the output of each region  $c$  is now described by

$$Q_{ct} = \left[ \alpha \frac{K_{ct}}{K_t} + (1 - \alpha) \frac{H_c}{H} \right] Q_t. \quad (15)$$

### 2.2.2 Specialisation

Define  $M_{cit}$  as the value of region  $c$ 's net imports of the  $i$ -intermediate. Since trade is balanced

$$M_{cHt} = \frac{\alpha(1 - \alpha)}{\alpha_K - \alpha_H} \left( \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right) Q_t = -M_{cKt}. \quad (16)$$

So long as  $K_{ct}/K_t - H_c/H > 0$ ,  $c$  will be a net importer of the  $H$ -good and a net exporter of the  $K$ -good. If  $K_{ct}/K_t - H_c/H < 0$ , the reverse will be the case. An increase in  $|K_{ct}/K_t - H_c/H|$  thus raises  $c$ 's trade with the rest of the world, and we may take this term as a measure of  $c$ 's specialisation. It is easy to show that, while (11) remains satisfied, an increase in  $|K_{ct}/K_t - H_c/H|$  causes  $c$  to increase more than proportionally its production of the intermediate good of which it is a net exporter, and to reduce its production of the other intermediate good. The region absorbs its growing factor abundance by means of structural transformation. This is the classic Rybczynski theorem.

Traditional trade theory takes the distribution of  $K_{ct}$  and  $H_c$  as given and

analyses the resulting patterns of specialisation. I shall go one step further by analysing the deeper causes of specialisation which underlie the observed distribution of factor endowments. Two extreme cases are of particular interest.

Let  $s = \sum_c s_c H_c / H$  be the world savings rate. Assume  $s_c \approx s$  and  $\sigma_c$  is large for all  $c$ . Then,

$$\left| \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right| \approx \left| \frac{A_{ct}}{\sum_c A_{ct} \frac{H_c}{H}} - 1 \right| \frac{H_c}{H}. \quad (17)$$

Under this assumption, the pattern of specialisation is determined purely by luck. Regions which receive large positive investment shocks relative to the world average will be capital-abundant, while regions which receive small shocks will be capital-scarce. Moreover, as the patterns of specialisation are essentially random, regions which specialise in capital-intensive exports in one generation may be specialised in labour-intensive exports in the next. Clearly this view of the fundamental forces behind trade specialisation is of limited empirical appeal. I shall therefore focus on an alternative case.

Assume that  $s_c$  differs across countries and  $\sigma_c \approx 0$ . Then,

$$\left| \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right| \approx \left| \frac{s_c}{s} - 1 \right| \frac{H_c}{H}. \quad (18)$$

Under this assumption, the pattern of specialisation is determined by savings behaviour. High-savings region will accumulate large capital stocks relative to low-savings regions and specialise in capital-intensive products. Low-savings regions will specialise in labour-intensive products. This is the view of the fundamental causes of differences in capital-labour ratios implicit in most traditional models of factor-proportions trade. In Section 2.4, I will show that it crucially depends on the assumption of financial autarky. Once international asset trades are feasible, the determinants of specialisation are fundamentally altered.

### 2.2.3 World Trade

While the model predicts region  $c$ 's net imports and net exports, gross trade flows are indeterminate. To pin down the latter, I assume that positive but infinitesimal transport costs cause agents to minimise gross trade flows - which are then equal to net flows - and I will refer to "imports/exports" and "*net* imports/exports" interchangeably from now on.

Based on (16), the traded share of world output is

$$\frac{\sum_c (|M_{cKt}| + |M_{cHt}|)}{2Q_t} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \sum_c \left| \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right|. \quad (19)$$

Equation (19) will be crucial in the remainder of the paper. It shows that the bigger the differences between regional shares in the world stocks of physical and human capital and, hence, the greater the extent of countries' specialisation in equilibrium, the larger will be the overall volume of trade.

## 2.3 Arrival of a New Country

### 2.3.1 A Labour-Abundant Country Appears

Imagine that at time  $t$  country *New* is discovered and all old regions begin to trade intermediate goods with *New*.<sup>13</sup> I assume that (11) still holds after the arrival of the new country and define

$$H_{New} \equiv x_H H, \quad (20)$$

$$K_{New,t} \equiv x_K K_t, \quad (21)$$

where  $H$  and  $K_t$  continue to denote, respectively, the world stock of human and physical capital prior to *New*'s arrival. The parameters  $x_H$  and  $x_K$  thus denote the percentage growth in the world human and physical capital resulting from the integration of *New* into the world economy.

Let  $C$  denote the set of regions before *New*'s arrival. I define  $C^H$  as the group of regions specialised in the  $H$ -intensive and  $C^K$  as the group of regions specialised the  $K$ -intensive intermediate good before *New* appeared, with  $C^H \cup C^K = C$  and  $C^H \cap C^K = \emptyset$ .

Note that

$$\frac{K_{New,t}}{H_{New}} = \frac{1 + x_K}{1 + x_H} \frac{K_t}{H} - \frac{x_H - x_K}{x_H(1 + x_H)} \frac{K_t}{H},$$

so *New* is labour-abundant if  $x_H > x_K$  and capital-abundant if  $x_K > x_H$ . I will assume  $x_H > x_K$  in the following.

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<sup>13</sup>It would be analytically equivalent but algebraically more cumbersome to assume that *New*, instead of being "discovered", was a previously autarkic region which opens up to trade at  $t$ .

### 2.3.2 Impact on Specialisation

The discovery of *New* has an impact on world trading patterns. *New* itself will be an importer of the *K*-intermediate and an exporter of the *H*-intermediate,

$$\frac{M_{New,Kt}}{Q_t} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \frac{x_H - x_K}{(1+x_H)(1+x_K)} = -\frac{M_{New,Ht}}{Q_t}, \quad (22)$$

which follows from the assumption that  $x_H > x_K$ . Meanwhile for  $c \in C^H$ ,

$$\frac{M_{cKt}}{Q_t} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left[ \left( \frac{H_c}{H} - \frac{K_{ct}}{K_t} \right) \frac{1}{1+x_H} - \frac{K_{ct}}{K_t} \frac{x_H - x_K}{(1+x_H)(1+x_K)} \right] = -\frac{M_{cHt}}{Q_t} \quad (23)$$

and for  $c \in C^K$ ,

$$\frac{M_{cHt}}{Q_t} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left[ \left( \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right) \frac{1}{1+x_H} + \frac{K_{ct}}{K_t} \frac{x_H - x_K}{(1+x_H)(1+x_K)} \right] = -\frac{M_{cKt}}{Q_t}. \quad (24)$$

As a comparison between (16) and equations (23) and (24) shows, the arrival of a new labour-abundant country unambiguously reduces the imports and exports of previously labour-abundant regions relative to world GDP, but may increase or decrease the imports and exports of previously capital-abundant regions. This is due to the simultaneous impact of two effects. On the one hand, *New*'s arrival increases world GDP which, holding everything else constant, reduces the value of all regions' trade flows relative to world output. On the other hand, the opening up of *New* increases the supply of *H*-intermediates relative to *K*-intermediates, causing *K*-exporters to increase their production and exports of the *K*-good as well as their imports of the *H*-good while *H*-exporters do the reverse.

*New*'s integration into the global economy thus increases the extent of specialisation and trade openness among *K*-exporters, but reduces specialisation and trade openness among *H*-exporters. The next section examines the overall impact on world trade.

### 2.3.3 Impact on World Trade

To simplify matters, let us assume that the arrival of *New* does not cause a previous net exporter of the *H*-intermediate to become a net exporter of the *K*-intermediate. Then the change in the traded share of world output due to *New*'s appearance is given by

$$\Delta \frac{\sum_c (|M_{cKt}| + |M_{cHt}|)}{2Q_t} =$$



$$\frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left\{ 2 \frac{x_H - x_K}{(1+x_H)(1+x_K)} \sum_{c \in C^K} \frac{K_{ct}}{K_t} - \frac{x_H}{1+x_H} \sum_{c \in C} \left| \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right| \right\}. \quad (25)$$

Note that if *New* is very labour-abundant and the differences between countries in  $C$  are small – so that there is little trade before the discovery of *New* –, its arrival will increase world trade. Note further that the increase in world trade will be larger, the larger the share of world capital located in the group of capital-abundant regions.

An increase in capital accumulation in capital-abundant regions relative to capital-scarce regions would thus amplify the impact of the opening-up of a labour-abundant country. In the next section I show that there exist conditions under which financial globalisation will have precisely this effect.

## 2.4 Financial Globalisation

### 2.4.1 International Asset Trade and Country Risk

Section 2.2.3 illustrates that, if investment risk is small, savings behaviour is the main determinant of capital accumulation and export specialisation in financial autarky. Yet in the face of the large and rising volume of international capital flows observed during the last three decades, this view of the causes of specialisation appears increasingly dated. The panel regressions in Appendix A2 suggest that the savings retention coefficient among the group of the largest economies was as low as 0.4 in the period 1980-2007, and that perceptions of country risk were a potentially important source of countries' ability to attract investment finance in increasingly global capital markets. In the light of this, I now analyse the determinants of capital-labour ratios – and the resulting patterns of specialisation – when domestic savings no longer need to be invested exclusively in domestic assets, and country-specific investment risk provides a strong motive for international risk sharing.

The most widespread view of the motive for international capital flows, based on macroeconomic models with a single tradable good, emphasises diminishing returns to capital. In this view, the return to capital investments is generally higher in regions with low capital-labour ratios, and capital flows from capital-abundant to capital-scarce regions in search of these higher returns. Unless regional factor productivities are strongly positively correlated with region's autarky capital stocks, the effect of international capital flows should be to *reduce* the dispersion of world capital-labour ratios. While this explanation for cross-border capital movements has considerable theoretical appeal, it has been known since at least Lucas (1990) that it is at odds with the empirical pattern of international financial flows.

The model outlined above provides an explanation why local diminishing returns to capital may be weak in open economies, even if the marginal product of capital in aggregate production is declining in the installed capital stock: once capital is installed in a given location, the possibility of trading derivative commodities in international goods markets may substitute for capital movements in equalising the marginal product of capital across different regions. With local diminishing returns thus out of the picture, the following will stress a different motive for international asset trade: the desire to share country-specific risk.

So far, it has been assumed that domestic capital constitutes the only store of value for the patient young in region  $c$ . This has made it unnecessary to specify how such agents might allocate their funds between competing investment opportunities. In this section I permit agents to trade freely in state-contingent assets across borders which allows them, indirectly, to access the investment technologies of different regions. In doing so, I assume that the patient young choose mean-variance efficient asset portfolios,<sup>14</sup> maximising

$$E_t(C_{t+1}) - \frac{1}{2}\gamma \text{Var}(C_{t+1}) \text{ with } \gamma \geq 0, \quad (26)$$

where  $\gamma$  is the parameter of relative risk aversion.

Suppose the number of countries,  $C$ , is large. Then, since country risk is perfectly idiosyncratic,

$$K_{t+1} = I_t = B_t = sQ_t,$$

i.e. the evolution of the world capital stock is deterministic. This implies that

$$r_{t+1} = \alpha \left( \frac{H}{B_t} \right)^{1-\alpha},$$

so that all uncertainty about the return to investment in a given  $c$  arises from realisation of the local investment shock.

Young residents of region  $c$  in period  $t$  are willing to supply a state-contingent asset that promises  $r_{t+1}A_{ct+1}$  units of consumption in  $t + 1$  at price 1 perfectly elastically. The reason is that they can hedge any amount of such claims by investing in a corresponding amount of domestic capital, also at price 1. It is easy to show that the possibility of buying and selling  $C$  of these regional assets exhausts all desirable asset trades in the world economy described here. Let  $\phi_c^c$  denote the share of savings of the patient young in  $c$

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<sup>14</sup>This behavioural assumption is common in modern finance, and provides a good approximation to expected utility maximisation if the distribution of asset returns is characterised well by its first two moments.

invested in assets of region  $c'$ . The patient young solve:

$$\begin{aligned} \max_{\{\phi_{c'}^c\}_{c'=1}^C} E_t \left( r_{t+1} B_{ct} \sum_{c'} A_{c't+1} \phi_{c'}^c \right) - \frac{1}{2} \gamma \text{Var} \left( r_{t+1} B_{ct} \sum_{c'} A_{c't+1} \phi_{c'}^c \right) \\ = r_{t+1} B_{ct} - \frac{1}{2} \gamma (r_{t+1} B_{ct})^2 \sum_{c'} (\sigma_{c'} \phi_{c'}^c)^2 \end{aligned}$$

*s.t.*

$$\sum_{c'} \phi_{c'}^c = 1.$$

Note that, while the final consumption good itself cannot be traded across regions, residents of region  $c$  can fulfil a promise to supply 1 unit of consumption to foreigners in a given state by supplying the necessary quantities of perfectly tradable intermediate goods to assemble 1 unit of final good in that state. This may require within-period factor-proportions trade with a third party before the required bundle of  $K$ - and  $H$ -good can be shipped to the final claimant.

#### 2.4.2 The Pattern of International Capital Flows

Since the patient young in all regions face the same optimisation problem, it follows that

$$\frac{I_{ct}}{B_t} = \phi_c = \frac{1}{\sigma_c^2} \left( \sum_{c'} \frac{1}{\sigma_{c'}^2} \right)^{-1}. \quad (27)$$

Investment in region  $c$  thus depends negatively on  $c$ 's country risk relative to a measure of world risk. In the limiting case in which  $\sigma_c \rightarrow 0 \forall c$ , investment patterns are once again indeterminate if international trade in both goods and assets is feasible. Therefore, one way of interpreting the indeterminacy result of Mundell (1957) is as a special case of the model in which country risk is absent. This finding is more general than the specific choice of objective function and the assumed return distribution would seem to suggest: given identical return expectations, any risk-averse agent will favour safer over riskier assets in their portfolio, but will invest in assets of different risk classes if this provides hedging benefits.

Region  $c$  is a net recipient of international capital flows if

$$\frac{1}{\sigma_c^2} \left( \sum_{c'} \frac{1}{\sigma_{c'}^2} \right)^{-1} > \frac{s_c \frac{H_c}{H}}{s}. \quad (28)$$

Let us consider the example of a world in which factor-proportions trade is prevalent, regional savings rates are similar but the safest regions are small (in terms of  $H_c/H$ ). In this world, financial globalisation should be accom-

panied by capital flows from capital-scarce to capital-abundant countries as well as large and persistent net foreign asset positions. As Caballero, Farhi and Gourinchas (2008) have shown, among others, this is fairly accurate description of the recent pattern of international capital flows. In Section 3.2 I will assess whether my model can deliver predictions about international investment patterns which are consistent with the data.

### 2.4.3 Impact on Specialisation

Consider now the following thought experiment. Suppose that for all  $t < \bar{t}$  regions had been able to trade in intermediate varieties but not in final goods or factors, nor in financial assets. This is the world described in Section 2.2. Assume now that in period  $\bar{t}$  all costs and frictions impeding international financial transactions disappear and global asset markets become fully integrated.

The feasibility of international asset trade implies that commodity trade no longer needs to be balanced for any  $c$  or  $t \geq \bar{t}$ . Defining

$$-NX_{ct} \equiv M_{cHt} + M_{cKt} \quad (29)$$

and noting that

$$Q_{ct} = C_{ct} + I_{ct} + NX_{ct}, \quad (30)$$

it can be shown that for all  $t \geq \bar{t}$

$$\begin{aligned} \frac{|M_{cKt}| + |M_{cHt}|}{2Q_t} &= \frac{1}{2} \left| \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left( \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right) + \theta \frac{NX_{ct}}{Q_t} \right| \\ &+ \frac{1}{2} \left| \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left( \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right) - (1-\theta) \frac{NX_{ct}}{Q_t} \right|. \end{aligned} \quad (31)$$

Equation (31) highlights that the presence of trade imbalances may obscure or reinforce the relationship between a region's true comparative advantage and its export-import patterns, depending on the values of  $\theta$  and  $NX_{ct}$ . By way of example, consider the case of a capital-abundant region ( $K_{ct}/K_t > H_c/H$ ) which is a large net importer ( $NX_{ct} < 0$ ) and let  $\theta$  be close to 1. While the region will be specialised in producing the  $K$ -intermediate, its net imports - due, for example, to net capital inflows - cause it to consume disproportionately more of the  $K$ -good. This reduces its exports in the  $K$ -sector while leaving its  $H$ -imports almost unchanged, and it reduces the sum of its exports and import overall.

The reverse would be true i) if  $c$  were a net exporter ( $NX_{ct} > 0$ ) or ii) if  $\theta$  were close to 0. In these cases, the presence of a trade imbalance would

increase the region's trade with the rest of the world by i) increasing the region's exports of the good in which it has a comparative advantage or ii) increasing the region's imports of the good in which it has a comparative disadvantage.

Irrespective of the impact of trade imbalances on export-import patterns, capital-abundant regions will continue to be specialised in the production of  $K$ -intermediates and labour-abundant regions in the production of  $H$ -intermediates. Yet the determinants of capital-abundance or -scarcity are changed by the nature of international asset trades: assuming, once again, that the absolute size of investment shocks is small ( $\sigma_c \approx 0$ ), then

$$\frac{K_{ct}}{K_t} - \frac{H_c}{H} \approx \frac{1}{\sigma_c^2} \left( \sum_{c'} \frac{1}{\sigma_{c'}^2} \right)^{-1} - \frac{H_c}{H}. \quad (32)$$

With factor-price equalising commodity trade and fully integrated international asset markets, savings rates are no longer the most relevant underlying cause of specialisation. Instead, relatively safe regions receive the largest share of capital investments out of the sum of world savings and, as a result, these regions will specialise in capital-intensive products.

#### 2.4.4 Impact on World Trade

Note that if  $\theta = 1/2$  and

$$|NX_{ct}| < 2 \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left| \frac{K_{ct}}{K_t} - \frac{H_c}{H} \right| Q_t \quad \forall c, \quad (33)$$

equation (31) reduces to (19), i.e. regardless of whether trade imbalances are present or not, the traded share of world output is the same as if trade were balanced. The reason is simple: as long as trade imbalances are not so large as to turn a country into a net importer or exporter of both intermediate goods – that is, as long as (33) is satisfied – a trade surplus with  $\theta = 1/2$  increases a country's exports by the same amount by which it reduces its imports (and a trade deficit reduces its exports by the same amount by which it increases its imports), leaving the sum of its exports and imports unchanged. In the aggregate, therefore, the traded share of world output is unaffected by trade imbalances. I will first analyse this special, but familiar case, then proceed to the more general case in which  $\theta \neq 1/2$ .

Assume  $\theta = 1/2$  and (33) holds. It is now straightforward to determine the conditions under which this sudden shift from financial autarky to financial

globalisation causes countries to become more specialised overall, namely:

$$\sum_c \left| \left( \frac{H_c \sigma_c^2}{H} \sum_{c'} \frac{1}{\sigma_{c'}^2} \right)^{-1} - 1 \right| > \sum_c \left| \frac{s_c}{s} - 1 \right|. \quad (34)$$

Financial globalisation increases specialisation if capital flows exacerbate any mismatch between human and physical capital that existed under autarky, i.e. if differences in regional savings rates are small ( $s_c \approx s \forall c$ ), and country risk is positively correlated with country size ( $Cov \{ \sigma_c, \frac{H_c}{H} \} > 0$ ). The result is an increase in world trade.

Suppose now that  $\theta \neq 1/2$ . The impact of financial globalisation on regions' specialisation patterns will be as in the previous case. Yet even if (34) is true, whether and by how much financial globalisation increases world trade relative to financial autarky depends on the value of  $\theta$  and the incidence of trade surpluses and deficits. Without loss of generality, consider the case in which  $\theta < 1/2$ . If deficit countries are capital-abundant on average and surplus countries are labour-abundant, trade imbalances will cause financial globalisation to increase global trade more than if  $\theta = 1/2$ . If deficit countries are labour-abundant on average and surplus countries are capital-abundant, financial globalisation increases global trade less.

## 3 Calibrations

In this section I assess the extent to which factor-proportions differences can explain the growth in world trade between 1980 and 2007 by taking the model developed above to the data. In accordance with conventional wisdom my model, with its exclusive focus on factor-proportions differences, cannot explain the overall *level* of world trade (see, for example, Helpman, 1987). However, I show that the evolution of relative factor endowments among the largest trading economies can explain 50-80% of the *growth* in world trade over the last three decades.

Having identified changes in relative factor abundance as a significant driving force behind the expansion of global trade, I use the model to examine the importance of two contributing factors: the emergence of China and the occurrence of financial globalisation. Financial globalisation, by giving rise to net capital flows from capital-scarce to capital-abundant countries, has exacerbated the dispersion of world capital-labour ratios. At the same time, the opening of China – a large and extremely capital-scarce economy – has increased the heterogeneity of factor endowments among the largest, most open countries. My calibrations suggest that financial globalisation accounts for 10-18% of the trade growth predicted by my model, with the remainder explained by the rise of China. I also demonstrate that their simultaneous occurrence has amplified the overall effect of both on relative factor endowments.

In the light of the observation that financial globalisation has increased factor-proportions differences, contrary to the predictions of conventional models, I examine in Section 3.2 whether my model predicts international investment patterns which are consistent with the data. I compare the variance of investment shocks implied by my calibrations with empirical measures of country risk and find that the country-risk profiles implied by the frictionless model of international asset trade set out in Section 2.4 are a poor match for the data. Introducing a small financial friction, however, allows me to match observed country-risk profiles and results in plausible predictions about countries' relative financial openness. I then illustrate the long-run growth of trade under several different hypothetical paths for the average financial friction.

### 3.1 The Growth in World Trade, 1980-2007

#### 3.1.1 Basic Data and Parameterisation

The model of Section 2 is characterised by an overlapping-generations structure and assumes full depreciation of capital between periods. To remain true to the spirit of the theory, I treat the years 1980 and 2007 as consecutive periods

of this model.

I use data for the 28 largest economies between 1980 and 2007. Together these countries accounted for 90% of world GDP in 2007. Their stocks of human and physical capital in 1980 and 2007 are estimated in accordance with the methodology explained in Appendix A1, which also provides a full list of countries' estimated shares in the stock of world production factors. Data on aggregate trade flows and country GDP is taken from the World Trade Organisation's database and the World Bank's World Development Indicators, respectively.

I initially let  $\theta = 0.5$  and note that in the data

$$|NX_{ct}| < 2 \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left| \frac{K_{ct}}{K_t} - \frac{H_{ct}}{H_t} \right| Q_t$$

for all countries and  $t = 1980, 2007$ . It follows from the discussion in Section 2.4.4 that the traded share of world output in 1980 and 2007, respectively, is given by

$$\frac{\sum_c (|M_{cK1980}| + |M_{cH1980}|)}{2Q_{1980}} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \sum_c \left| \frac{s_{c1980}}{s_{1980}} \frac{H_{c1980}}{H_{1980}} - \frac{H_{c1980}}{H_{1980}} \right|, \quad (35)$$

$$\frac{\sum_c (|M_{cK2007}| + |M_{cH2007}|)}{2Q_{2007}} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \sum_c \left| \frac{1}{\sigma_c^2} \left( \sum_c \frac{1}{\sigma_c^2} \right)^{-1} - \frac{H_{c2007}}{H_{2007}} \right|, \quad (36)$$

where I assume that financial globalisation occurred some time between these two years.<sup>15</sup> Equations (35) and (36) highlight the remaining data and parameters required to calibrate the model.

I take  $\{H_{c1980}/H_{1980}\}_c$  and  $\{H_{c2007}/K_{2007}\}_c$  from the data described in Appendix A1 and choose  $\{s_{c1980}\}_c$  to let  $\{s_{c1980}H_{c1980}/s_{1980}H_{1980}\}_c$  match my estimate of  $\{K_{c1980}/K_{1980}\}_c$ . I use  $\{\sigma_c^2\}_c$  to match the estimated  $\{K_{c2007}/K_{2007}\}_c$ . Note that the implied country variances merely rationalise my empirical estimates of countries' capital stocks in 2007 which, together with my human capital estimates, determine the volume of trade from equation (36). Whether these variances are, in fact, realistic is irrelevant for the model's predictions about the growth in world trade. Nevertheless, the model-implied country risk provides a consistency check for the determinants of international capital flows emphasised in Section 2.4. For this reason, I subject them to a more rigorous empirical assessment in Section 3.2.

As per convention, I set  $\alpha = 0.33$ . Together with my assumption about the value of  $\theta$  this implies  $\alpha_K = 0.67 - \alpha_H$  and I choose  $\alpha_K = 0.67$ ,  $\alpha_H = 0$ .

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<sup>15</sup>This assumption is innocuous as the absolute magnitude of international financial flows between 1950 and 1980 was sufficiently small to have had almost no perceptible impact on the patterns of capital accumulation across countries.



The latter has two advantages: given the remaining parameter choices, it maximises the set of capital-labour ratios for which equation (11) is satisfied and minimises the volume of factor-proportions trade for given differences in capital-labour ratios.<sup>16</sup> Put differently, the model will yield the most conservative predictions regarding the contribution of factor-proportions differences to overall world trade. I experiment with different values for  $\theta$ ,  $\alpha_K$  and  $\alpha_H$  in subsequent sections.

The WTO data puts the traded share of world output at 15.7% in 1980 and 22.2% in 2007. This implies an expansion of the traded share of world GDP by 6.5 percentage points.

### 3.1.2 Modelling Trade Openness

By using equation (35) and (36), I make the implicit assumption that all countries in my sample are completely open to trade with the rest of the world. While this may be a reasonable description of the set of advanced economies in 1980, the extent to which it applies to the developing countries in my sample is questionable. Since countries in the latter group are without exception characterised by relative capital scarcity, my assumptions about their trade openness are likely to affect the model's predictions about the volume and growth in world trade crucially.

As a first pass at addressing this issue, I divide my set of 28 large economies into two groups, separating all open economies in 1980 from largely closed economies. To determine openness, I employ the widely used index of trade openness by Sachs and Warner (1995), revised and updated by Wacziarg and Horn-Welch (2003). The index groups countries into open and closed economies based on information about tariff and non-tariff barriers to trade. Its realisations for my sample countries in 1980 are reported in appendix A1. I then assume that closed economies are autarkic as described in Section 2.1.4. Open economies are completely open to trade as in Sections 2.2 to 2.4. This results in an augmented version of equations (35) and (36):

$$\frac{\sum_{c \in C} (|M_{cK1980}| + |M_{cH1980}|)}{2(Q_{1980} + Q_{1980}^A)} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \sum_{c \in C} \left| \frac{s_{c1980}}{s_{1980}} \frac{H_{c1980}}{H_{1980}} - \frac{H_{c1980}}{H_{1980}} \right| \frac{Q_{1980}}{Q_{1980} + Q_{1980}^A}, \quad (35')$$

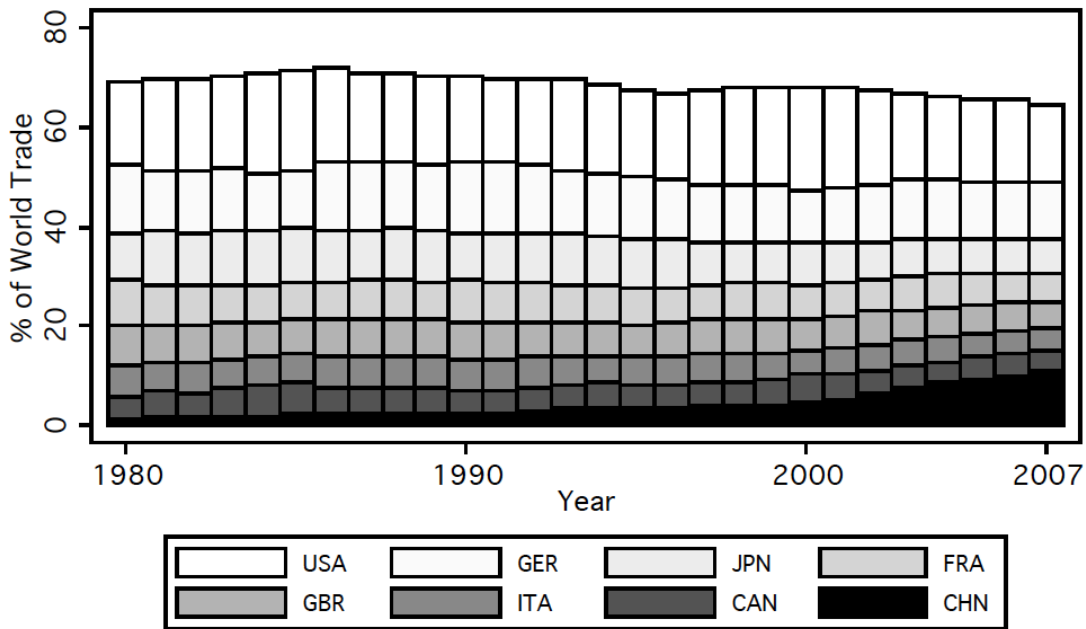
$$\frac{\sum_{c \in C} (|M_{cK2007}| + |M_{cH2007}|)}{2(Q_{2007} + Q_{2007}^A)} = \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \sum_{c \in C} \left| \frac{1}{\sigma_c^2} \left( \sum_c \frac{1}{\sigma_c^2} \right)^{-1} - \frac{H_{c2007}}{H_{2007}} \right| \frac{Q_{2007}}{Q_{2007} + Q_{2007}^A}, \quad (36')$$

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<sup>16</sup>Note that equation (11) holds and, hence, factor-price equalisation is predicted by the model for all parametrisation of  $\alpha_K$  and  $\alpha_H$  used in this section.

where  $Q_t^A = \sum_{c \in C^A} Q_{ct}^A$ , and  $C$  is the set of open and  $C^A$  the set of autarkic regions.

China constitutes a special case among my sample countries. The period of analysis coincides with the implementation of China’s “reform and opening up” which began in the late 1970s. While the significance of China’s integration into the global economy is widely acknowledged, it is difficult to overstate the momentous impact of incorporating China into any factor-proportions-based view of international commodity trade. With an estimated 37% of the world’s human capital and a capital stock per effective worker of approximately 10,000 GK\$ (both as of 2007), it is at once the largest economy in population terms by far, and one of the most capital-scarce.



Notes:  
Trade data is taken from the World Trade Organisation (WTO).

Figure 3.1: Country Shares of World Trade, 1980-2007

Figure 3.1 illustrates the rise of China by plotting the shares in world trade of the largest trading economies over the period 1980-2007. The figure shows that the relative size of these shares for all countries except China has been remarkably constant. The Chinese share in world trade, however, surged from under 1% to nearly 11% of world trade in the 27-year period, and the sum of Chinese exports and imports amounted to 0.68 of the sum of U.S. exports and imports by 2007.

Sachs and Warner (1995) and Wacziarg and Horn-Welch (2003) classify China as closed in 1980, and I follow their lead in grouping it among the set of autarkic regions in 1980. As Figure 3.1 indicates, assuming that China remained closed over the last three decades would cause the model to underestimate significantly the potential for factor-proportions trade in 2007. At the

same time, imposing a complete opening up of China by 2007 would perhaps overstate the extent of China’s contemporary trade openness and overestimate the current volume and, hence, the recent growth of factor-proportions trade.

I attempt to balance these concerns by allowing for a partial opening of China. In particular, I assume that China consists of a continuum of regions, all of which share the country’s aggregate capital-labour ratio. A share  $T_{China,2007}$  of these regions is completely open to trade in 2007, the remaining share  $1 - T_{China,2007}$  is completely autarkic.<sup>17</sup> I then calibrate  $T_{China,2007}$  to ensure that Chinese trade matches the observed share of Chinese exports and imports in world GDP in 2007, which is 2.4% according to WTO data.

### 3.1.3 Baseline Results

As a starting point, I calibrate the model using the data and parameters described in Section 3.1.1 and 3.1.2. The results are shown in Figure 3.2.

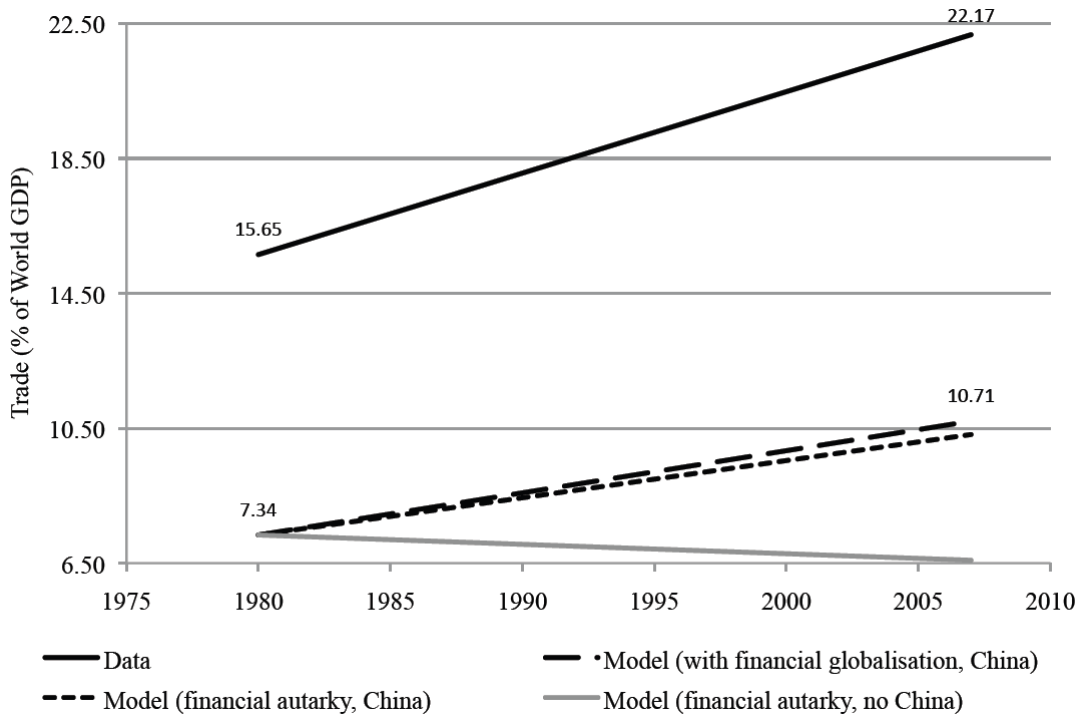


Figure 3.2: Basic Calibration

The model predicts an expansion of the traded share of world output by 3.4 percentage points, just over half of the increase observed in the data. By contrast, its predictions regarding the overall level of world trade in 1980 and 2007 – which are 7.3% and 10.7% of global output, respectively – fall short

<sup>17</sup>Assuming that globalisation proceeds as an increase in the share of a country’s “globalised” regions has the advantage of being highly tractable analytically. In particular, the share of globalised regions will have the same capital-labour ratio as the country as a whole and will satisfy equation (11) so long as the country’s aggregate factor proportions do.

of their empirical counterparts in both years. This accords with the view that factor-proportions-based models of international trade are of limited use in explaining the overall volume of trade. Yet, as evidenced by the above, such models are clearly capable of explaining a significant portion of the recent growth in world trade. In addition to this, my calibrated model predicts the overall level of trade by capital-scarce countries in 2007 well - 4.9% in the model as compared to 5.3% in the data - and matches the ratio of Chinese to U.S. trade in 2007 almost perfectly - 0.68 in the model as compared to 0.69 in the data.

Next I assess the contribution of financial globalisation and the opening of China to the growth in world trade as predicted by the model. Absent financial globalisation,

$$\frac{\sum_{c \in C} (|M_{cK2007}| + |M_{cH2007}|)}{2(Q_{2007} + Q_{2007}^A)} = \frac{\alpha(1 - \alpha)}{\alpha_K - \alpha_H} \sum_{c \in C} \left| \frac{s_{c2007}}{s_{2007}} \frac{H_{c2007}}{H_{2007}} - \frac{H_{c2007}}{H_{2007}} \right| \frac{Q_{2007}}{Q_{2007} + Q_{2007}^A}, \quad (37)$$

and to calibrate  $\{s_{c2007}\}_c$  I construct a set of counterfactual capital stocks for the year 2007,  $\{\hat{K}_{c2007}/K_{2007}\}_c$ , using the perpetual inventory method but letting domestic investment equal domestic savings. A detailed description of the construction of these counterfactual capital stocks, and countries' counterfactual shares in the world stock of capital are provided in Appendix A1. Using equations (35') and (37) I find that the occurrence of financial globalisation alongside the opening of China increased world trade as a share of world output by about 0.5 percentage points over and above the increase that would have occurred in continued financial autarky - enough to push the portion of world trade growth explained by the model above the 50%-mark.

Assuming financial globalisation but letting  $T_{China,2007} = T_{China,1980} = 0$ , the model predicts a *decrease* in the traded share of world output by 0.5 percentage points. This suggests, on the one hand, that the emergence of China accounts for most of the increase in world trade explained by the model and, on the other, that in the absence of China's opening the relative factor endowments of open economies would have become more homogeneous, reducing the motive for factor proportions trade. Had China remained autarkic and financial globalisation not occurred, countries' factor proportions would have become even more similar, and factor-proportions trade would have decline by 0.7 percentage points of world GDP. However, I will show in Section 3.1.4 that the finding of a decline in factor-proportions trade without China and financial globalisation is sensitive to the assumptions about the relative trade openness of countries in 1980 and 2007.

According to the model, China's opening under the assumption of financial

autarky would have increased the traded share of world output by 3 percentage points, while it would have decreased by 0.5 percentage points if financial globalisation had occurred but China had remained closed. Close to 30% of the predicted 3.5 percentage-point rise in the traded share of world GDP is thus due to the interaction between these two events. The size of this interactive effect should not come as a surprise. As previously noted, capital flows have raised the capital-labour ratios of some of the world’s most capital-abundant economies. If, in addition, the most recent wave of globalisation has integrated regions with below-average capital-labour ratios into global commodity markets – which is clearly true in the case of China – this ought to have exacerbated the effect of increased capital abundance among open, capital-importing countries in accordance with equation (25).

Parameters			Trade Growth			
$\alpha_K - \alpha_H$	$\theta$	Openness <sup>1)</sup>	% Explained	% Explained Without Capital Flows	China	Both
0.67	0.50	Sachs and Warner (1995) for $c \neq$ China; $T_{China,1980} = 0$ , $T_{China,2007}$ to match Chinese trade as a share of world GDP in 2007.	51.7	45.7	-8.5	-11.5
0.67	0.50	Trade Freedom Index for $c \neq$ China; $T_{China,1980} = 0$ , $T_{China,2007}$ to match Chinese trade as a share of world GDP in 2007.	67.9	61.4	10.7	8.1
0.67	0.50	Sachs and Warner (1995) for $c \neq$ China; $T_{China,1980} = 0$ , $T_{China,2007}$ and $T_c,2007$ for $c \in C^d$ to match Chinese and $C^d$ trade as a share of world GDP in 2007.	85.5	78.8	27.0	24.1
0.67	0.35	Sachs and Warner (1995) for $c \neq$ China; $T_{China,1980} = 0$ , $T_{China,2007}$ to match Chinese trade as a share of world GDP in 2007.	55.6	45.7	-5.7	-11.5
1.00	0.33	Sachs and Warner (1995) for $c \neq$ China; $T_{China,1980} = 0$ , $T_{China,2007}$ to match Chinese trade as a share of world GDP in 2007.	56.7	46.6	-1.0	-7.7

<sup>1)</sup> See text for details.

Table 3: Calibration Results

In the following sections, I explore a number of alternative calibrations to verify the robustness of the findings presented above. For ease of comparison, all calibration results are summarised in Table 3. The robustness checks reaffirm the broad message of the baseline calibration. A factor-proportions model of international commodity trade which accounts for the emergence of China as a major trading country can explain most of the growth in world trade over the last three decades. The majority of the predicted trade growth

is due to the opening of China, with a smaller but significantly sized share due to financial globalisation and the resulting pattern of South-North capital flows.

### 3.1.4 Alternative Assumptions About Trade Openness

To check whether my findings are sensitive to the use of the Sachs-Warner index to group the world into autarkic and open regions, I use the Heritage Foundation's Trade Freedom index as an alternative measure of initial trade openness.<sup>18</sup> Similarly to the case of China described in Section 3.1.2, I divide each country into a time-invariant share  $T_c$  of open and  $1 - T_c$  autarkic regions based on its Trade Freedom score. The fact that the index ranges from 0 to 1 facilitates this calibration. I treat China as before, setting  $T_{China,1980} = 0$  and  $T_{China,2007}$  sufficiently high to match the ratio of Chinese trade to world output in 2007.

Calibrating the model in this manner, I find that it predicts higher volumes of factor-proportions trade – namely 9.2% in 1980 and 13.6% in 2007 – and explains 68% of the growth in world trade since 1980. Assuming away financial globalisation reduces the explanatory power of the model by 10%, while assuming away the opening of China reduces it by 84%. However, even in the absence of both the model now predicts a modest increase in trade, suggesting that the evolution of relative factor endowments in the assumed absence of China's opening and financial globalisation depends on the precise composition of the (remaining) group of trading economies.

So far, I have kept trade openness in all countries except China constant throughout. I now relax this assumption. Once again, I use the Sachs-Warner index to determine whether or not a country is open in 1980, as in Section 3.1.2. I set  $T_{China,1980} = 0$  and  $T_{China,2007}$  to match Chinese trade over world GDP in 2007. Additionally, I allow for a uniform opening of all countries which are classified as closed in 1980 and set their openness parameter in 2007 so as to match their combined level of trade relative to world output in that year.

The model now explains a remarkable 86% of the growth in world trade since 1980. The comparative importance of financial globalisation for the explained increase remains unchanged but, intuitively, the role of China – which is still significant – is somewhat lessened by the assumed opening up of a sizable group of capital-scarce economies.

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<sup>18</sup>As the Trade Freedom index was first published in 1995, I use the Heritage Foundation's methodology to extend it back to 1980 using data on tariff rates from Clemens and Williamson (2004) and non-tariff barriers from Wacziarg and Horn-Welch (2003). I am grateful to Michael Clemens and Jeffrey Williamson for kindly sharing their data.

### 3.1.5 The Role of Trade Imbalances

So far I have arbitrarily let  $\theta = 0.5$ . As discussed in Section 2.4.4, this assumption is convenient because it ensures that sufficiently small trade imbalances will manifest themselves in the form of a reduction in exports and an equally-sized increase in imports, the combined effect of which leaves the sum of exports and imports unchanged. This allowed me to disregard the role of trade imbalances in determining the overall volume and growth of world trade up to now.

In this section I analyse the effect of choosing  $\theta \neq 0.5$ . To show the impact of trade imbalances in the calibration setting I employed so far, I retain the assumption that  $\alpha_K - \alpha_H = 0.67$  and  $\alpha = 0.33$ . Hence,  $\theta = 0.5 - 1.5\alpha_H$ . I choose  $\alpha_H = 0.1$ , the largest value for which equation (11) remains satisfied for all countries and years, yielding  $\theta = 0.35$ .

Given  $\theta \neq 0.5$ , equation (36') is replaced by

$$\begin{aligned} \frac{\sum_{c \in C} (|M_{cK2007}| + |M_{cH2007}|)}{2(Q_{2007} + Q_{2007}^A)} &= \frac{1}{2} \frac{Q_{2007}}{Q_{2007} + Q_{2007}^A} \times \\ \sum_{c \in C} \left\{ \left| \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left[ \frac{1}{\sigma_c^2} \left( \sum_c \frac{1}{\sigma_c^2} \right)^{-1} - \frac{H_{c2007}}{H_{2007}} \right] + \theta \frac{NX_{c2007}}{Q_{2007}} \right| + \right. & \quad (38) \\ \left. \left| \frac{\alpha(1-\alpha)}{\alpha_K - \alpha_H} \left[ \frac{1}{\sigma_c^2} \left( \sum_c \frac{1}{\sigma_c^2} \right)^{-1} - \frac{H_{c2007}}{H_{2007}} \right] - (1-\theta) \frac{NX_{c2007}}{Q_{2007}} \right| \right\}, \end{aligned}$$

while equations (35') and (37) remain unchanged because trade is necessarily balanced in financial autarky. I select  $\{NX_{c2007}\}_c$  to match countries empirical trade balances, using WTO data.

A comparison between rows 1 and 4 of Table 3 shows that allowing for trade imbalances with  $\theta = 0.35$  increases the share of world trade growth explained by the calibrated model by almost 4 percentage points. This, in turn, gives greater importance to financial globalisation as a source of trade growth between 1980 and 2007. The reason for this is as follows. With  $\theta < 0.5$ , a trade deficit increases domestic demand for capital-intensive products less than for labour-intensive products. Conversely, a trade surplus decreases domestic demand for capital-intensive products less than for labour-intensive products. Consequently, if deficit countries are – on average – capital-abundant and surplus countries labour-abundant, trade imbalances will increase global trade. The increase in trade growth predicted by the model is thus largely due to the substantial trade deficit of the United States in 2007 (amounting to 1.9% of world GDP) and the sizable trade surplus of China (about 0.6% of world GDP). If, on the other hand,  $\theta > 0.5$  had been chosen, the pattern would be reversed: the model would predict the observed pattern of trade surpluses and

deficits to reduce global trade, and it would predict a smaller increase in global trade.

I do not explore the latter case here because values of  $\theta$  significantly above 0.5 are incompatible with the requirement that (11) holds for all countries. Ultimately, the appropriate value of  $\theta$  depends on the extent to which trade imbalances affect the patterns of comparative advantage and the volume of trade in practice – an empirical question which is beyond the scope of this paper. Choosing  $\theta = 0.5$  enables me not to take a stance either way while this issue remains unresolved.

### 3.1.6 The Role of Industry Capital Intensities

While the difference between the capital intensities of the  $K$ - and the  $H$ -intermediate is a crucial determinant of the volume of trade generated by the model, it is difficult to know how to calibrate  $\alpha_K$  and  $\alpha_H$  appropriately to capture the real-life technological differences between more and less capital-intensive industries. An important question, therefore, is whether the precise choice of parameters matters for the model’s prediction regarding world trade growth. As it turns out, the nature of my calibration strategy implies that this is not the case.

As an example, I choose  $\alpha_K = 1$ ,  $\alpha_H = 0$ . Under this assumption, equation (11) holds for all country irrespective of the difference between their capital-labour ratio and the world’s. To ensure that  $\alpha = 0.33$  I now require  $\theta = 0.33$ , which means that trade imbalances will play the same role as in Section 3.1.5. All other aspects of the calibration exercise remain the same as in the baseline case. As rows 4 and 5 of Table 3 illustrate, the main difference between this calibration and the one in Section 3.1.5 is the difference between the capital intensities of the  $K$ - and  $H$ -intermediate. However, the results are strikingly similar, despite the model’s relatively lower propensity to generate trade from factor-proportions differences in row 5.

The reason for this is the way in which I model the opening up of China. Precisely because  $\alpha_K - \alpha_H = 1$  results in a lower propensity of the model to generate trade volume, it requires  $T_{China,2007}$  to be larger – i.e. China to have become more open – in order to match the level of Chinese exports and imports in 2007. The implied additional opening of China largely offsets the model’s reduced ability to generate high volumes of trade. Put differently, insofar as China’s trade with the rest of the world is mostly due to factor-proportions differences, the model’s ability to explain the growth in trade is highly robust to the precise choice of  $\alpha_K$  and  $\alpha_H$ .



## 3.2 The Pattern of Capital Flows, 1980-2007

### 3.2.1 Measuring Country Risk

In Section 2.4.1, I show that if international commodity trade equalises factor returns unimpeded international asset trade will lead to capital investments in different regions which only reflect their relative country risk, with each region's capital stock corresponding to its optimal share in the world's risk-minimising portfolio, i.e.

$$\frac{K_{ct}}{K_t} = \frac{1}{\sigma_c^2} \left( \sum_c \frac{1}{\sigma_c^2} \right)^{-1}.$$

Assuming that financial globalisation occurred some time prior to 2007, I choose  $\{\sigma_c^2\}_c$  so as to match  $\{K_{c2007}/K_{2007}\}_c$  throughout Section 3.1. In this section I will assess the empirical validity of the resulting country risk profiles.

In order to do so, it is first necessary to obtain empirical estimates of idiosyncratic country risk. I use the relationship between country and world variables in an integrated world economy established in Sections 2.2 to 2.4. Specifically, equation (15) can be used to show that

$$g_{ct} - g_t \approx \ln \left[ \alpha \frac{K_{ct}}{K_t} + (1 - \alpha) \frac{H_c}{H} \right] - \ln \left[ \alpha \frac{K_{ct-1}}{K_{t-1}} + (1 - \alpha) \frac{H_c}{H} \right], \quad (39)$$

where  $g_{ct}$  is the growth rate of  $c$ 's GDP and  $g_t$  is the growth rate of world GDP. Assuming - as I have throughout - that human capital accumulation proceeds sluggishly, any short-term fluctuations in  $g_{ct} - g_t$  can be attributed to country-specific investment shocks. I therefore estimate

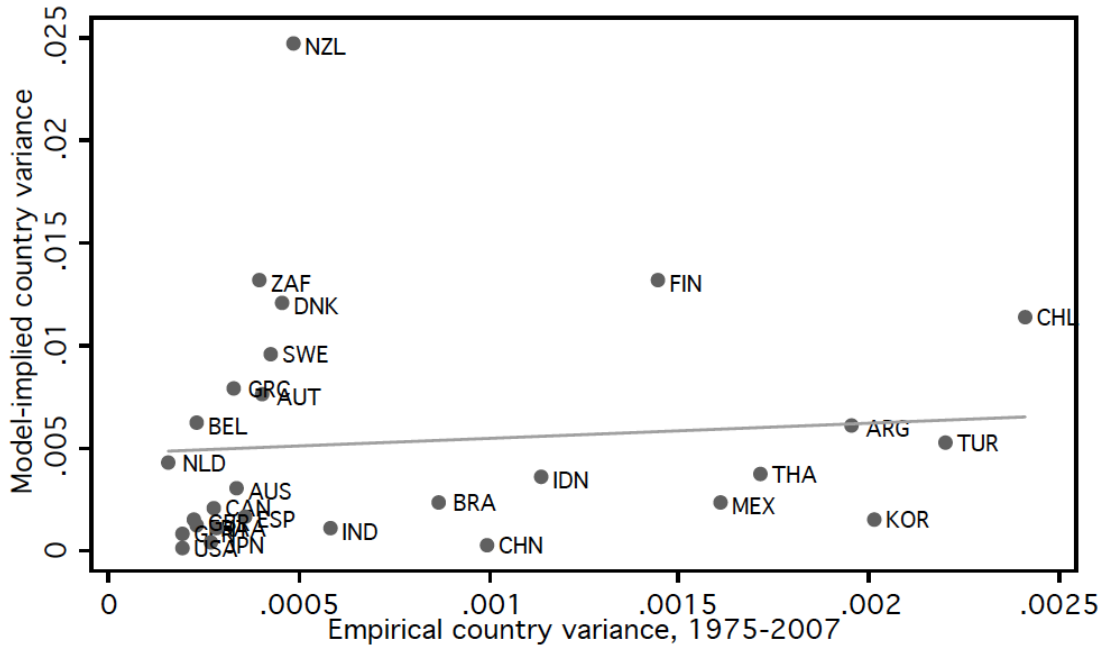
$$g_{ct} - g_t = \alpha_c + \beta_{1c}t + \beta_{2c}t^2 + \beta_{3c}t^3 + \varepsilon_{ct},$$

and let  $\hat{\sigma}_c^2 = \text{Var}(\hat{\varepsilon}_{ct})$ .<sup>19</sup> The growth-rate differential  $g_{ct} - g_t$  is based on cross-country per-capita GDP data in constant, PPP-adjusted dollars, based on Heston, Summers and Aten (2009).

The thus derived country variances for the period 1975-2007,  $\{\hat{\sigma}_c^2\}_c$ , are strongly and significantly correlated with the average PRSG country risk score for the same period, with a correlation coefficient of 0.6. The PRSG index, which is partly based on surveys of perceived country risk among international investment professionals, was used as a rough measure of country risk in the

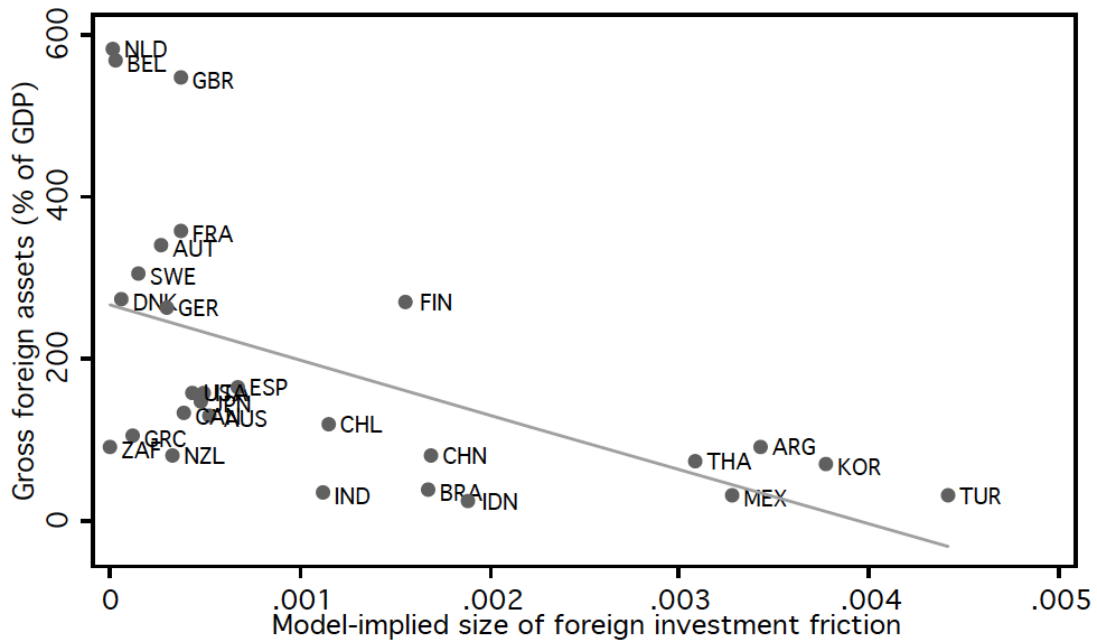
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<sup>19</sup>The subsequent findings are not sensitive to the use of a quadratic instead of a cubic time trend, or to letting  $\hat{\sigma}_c^2$  equal the variance of the HP-filtered difference between  $c$ 's and the world's growth rate.



Notes:  
 The model-implied country variance is derived by matching countries' shares in world investment from Section 2.4.1 with their shares in the world capital stock in 2007. The empirical country variance is the variance of idiosyncratic, short-term fluctuations in country GDP (see text). The correlation is .1.

Figure 3.3: Model-Implied and Empirical Country Risk



Notes:  
 The size of the country-specific foreign investment friction is derived by matching countries' shares in world investment from Section 3.2.2 with their shares in the world capital stock in 2007, given the estimated country variances (see text). Foreign asset data for 2007 is taken from Lane and Milesi-Ferretti (2009). The correlation is -.5.

Figure 3.4: Model-Implied Financial Openness and Foreign Asset Holdings

Introduction. It therefore seems safe to argue that my estimated country variances meaningfully rank countries in terms of their perceived investment risk.

### 3.2.2 Model-Implied and Actual Country Risk

Figure 3.3 plots countries' investment risk as implied by the calibration in Section 3.1 against the empirical country risk estimated in the previous section. As is immediately evident, the resulting fit is rather poor: the correlation between the two variables is a mere 0.1. The model-implied country risk is close to zero for almost all of the largest economies but assigns unrealistically high values to many of the small countries.

Upon second examination, this finding should come as no surprise. The risk-investment regressions referred to in the Introduction (and described in full in Appendix A2), highlight the continued importance of domestic savings as a determinant of domestic investment. In accordance with these findings, economies with a larger pool of domestic savings would be expected to have larger capital stocks for a given level of country risk. By contrast, in the benchmark model in Section 2 domestic savings play no role at all in determining investment in financially open economies. The model thus attributes the relatively large share of the world capital stock located in the largest economies to relatively low country risk.

The reason for this prediction of the model is that I have taken an extreme view of financial globalisation so far: trading in foreign assets is no more costly than buying or selling domestic assets for agents in a given  $c$ . Suppose, instead, that for each unit of consumption spent by an agent in  $c$  on assets from region  $c' \neq c$ , the agent can only appropriate the returns to  $1 - \tau_c$  units of the foreign asset.<sup>20</sup> This additional cost of foreign asset purchases reduces the expected returns from, and hence the relative attractiveness of, foreign assets and causes a "home bias" in investment portfolios. As a result, the optimal investment portfolio is no longer universal, and it can be shown that for agents in region  $c$

$$\phi_{c'}^c = \max \left\{ \frac{1}{\sigma_{c'}^2} \left( \sum_{c'} \frac{1}{\sigma_{c'}^2} \right)^{-1} \left( 1 - \frac{\tau_c}{\gamma \sigma_c^2} \right), 0 \right\} \quad \forall c' \neq c, \quad (40)$$

$$\phi_c^c = 1 - \sum_{c' \neq c} \phi_{c'}^c. \quad (41)$$

If  $\tau_c \geq \theta \sigma_c^2$ , agents in  $c$  will choose not to purchase foreign assets at all. If  $\tau_c \rightarrow 0$ , (40) and (41) approach the optimal frictionless world portfolio

<sup>20</sup>One could think of  $\tau_c$  as a tax on foreign transactions by  $c$ 's government, or an agency or information cost specific to  $c$  which is higher for foreign than for domestic investments.

described by equation (27). An immediate implication of (40) and (41) is that the higher the average  $\tau_c$  (and hence the average  $\phi_c^e$ ), the greater the role for domestic savings as a determinant of domestic investments.

Introducing a set of financial frictions permits me to set  $\{\sigma_c^2\}_c$  equal to  $\{\hat{\sigma}_c^2\}_c$  and use  $\{\tau_c\}_c$  to match  $\{K_{c2007}/K_{2007}\}_c$ . As agents now face a risk-return trade-off, I need to specify a value for  $\gamma$ , the coefficient of relative risk aversion. In line with the RBC literature, I let  $\gamma = 2$ . It turns out that the system of 28 equations described by

$$\frac{K_{c2007}}{K_{2007}} = \sum_{c'=1}^C \phi_{c'}^e(\{\tau_{c'}\}_{c'})$$

has a unique interior solution in which  $\tau_c > 0$  for all  $c$ . The resulting set of model-implied financial frictions provides an inverse measure of financial openness for my sample countries: the smaller  $\tau_c$ , the more open is  $c$  to foreign asset trade. This, however, raises the question whether the model's new implications for financial openness are more consistent with empirical reality than the country risk profiles implied by the frictionless model.

Figure 3.4 shows that this is indeed the case. It plots countries' gross holdings of foreign assets as a percentage of GDP – based on data from Lane and Milesi-Ferretti (2009) – against the model-implied values of country-specific foreign investment frictions. The correlation between both is strongly negative at  $-0.5$ , and statistically significant. Countries which face a higher cost of foreign asset purchases according to the model, do indeed seem to purchase fewer foreign assets in the data.

In the light of this section, we may interpret countries' observed shares in the world capital stock as consistent with an augmented version of the model from Section 2 in which countries, instead of having moved from financial autarky to complete financial integration between 1980 and 2007, still face small frictions in international asset trade. A natural question which arises from this is how the future evolution of these financial frictions will affect the long-term pattern of international investment and, hence, the growth in world trade. The next section makes a first pass at providing an answer.

### 3.2.3 Long-Run Implications of Financial Globalisation for World Trade Growth

I start from my baseline calibration in Section 3.1.3, but matching  $\{K_{c2007}/K_{2007}\}_c$  with my empirical country risk measure and the set of financial frictions,  $\{\tau_c\}_c$ , as described in the previous section. I then treat the long run as a third period of my model – following  $t = 1980, 2007$  – identical with the most recent year

in all respects, except the size of the prevailing financial frictions.

In doing so, I make several additional, somewhat heroic assumptions. First, I assume that countries' share in the world stock of human capital remains constant and, more contentiously, that the variance of countries' investment shocks remains unchanged over time. Second, I assume that the model's ability to predict the volume of trade is unaltered between 2007 and the long run, so that even over longer horizons the model's prediction as to the traded share of world output falls 52% short of the observed share. Finally, I keep the extent of China's trade openness constant. The latter assumption is not essential but allows me to illustrate the pure effect of increases in global financial integration.

Figure 3.5 plots world trade as a share of world output for different long-run paths of the average financial friction, assuming a uniform decline across countries. The first scenario (solid black line) depicts the case in which financial frictions remain at their model-implied size as of 2007. Unsurprisingly, the model predicts no further trade growth in this setting. The second, third, fourth and fifth scenarios describe the more optimistic cases in which the average friction declines by 25%, 50%, 75% and 100%, respectively.

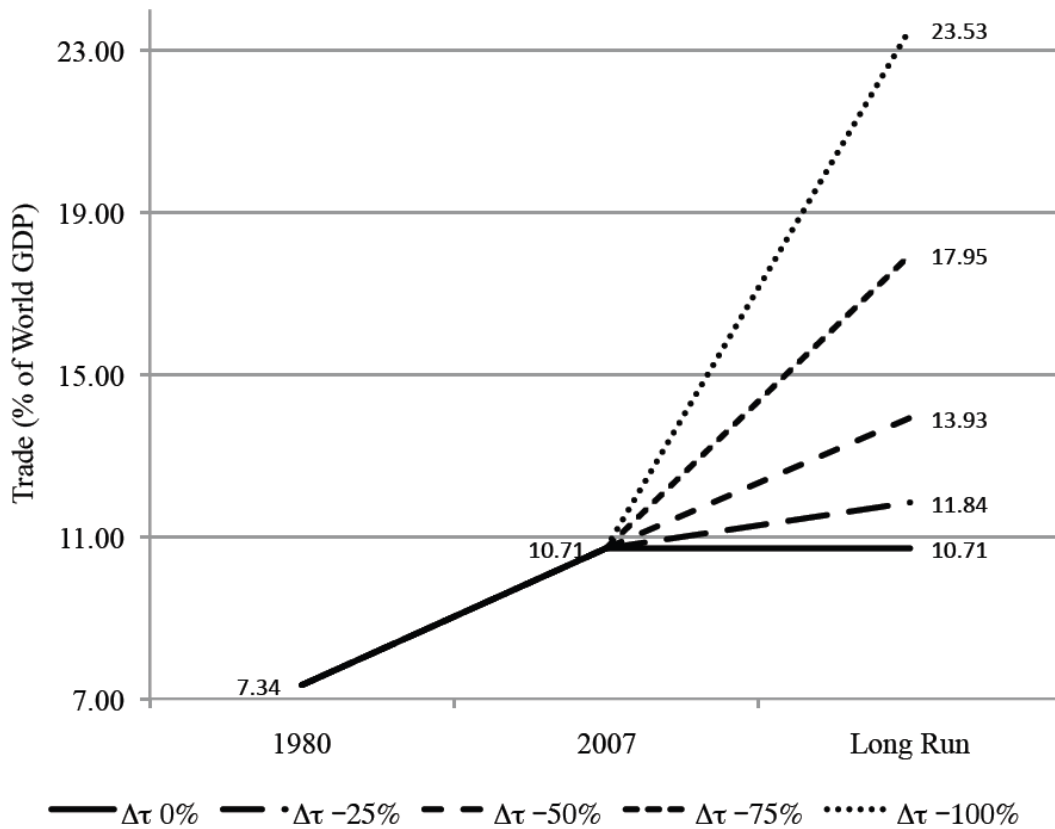


Figure 3.5: The Growth of World Trade in the Long Run

A 25% decline in the average financial friction raises the model-predicted level of trade relative to world output to 11.8%, suggesting that further financial integration may raise world trade by 11% in the long run. A 50% decline

would result in a long-run increase of 30% and a 75% decline in a long-run increase of 68%. If financial frictions were to disappear all together, world trade would grow by a staggering 120%. The present model thus predicts the marginal impact on trade of declining financial frictions to be increasing.

This finding is noteworthy because, in his discussion of the growth in world trade, Yi (2003) shows that standard trade models predict declining global tariffs to exert a diminishing impact on world trade. This observation leads him to describe the exponential growth of world trade as a “qualitative puzzle”. The analysis presented in this section suggests that, instead of declining trade barriers, decreasing international financial frictions may account for the exponential increase in the traded share of world GDP in recent years.

## 4 Summary and Conclusion

In this paper I document that a classical model of comparative advantage due to differences in countries' relative endowments of production factors can explain most of the recent growth of world trade. This largely reflects a rise in the volume of trade between countries with very different capital-labour ratios but also, to a significant extent, a pattern of international capital flows which has exacerbated factor-proportions differences, increasing the incentives for specialisation. My model and calibrations highlight that the growing prevalence of factor-proportions trade may explain why financial globalisation has taken this unexpected turn: if international commodity trade equalises factor returns – a classical prediction of factor-proportions models –, the importance of country risk as a determinant of international investment patterns is enhanced. Net financial flows to relatively safe countries may drive capital-labour ratios further apart if these countries also account for a small portion of the world's effective workforce.

My findings suggest that, while factor-proportions trade continues to account only for a fraction of world trade, its share has been rising. This calls for a reexamination of the importance of factor endowments as a determinant of specialisation. Half a century of empirical research, starting with Lerner (1952) and Leontieff (1953), has obtained mixed results concerning the ability of factor-proportions models to explain the factor content of trade.<sup>21</sup> However, recent work by Davis and Weinstein (2001, 2002) shows that a careful application of such models to the analysis of trade among OECD countries reveals a strong relationship between factor endowments and the patterns of exports and imports. A question which naturally arises from the above is whether the rise in the volume of North-South trade – and, in particular, in the volume of China's trade with the rest of the world – has affected specialisation patterns among developed economies. This paper has provided some suggestive evidence,<sup>22</sup> but a thorough investigation of this issue in future research should prove instructive.

If a growing share of world trade is due to classical comparative advantage, this also has significant implications for the analysis of international business cycles. Since most of world trade used to take place between relatively similar, highly industrialised countries the international real business cycle (IRBC) literature has tended to model international trade in a manner consistent with new trade theory.<sup>23</sup> In the light of my findings, it appears worthwhile to

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<sup>21</sup>This literature is surveyed in Helpman (1999).

<sup>22</sup>See Appendix A2.

<sup>23</sup>See, among others, Backus, Kehoe and Kydland (1994), Kose and Yi (2006) and

examine how robust the predictions of such models are to the inclusion of classical motives for trade. For example, in a factor-proportions model the impact of a trade deficit/surplus on a country's volume of trade with the rest of the world generally depends on the country's comparative advantage, as explained in Section 2. In a standard IRBC model, by contrast, it depends on the effect of the trade deficit/surplus on the country's GDP. The underlying assumption about the nature of trade may thus crucially affect a model's predicted impact of trade imbalances on trade volumes, both quantitatively and qualitatively.

I have attributed a large share of the recent growth in world trade to the deepening integration of China into the world economy, and financial globalisation which has given rise to the observed pattern of capital flows from capital-scarce to capital-abundant countries. Yet neither of these processes is concluded. My calibrations imply, reasonably, that China has not yet reached the same degree of trade openness as the group of developed countries and that some barriers to international asset trade remain. Holding everything else constant, therefore, these processes should continue to shape the patterns of specialisation and the growth of world trade for some time to come.

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Burstein, Kurz and Tesar (2008). Although these papers assume Armington trade in intermediate goods which are aggregated by means of a CES production into a composite final good, this is analytically equivalent with the standard Helpman-Krugman framework.



# Appendix A1 - Factor Endowment Data

## A1.1 Data Construction

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

I generate estimates of factual capital stocks,  $K_{ct}$ , using the perpetual inventory equation

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

where  $I_t$  is gross investment in country  $c$  at  $t$  and  $\delta$  is the constant depreciation rate. Investment data in constant, PPP-adjusted 2005 \$ is taken from Heston, Summers and Aten (2009) and, in line with convention, I set  $\delta = .06^{24}$ . I start in the year 1950 and, following standard practice, compute  $K_{c0}$  as  $\frac{I_{c0}}{g_{I_c} + \delta}$ , where  $g_{I_c}$  is the average geometric growth rate of the investment series. However, the choice of  $K_{c0}$  is immaterial since, with a depreciation rate of 6%, it has little impact on the estimated capital stock in 1980.

To construct capital stocks in the counterfactual scenario of financial autarky,  $\hat{K}_{ct}$ , I proceed as above but use an augmented version of the perpetual inventory equation

$$\hat{K}_{ct} = S_{ct} + (1 - \delta) \hat{K}_{ct-1},$$

where  $S_{ct}$  are gross domestic savings in country  $c$  at  $t$ . The reasoning behind this new equation is as follows: from the national accounting identities,

$$S_{ct} = I_{ct} + CA_{ct},$$

where  $CA_{ct}$  is country  $c$ 's current account at  $t$ , so  $I_{ct} = S_{ct}$  in financially closed economies. Assuming constant savings rates, the set of counterfactual capital stocks thus provides a benchmark against which the impact of net international financial flows on the observed pattern of capital accumulation can be judged.<sup>25</sup>  $S_{ct}$  is constructed using the aforementioned investment series as well as data on the current account (as a percentage of GDP) from the

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<sup>24</sup>The paper's qualitative results concerning the impact of international capital flows on the distribution of capital-labour ratios and the resulting patterns of trade are unaffected by the choice of  $\delta$ . However, as large-scale cross-border financial flows have increased over the course of the time period under consideration, a larger  $\delta$  - which increases the relative weight of *recent* investment patterns - increases the quantitative importance of capital flows as a determinant of present-day capital stocks. Correspondingly, a smaller  $\delta$  reduces it.

<sup>25</sup>The assumption that countries' observed savings rates would have been the same in counterfactual financial autarky may seem contentious because, in practice, the occurrence of financial globalisation is likely to have affected countries' interest rates. However, there is a large number of studies suggesting that the interest elasticity of savings is close to zero, both in advanced economies - see, for example, Blinder (1975, 1981), Mankiw (1981), Campbell and Mankiw (1989, 1991) - and in developing countries - see Giovannini (1983).

IMF's *International Financial Statistics* (2010).

Finally, I estimate the stock of human capital based on the size of the working-age population, using total population figures from Heston, Summers and Aten (2009) and multiplying with the population share of individuals between 15 and 65 from the World Bank's *World Development Indicators* (2010). The "quality adjustment" follows Hall and Jones (1999):

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

where  $L_{ct}$  is the working-age population and  $s_{ct}$  is the average number of years of schooling in country  $c$  at  $t$ . The function  $f()$  is piecewise linear with

$$f(s_{ct}) = \begin{cases} 0.13s_{ct} & \text{if } s_{ct} \leq 4 \\ 0.10s_{ct} & \text{if } 4 < s_{ct} \leq 8, \\ 0.07s_{ct} & \text{if } 8 < s_{ct} \end{cases}$$

and  $s_{ct}$  is based on the average years of schooling in the population above the age of 15 from Barro and Lee (2010).<sup>26</sup> Average years of schooling are observed quinquennially, most recently in 2010. Since  $s_{ct}$  moves slowly over time, a quinquennial observation can plausibly be employed for nearby dates as well.

Throughout the paper I assume that the accumulation of physical capital is affected by international financial flows, but the accumulation of human capital is not.

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<sup>26</sup>The paper's key empirical findings are, if anything, strengthened if population or the size of the workforce are used instead of the "quality adjusted" workforce to measure human capital endowments.

## A1.2 Shares of World Factor Endowments, 1980 and 2007

	Data				Counterf.	Sachs and Warner ('95)
	$(H_c/H)_{1980}$	$(K_c/K)_{1980}$	$(H_c/H)_{2007}$	$(K_c/K)_{2007}$	$(K_c/K)_{2007}$	Open in 1980?
Argentina	.012	.016	.009	.008	.009	No
Australia	.007	.017	.006	.017	.015	Yes
Austria	.003	.010	.002	.007	.007	Yes
Belgium	.004	.012	.003	.008	.009	Yes
Brazil	.035	.031	.049	.021	.020	No
Canada	.011	.025	.009	.024	.025	Yes
Chile	.005	.004	.004	.005	.004	Yes
China	.323	.034	.370	.152	.177	No
Denmark	.002	.005	.001	.004	.005	Yes
Finland	.002	.006	.001	.004	.004	Yes
France	.022	.062	.015	.042	.043	Yes
Germany	.031	.108	.023	.059	.064	Yes
Greece	.004	.011	.003	.006	.005	Yes
India	.174	.026	.209	.046	.045	No
Indonesia	.048	.008	.050	.014	.015	Yes
Italy	.024	.061	.013	.044	.043	Yes
Japan	.052	.146	.034	.119	.130	Yes
Korea, Rep.	.014	.010	.014	.032	.034	Yes
Mexico	.020	.026	.023	.022	.021	Yes
Netherlands	.006	.017	.004	.012	.014	Yes
New Zealand	.002	.003	.001	.002	.002	Yes
South Africa	.009	.006	.010	.004	.003	No
Spain	.015	.034	.010	.031	.028	Yes
Sweden	.004	.009	.002	.005	.006	Yes
Thailand	.014	.008	.017	.014	.014	Yes
Turkey	.013	.006	.017	.010	.009	No
U.K.	.022	.043	.014	.034	.031	Yes
U.S.	.121	.255	.086	.253	.220	Yes

# Appendix A2 - Empirical Appendix

## A2.1 Specialisation

The model described in Section 2 emphasises the importance of relative factor endowments for industrial specialisation and, consequently, as a reason for countries to trade. Appealing to the classical *Heckscher-Ohlin* theorem, the model predicts that countries with large amounts of installed physical capital relative to their endowment of human capital will be exporters of relatively capital-intensive products. Here, I verify that this prediction of the model is in tune with the empirical patterns of specialisation and trade using U.S. data on sector-level imports from its major trading partners.

Romalis (2004) shows that, under the reasonable assumptions that real-life international product markets are characterised by some degree of imperfect competition and small trading frictions, a two-factor Heckscher-Ohlin model would predict approximately the following relationship between import patterns and factor proportions:

$$\frac{M_{ci}^{US}}{M_i^{US}} = \beta_0 + \beta_1 \alpha_i \frac{K_c}{H_c} + \delta_c + \delta_i + \varepsilon_{ci},$$

where  $\frac{M_{ci}^{US}}{M_i^{US}}$  is the share of U.S. imports in industry  $i$  sourced from country  $c$ ,  $\alpha_i$  is a measure of the capital intensity of industry  $i$ ,  $\frac{K_c}{H_c}$  is  $c$ 's capital-labour ratio and  $\delta_c$  and  $\delta_i$  are, respectively, a full set of country and industry fixed effects. I will use this regression equation to test the Heckscher-Ohlin prediction of the model for the years 1980, 1985, 1990, 1995, 2000 and 2005.

In addition, the model predicts that countries should absorb an increase in their factor abundance by means of structural transformation, i.e. by becoming more specialised in industries which use the increasingly abundant factor relatively intensively. This corresponds to the classical *Rybczynski* theorem. I will use the equation

$$\Delta \frac{M_{ci}^{US}}{M_i^{US}} = \tilde{\beta}_0 + \tilde{\beta}_1 \alpha_i \Delta \frac{K_c}{H_c} + \tilde{\delta}_c + \tilde{\delta}_i + \tilde{\varepsilon}_{ci}$$

to test the Rybczynski prediction of the model for the periods 1985-1995 and 1995-2005.

To calculate U.S. sectoral import shares, I use sector-level data on imports from the U.S. Census, assembled and converted to the 4-digit level of SIC by Feenstra (2009). The data I employ covers U.S. imports from the 27 largest economies in more than 400 distinct sectors.

I construct an index of capital intensity at the 4-digit level of SIC from

data provided in the NBER-CES Manufacturing Industry Database. In line with previous papers, I rank industries by the average non-wage share of U.S. manufacturing value added in the period 1958 to 2005. This ranking, normalised between 0 and 1, is taken as a measure of capital intensity. Note that this amounts to assuming that the technological capital intensity measured for the United States in a given sector  $i$  is a good description of the properties of this sector's production function for *any* country. This standard assumption is made partly for reasons of empirical convenience - as detailed sector-level manufacturing data would not be available for all countries in the given sample -, and partly because U.S. product and factor markets are considered to be among the world's most competitive and frictionless, so that the relative usage of capital and labour in U.S. manufacturing is most likely to reflect the true technological properties of different industries, rather than allocative distortions.

Finally, country shares in world physical and human capital are calculated on the basis of the physical-capital and human-capital estimates discussed in Appendix A1.

<i>Dep. Variable: <math>m_{it}</math></i>	(1) 1980	(2) 1985	(3) 1990	(4) 1995	(5) 2000	(6) 2005
$\alpha_i * K_c / H_c$	-0.056 (0.037)	-0.033 (0.031)	0.012 (0.024)	0.038* (0.022)	0.046** (0.018)	0.074*** (0.017)
<i>Country dummies</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry dummies</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Observations</i>	6,047	7,201	8,562	8,896	9,271	9,508
<i>Adj. R<sup>2</sup></i>	0.23	0.24	0.25	0.29	0.31	0.32

Robust standard errors in parentheses

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

Table A2.1: Heckscher-Ohlin Regressions

<i>Dep. Variable: <math>\Delta m_{it}</math></i>	(1) 1985-1995	(2) 1985-1995	(3) 1995-2005	(4) 1995-2005
$\Delta K_c / H_c$	-0.289*** (0.032)		-0.128*** (0.021)	
$\alpha_i * \Delta K_c / H_c$	0.341*** (0.067)	0.363*** (0.067)	0.110** (0.046)	0.124*** (0.045)
<i>Country dummies</i>	No	Yes	No	Yes
<i>Industry dummies</i>	Yes	Yes	Yes	Yes
<i>Observations</i>	7,119	7,119	9,221	9,221
<i>Adj. R<sup>2</sup></i>	-0.00	0.07	0.01	0.20

Robust standard errors in parentheses

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

Table A2.2: Rybczynski Regressions

The regression results are displayed in Tables A2.1 and A2.2. As columns (1)-(6) of Table A2.1 show, the role of factor proportions as a determinant of trading patterns has increased over time: while there appears to have been no relationship between a country’s relative factor endowments and the type of goods sourced from it by the U.S. between 1980 and 1990, there has been a positive and increasingly strong relationship since 1990. As shown in Section 1, this coincides with an increased dispersion of factor proportions among the world’s largest economies as well as the opening of China to international goods markets, discussed in Section 3.

In addition to this, columns (1)-(4) of Table A2.2 suggest that a Rybczynski effect is also borne out by the data: an increase in a country’s capital abundance in the periods 1985-1995 and 1995-2005 seems to have increased that country’s share of sales of relatively capital-intensive goods to U.S. importers.

## A2.2 Investment and Country Risk

Differences in country-specific investment risk play a crucial role in the view of international asset trade proposed in this paper. In order to provide a preliminary assessment of the significance of country risk as a determinant of investment patterns among financially open economies, I estimate a regression of the form

$$\frac{I_{ct}}{Q_{ct}} = \beta_0 + \beta_1 \frac{S_{ct}}{Q_{ct}} + \beta_2 \sigma_{ct} + \delta_c + \delta_t + \varepsilon_{ct},$$

where  $I_{ct}$ ,  $S_{ct}$  and  $Q_{ct}$  are, respectively, investment, savings and GDP in country  $c$  and year  $t$ ,  $\sigma_c$  is a measure of country risk, and  $\delta_c$  and  $\delta_t$  represent country and time fixed effects. Note that, as a matter of national accounting, we should obtain  $\beta_1 = 1$ ,  $\beta_2 = 0$  if all sample countries are completely closed to international financial flows.

To construct the panel, I take the three macroeconomic series for the 28 largest economies between 1980 and 2007 from the World Bank’s *World Development Indicators* (2010). As a first measure of country-specific investment risk, I use the country risk index compiled by the Political Risk Services Group (PRSG). This index ranks countries by their economic, financial and political risk based on PRSG’s own macroeconomic analysis as well as surveys among international investment professionals. There are two main advantages to using the PRSG ranking in this context. First, it is compiled monthly, so an annual risk score can easily be constructed by taking the average over the corresponding 12-month period. Second, it largely captures countries’ *idiosyncratic* investment risk, as emphasised by the model in Section 2.

<i>Dep. Variable:</i> <i>Investment (% GDP)</i>	(1) <i>1980-2007</i>	(2) <i>1980-2007</i>	(3) <i>1980-2007</i>
<i>Savings (% GDP)</i>		0.398*** (0.054)	0.386*** (0.054)
<i>Country risk index (0-100)</i>			-0.199*** (0.026)
<i>Country dummies</i>	Yes	Yes	Yes
<i>Year dummies</i>	Yes	Yes	Yes
<i>Observations</i>	767	767	627
<i>Adj. R<sup>2</sup></i>	0.65	0.73	0.79

Robust standard errors in parentheses

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

Table A2.3: Investment and Country Risk

Table A2.3 reports the regression results. The first noteworthy finding appears in column 2. The estimated coefficient on  $\frac{S_{ct}}{Q_{ct}}$  - sometimes referred to as the “savings retention” coefficient - is around .4. This relatively low value suggests a high degree of financial globalisation.<sup>27</sup> The estimated value of this coefficient is almost unchanged when country risk is added to the regression in column (3). The country risk score itself is shown to be associated with significantly lower investment shares of GDP. Moreover, the economic impact of changes in country risk is substantial: an improvement in the average risk score from the 75th percentile of the country distribution (31) to the 25th percentile (16) would raise the average investment share by 3.0 percentage points. By way of comparison, an increase in the average savings rate from the 25th percentile of the country distribution (21%) to the 75th percentile (25%) would only raise the investment share by 1.4 percentage points.

<sup>27</sup>Obstfeld and Taylor (2004) estimate savings retention coefficients as one of several possible measures of financial globalisation for different time periods. Using a similar sample of countries, they report a coefficient of .83 for 1946-1972, and .75 for 1973-2000

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