Intranational and International Consumption Risk Sharing and Frictions in China*

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Abstract

This paper applies the gravity model to estimate the levels of intra-national and international consumption risk sharing across Chinese provinces from 2002 to 2007. We measure the risk sharing based on the volatility of the relative Pareto Weights for each province and find that the two types of risk sharing are both limited for most of the provinces. Second, we show that the overall international risk sharing is higher than the intra-national risk sharing since the relative international Pareto weights change less significantly and diversely than the intra-national ones. We argue that this higher international risk sharing can be explained by the great development of international goods trade from 2002 to 2007 and supported by the larger decreasing international trade costs than the domestic ones in our estimations. Furthermore, we provide evidence to support that the Backus-Smith condition holds for these 30 Chinese regions, i.e. that changes of relative real consumption per capita (compared to Shanghai) are positively correlated with the changes of the real exchange rate.

Keywords: Financial Frictions; Gravity Equations; Risk Sharing; Trade Costs;

JEL classification: F41, F14

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1 Introduction

With complete financial markets (regardless goods market frictions), countries can achieve an efficient consumption allocation, which predicts an equalization of marginal utility growth among countries, once corrected for possible fluctuations in the real exchange rate (RER) as in Backus and Smith (1993). Intuitively, efficient risk sharing tells that a country should consume more if her (aggregate) consumption basket is relative cheaper. Backus and Smith (1993) and following studies, however, reject this prediction, which is defined as the Backus-Smith puzzle. As pointed out by Cole and Obstfeld (1991),[1] efficient consumption risk sharing also requires that countries consume (import) more goods if their trade partners' goods are cheaper given substantial trade costs in goods markets. Guo (2015) rejects this implication for OECD countries during 1970-2000 whereas Fitzgerald (2012) rejects it for the case of a world with both developed and developing countries.[2] They both find that reducing trade costs in international goods markets help promoting the international consumption risk sharing across countries.

As a developing country, China has a low financial development and regions in China face both domestic and international financial frictions. Since China joined the WTO after 2001, significant tariff cuts, decreases in non-tariff barriers, and developments in domestic infrastructure lead to surges in domestic and international goods trade. This paper extends the international consumption risk sharing case of Fitzgerald (2012) and

[1]Cole and Obstfeld (1991) state that an optimal consumption risk sharing assuming complete markets and frictionless goods markets also implies a constant ratio of marginal utilities from consuming any good across states of nature among regions. They also find that countries attain optimal risk sharing even under financial autarky assuming homogeneous preference and frictionless goods markets. The interactions among heterogeneous preferences, frictions in goods and financial markets are essential for risk sharing in this paper.

[2]Fitzgerald (2012) defines the perfect consumption risk sharing as a constant relative marginal utility of consumption over time and across states in a world without any frictions in goods and asset markets, same in Cole and Obstfeld (1991). This definition is different from Backus and Smith (1993), Backus and Smith (1993) and Guo (2015). This paper follows the later. Fitzgerald (2012) also assumes homogeneous preferences and no home bias in consumption.

Guo (2015) to consider both intra-national (based on 30 domestic regions only, the case of within China) and international risk sharing (based on 30 domestic regions and 70 foreign partners, the overall case) in China. We estimate the gravity models on bilateral imports(components of the consumption basket), and study how the intra-national and international goods trade affect the regional risk sharing from 2002 and 2007. We find that levels of the international and intra-national risk sharing are limited in China but the former is significantly higher. This result supports the importance of the international goods trade in hedging risks, consistent to the previous studies.

In order to test the risk sharing, we first derive the structural gravity model based on Guo (2015) and estimate the utility based real exchange rate (RER, price index of Shanghai minuses price index of any other region where Shanghai is the base) for each region for two cases: within boarder and cross boarder (overall). Then we calculate the relative Pareto weights for each region in each case using the relative real consumption growth (real consumption growth of any other region minuses that of Shanghai) and RER. We measure the risk sharing based on the volatility of the relative Pareto Weights. More significant changes of the relative Pareto weights for each region indicate a larger failure of risk sharing among provinces. More dispersed changes of those weights across provinces imply a lower achieved risk sharing among the members. In the overall case, the weights change less significantly and are much more converged than those in the within China case. This result tells that the international risk sharing is higher than the intra-national risk sharing. The result is due to the great development of the international goods trade and is supported by a larger decline in the estimated international trade costs (measured by distance ranges) relative to the domestic trade costs during 2002-2007.

The result on the significant effect of reducing trade frictions on improving risk sharing is consistent to the trade credit literature, which finds that international goods markets provide trade credit to exporters and importers in low financial development regions/countries and promote trade. Here, a large reduction of international trade costs can reduce regions' borrowing constraints on production and consumption, influences the extensive and intensive margins of goods trade (composition of the aggregate consumption basket), and then help hedge the aggregate consumption risks (through the domestic and global input-output linkage or value chains). We also find that the effects are asymmetrical across regions in China. Guangdong, Xinjiang, Beijing and Tianjing (Liaoning, Xinjiang , Beijing and Tianjing) achieve good risk sharing in the intra-national (international) case whereas Hainan, Jiangxi, Shangdong and Hubei (Hainan, Hubei, Guangxi and Guangdong) hedge risks the least. We conclude that the developments of both domestic and international goods markets are essential for risk sharing given frictional financial markets.

This paper follows the international consumption risk sharing literature closely. Many studies test the risk sharing based on the correlations and co-movements among aggregate consumption(levels or growth), RER(levels or changes) and GDP/income(levels or growth).[3] Backus et al. (1992) and Corsetti et al. (2008) test the correlations of relative aggregate consumption growth and RER changes. Brandt et al. (2006) use an index on volatilities of RER and marginal utility growth across countries to measure the level of risk sharing (similar to correlation but controls for the violation of scale). In contrast, Obstfeld (1994), Lewis (1996), and Kose et al. (2009) assume that Purchase Power Parity holds (it is true in one single good model) and estimate the co-movement between idiosyncratic consumption growth (country-specific consumption growth adjusted for world consumption growth) on idiosyncratic GDP/income growth often with PPP measured data.[4] Here we test the risk sharing based on the components of ag-

[3]Another branch of literature on testing risk sharing uses international portfolio choices, for example Lewis and Liu (2015).

[4]They study the cross-sectional correlation. Kose et al. (2009), Sørensen et al. (2007), Bai and Zhang (2012) and Rangvid et al. (2016) study the dynamic co-movement between idiosyncratic con-

gregate consumption basket (imports) and their relative price. We also examine the Backus-Smith condition: a positive relationship between changes of relative real consumption per capita and the changes of the estimated RER and find that Backus-Smith condition holds in China. This finding is consistent to the evidence found in Hess and Shin (2010) by examining the intranational data across the U.S. states.

The paper is closely related to the studies on consumption risk sharing within China. Chan et al. (2014), Du et al. (2011), and Ho et al. (2010) test the inter-provincial consumption risk sharing in China only through the fiscal channel, intertemporal smoothing, self-insurance, and financial intermediaries etc.[5] Furthermore, our paper is also relative to the studies on market segmentation and trade costs in China. Poncet (2003), Poncet (2005), and Wong (2012), point out that the provinces that are more involved in the international trade, have decreased internal trade because of large provincial borders. They claim that China has become more segmented from late 80s to early 2000s. On the other hand, Lai et al. (2013) find that the Chinese internal capital market during 1978-2008 has moderately improved, with a temporary worsen period from 1994-1997. This paper connects the two literatures and identifies the effects of consumption diversion and creation on risk sharing. To our knowledge, this is the first paper to analyze both intranational and international risk sharing in China along with financial frictions and trade costs.[6]

The structure of the paper is as follows. Section 2 derives the theoretical gravity model in testing risk sharing based on Anderson and Van Wincoop (2003). Section 3 provides a empirical framework to estimate frictions and risk sharing. Section 4

sumption growth (country-specific consumption growth adjusted for world consumption growth) on idiosyncratic GDP/income growth. With perfect risk sharing, the co-movement should be low and close to zero.

[5]Some investigate the risk sharing before and after the reform 1978 and find contradicting results.

[6]Labor market frictions and migration costs can also change the consumption risk sharing among provinces in China given financial frictions in the domestic and international asset markets. Here we test the role of goods markets frictions on risk sharing based on the bilateral trade data.

presents the empirical results on risk sharing and trade costs in China. The last section concludes.

2 Theoretical Model

2.1 Intuition to Test Risk Sharing

As in Backus and Smith (1993), for any two regions/countries i and j, their relative marginal utility of aggregate consumption, $u^i_{c_t}/u^j_{c_t}$, should satisfy the following condition,

$$\frac{u^i_{c_t}}{u^j_{c_t}}\frac{P^j_t}{P^i_t} = \left(\frac{\lambda^i_t}{\lambda^j_t}\right)^{-1} \tag{2.1}$$

where $P^j_t/P^i_t = RER$ is defined as the real exchange rate in terms of country i's price index, and $\left(\frac{\lambda^i_t}{\lambda^j_t}\right)$ is the relative Pareto weight that a social planner assigns to regions. The Pareto weight, λ^i_t, is equal to the inverse of the marginal utility of nominal wealth in the decentralized optimization problem. An efficient consumption allocation with complete financial markets (allowing goods market frictions or not) requires a constant relative Pareto weight (λ^i/λ^k), or a constant relative marginal utility weighted by RER. With frictions in asset markets, regions cannot fully hedge income risks and RER risks. The relative pareto weights need not be constant.[7] Estimating and examining the volatility of the Pareto weights provide a natural way to measure the level of risk sharing.

The literature mostly studies the risk sharing based on the above aggregate consumption behaviors relative to GDP growth and RER changes, and do not directly estimate the λs from (2.1). Cole and Obstfeld (1991) propose that an optimal con-

[7] Cole and Obstfeld (1991) assume homogeneous preference and frictionless goods markets, and find that countries attain optimal risk sharing even under financial autarky. The interactions among heterogeneous preferences, frictions in goods and financial markets are essential for risk sharing.

sumption risk sharing assuming complete markets and frictionless goods markets also implies a constant ratio of marginal utilities from consuming any good across states of nature among regions. Like (2.1), the efficient allocation on any good k (produced in region/country k) by the two regions i and j should satisfy the following condition given the relative time-varying iceberg trade costs, $\frac{\tau_t^{jk}}{\tau_t^{ik}}$, paid by imports,

$$\frac{u_{k_t}^i}{u_{k_t}^j}\frac{\tau_t^{jk}}{\tau_t^{ik}} = \left(\frac{\lambda_t^i}{\lambda_t^j}\right)^{-1} \tag{2.2}$$

With frictionless asset markets, efficient risk sharing still implies a constant λ^j/λ^i, but a fluctuating relative marginal utility $u_{k_t}^i/u_{k_t}^j$ because of the changes in trade costs. With frictions in financial markets, both λ_t^j/λ_t^i and $u_{k_t}^i/u_{k_t}^j$ become volatile because they are influenced by the changes of trade costs in goods markets, financial frictions, preference differences, income/output risks and other shocks in the economy. In particular, reducing the trade costs in intra-nation and international goods markets expands the trade scope and help regions/countries switch consumption among different sources easily and hedge production risks more efficiently. For example, trade credits (export and import) reduce the credit constraints of exporters and importers.

2.2 Production, Preference, and Frictions

I combine Backus and Smith (1993)'s stochastic economy with production with Anderson and Van Wincoop (2003) to derive a structural gravity equation like Fitzgerald (2012) and Guo (2015). There are $N+1$ countries(regions) in the world, where they are indexed $i = 1, ..., N, N+1$, and the last country (China) has J regions, indexed $i = 1, ..., J$. Each region represented by a single agent who produces, trades goods with other regions, consumes and lives from date 0 to infinite. At each date t ($t \in 1, 2, ...$), the economy experiences one event, s_t, drawn from a finite the state space; and s^t is defined as the history of events, $s^t \equiv (s_1, s_2, ..., s_t)$ at date t, an element of the finite set S^t. The history, in addition to the initial event s_0, completely describes the state of the economy at date t. The probability of any state s^t, given s_0, is denoted$\pi(s^t)$. The following sections omit the history s^t in variables unless it is necessary. Each region stochastically produces a distinct tradeable final good (indexed as i for region i) only using labor. The final good i in region i at time t is produced with labor L_t^i and a realized productivity A_t^i: [8]

$$Y_t^i = F\left(A_t^i, L_t^i\right) \tag{2.3}$$

The productivity A_t^i follows a stochastic process.

Region i is inhabited by a single agent whose expected utility is described by:

$$U^i = \sum_{t=0}^{\infty}\sum_{s^t}\beta^t \pi_t u\left(C_t^i\right) \tag{2.4}$$

where N_t^i is the population, and π_t is the probability of history s^t at time t. The consumption level C_t^i comes from a CES aggregator on $N + J$ goods as follows:

$$C_t^i = \left[\sum_{k=1}^{N} (\alpha^{ik})^{\frac{1}{\eta}} (Z_t^{ik})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

where $\eta\,(> 0)$ is the elasticity of substitution between goods, Z_t^{ik} is the quantity of imports in country i from country k at history s^t (Z_t^{ii} is the domestic absorption), and α^{ik} captures the heterogeneous weight of each import in the consumption basket.

[8] Introducing capital to the production process still derive the same gravity model on bilateral imports.

In the empirical part, I assume a constant relative risk averse utility function,

$$u\left(c_t^i\right) = \frac{\left(c_t^i\right)^{1-\rho}}{1-\rho} \tag{2.5}$$

where $\frac{1}{\rho}\,(>0)$ is the intertemporal elasticity of substitution and the small letter c_t^i is per capita consumption.

The region i faces the following budget constraint:[9]

$$\begin{aligned} E_t^i \equiv \sum_{k=1}^{N+J} Q_t^{ik} Z_t^{ik} \equiv P_t^i C_t^i & \\ = Q_t^{ii} Y_t^i + \left[\mathbf{D}_t + \mathbf{R}_t\right] \mathbf{B}_t^i \left(s^{t-1}\right) - \mathbf{R}_t \mathbf{B}_{t+1}^i \left(s^t\right) & \end{aligned} \tag{2.6}$$

where P_t^i is the spot price for the aggregate consumption in region i, and Q_t^{ik} is the spot price for the import good k in region i (produced in region k). The first line represents the total (household) consumption expenditure of region i, at time t, on $N+J-1$ imports and her domestic good i, E_t^i. The second line is the total output/income from the good production $O_t^i = Q_t^{ii} Y_t^i$ and net asset holdings. Region i holds a vector of assets $\mathbf{B}_t^i\left(s^{t-1}\right)$ from last period $t-1$, and receives dividends $\mathbf{D}_t$ this period t. The income from asset holdings is $\left[\mathbf{D}_t + \mathbf{R}_t\right] \mathbf{B}_t^i\left(s^{t-1}\right)$, where $\mathbf{R}_t$ is the asset price vector. Then the country re-optimizes asset holdings to a new level $\mathbf{B}_{t+1}^i\left(s^t\right)$ this period.

Intra-national goods markets in China and International goods markets are assumed to have iceberg trade costs τ_t^{ik} with $\tau_t^{ii} = 1$, $\tau_t^{ik} \geq 1$ and $\tau_t^{ij}\tau_t^{jk} \geq \tau_t^{ik}$ $(j \subseteq N)$ a la Obstfeld and Rogoff (2000) and others. These transaction costs τ_t^{ik} are paid using

[9] All regions price their goods based on a world currency; nominal exchange rate is not involved here. In the empirical part, imports, consumptions and outputs are all measured in the current US dollar.

import good k by region i. Therefore, prices of imports differ across countries:

$$Q_t^{ik} = \tau_t^{ik} Q_t^{kk} = \tau_t^{ik} Q_t^k \tag{2.7}$$

where Q_t^k (Q_t^{ik}) is the spot prices of final good k in home county k (importer i). Consequently, the final goods resource constraints must take trade costs into account, and the market clearing condition for good k produced in region k at time t is:

$$Y_t^k = \sum_{i=1}^{N+J} \tau_t^{ik} Z_t^{ik} \tag{2.8}$$

Accordingly, the market clearing conditions for assets require zero net supply:

$$\sum_{i=1}^{N+J} \mathbf{B}_{t+1}^i \left(s^t\right) = 0$$

Asset markets within each region are assumed to be perfect/frictionless, but the intra-national financial markets in China and international asset markets are incomplete and have frictions. For example, we can assume that only bonds can be traded across regions with a credit/borrowing constraint. The tightness of credit conditions can differ across regions. As long as the financial frictions do not change the first order condition of the aggregate consumption as 2.1, we can derive the same equilibrium condition or the gravity model for bilateral imports.[10] So we can assume general asset market frictions, and does not specify a detailed asset structure like Fitzgerald (2012). The paper does not solve the equilibrium for bilateral asset holdings, but focuses on equilibrium conditions on the consumption goods only.

[10] If we model capital accumulation in the production, equity can also be traded across regions. The equilibrium condition or the gravity model for bilateral imports remain.

2.3 The First Order Conditions

A general equilibrium is defined as the set of quantities and prices, $\{\mathbf{Z}^*, \mathbf{L}^*, \mathbf{Y}^*, \mathbf{B}^*, \mathbf{D}^*, \mathbf{Q}^*, \mathbf{R}^*\}$, such that firms choose prices to maximize profits, the represent agents maximize utilities subject to the budget constraints, and all markets clear. The first order conditions with respect to aggregate consumption and each import are necessary to obtain the equilibrium — 1) a monopolistic firm in each country maximizes the profit to choose the price Q_t^i, labor demands L_{td}^i, outputs Y_t^i, and dividends D_t^i; 2) a representative agent maximizes the utility by choosing home good and imports $Z_t^i(k)$, labor supplies N_{ts}^i, and asset holdings $\mathbf{B}_{t+1}^i$; 3) market clearing conditions hold for labors, all goods and assets ($i = 1, ..., N + J$).

The first order condition (FOC) with respect to the aggregate consumption C_t^i is:

$$\lambda_t^i \left(C_t^i / N_t^i\right)^{-\rho} = P_t^i \tag{2.9a}$$

where $1/\lambda_t^i$ is the lagrange multiplier of the budget constraint/the marginal utility of current per capita (nominal) wealth for region i at time t, and $u_c(.)$ is the marginal utility of consumption per capita. λ_t^i also represents the Pareto weight for region i at time t in a world social planner problem such that $\sum_{i=1}^{N} \lambda_t^i = 1$. The social planner signs the weight to each country each period. With perfect international and intra-national asset markets, regions achieve complete risk sharing, and the Pareto weight for each region is constant over time. When regions cannot perfectly share risks due to financial frictions, the Pareto weights change over time. As a result, testing the volatilities of the Pareto weights λ_t^i is the key to test the significance of financial frictions. We also derive the FOC in terms of the value of consumption,

$$\left(\lambda_t^i\right)^{\frac{1}{1-\rho}} \left[P_t^i c_t^i\right]^{\frac{-\rho}{1-\rho}} = P_t^i \tag{2.9b}$$

The CES demand function for any final good k in region i (imports), IM_t^{ik}, gives the gravity model,

$$IM_t^{ik} \equiv Q_t^{ik} Z_t^{ik} = \alpha^{ik} \left(\frac{P_t^i}{Q_t^k \tau_t^{ik}} \right)^{\eta-1} \left(P_t^i C_t^i \right) \tag{2.10}$$

Correspondingly, the aggregate price index P_t^i can be derived as,

$$P_t^i = \left[\sum_{k=1}^{N+J} \alpha^{ik} \left(\tau_t^{ik} Q_t^k \right)^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{2.11}$$

2.4 Gravity Equation

With the resource constraint of each good (2.8) and the demand function (2.10), I get the gravity equation:

$$\frac{IM_t^{ik}}{E_t^i * O_t^k} = \alpha^{ik} \left(\frac{P_t^i \Pi_t^k}{\tau_t^{ik}} \right)^{\eta-1} \tag{2.12a}$$

$$= \alpha^{ik} \left(\frac{\left(\lambda_t^i\right)^{\frac{1}{1-\rho}} \left[P_t^i c_t^i\right]^{\frac{-\rho}{1-\rho}} \Pi_t^k}{\tau_t^{ik}} \right)^{\eta-1} \tag{2.12b}$$

$$\widetilde{\lambda}_t^i = \lambda_t^i / \left(\sum_{j=1}^{N} \lambda_t^j \right)$$

where the import value of country i from country k is $IM_t^{ik} \left(= \tau_t^{ik} Q_t (k) Z_t^i (k) \right)$; the value of country i's total expenditure is $E_t^i \ (= P_t^i C_t^i)$; the value of country k's output is $O_t^k \ \left(= Q_t (k) Y_t^k \right)$. The time-varying multilateral resistance Π_t^k is the weighted expenditure share of each country in the world,

$$\left(\Pi_t^k \right)^{1-\eta} = \sum_{j=1}^{N} \alpha^{ik} \left(\frac{P_t^j}{\tau_t^{jk}} \right)^{\eta-1} E_t^j \tag{2.13}$$

Substituting equation (2.9b), we can get another version of the gravity model (2.12b) with the Pareto weight.

3 Equation to Test Risk Sharing

Now, we derive the empirical gravity model to estimate the financial frictions and trade costs. Taking logs of the gravity equation (2.12b) yields the baseline estimation equation,

$$w_t^{ik} = cons + \delta_{ik} + \theta_t^i \left(\equiv \widetilde{\theta}_t^i + \beta_c lc_t^i\right) + \phi_t^k + \sum_{j=1}^{9} \gamma_{jt} g_j^{ik} + +\varepsilon_t^{ik} \tag{3.1}$$

where the dependent variable w_t^{ik} is the log of the bilateral import ratio, defined as:

$$w_t^{ik} \equiv log\left(\frac{IM_t^{ik}}{E_t^i * O_t^k}\right)$$

Regressors include the constant $cons$, the log of the share weights $\delta^{ik} \equiv log(\alpha^{ik})$, the log of Pareto weights $\widetilde{\theta}_t^i \equiv \frac{\eta-1}{1-\rho} log(\widetilde{\lambda}_t^i)$, the log of per capita consumption in term of dollar value $lc_t^i \equiv log\left(P_t^i c_t^i\right)$, the log of employment rate $ll_t^i \equiv log\left(l_t^i\right)$, the multilateral resistance terms $\phi_t^k \equiv (\eta - 1)log(\Pi_t^k)$ and bilateral trade costs g_j^{ik}. Like Anderson and Van Wincoop (2004) and Waugh (2010), bilateral trade costs take the form as follows,

$$log[\left(\tau_t^{ik}\right)^{1-\eta}] \equiv \sum_{j=1}^{9} \gamma_{jt} g_j^{ik} + f_{kt} + f_{kt} * China_{ik} \tag{3.2}$$

where $g_j^{ik} (\equiv log\left(G_j^{ik}\right))$, includes the eight dummy variables of bilateral distance ranges, one dummy variables for country border and (potential) asymmetric fixed export costs in domestic and international goods markets. The indicator $China_{ik}$ takes one if the importer and exporter are both in China, otherwise zero.

We collect manufactural trade data and output data (valued in the current US dollar) for 30 regions in China and 70 trade partners at years 2002 and 2007. Bilateral trade data within China are from the Input-Output data constructed by Shantong Li (2005) and Chinese Social Science. The trade data between Chinese regions and foreign countries are from Feenstra et al. (2009). The trade data across 70 countries are from UNCOMTRADE. Manufactural output are mainly from UNIDO and the missing values are based on the manufactural value added data from World Bank's World Development Indicators. Data on the household expenditure and consumption are from Chinese Statistics Year book for Chinese provinces and World Bank's World Development Indicators for other 70 countries.

Since we have two years of bilateral import flows among provinces and countries, we estimate the difference gravity model in two cases: within China and across border with all regions,

$$\Delta w_t^{ik} = cons + \Delta\theta_{it} + \Delta\phi_t^k + \sum_{j=1}^{9}(\Delta\gamma_{jt})g_j^{ik} + \Delta\varepsilon_t^{ik} \tag{3.3}$$

The former case estimates intra-national risk sharing and frictions on domestic goods and asset markets, and the later one estimates heterogeneous frictions in both intra-national and international goods and financial markets. The importer-year fixed effect $\Delta\theta_t^i$ contains two parts: the changes in Pareto weights $\widetilde{\theta}_t^i$ and changes in per capita real consumption $\beta_c lc_t^i$; i.e. $\Delta\theta_t^i = \Delta\widetilde{\theta}_t^i + \Delta\beta_c lc_t^i$. A constant relative $\widetilde{\theta}^i$ represents the condition of the efficient risk sharing or the special case of frictionless asset markets, where the relative normalized Pareto weights $\widetilde{\lambda}^i$ should be heterogeneous across countries but constant over time. A constant relative γ_j is regarded as the case with constant trade costs.

4 Estimation Results

We estimate the gravity model with the trade data only within China and then obtain the real exchange rate (RER) and trade costs within China, where Shanghai has the highest GDP per capita and is the base region. Based on the within-China RER, we can calculate the intranational Pareto weights (risk sharing/financial frictions) assuming reasonable parameters on the elasticity of substitution across goods and the intertemporal elasticity of substitution. Alternatively, with data on all 100 regions we get the (international) RER, the relative international Pareto weights and trade costs in the world markets. The two-year panel allows us to discuss the changes in the RER, the relative Pareto weights, risk sharing levels and trade costs across provinces in both intranational and international scenarios.

4.1 Volatile Relative Pareto Weights

Now we discuss how the relative changes in $\widetilde{\theta}_t^i$ ($= \frac{1-\rho}{\eta-1} log(\lambda_t^i)$) are related to the changes in the relative log of (real) consumption per capita from 2002 to 2007. We use Shanghai as the base region. As we know, the regional relative consumption growths are smooth; hence, efficient risk sharing requires a relative constant $\widetilde{\theta}_t^i$ or a convergence in $\Delta\widetilde{\theta}_t^i$ across provinces. Volatile $\widetilde{\theta}_t^i$s or time-varying Pareto weights indicate the existence of financial frictions and limited risk sharing. The larger $\Delta\widetilde{\theta}_t^i$ is, the less risk sharing and the more financial frictions the region has.

Table 1 shows the dispersion of the relative changes in θ_t^i (a function of the RER) and log of real and nominal consumption per capita in 29 Chinese regions. The $\Delta\theta_t^i$ is much more diverse compared with the nominal and real consumption per capita growth. In particularly, the relative θ_t^i in the intra-national case has a much larger dispersion than those in the overall international case, implying that price risks is higher in the intra-national case than the overall international case. In other words, intranational markets are more risky than international markets in terms of consumption risks.

Next we assume reasonable parameter values to calculate the Pareto weight for each region in China (Shanghai is the base) given by,

$$\widetilde{\lambda_t^i} = \frac{exp\left[\left(\frac{1-\rho}{\eta-1}\right)\theta_t^i + \rho lc_t^i\right]}{exp\left[\left(\frac{1-\rho}{\eta-1}\right)\theta_t^{SH} + \rho lc_t^{SH}\right]}.$$

We examine the relative Pareto weight in the two years for each region: $\widetilde{\lambda_{2007}^i}/\widetilde{\lambda_{2002}^i}$. According to the international macro literature, we assuming $\rho = 1.5$ and $\eta = 2$. An efficient risk sharing implies that the relative Pareto weights of these regions should be one (a constant Pareto weight). Figure 1 presents the relative intranational and international Pareto weights from 2002 and 2007. Four provinces Guangdong, Xinjiang, Beijing and Tianjing (Liaoning, Xinjiang , Beijing and Tianjing) achieve good risk sharing in the intra-national (international) case whereas another four provinces, Hainan, Jiangxi, Shangdong and Hubei (Hainan, Hubei, Guangxi and Guangdong) hedge risks the least. We conclude that both the intra-national and international risk sharing is limited.

Furthermore, except Guangdong, most provinces have relative similar or smaller changes in the international Pareto weights than in the intranational ones (below the 45 degree line) in Figure 1. Less volatile and more converged international relative Pareto weights implies a better international risk sharing than the intranational one. Table 2 provides more robustness checks on the variance of the relative Pareto weights with different parameter values on ρ and η. In all three cases, the relative Pareto weights in the overall international case have smaller means and variances, supporting a higher international risk sharing level. We argue that the international goods markets play an important role in hedge the consumption risks for most of the Provinces.

4.2 Decreasing Trade Costs

The significance of international goods markets in promoting risk sharing can be supported in larger decreases of the estimated international trade costs compared with the intranational ones. We use dummies on distance and border to measure the trade costs. The trade costs measured by the border dummy reduces significantly from 2002 to 2007 in the intranational case only; we focus on the changes in aggregate trade costs measured by the distance from the following definition,

$$log\widehat{\left(\tau_{2007}^{ik}\right)}^{1-\eta} - log\widehat{\left(\tau_{2002}^{ik}\right)}^{1-\eta} = \sum_{j=1}^{8} \widehat{\gamma_{j2007}} g_j^{ik} - \sum_{j=1}^{8} \widehat{\gamma_{j2002}} g_j^{ik}.$$

Table 3 shows the results for the relative intranational, international and overall trade costs; the base region is Shanghai. The relative trade costs in all three cases are decreasing significantly and the changes in the trade costs slightly show an inverse U trend. Trade costs between 300 to 1200 miles decrease most. The table also shows that the large decreases of the overall trade costs with both intranational and international goods markets are mainly due to the large drops of trade costs in the international goods markets. Results on the large decreasing international and overall trade costs remain if we assuming that effects of distances on imports are asymmetric in the intranational and international goods markets or no asymmetric fixed exporting costs.

4.3 The Balassa-Samuelson effect and Backus-Smith condition

Now, we discuss the relationships between the RER and income/consumption, respectively. Since RER is defined as the relative price between Shanghai and any province,

$$RER_t^i \equiv \frac{P_t^{SH}}{P_t^i} = exp\left(\frac{\theta_t^{SH} - \theta_t^i}{\eta - 1}\right),$$

we know that the RER is positively related with the relative θ given the elasticity of substitution between goods is larger than one ($\eta > 1$). We assume $\eta = 2$ and calculate the log of the RER for each province in each year. Figure 2 shows that provinces with a relative higher growth in real per capita income (regional changes in the relative real GDP per capita minuses that of Shanghai) have higher living costs (RER decreases) from 2002 to 2007. This implies that the Balassa-Samuelson effect holds across provinces in China. Note that three provinces, Guangdong, Jiangsu and Zhejiang have no relative price changes in the intranational case whereas eight provinces including Jiangsu, Zhejiang, Beijing, Tianjing, Chongqing, Shanxi, Inner Mengolia and Ningxia have no relative price changes in the international case. If we exclude the provinces with insignificant price changes, the Balassa-Samuelson effect holds better within China.

Then we turn to the relationship between the changes of RER and the relative real per capita consumption growth. Figure 3 shows that this relationship is inverse U-shaped. Excluding the provinces with insignificant changes in RER, RER is positively correlated with the relative real consumption growth in both cases and the positive relationship is larger in the overall case than in the intranational case. These results are consistent to the findings in Hess and Shin (2010), who show that the the Backus-Smith condition holds if they control for the volatility of the nominal exchange rate. They also find that the Backus-Smith condition holds across states within the USA, similar to our case within China.

5 Conclusion

This study shows the existence of international and intranational financial market frictions in undermining the risk sharing for Chinese provinces. The international goods markets, however, help provinces diversify the consumption risks more than the domestic goods markets. We provide evidence with a sample of 30 Chinese regions and 70 foreign trade partners in 2002 and 2007. Particularly, we are interested in the intranational and international risk sharing for each regions in China. Borrowing the gravity model from the trade literature, we test and estimate the levels of risk sharing and trade costs based on the elements/imports in the aggregate consumption basket for each region. This approach is different from the traditional risk sharing test and can estimate the risk sharing directly along with trade costs in goods markets. We find that both the intranational and international risk sharing of the Chinese regions is quite limited. We support that the international goods are important to the consumption risk sharing in China based on two results: a higher level of international risk sharing than that of the intranational risk sharing and a larger decrease of international trade costs. Finally, we show that the Balassa-Samuelson effect and Backus-Smith condition both hold across provinces within China.

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Table 1: Changes in relative θ_t^i, consumption per capita and GDP per capita from 2002 to 2007

Variable	Obs	Mean	Std. Dev.	Min	Max
$\triangle(\theta_t^i - \theta_t^{SH})$_intra	29	-0.855	0.639	-3.374	0.284
$\triangle(\theta_t^i - \theta_t^{SH})$_overall	29	-0.646	0.370	-1.428	0.066
$\triangle log(rc_t^i/rc_t^{SH})$	29	-0.006	0.078	-0.146	0.131
$\triangle log(c_t^i/c_t^{SH})$	29	.0204	.086	-.167	.154
$\triangle log(ry_t^i/ry_t^{SH})$	29	0.160	0.082	0.010	0.465

$\triangle$ refers to the change. rc_t^i or c_t^i is the real and nominal consumption per capita. ry_t^i is the real GDP per capita.

Table 2: Higher international risk sharing from 2002 to 2007

Para.	Case	Obs	Mean	S.D.	Min	Max
$\eta = 2, \rho = 1.5$	intra	29	1.708	0.762	0.998	5.088
	overall	29	1.470	0.304	0.871	2.298
$\eta = 2, \rho = 2$	intra	29	3.410	4.682	0.907	26.944
	overall	29	2.177	0.863	0.814	4.810
$\eta = 4, \rho = 2$	intra	29	1.448	0.411	0.864	2.842
	overall	29	1.325	0.249	0.846	1.912

This table shows the robustness of higher international risk sharing for different parameter values on η and ρ.

Table 3: Changes in trade costs from 2002 to 2007 for three cases

Dist.(miles)	$\triangle$Onverall	$\triangle$Inter	$\triangle$Intra
0-150	1.018***	1.137***	-0.180
150-300	1.071***	1.138***	-0.106
300-600	1.444***	1.371***	0.406*
600-1200	1.340***	1.250***	0.490**
1200-2400	1.187***	1.204***	0.172
2400-4800	1.116***	1.142***	-0.346
4800-9600	1.186***	1.181***	
>9600	1.201***	1.194***	
border	0.00281	-0.163**	0.474***

$\triangle$Intra ($\triangle$Inter or $\triangle$overall) is the changes in the coefficients of the intranational (international or overall) trade costs measured by the distance from 2002 to 2007. The ”intra” case uses the domestic bilateral import data across 30 provinces only. The case of ”no-intra and inter only” estimates the gravity model without intranational bilateral trade data. The ”overall” case uses bilateral data on all 100 regions. Positive values represent decreasing trade barriers measured by distance. *** significant at 1%; ** significant at 5 %; * significant at 10% based on robust standard deviations.

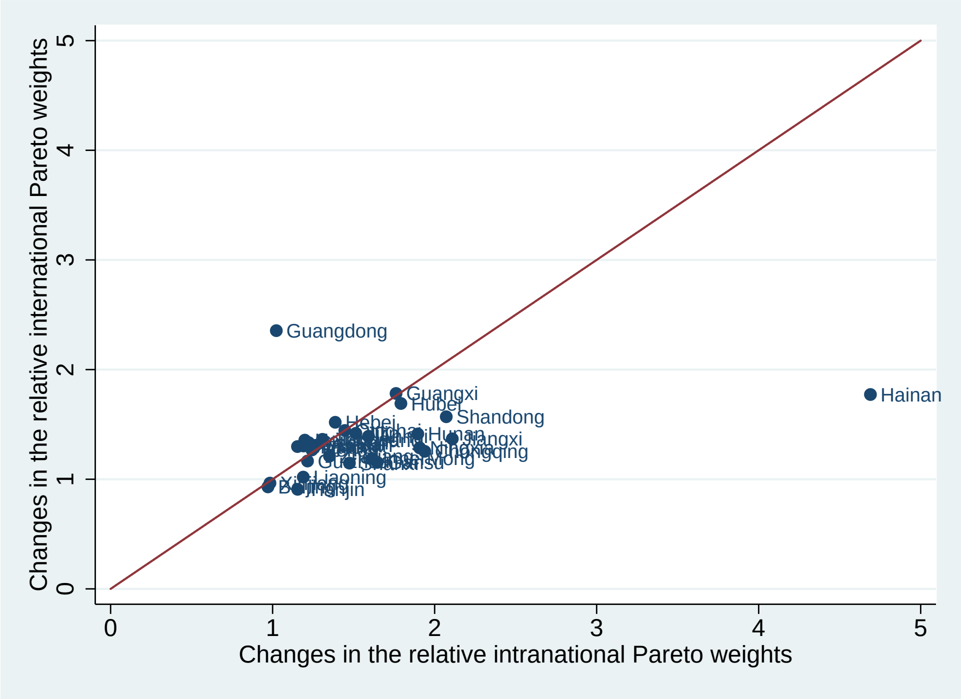

Figure 1: Risk Sharing with $\eta = 2$, $\rho = 1.5$

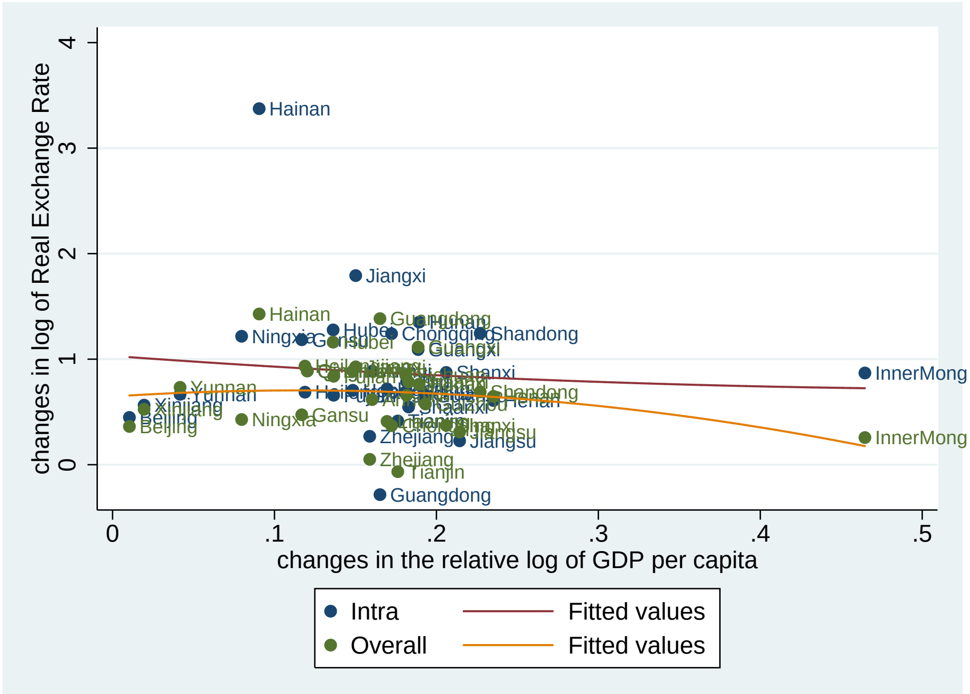

Figure 2: The Balassa-Samuelson effect within China, 2002 and 2007

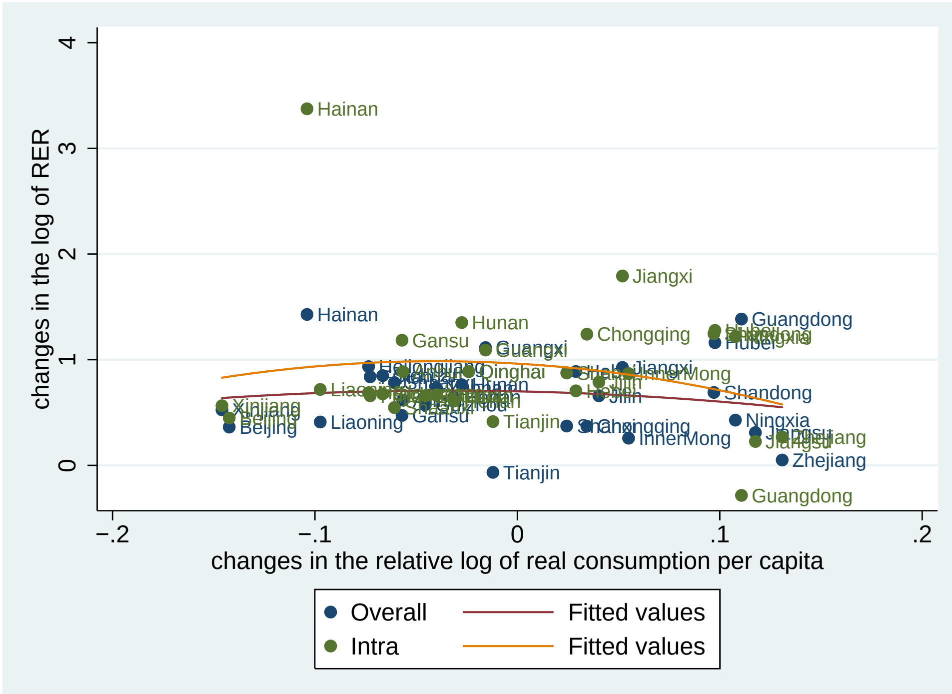

Figure 3: The Backus-Smith condition from 2002 to 2007

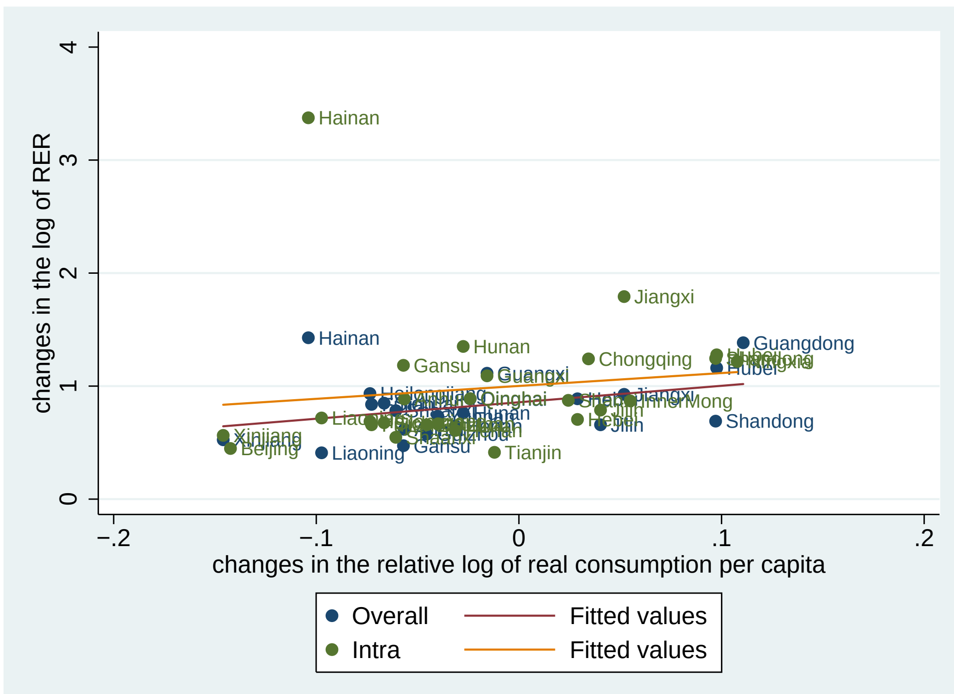

Figure 4: The Backus-Smith condition from 2002 to 2007: significant changes only