Department of
Economics and Finance

International Capital Markets Structure, Preferences and Puzzles: The US-China Case

GUGLIELMO MARIA CAPORALE

Brunel University, London, CESifo Munich and DIW Berlin

MICHAEL DONADELLI

Center of Excellence SAFE, Goethe University Frankfurt

ALESSIA VARANI

HEC Montreal

February 2014

Abstract

A canonical two country-two good model with standard preferences does not address three classic international macroeconomic puzzles as well as two well-known asset pricing puzzles. Specifically, under financial autarky, it does not account for the high real exchange rate (RER) volatility relative to consumption volatility (RER volatility puzzle), the negative RER-consumption differentials correlation (Backus-Smith anomaly), the relatively low cross-country consumption correlation (consumption correlation puzzle), the low risk-free rate (risk-free rate puzzle) and the high equity risk premium (equity premium puzzle) in the data. In this paper, we show that instead a two country-two good model with recursive preferences, international complete markets and correlated long-run innovations can address all five puzzles for a relatively large range of parameter values, specifically in the case of the US and China. Therefore, in contrast to other IBC models, its performance does not rely on any financial market imperfections.

Keywords: Financial autarky, complete markets, long-run risk, anomalies

JEL Codes: F3, F4

1 Introduction

The international business cycle (IBC) literature of the last 20 years points out that the risk-sharing predictions of standard IBC models with complete markets do not match cross-country movements in consumption. Early studies show that a standard IBC model with complete markets encounters difficulties in matching international consumption and asset pricing data (Backus et al., 1994, 1995). In particular, it tends to produce international asset prices that are less volatile than the actual series. Even under a financial autarky regime, the level of international risk sharing generated by the model is unrealistically high. It turns out that the correlation between the RER and consumption differentials (Backus and Smith's (1993) correlation) is close to unity. In addition, in a scenario characterized by low RER volatility and high degrees of international risk-sharing the domestic and foreign consumption growth rates are highly correlated.

In a seminal contribution, Lewis (1996) suggests that high degrees of international risk-sharing might be generated by the non-separability of tradable and non-tradable goods in the utility function employed in the model as well as by the presence of international complete markets (i.e. full risk-sharing). He concludes that both capital market restrictions and non-separability are required to explain the lack of international risk-sharing observed in the data. Overall, the international risk sharing mechanism embodied in this class of models gives rise at least to three international macroeconomic puzzles: i) the high volatility of the RER relative to the volatility of consumption (real exchange-rate volatility puzzle); ii) the negative correlation between RER and consumption differentials (Backus and Smith puzzle); iii) the low correlation of consumption growth across countries (consumption correlation puzzle).[1] In addition, standard IBC models with complete markets and standard preferences do not address the equity premium puzzle, EPP, (Mehra and Prescott, 1985; Mehra, 2003) and the risk-free rate puzzle (Weil, 1989).

[1] For additional details see Bodenstein (2008).

The international risk-sharing mechanism present in these models and its implications for the resolution of the various international macroeconomic and asset pricing puzzles have received considerable attention in the IBC literature, much of it addressing individual anomalies (Benigno and Thoenissen, 2008; Corsetti et al., 2008; Kollman, 2012; Hamano, 2013). Relatively little research, however, has focused on the joint resolution of these puzzles (Bodenstein, 2008; Colacito and Croce, 2013). Benigno and Thoenissen (2008) develop a standard IBC model with non-traded goods and incomplete markets. They show that under strong complementary between domestic and foreign tradables the model addresses the Backus-Smith puzzle. Similarly, Corsetti et al. (2008) argue that international nancial markets are not developed enough to generate full risk sharing and show that standard IBC models with incomplete markets account for the Backus-Smith correlation. In particular, if there is a high level of complementary between exported and imported goods, then the model produces substantial movements in the RER as well as a negative correlation between the RER and relative consumption, and reduces the correlation between domestic and foreign consumption. However, these results are not robust to the introduction of a second trade asset (Benigno and Kukuc-Tuger, 2010). Kollman (2012) shows that the Backus-Smith anomaly can be explained by a simple IBC model in which a fraction of households cannot participate in the trading activity.

Bodenstein (2008) develops a two country model with complete asset markets and limited enforcement for international nancial contracts where the ability to share risk depends on the degree of patience of the agents. He shows that, if agents are su ciently impatient (i.e. markets are incomplete), the model addresses the RER volatility puzzle, the Backus-Smith puzzle and the consumption correlation puzzle simultaneously. Following Corsetti et al. (2008), Thoenissen (2011) shows that a standard IBC model with incomplete markets is able to solve the RER volatility puzzle, the RER persistence puzzle and the Backus-Smith anomaly. However, the success of the model heavily depends on the choice of the elasticity of substitution between domestic and foreign produced goods. In particular, the range of elasticity values that allows the model to address the macro-puzzles is very narrow. In line with these IBC studies, Hamano (2013) shows that market incompleteness (i.e. a partial risk-sharing environment) is crucial for the resolution of the consumption-real exchange rate anomaly.

There is an extensive debate in the literature on whether or not \ nancial autarky" and \one-bond world" regimes represent realistic nancial environments and the international risk sharing mechanism is e cient. On the one hand, numerous international nance studies show that both developed and emerging capital markets have become largely integrated over the last two decades (Pukthuanthong and Roll, 2009; Bekaert et al., 2011; Volosovyvh, 2011; Donadelli, 2013: Ma and McCauley, 2013; among others). For example, Fitzgerald (2012) nds that nancial risk-sharing among developed countries is nearly optimal. A higher degree of nancial integration improves household consumption smoothing, that is, the consumers' ability to hedge against good or bad news (Jappelli and Pistaferri, 2011). On the other hand, some theoretical studies argue that a \ nancial autarky" regime or a \one-bond world" do not represent realistic nancial environments. Heathcote and Perri (2002) conclude that an e cient international trading activity environment (i.e. international borrowing and lending opportunities) is important for the IBC. Kollman (2012) points out that international capital markets allow for an almost frictionless trading activity in a large variety of securities (e.g. equities, futures, options, CDS, bonds). Crucini (1999) and Santos Monteiro (2008) argue that standard incomplete markets models are problematic in that they are characterised by limited consumption risk-sharing both at the domestic and international level.

The aim of the present paper is to compare the international macroeconomic quantities and prices produced by an IBC model under a nancial autarky regime with those produced by a model with international complete markets. In other words, we ask the question whether a limited international risk sharing environment is necessary to solve simultaneously the three classic international macroeconomic

a two country-two good model with recursive preferences, complete and frictionless markets, consumption home bias and correlated long-run shock accounts for three important international macroeconomics anomalies as well as two well known asset pricing puzzles. We stress that its performance is not a ected much by changes in the parameter values.

The rest of the paper is organized as follows. Section 2 presents some stylized facts for China and the US. Section 3 outlines the model. Section 4 discusses the results. Section 5 concludes.

2 On the US-China relationship

2.1 *Why US-China?*

The debate on when China will overtake the US in terms of GDP is ongoing. At current growth rates, China will probably be the world's largest economy in the next decade. At present, the US and China account for almost one third of the world's GDP (33% in 2012). Both goods and nancial trade have increased sharply since during the mid 90's. Recent estimates suggest that China's GDP is almost double Japan's GDP and almost three times higher than the GDP of the UK, France and Italy GDPs.[2]

China ERP, risk-free rate, RER volatility-consumption volatility ratio, correlation between RER and consumption differentials, cross-country consumption correlation over two different sub-samples: i) pre-liberalisation era (i.e. 1972-1990); ii) post-liberalisation era (i.e 1991-2009). International macroeconomic quantities and prices are then computed by assuming two different international capital market structures.

Complete markets are almost invariably assumed in international finance and IBC studies (Colacito and Croce, 2010; Ready et al., 2013, among others). Such environment is supported by recent studies showing that risk-sharing via financial markets is nearly optimal, and that trade frictions in goods markets are not negligible (Fitzgerald, 2012). However, the debate on whether emerging markets are fully integrated is still open. A large number of studies show that the post-9/11 era has been characterized by a steep increase in the level of financial integration across emerging and developed markets (Pukthuanthong and Roll, 2009; Bekaert et al., 2011; Volosovych, 2011; Donadelli, 2013; among others). For example, Ma and McCauley (2013) measure the *de facto* capital account openness for China and India. They show that both economies are becoming more financially open over time.[3] Evidence of a sharp increase in the level of financial integration in China can be found also in Cheung et al. (2006) and Lane and Schmukler (2007). According to this evidence, a full financial risk-sharing environment in the post-liberalisations era might represent a realistic US-China capital markets scenario.[4] Anyhow, in line with recent studies (see Tretvoll, 2008; Bacchetta and van Wincoop, 2013; Ready et al., 2013), we introduce partial risk-sharing by means of good markets frictions (consistently with the empirical evidence).

[3]International data confirm that financial and trade openness in China has largely increased in the mid 1990s (see the following measures: i) China's foreign trade with related counties and territories; ii) amount of foreign capital actually used by country or territory, freely available at `http://www.stats.gov.cn/english/`)

[4]We stress that existing empirical studies showing partial risk-sharing across emerging capital markets employ mostly pre-2000 data (Kose et al., 2007; Fitzgerald, 2012).

2.2 *US-China stylized facts*

Figure 1 suggests that these two countries substantially increased their degree of openness toward international markets after 1990, and that their currencies' fluctuations largely increased after capital market liberalisations. This is clear from the dynamics of the ratios of the sum of US and China trade to world trade and the sum of US-owned assets abroad and foreign-owned assets in the US to the sum of US and China's GDPs. Both measures are increasing over time (Figure 1, top-left panel). We would argue that the increasing degree of integration across both equity and goods markets (Figure 1, top-left panel)[5] has also largely influenced the RER volatility-consumption volatility ratio and the Backus-Smith correlation. The former has largely increased (Figure 1, top-right panel), whereas the latter has significantly decreased (Figure 1, bottom-left panel). The ratio between the RER and consumption volatility is constantly above one. Over the post-liberalizations period the average is 5.2, a much higher value than that produced by standard IBC models. The correlation between RER and real consumption growth differentials declined sharply immediately after 1990 and started to become negative in the mid 90's (Figure 1, bottom-left panel). It particular, it is positive under financial autarky (i.e. 0.34 over the period 1972-1990), and negative after equity market liberalisations (i.e. -0.56 over the period 1991-2009).[6] At odds with the results of a standard IBC model with complete markets, the correlation between the US and China real consumption growth rates is consistently far from unity (Figure 1, bottom-right panel).

[5] The current account-GDP ratio follows a similar dynamics.

[6] A similar results is obtained by Colacito and Croce (2013) on US-UK data.

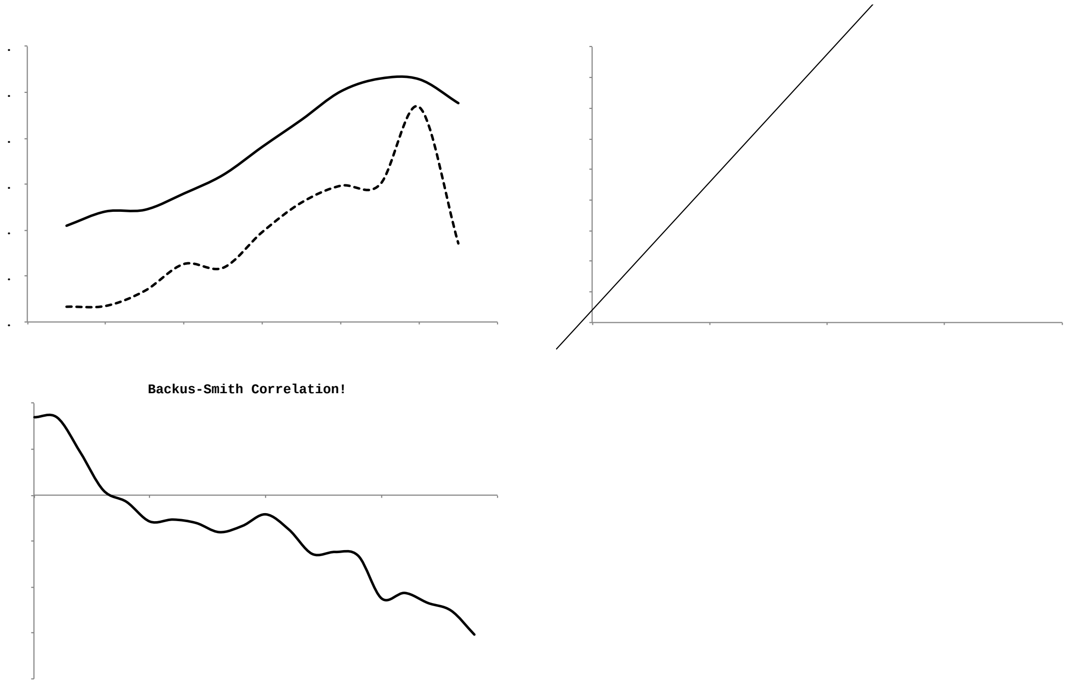

Figure 1: Financial and trade openness vs. puzzles. *Notes*: The trade openness is the ratio between sum of US-China imports and exports and sum of US and China GDPs. Financial openness is measured as the ratio between sum of U.S.-owned assets abroad and Foreign-owned assets in the United States and sum of US and China GDPs. The ratio between real exchange rate (RER) volatility and consumption growth volatility, the correlation between the real exchange rate and consumption di erentials and the cross-country consumption correlation are computed using a rolling window of 20 years. Details on data sources are given in the appendix.

3 The model: A Review

A. Consumption aggregate.

The economy comprised two countries, home (H) and foreign (F), and two goods G_h and G_f. The home (foreign) country is endowed with good G_H (G_F). The agents' preferences are de ned over a consumption aggregate of good G_H and good G_H. Formally,

$$C_{h;t} = (g^h_{h;t}) \;\; (g^h_{f;t})^1 \tag{1a}$$

$$C_{f;t} = (g^f_{h;t})^1 \quad (g^f_{f;t}) \tag{1b}$$

where $C_{h;t}$ ($C_{f;t}$) is the consumption aggregate in the home (foreign) country, $g^h_{h;t}$ ($g^f_{h;t}$) and $g^h_{f;t}$ ($g^f_{f;t}$) denote the consumption of good G_h and good G_f in the home (foreign) country at time t, and $\; 2 \; (0; 1)$ represents the home bias parameter.

B. Preferences.

B.1 Standard preferences

In the rst part of our analysis preferences are represented by the power utility function. Formally,

$$U_{h;t} = \frac{C_{h;t}^{1} \quad 1}{1} \tag{2a}$$

$$U_{f;t} = \frac{C_{f;t}^{1} \quad 1}{1} \tag{2b}$$

where is the RRA coe cient.

B.2 Recursive preferences

Recursive Epstein and Zin (1989) preferences are as follows

$$U_{h;t} = [(1 \quad)(C_{h;t})^{\frac{1}{}} + \; E_t[(U_{h;t+1})^{(1 \quad)}]^{\frac{1}{}}]^{\frac{}{1}} \tag{3a}$$

$$U_{f;t} = [(1 \quad)(C_{f;t})^{\frac{1}{}} + \; E_t[(U_{f;t+1})^{(1 \quad)}]^{\frac{1}{}}]^{\frac{}{1}} \tag{3b}$$

where $0 < \; < 1$ is the subjective discount factor and $^{1} \; 1$ the rate of time preference, $\; > 0$ is the risk aversion parameter, $\; = \frac{1}{1 \; 1=}$, and is the intertemporal elasticity of substitution. In this setup, agents care about future uncertainty if $\; 1= \; > 0$.

B. Endowments.

Endowments are cointegrated processes and embody a long-run risk component. Formally,

$$logG_{h;t} = \; + !_{h;t \; 1} + \; (logG_{f;t \; 1} \quad logG_{h;t \; 1}) + \; {}^{SR}_{h;t} \tag{4a}$$

$$logG_{f;t} = \; + !_{f;t \; 1} + \; (logG_{h;t \; 1} \quad logG_{f;t \; 1}) + \; {}^{SR}_{f;t} \tag{4b}$$

$$\omega_{h,t} = \rho_h \omega_{h,t-1} + \varepsilon^{LR}_{h,t} \tag{5a}$$

$$\omega_{f,t} = \rho_f \omega_{f,t-1} + \varepsilon^{LR}_{f,t}. \tag{5b}$$

where μ is the long-run endowment growth rate, $\lambda \in (0,1)$ denotes the co-integration parameter, $\omega_{h,t}$ and $\omega_{f,t}$ are highly persistent AR(1) processes, $\varepsilon^{SR}_{h,t}$ and $\varepsilon^{SR}_{f,t}$ are short-run shocks, and $\varepsilon^{LR}_{h,t}$ and $\varepsilon^{LR}_{f,t}$ are long-run shocks. Shocks are distributed as follows

$$\underbrace{\begin{pmatrix} \varepsilon^{SR}_{h,t} \\ \varepsilon^{SR}_{f,t} \\ \varepsilon^{LR}_{h,t} \\ \varepsilon^{LR}_{f,t} \end{pmatrix}}_{\varepsilon_t} \quad i.i.d.\ N\left(\underbrace{\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}}_{\mathbf{0}} ; \underbrace{\begin{pmatrix} \sigma^2_{SR_h} & \sigma_{SR_h, SR_f} & 0 & 0 \\ \sigma_{SR_f, SR_h} & \sigma^2_{SR_f} & 0 & 0 \\ 0 & 0 & \sigma^2_{LR_h} & \sigma_{LR_h, LR_f} \\ 0 & 0 & \sigma_{LR_f, LR_h} & \sigma^2_{LR_f} \end{pmatrix}}_{\Sigma} \right)$$

where ε is the shock vector and Σ is the variance-covariance matrix of the cross-country short- and long-run shocks.

C. Capital market structure and optimal allocations.

C.1 Financial Autarky

As suggested by Cole and Obstfeld (1991), in a financial autarky regime trade in the goods market takes place and it must be balanced in every period. Formally, the budget constraint for the home and foreign country is

$$g^h_{h,t} + p_t g^h_{f,t} = G_{h,t} \tag{6a}$$

$$g^f_{h,t} + p_t g^f_{f,t} = p_t G_{y,t} \tag{6b}$$

Under financial autarky agents cannot trade securities internationally. In practice, markets are complete only domestically. Therefore, there is no room for international consumption smoothing. This capital market structure gives rise to the following optimal allocation

$$g^h_{h;t} = \quad G_{h;t}; \qquad g^f_{h;t} = (1 \qquad)G_{h;t} \tag{7a}$$

$$g^h_{f;t} = (1 \qquad)G_{f;t}; \qquad g^f_{f;t} = \quad G_{f;t} \tag{7b}$$

In this setup, the real exchange rate is simply represented by the home-bias adjusted current relatively supply of the home and foreign goods. Formally,

$$e_t = (2 \qquad 1)(\quad G_{h;t} \qquad G_{f;t}) \tag{8}$$

C.2 Complete markets

In order to empha the1(nat-422(thee-422(eeseoluion)-322(orf-422(toee-422(epuzzls)-322(ed)-27(ds)-3 on the realization of s^{t+1} at time $t+1$). In equilibrium, the following holds:

$$A_{h;t} + A_{f;t} = 0; \quad 8t$$

. The e cient allocation is the solution of a planner's problem choosing a sequence of allocations $fg^{h}_{h;t}; g^{f}_{h;t}; g^{h}_{f;t}; g^{f}_{f;t} g^{+1}_{t=0}$ to maximize

$$Q = W_h U_{h;0} + W_f U_{f;0}$$

subject to the following feasibility constraints:

$$g^{h}_{h;t} + g^{f}_{h;t} = G_{h;t}; \quad g^{h}_{f;t} + g^{f}_{f;t} = G_{f;t} \quad 8t \quad 0$$

where W_h and W_f are the date $t = 0$ non-negative Pareto weights attached to the consumer by the planner. By assuming $S_t = W_{h;t} = W_{f;t}$, the rst order conditions of the social planning problem give rise to the following Pareto optimal allocation[7]

$$g^{h}_{h;t} = \quad G_{h;t} \quad 1 + \frac{(1 \quad)(S_t \quad 1)}{1 \quad + \quad S_t} \quad ; \quad g^{f}_{h;t} = (1 \quad)G_{h;t} \quad 1 + \frac{(S_t \quad 1)}{1 \quad + \quad S_t} \qquad (10a)$$

$$g^{h}_{f;t} = (1 \quad)G_{f;t} \quad 1 + \frac{(S_t \quad 1)}{+ (1 \quad)S_t} \quad ; \quad g^{f}_{f;t} = \quad G_{f;t} \quad 1 + \frac{(1 \quad)(S_t \quad 1)}{+ (1 \quad)S_t} \qquad (10b)$$

where

$$S_t = S_{t \quad 1} \frac{M_{h;t}}{M_{f;t}} \quad \frac{e^{\quad c_{h;t}}}{e^{\quad c_{f;t}}}$$

and $M_{h;t}$ ($M_{f;t}$) is the home (foreign) stochastic discount factor. Under complete markets changes in the real exchange rate are equal to the di erence between the log of the foreign and domestic stochastic discount factors.

$$e = \log M_{f;t} \quad log M_{h;t} \qquad (11)$$

E. The stochastic discount factor.

[7]For details, see Croce and Colacito (2013).

E.1 Standard preferences

CRRA preferences imply the following stochastic discount factor

$$M_{h;t+1} = \frac{C_{h;t+1}}{C_{h;t}} \qquad (12a)$$

$$M_{f;t+1} = \frac{C_{f;t+1}}{C_{h;t}} \qquad (12b)$$

for the home and foreign country, respectively.

E.2 Recursive preferences

As shown in Epstein and Zin (1989), the stochastic discount factor in the home and foreign country takes the following form

$$M_{h;t+1} = \left(\frac{C_{h;t+1}}{C_{h;t}}\right)^{(1= \ )} \left(\frac{U^{1}_{h;t+1}}{E_t[U^{1}_{h;t+1}]}\right)^{\frac{1}{1}} \qquad (13a)$$

$$M_{f;t+1}+1$$

+13.2 2.676 Td ...512 -14.18 Td (h(8)) TJ 7.9701 Tf 6.9 Td 14 11.8 Td ((12a)) TJ 0 11.0 (h(8(811 ((1)) TJ 7.9701 Tf 7.527 0 Td (=) TJ 5 7.9701 Tf 10.057 0 Td ()) TJ 6 11.9552 Tf 3.792)-2

Parameter		Value	Parameter	Value
	Endowment long-run growth rate	2.00%	Consumption home-bias	0.97
^{LR}	Long-run shock volatility	1.87%	Co-integration parameter	0.05%
^{SR}	Short-run shock volatility	4%	Subjective discount factor	0.9825
	Long-run component persistence	0.985	RRA	8
$^{LR}_{h}$ $^{LR}_{f}$	Long-run shocks correlation	0.90	IES	1.5
$^{SR}_{h}$ $^{SR}_{f}$	Short-run shocks correlation	0.05		

Table 1: Benchmark calibration

4.2 *Results: Financial autarky vs. complete markets*

To compare the role of the novel risk sharing mechanism embodied in the model, we compare the results obtained in an international complete markets regime with those obtained under nancial autarky. First, we present the results of the model with standard preferences and both long-run risk and no long-run risk. Second, we turn our attention to the model with recursive preferences.[9]

4.2.1 Standard preferences

It is well known that in presence of complete markets and a power utility function, the ratio of domestic and foreign consumption determines the real exchange rate between two countries. It turns out that the correlation between consumption di erentials and the real exchange rate equals unity. In addition, market completeness tends to produce a high degree of co-movement between domestic and foreign consumption growth rates. As a result, the real exchange rate rarely moves. Standard IBC models, by assuming complete and frictionless domestic asset markets and standard preferences, do not account also for all the domestic asset pricing puzzles. In practice, a model with standard preferences, frictionless and complete domestic markets does not solve the risk-free rate and the EPP puzzles. The results of canonical IBC models are partially con rmed in Table 2, which reports data from the US and China for the pre- and post-liberalisations periods along with the results for the benchmark calibration for two di erent capital market structures (i.e. nancial

[9] The system of equations is solved by employing the perturbation methods. We compute our policy functions using the dynare++4.3.3 package.

autarky and complete markets), both in the presence and absence of long-run risk. As discussed in section 2, we nd that the RER volatility is higher and the RER-consumption di erentials correlation becomes negative in the post-liberalizations period. Under both international ca(IoFI)-431(cark)27(ets-431(cregies)-451(che)-451(ca)-27(d.e)-43

4.2.2 Recursive preferences

As is well known, recursive preferences allow to separate the RRA parameter from the IES. Such separability is a necessary condition to match asset pricing data (Bansal and Yaron, 2004; Croce, 2012; Pancrazi, 2013). Table 3 reports data on the US and China for the pre- and post-liberalisations periods along with the key moments produced by the model with recursive preferences for the benchmark calibration for two di erent capital market structures (i.e. nancial autarky and complete markets), both with and without long-run risk.

Model EZ	Data (pre-lib)	Financial Autarky (no LRR)	Financial Autarky (with LRR)	Data (post-lib)	Complete Markets (no LRR)	Complete Markets (with LRR)
Key Stat						
ERP	4.357	0.237	2.610	7.542	0.189	2.470
$E(R^f)$	1.458	2.892	1.646	0.999	2.926	1.747
(e)= (c)	4.869	1.115	1.128	5.259	5.112	7.595
$Corr($ $c_h;$ $c_f)$	0.112	0.404	0.392	0.016	0.768	0.578
$Corr($ c_h $c_f;$ $e)$	0.338	1.000	1.000	-0.557	1.000	-0.145

Table 3: MODEL VS. DATA: MACROECONOMIC QUANTITIES AND PRICES. *Notes*: This table reports the average equity premium, ERP, risk-free rate, R^f, real exchange rate volatility-consumption growth volatility puzzle, (e)= (c), the cross-country consumption growth correlation, $Corr($ $c_h;$ $c_f)$, and the Backus-Smith correlation, $Corr($ c_h $c_f;$ $e)$, simulated under di erent international capital market structures. All parameters are calibrated to the values reported in Table 1. With no-LRR the long-run shock volatility and the cross-country long-run shock correlations are re-calibrated, $^{LR} = 0$ and $_{h}^{SR}$ $_{f}^{SR} = 0{:}35$. Moments are calculated as the average over 200 simulations of 8 T -367(c)270Iriryc

onward and domestic consumption moves symmetrically with the RER (see Figure 2). On the other hand, in contrast to the economy with standard preferences, the model produces a sizable ERP and a relatively low risk-free rate (consistent with asset pricing data). The inclusion of complete markets in the model without long-run risk only affects the RER volatility which is more than five times the consumption volatility (consistently with post-liberalization data).

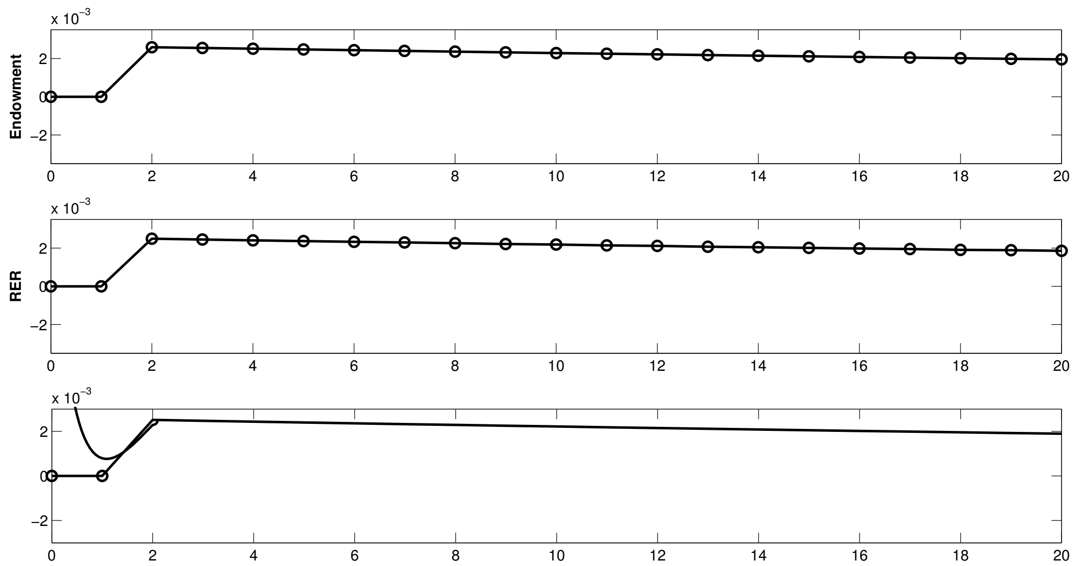

Figure 2: Impulse response functions: Financial Autarky. *Notes*: This figure shows the impulse response functions of endowment, exchange rate and domestic (black line) and foreign (pink line) consumption to a long-run positive news to the supply of the domestic goods.

By contrast, the novel risk sharing mechanism embodied in the two country-two good model with recursive preferences and complete markets produces endogenous time variation in the distribution of consumption and currency risk across countries. Therefore, the combination of recursive preferences, complete and frictionless markets, and long-run risk can simultaneously address the three international macroeconomic puzzles as well as the risk-free rate puzzle and the EPP. In this environment, risk-sharing takes place through imports and exports. In other words, endowments flow from the low-marginal utility country to the high-marginal utility one. For example, following positive long-run news on the supply of the domestic good, there is long-lasting impact on the domestic marginal utility. This implies that domestic agents will steadily decrease their share of world consumption (via exports) from time $t + 1$ onward (as long-run news does not a ect current consumption). It turns out that domestic consumption decreases and foreign consumption increases. Because of the excess supply of the domestic good, the RER depreciates.

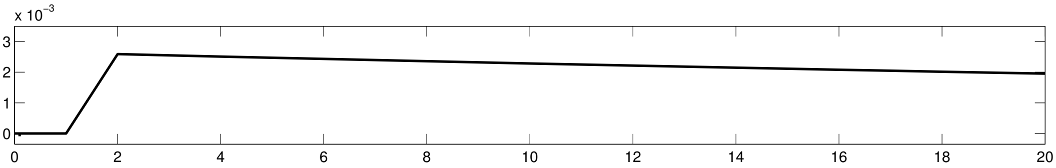

Figure 3: Impulse response functions: Complete Markets. *Notes*: This gure shows the impulse response functions of endowment, share of world consumption, exchange rate and domestic (black line) and foreign (pink line) consumption to a long-run positive news to the supply of the domestic goods.

risk-sharing based parameters. In practice, they control agent's willingness to share risk. This implies that changes in these parameters tend to a ect mainly the agents' utility function but leave the set of feasible allocations unchanged. In other words, di erent values of , and alter the ERP and the risk-free rate. As is standard in the long-run risk literature (Bansal and Yaron, 2004; Pancrazi, 2013), a higher RRA or IES produces a higher ERP as well as a higher RER volatility-consumption volatility ratio. The explanation is straightforward. With higher RRA or IES values, agents become more risk averse to consumption and utility risk and their willingness to buy insurance assets (for consumption smoothing) increases. Therefore, asset prices change and the currency becomes much more volatile.

By assuming su ciently impatient agents (i.e. = 0:96), the model is still able to produce a high RER volatility, a negative correlation between RER and consumption di erentials, and a relatively low cross-country consumption correlation.

Model (with LRR) Complete markets (EZ)	Higher RRA = 10	Higher IES = 2	Lower = 0:9	Lower Corr $_{h}^{LR}$ $_{f}^{LR}$ = 0:75	Lower = 0:96	Data (Post-Lib)
Key Statistics						
ERP	3.153	4.760	2.434	2.305	0.76	7.542
$E(R^f)$	1.408	0.700	1.773	1.843	4.91	0.999
(e)= (c)	9.428	9.525	3.053	9.381	2.62	5.259
$Corr($ $c_h;$ $c_f)$	0.510	0.631	0.484	-0.012	0.69	0.016
$Corr($ c_h $c_f;$ e						

periods (see Figure 1, bottom-right panel). In addition, if the correlation between domestic and foreign long-run shocks ranges from 0.9 (benchmark calibration) to 0.76, the performance of the model is not affected, that is, it still solves the five puzzles simultaneously. This is clear from Figure 4, which plots the real exchange rate volatility-consumption volatility ratio, $\sigma(\Delta e)/\sigma(\Delta c)$, the correlation between the real exchange rate and consumption differentials, $Corr(\Delta c_h - \Delta c_f; \Delta e)$, the cross-country consumption growth correlation, $Corr(\Delta c_h; \Delta c_f)$, for various values of the the cross-country long-run shocks correlation (on the horizontal axes), $\rho_{\varepsilon_h^{LR} \varepsilon_f^{LR}}$, by assuming $\rho = 0.97$ (Panel a) and $\rho = 0.9$ (Panel b).[11]

[11] It is also worth noting that the model produces a cross-country consumption correlation lower than an empirical cross-country GDP correlation (see dotted blue line in Figure 4). This holds if the parameter space of $\rho_{\varepsilon_h^{LR} \varepsilon_f^{LR}}$ is quite narrow.

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A *Data*

We base our analysis on US-China data over the period 1972-2009. Real consumption data are from the Robert Barro's website (Barro-Ursua Macroeconomic Data, 2010, freely available at `http://rbarro.com/data-sets/`).The annual av-