Under complete international financial markets, as assumed in standard international business cycle models, a country’s aggregate consumption rises relative to foreign consumption, in states of the world in which the country’s real exchange rate depreciates. Empirically, relative consumption spending and the real exchange rate are essentially uncorrelated. I show that this ‘consumption-real exchange rate anomaly’ can be explained by a model in which only a fraction of households trade in complete financial markets, while the remaining households do not participate in financial markets, and thus act in a hand-to-mouth (HTM) manner. HTM behavior also generates a more volatile real exchange rate, which also brings the model closer to the data.
1. Introduction

There is overwhelming evidence that consumption risk is imperfectly shared across countries (Obstfeld (1989, 1992)). Under full risk sharing (complete international financial markets), a country’s aggregate consumption would rise relative to foreign consumption, in states of the world in which the country’s real exchange rate depreciates. Yet, as documented in Table 1, relative consumptions and real exchange rates are essentially uncorrelated. That ‘consumption-real exchange rate anomaly’ is one of the major puzzles in international macroeconomics (Obstfeld and Rogoff (2000)).

This paper investigates whether this anomaly can be explained by a very simple model in which only a fraction of households trade in complete financial markets, while the remaining households do not participate in financial markets, and thus lead a hand-to-mouth (HTM) life; each period, HTM households consume their current labor income. Empirically, a sizable fraction of households fails to participate in asset markets (Haliassos (2006)). As discussed by Mankiw (2000), HTM behavior can reflect myopia on the part of households, or simple ‘rule-of-thumb’ decision making. Empirically, a country’s aggregate consumption growth closely tracks the growth of income (see Engel and Rogers (2008) for evidence for G7 countries). The closed economy literature has argued that the presence of HTM households may help to explain this fact (Campbell and Mankiw (1989)); that literature has also argued that HTM households may rationalize the macroeconomic effects of fiscal policy (e.g., Gali, Lopez-Salido and Vallès (2007); Forni, Monteforte and Sessa (2007)) and the equity premium (e.g., Weil (1990), Chien, Cole and Lustig (2007)).

In the open economy literature, the HTM assumption has received much less attention. To capture limited international risk sharing, that literature has mostly focused on models in which only a restricted set of assets can be traded across internationally (e.g., just a risk free bond)—however, most of these models assume that each country is

---

2 Some large multi-country models allow for HTM households (e.g., Erceg et al. (2004), Ratto, Roeger and in ‘t Veld (2008)), but the complexity of those models makes it hard to understand the role of the HTM feature.
inhabited by a representative household. Yet, in reality there is large-scale international trade in state-contingent assets (equity, derivatives); see Lane and Milesi-Ferretti (2003). Also, the data show that risk sharing is not only limited across countries, but also among the residents of the same country (e.g., Santos Monteiro (2008)).

The model here assumes complete international financial markets, but only some households have access to those markets. The remaining households lead hand-to-mouth lives. The setup here thus provides a very simple integration of within-country heterogeneity of households, in a model of the world economy.

In a related contribution, Kocherlakota and Pistaferri (2007) develop a model of a two-country world in which households can fully insure themselves against home and foreign aggregate productivity shocks, but not against individual-specific shocks to labor productivity. In that setup, cross-sectional heterogeneity matters for the real exchange rate. Under a private information-Pareto optimal (PIPO) insurance mechanism, a country’s real exchange rate appreciates when foreign right-tail cross-sectional consumption inequality increases relative to domestic right-tail inequality. Kocherlakota and Pistaferri (2007) claim that this prediction is consistent with data on the US and UK real exchange rate and on individual US and UK household consumption. Kollmann (2009) casts doubts on the success of the PIPO model. Also, so far, the ability of the PIPO structure to match a broader set of macroeconomic stylized facts has not been studied. The PIPO model implies that the consumption of rich (high-productivity) households tracks their income more closely, than for poor households. By contrast, in the model here, wealthy households trade in complete markets.

The present model is much simpler, and it is thus more suitable for analyzing a broad set of international macroeconomic stylized facts. Devereux, Smith and Yetman (2009) also discuss the possibility that the presence of HMT households may help to explain the consumption real exchange rate anomaly. However the model used by these

---

3 See, e.g. Kollmann (1991,1996), Baxter and Crucini (1995), Chari, Kehoe and McGrattan (2002), Corsetti, Dedola and Leduc (2008) for multi-country bonds-only models in which each country is inhabited by a representative household. The bonds-only structure fails to explain the consumption-real exchange rate anomaly, unless the elasticity of substitution between local and imported goods is close to zero (Corsetti et al. (2008)).

4 This paper was brought to my attention after the research here had been completed.
authors differs from that here; also, they do not discuss implications of HTM behavior for other exchange rate volatility and other macroeconomic stylized facts here.

The model here assumes a two-country world with two goods. Each country produces a single good, but uses domestic and foreign goods for consumption and physical investment; there is a local bias in consumption/investment spending. The economy is hit by shocks to output, investment spending, and to the shares of GDP received by HTM households.

In the structure here (as in standard models), output supply shocks induce a negative co-movement between a country’s relative aggregate consumption, and its relative CPI (i.e. its consumption based real exchange rate): when the country’s output rises, its relative consumption rises (due to a preference bias for the local good), while the relative price of the good produced by the country drops, which implies a depreciation of the country’s real exchange rate.

The presence of HTM households generates two mechanisms that weaken the negative correlation between the real exchange rate and relative consumption: (i) With HTM households, relative Home consumption responds less strongly negatively to shocks that raise Home real investment—in fact a Home investment shock may increase Home relative consumption if households are sufficiently risk averse. A rise in Home country investment spending raises the relative price of the good produced by Home, which raises the relative income and consumption of Home HTM households; the relative consumption of Home non-HTM households falls—however, if risk aversion is sufficiently high, the fall of non-HTM consumption is small, and thus relative Home consumption (by HTM and non-HTM households) falls less, and may actually increase. (ii) An increase in the share of Home GDP received by Home HTM households likewise improves the Home terms of trade, and it raises Home consumption (by HTM and non-HTM households).

The responses of the real exchange rate to demand shocks (investment shocks and shocks to the share of GDP received by HTM households) are greater when there are HTM households. Intuitively, a rise in the relative price of the Home good raises the (relative) income of the HTM households. Due to consumption home bias, that income effect counteracts the negative substitution effect of the price change on the relative
demand for the Home good. The positive Home income effect is stronger, the greater the share GDP received by HTM households. Hence, the (relative) demand for the Home good is less sensitive to terms of trade changes, when the income share of HTM households is high. With a high HTM income share, larger terms of trade (and real exchange rate) adjustments are thus needed to clear the goods market, in response to demand shocks. When the local spending bias is strong, the sensitivity of the real exchange rate to output shocks is likewise greater, the greater the income share of HTM household. The presence of HTM households raises the sensitivity of relative (Home versus Foreign) consumption to income shocks, but it dampens the effect of investment shocks.

I calibrate the model to data for the US and an aggregate of the remaining G7 countries, using the labor share (ratio of labor income to GDP) as an empirical proxy for the fraction of GDP received by HTM households. Empirically, relative (domestic vs. foreign) physical investment spending is more volatile than relative output, while the relative labor share is less volatile. Also, relative investment is highly positively correlated with relative output. With this empirical pattern of output, investment and the labor share, the model with HTM households predicts that a country’s relative consumption is, essentially, uncorrelated with its real exchange rate, as is consistent with the data. The strong positive empirical correlation between output and investment is important for the ability of the model to generate a realistic consumption-real exchange rate correlation. In addition, numerical simulations show that the presence of HTM households can significantly increase the volatility of the real exchange rate, of consumption and net exports. The HTM assumption thus brings the model closer to the data, compared to standard International RBC models in which all households trade in complete financial markets (as is well known, those models underpredict the empirical volatility of the real exchange rate and of net exports, and produce cross-country consumption correlations that are too high when compared to the data).

Sections 2 present the main analytical results, based on a static model. Section 3 calibrates the static model, and reports quantitative predictions. Section 4 embeds the HTM assumption in a dynamic international RBC model. Section 5 concludes.
2. The model

2.1. Preferences, endowments and markets

I consider a world with two ex ante symmetric countries, Home (H) and Foreign (F), and two goods. Country \( i \) = H,F produces \( Y_i \) units of good \( i \). Country \( i \) is inhabited by two households: the first household is a hand-to-mouth household, HTM, whose income equals an exogenous random fraction \( 0 \leq \lambda_i < 1 \) of her country’s GDP; the HTM household consumes her entire income. The second country \( i \) household receives the country’s GDP, net of the income of the HTM household, and net of exogenous real ‘investment’ spending, \( X_i \); that household trades in a complete financial market; we refer to that household as a ‘risk sharer’, RS. The HTM and RS households can be interpreted as a workers, and as an entrepreneur (residual claimant), respectively.

Both types of households have identical preferences. The country \( i \) household of type \( h = \text{HTM,RS} \) has utility

\[
U(C^h_i) = \frac{1}{1-\sigma}((C^h_i)^{\sigma} - 1),
\]

where \( C^h_i \) is aggregate consumption:

\[
C^h_i = [\alpha^{1/\phi}(c^{i,h}_i)^{(\phi-1)/\phi} + (1-\alpha)^{1/\phi}(c^{j,h}_i)^{(\phi-1)/\phi}]^{\phi/(\phi-1)}, \quad j \neq i; \tag{1}
\]

\( c^{i,h}_i \) and \( c^{j,h}_i \) are the household’s consumptions of goods \( i \) and \( j \), respectively. \( \sigma > 0 \) and \( \phi > 0 \) are the risk aversion coefficient, and the substitution elasticity between the two goods, respectively. There is a preference bias for the local good: \( 1/2 < \alpha < 1 \). The welfare based consumer price index corresponding to these preferences is:

\[
P_i = p_i(p_i^{-\phi} + (1-\alpha)(p_j)^{(1-\phi)})^{1/(1-\phi)}, \tag{2}
\]

where \( p_i \) is the price of good \( i \).

The Home terms of trade and the Home (CPI-based) real exchange rate are \( q \equiv p_H/p_F \) and \( \text{RER} \equiv p_H/p_F \), respectively.

The real consumption of the HTM household is:

\[
C^{\text{HTM}}_i = p_i\lambda_i Y_i / p_i. \tag{3}
\]

Efficient risk sharing between Home and Foreign ‘RS’ households implies that the ratio of their marginal utilities of real consumption spending is equated to the real exchange rate (Kollmann (1991, 1995), Backus and Smith (1993)):

\[
(C^{RS}_H)^{-\sigma}/(C^{RS}_F)^{-\sigma} = \xi \cdot \text{RER}, \tag{4}
\]
where $\xi$ is a state-independent term that reflects the two countries’ ex ante wealth; in the setting here, $\xi = 1$ holds, due to the ex ante symmetry of the countries.

Real investment $I_i$ is a composite good that has the same structure as aggregate consumption (1). Spending is allocated between goods H and F so that the marginal rate of substitution between these goods is equated to their relative price. Thus:

$$c_i^{i,k} = \alpha\left(\frac{p_H}{p_i}\right)^\delta c_i^H, \quad c_i^{j,k} = (1-\alpha)\left(\frac{p_i}{p_j}\right)^\delta c_i^H, \quad x_i^j = \alpha\left(\frac{p_i}{p_j}\right)^\delta X_i, \quad x_i^j = (1-\alpha)\left(\frac{p_i}{p_j}\right)^\delta X_i \quad (j \neq i), \quad (5)$$

where $x_i^j$ is country $i$ investment demand for good $j$.

Market clearing requires:

$$c_i^{i,HTM} + c_i^{j,RS} + x_i^j + c_i^{j,HTM} + c_i^{j,RS} + x_i^j = Y_i \quad \text{for} \quad i, j = H, F \quad (\text{with } j \neq i). \quad (6)$$

The distributions of the exogenous variables are symmetric across countries; their expected values are: $E_Y = 1, \Lambda = \sum \lambda_i \geq 0, \Xi = \sum \Xi_i > 0$ with $0 < \Lambda + \Xi < 1$, for $i = H, F$.

The above equations pin down consumption and the real exchange rate, given $Y_i, I_i, \bar{\lambda}_i$ for $i = H, F$. In the first part of the analysis, I will take the behavior of $Y_i, I_i, \bar{\lambda}_i$ as given. I calibrate the model using data on first and second moments of $Y_i, I_i, \bar{\lambda}_i$ observed for the US and an aggregate of the remaining G7 countries, and I compute the implied moments of consumption, the real exchange rate and net exports. A dynamic model is needed to endogenize investment. But note that a dynamic model will generate the same consumption-real exchange rate correlation as the static model, if the dynamic model reproduces the empirical first and second moments of relative outputs, investment and HTM income shares that are used to calibrate the static model. In the Section 4, I embed the HTM assumption in a dynamic international RBC model with endogenous output and investment spending.

2.2. Model solution

I compute an approximate model solution by linearizing equations (1)-(6) around mean values of the forcing variables. Endogenous variables with an upper bar refer to the point of linearization. $\hat{z} = (z - \bar{z})/\bar{z}$ denotes the relative deviation of a variable $z$ from the point
of linearization, \( \bar{z} \). Variables without country-subscript represent ratios of Home to Foreign variables: \( C^{HTM} \equiv C_{HTM}^{HTM}, C^{RS} \equiv C_{RS}^{HTM}, I \equiv I_{HTM}^{HTM}, Y \equiv Y_{HTM}^{HTM}, \lambda \equiv \lambda_{HTM} \), etc.

Linearization of (2) implies:

\[
\widehat{RER} = (2\alpha - 1)\hat{q} \quad (7)
\]
due to local spending bias, a Home terms of trade improvement induces a real exchange rate appreciation. Linearizing (3) gives:

\[
\widehat{C}^{HTM} = \hat{Y} + \hat{\lambda} + 2(1 - \alpha)\hat{q}. \quad (8)
\]

An increase in Home GDP, an increase in the fraction of GPD received by the Home HTM household, and an improvement in Home terms of trade all raise the relative consumption of the Home HTM household (compared to the consumption of the Foreign HTM household).

From (4), the relative (Home vs. Foreign) consumption of households that engage in risk sharing (RS) is a decreasing function of Home terms of trade:

\[
\widehat{C}^{RS} = -\frac{1}{\sigma}(2\alpha - 1)\hat{q}. \quad (9)
\]

From (5), relative world demand for goods H and F obeys:

\[
d \equiv \frac{c_{H, HTM}}{c_{F, HTM}} + \frac{c_{H, RS}}{c_{F, RS}} + \frac{x_{H}}{x_{F}} + \Phi = q^{-\phi} \Omega(RER^\Phi A), \quad (10)
\]

with \( \Omega(x) \equiv \frac{x_{1}^{1-\alpha}}{1 + x_{1}^{-\alpha}} \), \( A \equiv A_{H}/A_{F} \) where \( A_{i} \equiv C_{i}^{HTM} + C_{i}^{RS} + I_{i} \) is absorption in country \( i \). Note that \( \frac{\partial \Omega(x)}{\partial x} \bigg|_{x=1} = 2\alpha - 1 \). A linear approximation of (10) gives thus:

\[
\hat{d} = -\phi\hat{q} + (2\alpha - 1)(\phi\widehat{RER} + \hat{A}). \quad (11)
\]

Using (7)-(9), relative demand for good H (\( d \)) can be expressed as:

\[
\hat{d} = -\Gamma\hat{q} + (2\alpha - 1)\Lambda(\hat{\lambda} + \hat{Y}) + (2\alpha - 1)\Xi\hat{I}. \quad (12)
\]

Here \( \Gamma \equiv (l - 2\alpha)^{3}(l - \Lambda - \Xi)\sigma - 2(2\alpha - 1)(l - \alpha)\Lambda + 4\alpha(l - \alpha)\phi \) is the price elasticity of \( d \). Unless the substitution elasticity \( \phi \) is very close to zero, relative demand for good H is decreasing in

---

5 Similar equations for relative Home vs. Foreign demand are derived in Coeurdacier, Kollmann and Martin (2007, 2008).
the relative price of good H, \( q \): \( \Gamma > 0 \) (see Appendix).\(^6\) The following discussions assume \( \Gamma > 0 \).

Market clearing requires \( \hat{Y} = \hat{d} \). (12) shows that increases in the relative share of GDP received by Home HTM households (\( \lambda \)) and in relative Home real investment spending (\( I \)) both raise the relative demand for good H; to ensure market clearing, those shocks thus require an improvement of the Home terms of trade (when \( \Gamma > 0 \)), and thus an appreciation of the Home real exchange rate. Intuitively, a rise in \( \lambda \) or in \( I \) lowers the quantity of good H consumed by (Home and Foreign) RS households; the relative consumption of Home RS households has to fall relative to that of Foreign RS households—and as a result, the relative price of good H increases (from (9)). By contrast, a rise in (relative) Home output triggers a worsening of Home terms of trade, \( q \): At unchanged terms of trade, a 1% increase in \( Y_H \) raises relative demand for good H by less than 1%, namely by \((2\alpha - l)\Lambda \%\); market clearing thus requires a fall in \( q \). In summary:

\[
\hat{RER} = a_y \hat{Y} + a_I \hat{I} + a_\lambda \hat{\lambda} \quad \text{with } a_y < 0, a_I > 0, a_\lambda > 0. \tag{13}
\]

Closed form expressions for the coefficients \( a_y, a_I, a_\lambda \) are provided in the Appendix.

Using the solution for \( \hat{q} \), one can use (4) and (9) to determine relative ‘national’ consumption \( \hat{C} = C_H / C_F \), where \( C_i \equiv C_{iHTM} + C_{iRS} \) (\( i = H, F \)):

\[
\hat{C} = b_y \hat{Y} + b_I \hat{I} + b_\lambda \hat{\lambda}. \tag{14}
\]

As an increase in \( \lambda \) improves the Home terms of trade (provided \( \Gamma > 0 \)), it raises relative absorption in the Home country; \(^7\) holding constant relative investment, this means that relative Home consumption rises: hence, \( b_\lambda > 0 \).

Not surprisingly, an increase in relative Home output (\( Y \)) raises Home relative aggregate consumption (\( b_y > 0 \)), for plausible parameter values (see Appendix).

\(^6\) For very low \( \phi \), the (negative) substitution effect of a rise in Home terms of trade \( q \) on the demand for good H is weak, and that effect may thus be dominated by the (positive) income effect experienced by country Home HTM households; the (relative) demand for good H is then an increasing function of \( q \).

\(^7\) (11) and \( \hat{Y} = \hat{d} \) imply \( \hat{Y} = -\phi 4\alpha (1 - \alpha) q^2 + (2\alpha - I) \hat{\lambda} \). Thus, any shock that improves the Home terms of trade, at an unchanged value of relative output, has to be associated with a rise in relative Home absorption.
An increase in relative Home investment likewise improves the Home terms of trade; this raises the relative consumption of the Home HTM household ($C^{HTM}$), but it reduces the relative consumption of the Home ‘RS’ households ($C^{RS}$); see (8),(9). For plausible values of $\Lambda$, the second effect dominates, i.e. $b_i<0$ (see Appendix).

Note that $\Gamma$ (the elasticity of relative demand for the two goods, with respect to the terms of trade) is decreasing in $\Lambda$ (mean GDP share received by HTM households). Intuitively, a rise in the relative price of the Home good raises the (relative) income of the HTM households. Due to consumption home bias, that income effect counteracts the negative substitution effect of the price change on the relative demand for the Home good. The positive income effect experienced by Home HTM households is stronger, the greater the share of HTM households--which explains why $\Gamma$ is decreasing in $\Lambda$.

As a result, the sensitivity of the real exchange rate to (relative) investment shocks and to shocks to the GDP received by HTM households ($\lambda$) is higher, the greater is $\Lambda$ (see Appendix.): with a high HTM income share, larger terms of trade (and real exchange rate) adjustments are needed to clear the goods market, in response to exogenous demand shocks. Relative national consumption is less sensitive to investment shocks, but more sensitive to shocks to $\lambda$ the greater is $\Lambda$.

At constant terms of trade, an increase in Home output creates an excess supply in the market for the Home good. The greater is $\Lambda$, the smaller is that excess supply, as a greater $\Lambda$ means that Home HTM households’ income rises more strongly. As the elasticity of relative demand for the two goods, with respect to the terms of trade is lower when $\Lambda$ is greater, the effect of the presence of HTM households on the sensitivity of the real exchange rate to output shocks is ambiguous. It appears that when the local spending bias is strong, the sensitivity of the real exchange rate to output shocks is higher, the greater is $\Lambda$, while the sensitivity of relative consumption is weaker (see Appendix). For values of $\alpha$ arbitrarily close to unity, the real exchange and relative consumption are approximately given by

$$\hat{RER} = -\frac{\sigma(1-\Lambda)}{1-\alpha-\Sigma} \hat{\gamma} + \frac{\sigma}{1-\alpha-\Sigma} \{\Lambda \hat{\lambda} + \hat{\Sigma}\}, \quad \hat{C} = \frac{1}{1-\Sigma} \hat{\gamma} - \frac{\Sigma}{1-\Sigma} \hat{I};$$

(15)
In this limiting case, the sensitivity of the real exchange rate to shocks is greater, the greater the degree of risk aversion, but it does not depend on the substitution elasticity between domestic and foreign goods, \( \phi \).

In summary, output and investment shocks induce negative co-movement between the real exchange rate and relative consumption. However, the presence of HTM households dampens the negative effect of a Home investment shocks on Home relative consumption, and it strengthens the response of the real exchange rate to those shocks. Shocks to the GDP share received by HTM households are a source of positive co-movement between a country’s real exchange rate and its relative national consumption. This helps to understand why, as shown below, the HTM model generates a lower and thus more realistic correlation between the real exchange rate and relative consumption, and greater real exchange rate fluctuations than a model with full risk sharing (in which there are no HTM households).

2.3. Two alternative asset structures
It seems interesting to compare the above model to two alternative asset market set-ups that have widely been studied in the literature: full risk sharing (e.g. Backus, Kehoe and Kydland (1994)) and financial autarky (e.g. Heathcote and Perri (2004)):

*Full risk sharing (not HTM households)*
There is full risk sharing when there are no HTM households \((\lambda_\text{HT}=\lambda_\text{RF}=0)\). It follows from the formulae shown in the Appendix that then \(a_\text{R}<0,a_\text{I}>0\) and \(b_\text{R}>0,b_\text{I}<0\) irrespective of the values of the preference parameters and of the mean level of investment. Thus a rise in relative output always triggers a real exchange rate depreciation, and an increase in relative consumption. A rise in relative investment appreciates the real exchange rate and lowers Home relative consumption.

*Financial autarky*
Under financial autarky, the ‘RS’ household cannot share risk with the rest of the world anymore, and thus her consumption equals her endowment. Therefore, total country \(i\) consumption equals the value of country \(i\) GDP, net of real investment: \(C_i=p_iY_i/P_i-I_i\).
The real exchange rate and relative consumption are given by:

\[ \widehat{RER} = -\frac{2\alpha - 1}{1 + 2\alpha (\phi - 1)} \hat{Y}, \]

\[ \hat{C} = \frac{1}{1 - \varepsilon} \frac{2\alpha - 1}{1 + 2\alpha (\phi - 1)} \hat{Y} - \frac{\varepsilon}{1 - \varepsilon} \hat{I}. \]

Unless the substitution elasticity \( \phi \) is close to zero, a Home relative output shock depreciates the real exchange rate and it raises Home relative consumption.\(^8\) Note that, under financial autarky, a rise in investment always crowds out private consumption, and that it has no effect on the real exchange rate; shocks to \( \lambda \) have no effect on relative consumption or the real exchange rate.

**Comparison between the three asset market structures**

All three asset markets setups predict that the Home real exchange rate and relative Home consumption move in opposite directions, in response to output shocks (unless \( \phi \) is very low). In all three setups, investment shocks likewise induce the real exchange rate and relative consumption to move in opposite directions; but, as discussed above, the presence of HTM households strengthens the response of the real exchange rate, and dampens the response of relative consumption to investment shocks. Finally, the HTM model includes a shock that induced positive co-movement between the real exchange rate and relative consumption: shocks to the fraction of output received by HTM households (\( \lambda_i \)).

**2.4. Model calibration**

Building on Kollmann (1998 and 2004), I calibrate the model to data for the US and an aggregate of the remaining G7 countries (Japan, Germany, France, UK, Italy and Canada), henceforth referred to as the ‘G6’.

**Preference parameters, investment and HTM income shares**

US exports [imports] to/from the G6 amounted to 3.10% [4.64%] of US GDP and 2.44% [3.71%] of G6 GDP, on average during the period 1980-2003. Thus the average US-G6 trade share was about 3.5%.\(^9\) Accordingly, I set \( \alpha = 0.965 \) in the model.

---

\(^8\) The real exchange depreciates if \( \phi > \frac{2\alpha - 1}{2\alpha} \) (e.g., if \( \alpha = 0.8 \) there is a depreciation when \( \phi > 0.375 \)).

\(^9\) Data source: IMF Directions of Trade Statistics database. Unless indicated otherwise, all other data used in this paper are taken from IMF International Financial Statistics.
The substitution elasticity $\phi$ corresponds to the price elasticity of a country's (aggregate) import and export demand functions. Hooper and Marquez (1995) survey a large number of time-series studies that estimated price elasticities of aggregate trade flows, for the US, Japan, Germany, the UK and Canada; the median estimates (post-Bretton Woods era) of $\phi$ for those countries are 0.97, 0.80, 0.57, 0.6, and 1.01, respectively; the median estimate across all 5 countries is 0.9. Accordingly, I set $\phi = 0.9$.

Estimates of the risk aversion coefficient $\sigma$ in the range of 2 or greater are common for industrialized countries (e.g., Barrionuevo (1992)). I set $\sigma = 2$.

Across G7 countries, the mean investment spending/GDP ratio (1972-2003) is 22%. I hence set $\Xi = 0.22$.

I consider a benchmark case in which, on average, 50% of total consumption accrues to HTM households, as suggested by Campbell and Mankiw’s empirical study (1989)). Ss investment spending is 22% of GDP on average, this implies that HTM consumption represents 39% ($=0.5*(1-0.22)$) of GDP, on average: $\Lambda = 0.39$.

**Stochastic properties of the forcing variables**

Empirically, participation in financial markets is highly positively correlated with household wealth; households whose main source of income is labor income are less likely to hold internationally traded assets (e.g., Haliassos (2006)). I thus take fluctuations in the labor share (fraction of GDP received by labor) as a proxy for movements in the fraction of GDP received by HTM households, $\lambda_i$.

US and G6 output, investment and labor shares undergo highly persistent fluctuations. I calibrate the second moment of the forcing variables to second moments of growth rates of US and G6 annual GPD, real investment and labor shares for 1973-2003 (all empirical time series used in this paper are annual).\(^{10}\)

The standard deviations of annual growth rates of relative US/G6 real GDP is 1.70%; the standard deviations of the growth rates of relative real physical investment

---

\(^{10}\) G6 variables are geometric weighted averages of individual G6 countries’ variables (weights: time averaged shares in aggregate G6 GDP). In the theoretical model, $X_i$ represents country $i$ real investment spending, in units of final consumption; hence, my empirical measure of $X_i$ is nominal investment deflated by the CPI. The empirical measure of the wage share is (compensation of employees)/(GDP-indirect taxes), from OECD National Accounts.
and of the relative labor shares are 7.69% and 1.41%, respectively. The correlation between growth rates of relative US/G6 output and relative investment is 0.86; relative labor share growth is slightly positively correlated with relative output growth (0.09) and negatively correlated with relative investment growth (-0.16). The growth rates of US and G6 relative investment are markedly volatile than relative output growth, while the growth rate of the relative labor share is slightly less volatile. Relative output and relative investment (growth) are highly positively correlated. Based on this evidence, I set:

\[
\text{std}(\hat{Y})=1.70\%, \text{std}(\hat{I})=7.69\%, \text{std}(\hat{\lambda})=1.41\%,
\]

\[
\text{Corr}(\hat{Y}, \hat{I})=0.86, \text{Corr}(\hat{Y}, \hat{\lambda})=0.09, \text{Corr}(\hat{I}, \hat{\lambda})=−0.16.
\] (16a)

These six moments pin down the standard deviations and cross-correlations of the real exchange rate and relative consumption, in the model. In addition, the predictions of the model for the moments of consumption in an individual country are of interest. To obtain those predictions, the second moments of the levels of the forcing variables have to be specified. To ensure symmetry of distributions across countries, I set the standard deviations and \textit{within-country} correlations of forcing variables at averages (across the US and G6) of the corresponding empirical moments. This gives:

\[
\text{std}(\hat{Y}_i)=1.76\%, \text{std}(\hat{I}_i)=6.84\%, \text{std}(\hat{\lambda}_i)=1.04\% , 
\]

\[
\text{Corr}(\hat{Y}_i, \hat{I}_i)=0.90, \text{Corr}(\hat{Y}_i, \hat{\lambda}_i)=−0.26, \text{Corr}(\hat{I}_i, \hat{\lambda}_i)=−0.36 \text{ for } i=H,F.
\] (16b)

Thus, investment in a given country is more volatile than output or the labor share. Investment is strongly procyclical, while the labor share is countercyclical. The moments in (16a)-(16b) pin down the \textit{cross-country} correlations of the forcing variables.\textsuperscript{11} The implied cross-country correlations are: \text{Corr}(\hat{Y}_H, \hat{Y}_F)=0.53, \text{Corr}(\hat{I}_H, \hat{I}_F)=0.36, \text{Corr}(\hat{\lambda}_H, \hat{\lambda}_F)=0.09, \text{Corr}(\hat{Y}_H, \hat{I}_F)=0.42, \text{Corr}(\hat{Y}_H, \hat{\lambda}_F)=−0.34, \text{Corr}(\hat{I}_H, \hat{\lambda}_F)=−0.24 \text{ for } i\neq j.

\textsuperscript{11} E.g. the cross-country output correlation can be computed using \text{Corr}(\hat{Y}_H, \hat{Y}_F)=1−0.5Var(\hat{Y}_H−\hat{Y}_F)Var(\hat{Y}_H).

As the shock processes is calibrated so that it matches the empirical second moments of relative (US vs. G6) forcing variables exactly (see (16a)), and so that it reproduces the \textit{average} values (across the US and G6) of empirical within-country second moments (see (16b)), the implied theoretical cross-country correlations differ from the empirical correlations (this is the price one has to pay, in order to keep cross-country symmetry of the distribution of forcing variables). However, the implied cross-country correlations are close to the empirical correlations. For example, the implied cross-country correlations of output and of investment are 0.53 and 0.36, respectively (as reported in the text); the corresponding empirical correlations (between the US and G6) are 0.56 and 0.40, respectively.
Thus, output is highly positively correlated across countries. Output in a given country is positively correlated with foreign investment and negatively correlated with the foreign labor share.

3. Stylized facts and model predictions

3.1. Stylized facts

Table 1 (Column 1) reports empirical correlations between relative US/G6 (annual) consumption and the relative US/G6 real exchange rate. The correlations are reported both for non-durables plus services purchases, and for total consumption (that includes spending on durables). The correlations pertain to logged times series that were detrended by first differencing, HP filtering and linearly detrending. The US/G6 consumption-real exchange rate correlations for non-durables are close to zero, and statistically insignificant. By contrast, relative total US/G6 consumption is positively correlated with the relative price of US consumption.

Table 1 also shows consumption-real exchange rate correlations for each other G7 country (relative to an aggregate of the remaining G7 countries). The correlations are generally close to zero and statistically insignificant.

Table 3 (column labeled ‘Data’) reports other empirical macro statistics (averages of US and G7 statistics based on growth rates of annual time series, 1972-2003).

Empirically, consumption and net exports (normalized by GDP) are less volatile than output, while the real exchange rate is markedly more volatile than GDP. The standard deviations of output, consumption, net exports and the real exchange rate are 1.76%, 1.19%, 0.29% and 7.70%, respectively (the empirical consumption measure used here is non-durables plus services spending; empirical net exports are net exports between the US and G6, normalized by GDP). Empirically, consumption is procyclical, while net exports and the real exchange rate are slightly countercyclical. The US-G6 cross-country correlations of consumption (0.42) and investment (0.36) are somewhat smaller than the correlation between US and G6 GDP (0.53).
3.2. Model predictions

Table 2 reports the coefficients of the solutions for the real exchange rate and relative (Home vs. Foreign) consumption, for the HTM model, and for the model with full risk sharing (no HTM households). In the benchmark HTM model, the equilibrium real exchange rate and relative consumption are (see Panel (a), Table 2):

$$\hat{RER} = -2.23\hat{Y} + 0.71\hat{I} + 1.24\hat{\lambda}, \quad \hat{C} = 0.97\hat{Y} - 0.15\hat{I} + 0.23\hat{\lambda}.$$ 

Thus, a 1% relative Home output increase depreciates the Home real exchange rate by 2.23%, and it raises Home relative consumption by 0.97%. A 1% shock to relative Home investment appreciates the Home real exchange rate by 0.71% and reduces relative Home consumption by 0.15%. A 1% shock to the share of the Home GDP received by HTM households appreciates the Home real exchange rate by 1.27% and raises Home relative consumption by 0.23%.

With full risk sharing (no HTM households), the real exchange rate and relative consumption obey:

$$\hat{RER} = -2.02\hat{Y} + 0.41\hat{X}, \quad \hat{C} = 1.01\hat{Y} - 0.20\hat{X}.$$ 

Thus, the response of the real exchange rate to investment shocks is 73% stronger, while the response of relative consumption is 75% weaker in the benchmark HTM structure (compared to the model with full risk sharing).

Table 3 reports the predicted consumption-real exchange rate correlation and other moments generated by the model. Columns (1)-(3) pertain to the benchmark HTM structure (Col. (1) assumes $Y, I, \lambda$ shocks, while Cols. (2) and (3) assume just $Y$ and $I$ shocks, and just $Y$ and $\lambda$ shocks, respectively). Col. (4) assumes full risk sharing, while Col. (5) assumes financial autarky.

The benchmark HTM model with $(Y, I$ and $\lambda$ shocks) predicts $\text{corr}(\hat{C}, \hat{RER}) = -0.07$ (see Panel (a) of Table 3). Thus, the predicted correlation is close to zero—and hence close to the empirical correlation (0.03). The ‘full-risk-sharing’ structure predicts that $\text{corr}(\hat{C}, \hat{RER}) = -1$, while $\text{corr}(\hat{C}, \hat{RER}) = -0.10$ under financial autarky.

The presence of all three (relative) shocks is key for explaining the low C-RER correlation generated by the benchmark HTM model; when there are just output and
investment shocks (no \( \lambda \) shock), the predicted consumption-RER correlation is -0.39 in the HTM model; with just \( Y \) and \( \lambda \) shocks, the correlation is -0.79.

The strong positive correlation between \( Y \) and \( I \) (0.90) assumed in the model is a key ingredient that enables that model to generate a realistic C-RER correlation. Shocks to \( Y \) and \( I \) drive \( C \) and RER in opposite directions. However, in the benchmark calibration, a positive \( Y \) shock tends to be associated with a positive \( I \) shock—which dampens the volatility of the real exchange rate and of consumption, and makes the C-RER correlation less negative. The role of the positive \( Y-I \) correlation is highlighted in Panel (b) of Table 3, where I set the \( Y-I \) correlation to zero; in that case, the C-RER correlation in the HTM structure is noticeably smaller than in the benchmark model: -0.86 (with simultaneous \( Y,I, \lambda \) shocks). (In the benchmark model, \( \lambda \) is correlated with \( Y \) and \( I \). But as those correlations are small, they have a minor effect on the predicted C-RER correlation. Setting the correlation of \( \lambda \) with \( Y \) and \( I \) to zero lowers the C-RER correlation slightly to -0.13; not shown in Table.)

The predicted standard deviation of the real exchange rate is 2.69% in the benchmark HTM structure, compared to 1.74% under full risk sharing and 1.96% under financial autarky. In the HTM structure, the predicted standard deviations of consumption (0.96%) and net exports (0.13%), and the correlation between consumption and output (0.63) are likewise higher, and closer to the corresponding empirical moments (1.19%, 0.29% and 0.57); the predicted correlation between Home and Foreign correlation is 0.40, which is very close to the empirical correlation, 0.42 (the full risk sharing generates a cross-country consumption correlation of 0.54). The HTM and full risk sharing models both capture the fact that net exports are countercyclical.

\textit{A model variant with a larger expected income share of HTM households} (\( \Lambda = 0.6 \))

The predicted C-RER correlation is increasing in the mean income share of HTM households, \( \Lambda \). In Panel (c) of Table 3, I set \( \Lambda \) at a larger value than in the benchmark calibration, namely at the labor share observed in G7 countries: \( \Lambda = 0.6 \) (compared to \( \Lambda = 0.39 \) in the benchmark case); in other terms it is assumed there that all workers are hand-to-mouth consumers. When \( \Lambda = 0.6 \), the predicted standard deviation of the real exchange rate (6.91%) almost matches the empirical volatility (7.7%), but the
consumption-real exchange rate correlation now is too large (0.62), while the predicted cross-country consumption correlation (0.04) is too low (with simultaneous $Y, I, \lambda$ shocks). In the variant with $\Lambda=0.6$ the real exchange rate is much more sensitive to shocks to $I$ and $\lambda$ than under the benchmark calibration, while relative consumption is less sensitive to shocks to $I$ and more sensitive to $\lambda$ shocks ($a_I=1.18, a_\lambda=3.23, b_I=-0.06, a_\lambda=0.58$; see Panel (c) in Table 2).

**Model variant with a lower expected income share of HTM households ($\Lambda = 0.25$)**

Panel (d) in Table 3 reports results for a model variant with $\Lambda=0.25$. The predicted C-RER correlation generated by the HTM structure now is $-0.61$, while the standard deviation of the real exchange rate is 1.92%. Thus, even a relatively small HTM income share of 25% generates a C-RER correlation that is markedly closer to the empirical correlation than the model with full risk sharing (where the C-RER correlation is -1).

**Model variant with greater risk aversion ($\sigma=5$)**

With greater risk aversion, $\sigma=5$ (compared to $\sigma=2$ in the benchmark calibration), the relative consumption of Home vs. Foreign non-HTM households responds less to a given change in the terms of trade, $q$ (see (4)); this implies that relative worldwide demand for the Home good is less sensitive to the terms of trade. As a result, the real exchange rate becomes more sensitive to the three (relative) shocks. Greater risk aversion dampens the response of relative consumption to output and investment shocks, but strengthens the response to $\lambda$-shocks (see Table 2 and Appendix). Panel (e) reports results for a model variant in which the risk aversion coefficient is set at $\sigma=5$ (compared to $\sigma=2$ in the benchmark calibration). In the HTM structure, the real exchange rate is now positively correlated with relative Home vs. Foreign consumption (correlation: 0.20), and the standard deviation of the real exchange rate is 4.35%--i.e. the real exchange rate is now about 2.4 times as volatile as output. The other predicted moments reported in the Table are also roughly in line with the empirical moments.
Note that the structure with full risk sharing also generates a greater standard deviation of the real exchange rate (3.12%) when the risk aversion coefficient is set at \( \sigma=5 \); but note the real exchange rate remains less volatile than in the HTM structure, and that the cross-country consumption correlation under full risk sharing (0.73) is larger than the empirical correlation (0.42).

*Model variants with a higher substitution elasticity between domestic and foreign goods (\( \phi=2 \)) and with a higher trade share (\( \alpha=0.8 \))*

Panels (f) of Table 3 reports results for a model variant in which domestic and foreign goods are more substitutable than in the benchmark calibration (\( \phi=2 \)), while Panel (g) assumes a 20% mean trade share (mean trade share in benchmark case: 3.5%); this ‘high-trade’ variant may shed light on the effect of shocks within Europe.

The real exchange rate and relative consumption respond less strongly to shocks when the substitution elasticity and the trade shares are higher than in the benchmark calibration. The predicted volatility of the real exchange rate falls thus (to 1.72% in variant with \( \phi=2 \) and 0.65% in the ‘high-trade’ model variant). Empirically, more open economies have less volatile real exchange rates (e.g., Kollmann (2004)). However, the correlation between the real exchange rate and relative consumption induced by the HTM-structure remains much larger than under full risk sharing: 0.12 when \( \phi=2 \), and \(-0.41 \) when \( \alpha=0.8 \).

4. A dynamic model with endogenous production and investment

This Section discusses a model variant with endogenous production and physical investment. I assume that country \( i \) output is generated using the production function \( Y_{i,t} = \theta_{i,t}(K_{i,t})^\kappa \), where \( K_{i,t} \) is the country’s physical capital stock in period \( t \), while \( \theta_{i,t} > 0 \) is an exogenous technology parameter (TFP). The law of motion of the capital stock is: 

\[
K_{i,t+1} = K_{i,t}(1-\delta) + \chi_{i,t}I_{i,t},
\]

where \( 0 < \delta < 1 \) is the depreciation rate of capital. \( I_{i,t} \) is gross investment in period \( t \). \( \chi_{i,t} > 0 \) is an exogenous shock to the efficiency of physical investment (see Fischer (2002, 2006), Greenwood, Hercowitz and Krusell...
The stochastic properties of the exogenous shocks $\theta_{i,t}, \chi_{i,t}$ are symmetric across countries.

In both countries, gross investment is generated using Home and Foreign inputs, using an aggregator that has the same form as the consumption aggregator (1). Optimal physical investment in country $i$ obeys the following Euler equation:

$$1 = E_t \beta \left( \frac{C_{i,t+1}}{C_{i,t}} \right)^{\sigma} \left( \frac{P_{i,t+1}}{P_{i,t}} \right) \left[ \frac{P_{i,t+1}}{P_{i,t}} \theta_{i,t+1} \chi_{i,t+1} \kappa (K_{i,t+1})^{\kappa - 1} + (1 - \delta) P_{i,t+1} / \chi_{i,t+1} \right].$$

As is standard in annual macro models, I set the depreciation rate of capital and the subjective discount factor at $\delta = 0.1$ and $\beta = 0.96$, respectively. All other preference parameters are set at the same values as in the static model discussed above. The parameter of the production function, $\kappa$, is set at $\kappa = 0.40$.

As in the static model above, an exogenous share $\lambda_i$ of country $i$ GDP is received by the country’s HTM household. All exogenous variables follow AR(1) processes:

$$\log(\theta_{i,t+1}) = \rho^\theta \log(\theta_{i,t}) + \varepsilon_{\theta,i,t},$$

$$\log(\chi_{i,t+1}) = \rho^\chi \log(\chi_{i,t}) + \varepsilon_{\chi,i,t},$$

$$\log(\lambda_{i,t+1} / \Lambda) = \rho^\lambda \log(\lambda_{i,t} / \Lambda) + \varepsilon_{\lambda,i,t}. $$

Following Coeurdacier, Kollmann and Martin (2008), I take the ratio of a country’s CPI to its investment expenditure deflator as an estimate of the efficiency of physical investment, $\chi_{i,t}$. I fit AR(1) processes to US and G6 times series on TFP, and labor shares and this measure of investment efficiency (a linear time trend is included in the AR regression for TFP and investment efficiency). The mean values (across the US and G6) of the estimated autoregressive coefficients are ....

[TO BE COMPLETED]

Based on annual time data, these authors report that the mean (across G7 countries) autocorrelation of these variables are 0.75, 0.79 and 0.72, respectively, and that mean standard deviations of innovations to the three forcing variables are 1.20%, 1.73% and 1.40%, respectively. Accordingly, the simulations assume $\rho^\theta = 0.75$, $\rho^\chi = 0.79$ and $\rho^\lambda = 0.72$.

---

12 The model here builds on Coeurdacier, Kollmann and Martin’s (2008) two–country RBC model with shocks to TFP and investment efficiency. A closely related model is also studied by Raffo (2008).
\[ \rho^* = 0.72; \quad \text{Std}(\varepsilon^0_{i,t}) = 1.20\%, \quad \text{Std}(\varepsilon^x_{i,t}) = 1.73\%, \quad \text{Std}(\varepsilon^i_{i,t}) = 1.40\%. \] Empirically, the cross country correlation of each type of innovation is positive; TFP innovations are weakly positively correlated with innovations to investment efficiency, while labor share innovations are negatively correlated with TFP and investment efficiency innovations. The simulations allow for correlation between the innovations to the Home and Foreign forcing variables.\(^\text{13}\) As in the static model, I assume that 50% of consumption is accounted for by HTM households, in steady state.

Table 4 shows simulation results for the dynamic model. The dynamic model matches the low consumption-real exchange rate correlations seen in the data, but it generates a real exchange rate that is not sufficiently volatile, essentially, because the IRBC model generates investment series that are insufficiently volatile.

[TO BE COMPLETED]

5. Conclusion
This paper has shown that a model with hand-to-mouth (HTM) households can contribute to solving one of the main puzzles in international macroeconomics—the fact that real exchange rates and relative consumptions are essentially uncorrelated. The model can also generate markedly more volatile real exchange rates, especially when trade shares are low and households are highly risk averse.

\(^{13}\) Based on G7 data, the following (symmetrized) correlations are assumed: \( \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^0_{i,j}) = 0.04, \quad \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^x_{i,j}) = -0.49, \quad \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^i_{i,j}) = -0.17, \quad \text{for } i=H,F; \quad \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^0_{j,j}) = 0.43, \quad \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^x_{j,j}) = 0.19, \quad \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^i_{i,j}) = 0.32, \quad \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^x_{j,j}) = 0.09, \quad \text{Corr}(\varepsilon^0_{i,j}, \varepsilon^i_{j,j}) = -0.27, \quad \text{Corr}(\varepsilon^x_{i,j}, \varepsilon^i_{i,j}) = -0.14 \text{ for } i\neq j. \)
APPENDIX

Closed form solution for the equilibrium real exchange rate and relative national consumption (HTM model)

(12) and the market clearing condition \( \hat{Y} = \hat{d} \) imply

\[
\text{\( \hat{RER} = a_\alpha \hat{Y} + a_\lambda \hat{\lambda}, \) with
\]

\[
a_\alpha \equiv \Lambda (2\alpha - 1)^2 + (1 - 2\alpha)/\Gamma,
\]

\[
a_\lambda \equiv \Xi (2\alpha - 1)^2/\Gamma,
\]

\[
a_\lambda \equiv \Lambda (2\alpha - 1)^3/(\sigma \Gamma).
\]

Country \( i \) total consumption is \( C_i \equiv C_i^{HTM} + C_i^{RS} \). Thus, relative consumption \( C \equiv C_H/C_F \) obeys: \( \hat{C} = a_\alpha \hat{Y} + a_\lambda \hat{\lambda} \), with

\[
\hat{C} = b_1 \hat{Y} + b_2 \hat{\lambda} \text{, with }
\]

\[
b_1 = \frac{1}{1 - \alpha} \left( \Xi - \lambda \Phi \right) (2\alpha - 1) (1 - \alpha) \Phi,
\]

\[
b_2 = \frac{1}{\Gamma} \left[ (1 - \lambda - \Xi) (2\alpha - 1) (1 - \lambda) \Phi \right] (2\alpha - 1) (1 - \lambda) \Phi,
\]

\[
b_3 = \frac{2}{1 - \alpha} \left( \Lambda + \Xi \right) (2\alpha - 1) (1 - \alpha) \Phi
\].

Recall that \( \Gamma = (1 - 2\phi) (1 - \lambda - \Xi) / (1 - \lambda + 4\alpha (1 - \lambda) \phi) \) is the price elasticity of relative world demand for the Home-produced good (see (12)). Note that \( \Gamma > 0 \) holds iff \( \phi > \frac{2\alpha - 1}{2\alpha} - \frac{(1 - 2\alpha)^2 (1 - \lambda - \Xi)}{4\alpha (1 - \alpha) \phi} \). The right-hand side of this inequality cannot exceed 0.5 (as \( \alpha < 1 \) and \( \lambda \leq 1 \)); in fact, for reasonable parameter values, the right-hand side is much below 0.5. Consider the values for \( \alpha, \Xi, \Lambda \) used in the model calibration: \( \alpha = 0.965, \Xi = 0.22, \Lambda = 0.39 \). For these values, \( \Gamma > 0 \) holds whenever \( \phi > 0.188 - 2.497/\sigma \). As discussed in the text, estimates of \( \phi \) based on the response of aggregate trade flows to terms of trade changes are generally in the range of unity; estimates of \( \phi \) based on sectorally disaggregated trade data are mostly greater than 4 (see Kollmann (2006)). Hence, \( \Gamma > 0 \) is plausible. \( \Gamma > 0 \) implies that \( a_\alpha > 0, a_\lambda > 0, a_\lambda > 0 \): an increase in Home (relative) output depreciates the Home real exchange rate; while increases in Home investment and in the share of Home GDP that accrues to Home HTM households appreciate the real exchange rate.

An increase in relative output raises relative consumption \( (b_1 > 0) \), for plausible parameter values: when \( \Gamma > 0 \) holds, then \( b_1 > 0 \) obtains when \( \phi > \frac{1}{2\alpha} - \frac{1 - \lambda - \Xi}{\lambda} \). Again, assume \( \alpha = 0.965, \Xi = 0.22, \Lambda = 0.39 \); then \( b_1 > 0 \) when \( \phi > 0.518 - 6.88/\sigma \). Assume (as in the baseline calibration) that \( \sigma = 2 \); then \( b_1 > 0 \) holds for any admissible (positive) value of \( \phi \). An increase in relative investment lowers relative consumption \( (b_2 < 0) \) when \( \Gamma > 0 \) and \( \sigma < \frac{1 - \lambda - \Xi}{\Lambda} \frac{2\alpha - 1}{2(1 - \alpha)} \) hold; for the values of \( \alpha, \Lambda, \Xi \) used in the calibration, \( b_2 < 0 \) obtain when \( \sigma < 13.285 \).
Effect of changes in $\Lambda$ on the sensitivity of the real exchange rate and relative consumption to shocks

The effect of an increase in $\Lambda$ (the average share of GDP received by the HTM households) on the sensitivity of the real exchange rate and of relative consumption to output shocks is ambiguous. Because $a_t < 0$ and $b_t > 0$ (under plausible assumptions; see above), an increase in $\Lambda$ makes the real exchange rate and relative consumption more sensitive to output shocks when $\partial a_t / \partial \Lambda < 0$ and $\partial b_t / \partial \Lambda < 0$. These inequalities hold iff $\sigma < [(2\alpha -1)^2\Xi + 2(2\alpha -1)(1-\alpha)]/[2(1-\alpha)(2\alpha\phi-1)]$. This condition is always met under log preferences, $\sigma = \phi = 1$; it also holds when the local spending bias parameter $\alpha$ is sufficiently close to unity (the right-hand side of the above inequality tends to infinity when $\alpha$ tends to 1).

Note that $\partial \Gamma / \partial \Lambda = -(1-2\alpha)^2 - 2(2\alpha -1)(1-\alpha)<0$. When $\Gamma > 0$ holds, an increase in $\Lambda$ raises thus the absolute value of the coefficients $a_t$ and $a_x$. Hence the sensitivity of the real exchange rate to shocks to investment and to the income share of HTM households is greater, the higher $\Lambda$.

By contrast, the effect of an increase in $\Lambda$ on the sensitivity of relative consumption to shocks to investment and to the income share of HTM households is ambiguous. $\partial b_t / \partial \Lambda > 0$ and $\partial b_t / \partial \Lambda > 0$ hold iff $\Lambda < (2\alpha -1)(1-\Xi)/[2(1-\alpha)(2\alpha\phi+2\alpha-1)]$. Thus, as long as this inequality holds, an increase in $\Lambda$ makes relative consumption less sensitive to investment shocks. Take an economy with full risk sharing, i.e. where $\Lambda = 0$; in that economy, a small increase in $\Lambda$ will raise $b_t$ and thus make relative consumption less sensitive to investment shocks. When $\alpha$ is close to unity, i.e. when the trade share is low, then the right-hand side of the above inequality is close to $1 - \Xi$, and thus $\partial b_t / \partial \Lambda > 0$ holds, unless $\Lambda$ is very close to its upper bound $1 - \Xi$. For the values of $\alpha, \sigma, \Xi$ used in the benchmark calibration, $\partial b_t / \partial \Lambda > 0$ holds when $\Lambda < 0.68$.

Effect of changes in risk aversion $\sigma$ on responses of the real exchange rate and relative consumption to shocks

An increase in the risk aversion coefficient $\sigma$ lowers the elasticity of the relative demand for Home/Foreign goods with respect to the Home terms of trade: $\partial \Gamma / \partial \sigma = -(2\alpha -1)^2 (1-\Lambda - \Xi) / \sigma^2 < 0$. This explains why an increase in $\sigma$ makes the real exchange rate more sensitive to the three shocks:

$\partial a_t / \partial \sigma = (2\alpha -1)^3[(2\alpha -1\Lambda -1)(1-\Xi)] / \Gamma^2 < 0$ (NB $(2\alpha -1)\Lambda - 1 < 0$);
$\partial a_t / \partial \sigma = (2\alpha -1)^4(1-\Lambda - \Xi) / \Gamma^2 > 0$.

(Note that $a_t < 0$, so that $\partial a_t / \partial \sigma < 0$ means that the real exchange rate responds more strongly to output shocks when $\sigma$ is greater.)

An increase in risk aversion dampens the effect of output and investment shocks on relative consumption, and strengthens the effect of shocks to $\lambda$:

$\partial b_t / \sigma = (1-\Xi)^{-1} 4\alpha (1-\alpha) \phi (2\alpha -1)((2\alpha -1)\Lambda - 1)(1-\Lambda - \Xi) / \Gamma^2 < 0$;
$\partial b_t / \partial \sigma = \partial b_t / \partial \sigma = (1-\Xi)^{-1} 4\alpha (1-\alpha) \phi (2\alpha -1)^2(1-\Lambda - \Xi) / \Gamma^2 > 0$. 

23
BIBLIOGRAPHY


Table 1. Empirical correlation between relative consumption and real exchange rate

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>Japan</th>
<th>Germany</th>
<th>France</th>
<th>UK</th>
<th>Italy</th>
<th>Canada</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td>(a) Non-durables and services consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First differenced</td>
<td>0.03</td>
<td>-0.29</td>
<td>--</td>
<td>-0.10</td>
<td>0.29</td>
<td>-0.11</td>
<td>-0.00</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>(0.77)</td>
<td>(0.14)</td>
<td>(0.69)</td>
<td>(0.00)</td>
<td>(0.31)</td>
<td>(0.98)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP-filtered</td>
<td>-0.01</td>
<td>-0.29</td>
<td>--</td>
<td>-0.21</td>
<td>0.05</td>
<td>-0.21</td>
<td>-0.30</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>(0.94)</td>
<td>(0.23)</td>
<td>(0.24)</td>
<td>(0.70)</td>
<td>(0.06)</td>
<td>(0.30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linearly detrended</td>
<td>0.09</td>
<td>-0.15</td>
<td>--</td>
<td>-0.17</td>
<td>-0.14</td>
<td>-0.24</td>
<td>-0.35</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>(0.62)</td>
<td>(0.54)</td>
<td>(0.31)</td>
<td>(0.34)</td>
<td>(0.05)</td>
<td>(0.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Total consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First differenced</td>
<td>0.13</td>
<td>-0.12</td>
<td>-0.06</td>
<td>0.09</td>
<td>0.05</td>
<td>0.10</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.34)</td>
<td>(0.37)</td>
<td>(0.34)</td>
<td>(0.75)</td>
<td>(0.53)</td>
<td>(0.90)</td>
<td></td>
</tr>
<tr>
<td>HP-filtered</td>
<td>0.34</td>
<td>0.06</td>
<td>0.31</td>
<td>-0.08</td>
<td>0.08</td>
<td>0.16</td>
<td>-0.02</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.73)</td>
<td>(0.00)</td>
<td>(0.51)</td>
<td>(0.47)</td>
<td>(0.22)</td>
<td>(0.88)</td>
<td></td>
</tr>
<tr>
<td>Linearly detrended</td>
<td>0.51</td>
<td>0.56</td>
<td>0.45</td>
<td>-0.20</td>
<td>0.03</td>
<td>0.03</td>
<td>-0.03</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.22)</td>
<td>(0.82)</td>
<td>(0.82)</td>
<td>(0.83)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Columns (1)-(7) shows correlations between the detrended log of relative consumption in a given country (compared to a GDP weighted geometric mean of consumption in an aggregate of the remaining G7 countries) and the detrended log of that country’s real exchange rate (the country’s consumption price index, divided by a GDP weighted average of the price indices of the remaining G7 countries, expressed in a common currency). Column (8) shows mean correlations (across the G7 countries). All data are annual. Panel (a) is based on the 1971-1987 price and quantity data on non-durables and services consumption (from OECD National Accounts) used by Kollmann (1995)). Panel (b) is based on total consumption data (including durables), for 1972-2003. Results are show for three detrending methods: first differencing, HP-filtering and linear detrending. Figures in parentheses: p-values of two-sided test of the hypothesis that correlations are zero (from GMM-based standard errors or correlation, assuming fourth order serial correlation of residuals).
<table>
<thead>
<tr>
<th></th>
<th>HTM model</th>
<th></th>
<th>Full risk sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a_y)</td>
<td>(a_I)</td>
<td>(b_y)</td>
</tr>
<tr>
<td>(a) Baseline calibration</td>
<td>-2.23</td>
<td>0.71</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>0.97</td>
<td>-0.15</td>
<td>0.23</td>
</tr>
<tr>
<td>(b) Zero correlation between investment and output</td>
<td>-2.23</td>
<td>0.71</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>0.97</td>
<td>-0.15</td>
<td>0.23</td>
</tr>
<tr>
<td>(c) High HTM income share, (\lambda = 0.6)</td>
<td>-2.56</td>
<td>1.18</td>
<td>3.23</td>
</tr>
<tr>
<td></td>
<td>0.91</td>
<td>-0.06</td>
<td>0.58</td>
</tr>
<tr>
<td>(d) Low HTM income share, (\lambda = 0.25)</td>
<td>-2.13</td>
<td>0.56</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>0.99</td>
<td>-0.18</td>
<td>0.11</td>
</tr>
<tr>
<td>(e) High risk aversion, (\sigma = 5)</td>
<td>-3.62</td>
<td>1.16</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td>0.72</td>
<td>-0.07</td>
<td>0.37</td>
</tr>
<tr>
<td>(f) High substitution elasticity between domestic and foreign goods, (\phi = 2)</td>
<td>-1.43</td>
<td>0.46</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>0.80</td>
<td>-0.09</td>
<td>0.32</td>
</tr>
<tr>
<td>(g) High trade share, (\alpha = 0.8)</td>
<td>-0.83</td>
<td>0.14</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>0.43</td>
<td>0.01</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Note: The Table reports the coefficients of the (log-)linearized model solution that express the real exchange rate \(RER \equiv P_H / P_F\) and relative (Home versus Foreign) consumption \(C \equiv C_H / C_F\) as functions of relative output \(Y \equiv Y_H / Y_F\), relative investment \(I \equiv I_H / I_F\) and the relative shares of Home and Foreign GDP received by hand-to-mouth (HTM) households \(\lambda \equiv \lambda_H / \lambda_F\): \[\hat{RER} = a_y \hat{Y} + a_I \hat{I} + a_\lambda \hat{\lambda}, \quad \hat{C} = b_y \hat{Y} + b_I \hat{I} + b_\lambda \hat{\lambda}\]
Table 3. The static model: predicted moments

<table>
<thead>
<tr>
<th></th>
<th>HTM model (1)</th>
<th>Full risk sharing (2)</th>
<th>Financial autarky (3)</th>
<th>Data (4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Y,I,λ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Y,I</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Y,λ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shocks to:</strong></td>
<td><strong>Shocks to:</strong></td>
<td><strong>Shocks to:</strong></td>
<td><strong>Shocks to:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y,I,λ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y,I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y,λ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calibrated moments:

$Std(\hat{Y}_I) = 1.76\%$, $Std(\hat{I}_I) = 6.84\%$, $Corr(I_I, Y_I) = 0.90$, $Corr(Y_H, Y_I) = 0.53$, $Corr(I_H, I_I) = 0.36$

(a) Model predictions: Baseline calibration

- $Corr(RER, C_H/C_F)$: 
  - $-0.07$  
  - $-0.39$  
  - $-0.79$  
  - $-1.00$  
  - $-0.10$  
  - $0.03$

- $Std(RER)$ in %: 
  - $2.69$  
  - $2.94$  
  - $4.06$  
  - $1.74$  
  - $1.96$  
  - $7.70$

- $Std(C_I)$ in %: 
  - $0.96$  
  - $0.91$  
  - $2.15$  
  - $0.91$  
  - $0.97$  
  - $1.19$

- $Std(NX_i/(p_y))$ in %: 
  - $0.13$  
  - $0.13$  
  - $0.08$  
  - $0.06$  
  - $0.00$  
  - $0.29$

- $Corr(C_I, Y_I)$: 
  - $0.63$  
  - $0.65$  
  - $0.99$  
  - $0.57$  
  - $0.48$  
  - $0.83$

- $Corr(NX_i/(p_y), Y_I)$: 
  - $-0.38$  
  - $-0.35$  
  - $0.33$  
  - $-0.30$  
  - $--$  
  - $-0.25$

- $Corr(C_H, C_F)$: 
  - $0.40$  
  - $0.54$  
  - $0.67$  
  - $0.54$  
  - $0.37$  
  - $0.42$

(b) Zero correlation between investment and output

- $Corr(RER, C_H/C_F)$: 
  - $-0.86$  
  - $-0.93$  
  - $-0.79$  
  - $-1.00$  
  - $-0.67$  
  - $0.03$

- $Std(RER)$ in %: 
  - $6.61$  
  - $6.72$  
  - $4.06$  
  - $4.70$  
  - $1.96$  
  - $7.70$

- $Std(C_I)$ in %: 
  - $2.74$  
  - $2.73$  
  - $2.15$  
  - $2.79$  
  - $2.93$  
  - $1.19$

- $Std(NX_i/(p_y))$ in %: 
  - $0.18$  
  - $0.19$  
  - $0.08$  
  - $0.11$  
  - $0.00$  
  - $0.29$

- $Corr(C_I, Y_I)$: 
  - $0.77$  
  - $0.78$  
  - $0.99$  
  - $0.76$  
  - $0.75$  
  - $0.83$

- $Corr(NX_i/(p_y), Y_I)$: 
  - $0.14$  
  - $0.15$  
  - $0.33$  
  - $0.20$  
  - $--$  
  - $-0.25$

- $Corr(C_H, C_F)$: 
  - $0.70$  
  - $0.72$  
  - $0.67$  
  - $0.64$  
  - $0.49$  
  - $0.42$

(c) High HTM income share, $\Lambda = 0.6$

- $Corr(RER, C_H/C_F)$: 
  - $0.63$  
  - $0.40$  
  - $-0.24$  
  - $-1.00$  
  - $-0.10$  
  - $0.03$

- $Std(RER)$ in %: 
  - $6.04$  
  - $5.78$  
  - $6.01$  
  - $1.74$  
  - $1.96$  
  - $7.70$

- $Std(C_I)$ in %: 
  - $1.11$  
  - $0.98$  
  - $2.17$  
  - $0.91$  
  - $0.97$  
  - $1.19$

- $Std(NX_i/(p_y))$ in %: 
  - $0.24$  
  - $0.23$  
  - $0.16$  
  - $0.06$  
  - $0.00$  
  - $0.29$

- $Corr(C_I, Y_I)$: 
  - $0.65$  
  - $0.72$  
  - $0.97$  
  - $0.57$  
  - $0.48$  
  - $0.83$

- $Corr(NX_i/(p_y), Y_I)$: 
  - $-0.38$  
  - $-0.37$  
  - $0.19$  
  - $-0.30$  
  - $--$  
  - $-0.25$

- $Corr(C_H, C_F)$: 
  - $0.04$  
  - $0.33$  
  - $0.64$  
  - $0.54$  
  - $0.37$  
  - $0.42$

(d) Low HTM income share, $\Lambda = 0.25$

- $Corr(RER, C_H/C_F)$: 
  - $-0.61$  
  - $-0.77$  
  - $-0.94$  
  - $-1.00$  
  - $-0.10$  
  - $0.03$

- $Std(RER)$ in %: 
  - $1.92$  
  - $2.20$  
  - $3.66$  
  - $1.74$  
  - $1.96$  
  - $7.70$

- $Std(C_I)$ in %: 
  - $0.93$  
  - $0.91$  
  - $2.15$  
  - $0.91$  
  - $0.97$  
  - $1.19$

- $Std(NX_i/(p_y))$ in %: 
  - $0.09$  
  - $0.10$  
  - $0.06$  
  - $0.06$  
  - $0.00$  
  - $0.29$

- $Corr(C_I, Y_I)$: 
  - $0.60$  
  - $0.61$  
  - $0.99$  
  - $0.57$  
  - $0.48$  
  - $0.83$

- $Corr(NX_i/(p_y), Y_I)$: 
  - $-0.36$  
  - $-0.33$  
  - $0.42$  
  - $-0.30$  
  - $--$  
  - $-0.25$

- $Corr(C_H, C_F)$: 
  - $0.49$  
  - $0.56$  
  - $0.68$  
  - $0.54$  
  - $0.37$  
  - $0.42$
Table 3—ctd.

<table>
<thead>
<tr>
<th>Shocks to:</th>
<th>HTM model</th>
<th>Full Risk Sharing</th>
<th>Financial Autarky</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$Y,I,\lambda$</td>
<td>$Y,I$</td>
<td>$Y,I$</td>
</tr>
<tr>
<td>(e) High risk aversion, $\sigma = 5$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Corr}(\text{RER}, C_{H}/C_{F})$</td>
<td>0.20</td>
<td>-0.02</td>
<td>-0.66</td>
</tr>
<tr>
<td>$\text{Std}(\text{RER})$ in %</td>
<td>4.35</td>
<td>4.76</td>
<td>6.57</td>
</tr>
<tr>
<td>$\text{Std}(\hat{C}_i)$ in %</td>
<td>0.96</td>
<td>0.90</td>
<td>2.09</td>
</tr>
<tr>
<td>$\text{Std}(\text{NX}_i/(p_iY_i))$ in %</td>
<td>0.17</td>
<td>0.18</td>
<td>0.16</td>
</tr>
<tr>
<td>$\text{Corr}(C_i, Y_i)$</td>
<td>0.65</td>
<td>0.69</td>
<td>0.97</td>
</tr>
<tr>
<td>$\text{Corr}(\text{NX}_i/(p_iY_i), Y_i)$</td>
<td>-0.33</td>
<td>-0.29</td>
<td>0.39</td>
</tr>
<tr>
<td>$\text{Corr}(C_{H_i}, C_{F_i})$</td>
<td>0.39</td>
<td>0.60</td>
<td>0.79</td>
</tr>
</tbody>
</table>

(f) High substitution elasticity between domestic and foreign goods, $\phi = 2$

<table>
<thead>
<tr>
<th>Shocks to:</th>
<th>HTM model</th>
<th>Full Risk Sharing</th>
<th>Financial Autarky</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$Y,I,\lambda$</td>
<td>$Y,I$</td>
<td>$Y,I$</td>
</tr>
<tr>
<td>$\text{Corr}(\text{RER}, C_{H}/C_{F})$</td>
<td>0.12</td>
<td>-0.14</td>
<td>-0.71</td>
</tr>
<tr>
<td>$\text{Std}(\text{RER})$ in %</td>
<td>1.72</td>
<td>1.88</td>
<td>2.60</td>
</tr>
<tr>
<td>$\text{Std}(\hat{C}_i)$ in %</td>
<td>0.96</td>
<td>0.90</td>
<td>2.10</td>
</tr>
<tr>
<td>$\text{Std}(\text{NX}_i/(p_iY_i))$ in %</td>
<td>0.23</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>$\text{Corr}(C_i, Y_i)$</td>
<td>0.65</td>
<td>0.68</td>
<td>0.98</td>
</tr>
<tr>
<td>$\text{Corr}(\text{NX}_i/(p_iY_i), Y_i)$</td>
<td>-0.30</td>
<td>-0.26</td>
<td>0.40</td>
</tr>
<tr>
<td>$\text{Corr}(C_{H_i}, C_{F_i})$</td>
<td>0.40</td>
<td>0.59</td>
<td>0.75</td>
</tr>
</tbody>
</table>

(g) High trade share, $\alpha = 0.8$

<table>
<thead>
<tr>
<th>Shocks to:</th>
<th>HTM model</th>
<th>Full Risk Sharing</th>
<th>Financial Autarky</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$Y,I,\lambda$</td>
<td>$Y,I$</td>
<td>$Y,I$</td>
</tr>
<tr>
<td>$\text{Corr}(\text{RER}, C_{H}/C_{F})$</td>
<td>-0.41</td>
<td>-0.59</td>
<td>-0.54</td>
</tr>
<tr>
<td>$\text{Std}(\text{RER})$ in %</td>
<td>0.65</td>
<td>0.72</td>
<td>1.43</td>
</tr>
<tr>
<td>$\text{Std}(\hat{C}_i)$ in %</td>
<td>0.98</td>
<td>0.90</td>
<td>2.04</td>
</tr>
<tr>
<td>$\text{Std}(\text{NX}_i/(p_iY_i))$ in %</td>
<td>0.43</td>
<td>0.43</td>
<td>0.18</td>
</tr>
<tr>
<td>$\text{Corr}(C_i, Y_i)$</td>
<td>0.66</td>
<td>0.70</td>
<td>0.93</td>
</tr>
<tr>
<td>$\text{Corr}(\text{NX}_i/(p_iY_i), Y_i)$</td>
<td>-0.41</td>
<td>-0.39</td>
<td>0.20</td>
</tr>
<tr>
<td>$\text{Corr}(C_{H_i}, C_{F_i})$</td>
<td>0.34</td>
<td>0.59</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Table 4. The dynamic model: predicted moments (HP filtered)

<table>
<thead>
<tr>
<th></th>
<th>HTM model</th>
<th>Full risk sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shocks to:</td>
<td>Shocks to:</td>
</tr>
<tr>
<td></td>
<td>$\theta, \chi, \lambda$</td>
<td>$\theta, \lambda$</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Baseline calibration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Corr}(\text{RER}, C_{H}/C_{F})$</td>
<td>-0.30</td>
<td>-1.00</td>
</tr>
<tr>
<td>$\text{Std}(\text{RER})$ in %</td>
<td>1.98</td>
<td>1.69</td>
</tr>
<tr>
<td>$\text{Std}(\hat{\gamma})$ in %</td>
<td>1.10</td>
<td>1.08</td>
</tr>
<tr>
<td>$\text{Std}(I_{1})$ in %</td>
<td>2.55</td>
<td>2.49</td>
</tr>
<tr>
<td>$\text{Corr}(Y_{H}, Y_{F})$</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>$\text{Corr}(C_{H}, C_{F})$</td>
<td>0.24</td>
<td>0.14</td>
</tr>
<tr>
<td>$\text{Corr}(I_{H}, I_{F})$</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>High risk aversion, $\sigma = 5$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Corr}(\text{RER}, C_{H}/C_{F})$</td>
<td>-0.03</td>
<td>-1.00</td>
</tr>
<tr>
<td>$\text{Std}(\text{RER})$ in %</td>
<td>2.23</td>
<td>1.37</td>
</tr>
<tr>
<td>$\text{Std}(\hat{\gamma})$ in %</td>
<td>1.09</td>
<td>1.08</td>
</tr>
<tr>
<td>$\text{Std}(I_{1})$ in %</td>
<td>2.56</td>
<td>2.58</td>
</tr>
<tr>
<td>$\text{Corr}(Y_{H}, Y_{F})$</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>$\text{Corr}(C_{H}, C_{F})$</td>
<td>0.16</td>
<td>0.11</td>
</tr>
<tr>
<td>$\text{Corr}(I_{H}, I_{F})$</td>
<td>0.49</td>
<td>0.43</td>
</tr>
<tr>
<td>High substitution elasticity between domestic and foreign goods, $\phi = 2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Corr}(\text{RER}, C_{H}/C_{F})$</td>
<td>-0.25</td>
<td>-1.00</td>
</tr>
<tr>
<td>$\text{Std}(\text{RER})$ in %</td>
<td>1.76</td>
<td>0.70</td>
</tr>
<tr>
<td>$\text{Std}(\hat{\gamma})$ in %</td>
<td>1.11</td>
<td>1.09</td>
</tr>
<tr>
<td>$\text{Std}(I_{1})$ in %</td>
<td>2.61</td>
<td>2.48</td>
</tr>
<tr>
<td>$\text{Corr}(Y_{H}, Y_{F})$</td>
<td>0.32</td>
<td>0.34</td>
</tr>
<tr>
<td>$\text{Corr}(C_{H}, C_{F})$</td>
<td>0.24</td>
<td>0.15</td>
</tr>
<tr>
<td>$\text{Corr}(I_{H}, I_{F})$</td>
<td>0.42</td>
<td>0.40</td>
</tr>
<tr>
<td>High trade share, $\alpha = 0.8$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Corr}(\text{RER}, C_{H}/C_{F})$</td>
<td>-0.04</td>
<td>-1.00</td>
</tr>
<tr>
<td>$\text{Std}(\text{RER})$ in %</td>
<td>1.35</td>
<td>0.63</td>
</tr>
<tr>
<td>$\text{Std}(\hat{\gamma})$ in %</td>
<td>1.13</td>
<td>1.10</td>
</tr>
<tr>
<td>$\text{Std}(I_{1})$ in %</td>
<td>3.40</td>
<td>2.63</td>
</tr>
<tr>
<td>$\text{Corr}(Y_{H}, Y_{F})$</td>
<td>0.26</td>
<td>0.31</td>
</tr>
<tr>
<td>$\text{Corr}(C_{H}, C_{F})$</td>
<td>0.24</td>
<td>0.13</td>
</tr>
<tr>
<td>$\text{Corr}(I_{H}, I_{F})$</td>
<td>-0.15</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Household Heterogeneity and the Real Exchange Rate: Still a Puzzle

Robert Kollmann (*)

ECARES, Université Libre de Bruxelles and CEPR

May 2, 2009

Kocherlakota and Pistaferri (EJ, 2007) [KP] develop a model of a world economy with private-information Pareto optimal (PIPO) risk sharing; in that model, the real exchange rate tracks relative domestic/foreign cross-sectional distributions of consumption. KP claim that the PIPO model fits the UK/US real exchange rate well.

This paper shows that the PIPO model is inconsistent with the UK/US data. Minor specification changes overturn KP’s regression results. I also document that the relevant (relative) cross-sectional consumption moment is orders of magnitude more volatile than the real exchange rate, and less persistent. The link between the real exchange rate and consumption (heterogeneity) remains a puzzle.

(*) I am very grateful to Narayana Kocherlakota and Luigi Pistaferri for sharing their data set with me. I also thank Klaus Adam, Susana Cociuba, Ivan Faiella, Stéphane Guibaud, Urban Jermann, Sylvain Leduc, Fabrizio Perri, Ananth Ramanarayanan, Stijn Van Nieuwerburgh, David Veredas and Philippe Weil for useful suggestions and discussions. Thanks are also due to the National Bank of Belgium and the EU Commission for financial support.

Author’s address: ECARES, CP 114, Université Libre de Bruxelles, 50 Avenue F.D. Roosevelt, B-1050 Brussels, Belgium; robert_kollmann@yahoo.com.
1. Introduction

Standard models of the world economy that postulate full international risk sharing (complete asset markets) predict that a country’s aggregate consumption is high, relative to foreign consumption, when the relative price of domestic final consumption is low. Yet, as first documented by Kollmann (1991, 1995) and Backus and Smith (1993), CPI-based real exchange rates are essentially uncorrelated with cross-country aggregate consumption differences. This ‘consumption-real exchange rate anomaly’ is one of the major puzzles in international macroeconomics (Obstfeld and Rogoff, 2000).

In their widely discussed *Economic Journal Lecture* at the 2006 Royal Economic Society meetings, Kocherlakota and Pistaferri (2007) [KP] develop a model of a world economy in which individuals cannot fully insure against individual-specific shocks that are only privately observable. KP show that a private-information Pareto-optimal (PIPO) insurance scheme entails that the log real exchange rate tracks one-to-one the logged ratio of the $\gamma$–th non-central moments of the cross-sectional distributions of consumption in the domestic and foreign economies, where $\gamma$ is the coefficient of relative risk aversion. Thus, inequality matters for the real exchange rate. If $\gamma>1$, the real exchange rate is influenced by the right tail of the within-country consumption distribution (i.e. by the consumption of the rich).

Let $e_{t}^{j,k}$ be the date $t$ real exchange rate between countries $j$ and $k$, defined as the ratio of $k$’s CPI to $j$’s CPI (in same currency); let $C_{\gamma,t}^{j}$ be the $\gamma$–th (non-central) moment of the cross-sectional consumption distribution in country $j$. The PIPO model implies:

$$\ln e_{t}^{j,k} = \ln(C_{\gamma,t}^{j}/C_{\gamma,t}^{k}) + \nu_{\gamma}^{j,k},$$

for some constant $\nu_{\gamma}^{j,k}$. (1)

KP test this prediction for the UK and US, using monthly time series on cross-sectional moments of consumption (1980-1999) estimated from household-level data (US CEX and UK FES surveys). KP create an error term by subtracting the logged relative sample consumption moment from the log real exchange rate; they regress quarterly first differences of that ‘model error’ on quarterly first differences of the real exchange rate. If the PIPO model is true, the regression coefficient should be zero. KP find that the slope coefficient is zero, when $\gamma \approx 5$. This is the basis of KP’s claim that the PIPO model ‘is able to account for movements in the real exchange rate’ (p.C3). (Kocherlakota and

---

1 A rise in $e_{t}^{j,k}$ is a depreciation of the country $j$ real exchange rate.
Pistaferri (2005) claim that the PIPO model also solves the equity premium puzzle for $\gamma=5$.) This is a noteworthy claim, as standard macro fundamentals fail to explain the real exchange rate, in the short/medium run (e.g., Obstfeld and Rogoff, 2000).

This paper shows that the PIPO model is inconsistent with the behavior of the UK/US real exchange rate, and with KP’s household-level consumption data.

Section 2 documents that the logged ratio of UK/US high-order sample consumption moments is vastly more volatile than the logged real exchange rate, and much less persistent. Thus, the real exchange rate does not track the relevant relative sample consumption moment. KP do not report these striking facts.

To formally test the PIPO model, I extend KP’s regression analysis (summarized in Section 3). Section 4 shows that minor specification changes overturn KP’s regression results. E.g., KP only test the model using quarterly first differenced variables. I show that regression results based on annual first differences are inconsistent with the model. I also extend KP’s empirical analysis by regressing the model error on additional macro variables. I document that the model error is correlated with relative UK/US industrial production and stock prices, as well as with future values of the real exchange rate, which likewise implies a rejection of the PIPO model. KP’s results are sensitive to extreme observations; estimation techniques that are more robust to outliers yield clear rejections of the model.

In Section 5, I use Kocherlakota and Pistaferri’s (2008) idea that the fraction of aggregate consumption due to the richest households is a proxy for higher cross-sectional consumption moments. Based on KP’s data, I show that this proxy is not correlated with the UK-US real exchange rate, which casts further doubts on the PIPO model.

2. Properties of UK/US cross-sectional consumption moments and of model error

Let $\overline{C}_{\gamma,j}$ be the sample $\gamma$-th non-central moment of the consumption distribution in country $j$, based on survey data. Table 1 reports the standard deviation and autocorrelation of the time series of $\ln(\overline{C}_{\gamma,j}^{UK}/\overline{C}_{\gamma,j}^{US})$, as well as its correlation with the logged real exchange rate $\ln(e_{t}^{UK,US})$, for $\gamma=1,2,...,9$. All data used in this paper are monthly, for 1980-99, and are from KP’s data set (unless stated otherwise).
The standard deviation and autocorrelation of the monthly logged real exchange rate are 13.9% and 0.99%, respectively. For all values of $\gamma$ considered in Table 1, the relative sample cross-sectional consumption moments are less persistent than the real exchange rate, and negatively or weakly positively correlated with the real exchange rate. When $\gamma \geq 2$ the relative consumption moment is several times more volatile than the real exchange rate. These facts cast doubts on the PIPO model. KP do not discuss the facts in Table 1.

KP claim that for $\gamma \approx 5$ the PIPO model fits the data well. For $\gamma = 5$, the standard deviation of $\ln(C_{\gamma,t}^{UK} / C_{\gamma,t}^{US})$ is 245.4%, while its autocorrelation and correlation with $\ln(e_{t}^{UK,US})$ are 0.08 and 0.06, respectively; thus, the logged relative consumption moment is 17.6 (!) times more volatile than the log real exchange rate, and much less persistent.

Figure 1 plots $\ln(e_{t}^{UK,US})$, and $\ln(C_{\gamma,t}^{UK} / C_{\gamma,t}^{US})$ for $\gamma = 1$ and $\gamma = 5$. Visually, the real exchange rate is ‘disconnected’ from relative consumption moments.

As shown in Table 1 (Row 4), the ‘model error’ $\Psi_{\gamma,t}^{j,k} = \ln(e_{t}^{j,k}) - \ln(C_{\gamma,t}^{j} / C_{\gamma,t}^{k})$ is roughly as volatile as $\ln(C_{\gamma,t}^{UK} / C_{\gamma,t}^{US})$. E.g. for $\gamma = 5$ the standard deviation of the model error is 244.9%.

Under the null hypothesis that the PIPO model is true, the model error just reflects cross-sectional sampling error:

$$\Psi_{\gamma,t}^{j,k} = \ln(C_{\gamma,t}^{j} / C_{\gamma,t}^{k}) + \ln(e_{t}^{j} / e_{t}^{k}) \approx -\epsilon_{\gamma,t}^{j} / C_{\gamma,t}^{j} + \epsilon_{\gamma,t}^{k} / C_{\gamma,t}^{k},$$

where $\epsilon_{\gamma,t}^{j} = C_{\gamma,t}^{j} - C_{\gamma,t}^{j}$ is the country $j$ sampling error. If $\epsilon_{\gamma,t}^{j}, \epsilon_{\gamma,t}^{k}$ have mean zero, the mean model error is thus (approximately) zero, under the null hypothesis.

I use bootstrap simulations (5000 random samples of UK and US households) to approximate the sampling distribution of the logged relative $\gamma$-th cross-sectional consumption moment, at each date $t$. 3 Table 2 reports the fraction of months in the

---

2 KP’s empirical analysis is based on quarterly first differenced time series. The standard deviation and autocorrelation of the quarterly first differenced log real exchange rate are 5.0% and 0.87, respectively. For $\gamma = 5$ the standard dev. and autocorr. of the quarterly first differenced log relative consumption moment are 322.8% (!) and 0.01, respectively (correlation with first differenced log real exchange rate: 0.01).

3 Each of the 5000 bootstrap samples for date $t$ is drawn with replacement from the sets of UK and US households in KP’s data base, for $t$ (and includes the same number of households as in the data base). Krueger and Perri (2007) also use bootstraps to evaluate the distribution of cross-sectional consumption moments.
sample (1980-1999) in which the log real exchange rate adjusted for an estimate of $\nu_{j,k}^{l,k}$ (see (1)), $\ln e_t^{j,k} - \hat{\nu}_{j,k}^{l,k}$, lies outside the 99% bootstrap confidence interval for the date $t$ logged relative consumption moment; if the PIPO model is true, that fraction should be close to 1%. In fact, the fraction is much higher: e.g., 35.3% for $\gamma=2$; and 10.9% for $\gamma=5$. $\ln e_t^{j,k} - \nu_{j,k}^{l,k}$ lies outside the range of the simulated 5000 logged relative consumption moments, in 17.6% [5.9%] of the periods, when $\gamma=2$ [5]. This suggests that the historical real exchange rate is inconsistent with the sampling distribution of relative UK/US consumption moments.

3. KP’s regression analysis

KP note that if the PIPO model is true, then the model error is uncorrelated with any variables that are uncorrelated with cross-sectional sampling error. KP regress the first-differenced model error on the first-differenced log real exchange rate:

$$\Delta_u \{ \ln e_t^{j,k} - \ln (C_{j,t} / C_{j,t-1}) \} = b \Delta_u \ln e_t^{j,k} + \eta_t,$$

where $\Delta_u x_t \equiv x_t - x_{t-u}$; $\eta_t$ is a regression error. The PIPO model implies $b = 0$.

KP only work with $u=3$, i.e. they solely test the model using monthly observations of quarterly first differences. They do not consider regressors other than the real exchange rate. KP report that the estimate of $b$ is zero when $\gamma \approx 5$.

Table 3 (Col. (2)) reports slope estimates obtained by fitting (3) to KP’s data, for $u=3$ and $\gamma=1,2,\ldots,9$. I did not manage to reproduce KP’s regression results exactly (see their Table 1), but results here are similar. The estimate of $b$ is zero for $\gamma=5.47$; for smaller [larger] values of $\gamma$, the slope estimate is positive [negative]. As in KP, the estimates of $b$ are not statistically significant, when $\gamma>2$. For $\gamma=5$ one cannot reject the hypothesis that the slope coefficient is zero, but (at conventional significance levels) one also fails to reject the hypothesis that the slope coefficient equals any other value between -7 and +7.

---

4 $\nu_{j,k}^{l,k} = \sum_{t=1}^{T} ( \ln e_t^{j,k} - \ln (C_{j,t} / C_{j,t-1}) )$. Under the null hypothesis, $\nu_{j,k}^{l,k}$ is a consistent estimate of $\nu_{j,k}^{l,k}$. A very similar estimate of $\nu_{j,k}^{l,k}$ is obtained by subtracting the mean simulated log relative consumption moment (averaged over all simulations and over all sample periods) from the mean log real exchange rate.

5 Table 2 also shows that the fraction of months in which $\ln e_t^{j,k} - \nu_{j,k}^{l,k}$ lies outside $\alpha \%$ confidence intervals is markedly larger than 100%–$\alpha \%$, for $\alpha=95\%, 90\%$ and $80\%$. 

---
As shown above, the model error is very volatile. It is thus important to investigate the robustness of KP’s regression results.

4. Sensitivity analysis

4.1. Regressions based on annual 1st differences, levels, and moving averages

Column (3) of Table 3 reports slope estimates based on regression (3) with \( u=12 \) (monthly time series of annual first differences), while Column (4) reports estimates from a regression based on variables in (log) levels:

\[
\ln e^{j,k}_{t} - \ln \left( \frac{C^{j}_{t,d}}{C^{k}_{t,d}} \right) = a + b \ln e^{j,k}_{t} + \eta_{t}. \tag{4}
\]

(An intercept is included in (4), to capture the term \( \nu^{j,k}_{\gamma} \) in equation (1).) Column (5) reports slope coefficients based on a regression of a 12-month moving average of \( \ln e^{j,k}_{t} - \ln \left( \frac{C^{j}_{t,d}}{C^{k}_{t,d}} \right) \) on a 12-month moving average of the real exchange rate:

\[
\frac{1}{12} \sum_{h=0}^{11} \{ \ln e^{j,k}_{t-h} - \ln \left( \frac{C^{j}_{t-h,d}}{C^{k}_{t-h,d}} \right) \} = a + b \frac{1}{12} \sum_{h=0}^{11} \ln e^{j,k}_{t-h} + \eta_{t}. \tag{5}
\]

Using moving averages may lower the influence of measurement error and outliers. All regressions are run for \( \gamma=1, 2, ..., 9 \).

The ‘levels’ regression (equation (4)) yield results that are roughly in line with KP’s result: for \( \gamma \) close to 5, the estimate of the slope coefficient \( b \) is zero.

By contrast, the ‘annual 1st differences’ and ‘moving averages’ regressions both overturn the KP findings, in the sense that the slope coefficient is positive for all values of \( \gamma \). However the slope coefficient \( b \) is again estimated imprecisely when \( \gamma \) is large. I thus investigate whether other regressors yield more precisely estimated slope coefficients.

4.2. Other regressors

Lags and Leads of the real exchange rate

If the PIPO model is true, then a regression of the model error on past and future values of the exchange rate should also yield zero slope estimates. I added the first 12 lags and leads of the logged real exchange rate as regressors to equations (3) and (4). \(^6\) The coefficients of lagged exchange rates are never jointly significant, in the ‘quarterly 1st

---

\[ \Delta \ln e^{j,t} = b \sum_{s=1}^{s=12} \Delta \ln e^{j,s} + \eta_{t}; \quad \ln e^{j,t} - \ln \left( \frac{C^{j}_{t,d}}{C^{k}_{t,d}} \right) = a + b \sum_{s=1}^{s=12} \ln e^{j,s} + \eta_{t}. \]
differences’ and ‘levels’ regressions; they are jointly significant (at a 10% level), in the ‘annual 1st differences’ regressions, for $\gamma \geq 3$.

However, the model error is strongly correlated with future values of the real exchange rate. Table 4 reports p-values (from Wald tests) of the null hypothesis that all leads of the exchange rate have zero coefficients. In the ‘quarterly 1st differences’ regressions, the p-values are smaller than 10% when $\gamma \geq 2$; for $\gamma = 1$, the leads of the real exchange rate do not enter significantly in the regression—however, for $\gamma = 1$ the contemporaneous real exchange rate has a highly significant slope coefficient (see Table 3, Col. (2)); thus, either the current or the future values of the real exchange rate have significant coefficients, in the ‘quarterly 1st differences’ regressions—which implies rejection of the PIPO model.

In the ‘annual 1st differences’ regressions, the p-values of leads of the real exchange rate are all smaller than 1.3%, for all values of $\gamma$ considered in Table 4. In the and ‘levels’ regressions, the p-values are all smaller than 7.4%. This again is a clear rejection of the PIPO model. The real exchange rate does not track the relevant relative cross-sectional consumption moments in the manner predicted by the PIPO model.

Relative industrial production and stock indices

Table 5 reports slope estimates from regressions of the model error on log relative UK/US industrial production (Panel a), and on the logged relative UK/US stock price (Panel b). (See Table 5 for data sources.)

In the ‘levels’ and ‘moving averages’ regressions (Columns (4),(5)), relative industrial production has negative slope coefficients, for all values of $\gamma$; those estimates are significant, at a 1% level, for $\gamma \geq 2$ and $\gamma \geq 3$, respectively.

The slope estimates of the relative stock price are negative, for all four regression specifications, and for all values $\gamma$. In the ‘quarterly/annual 1st differences’ regressions, the slope coefficient is statistically significant for $\gamma \leq 4$. In the ‘levels’ and ‘moving averages’ regressions, the slope coefficient is statistically significant (often very highly) for all values of $\gamma$. This too implies rejection of the PIPO model.
4.3. Alternative estimates of cross-sectional moments of consumption

Higher-order cross-sectional consumption moments are largely driven by the consumption of the richest households, and may thus be especially sensitive to measurement error in the right-tail of the distribution. In the US [UK] sample, the largest observation accounts for 26.2% [38.7%] of the sum of the fifth power of all household consumptions for that country, over the entire sample period 1980-1999.

Trimmed and winsorized estimates of cross-sectional moments of consumption

In order to reduce the influence of extreme observations, I estimated the cross-sectional $\gamma$-th consumption moment for each country using trimmed means and winsorized means of individual consumptions raised to the power $\gamma$; I set the truncation points at the smallest and largest 1% observations. (The trimmed mean is obtained by discarding the top and bottom 1% observations; the winsorized mean ‘accumulates’ the top and bottom 1% observations at the truncation point.) Trimming and winsorizing may provide more robust estimates of moments of heavy tailed distributions (Amemiya (1985). As both approaches yield very similar results, I only report results for winsorized moments.

Winsorizing greatly reduces the volatility of the relative cross-sectional consumption moments. E.g., for $\gamma=5$, the standard deviation and autocorrelation of the logged relative winsorized cross-sectional consumption moments are 72.4% and 0.51, respectively, and its correlation with the logged real exchange rate is -0.25 (corresponding statistics without winsorizing: 245.4%, 0.08 and 0.06; see above).

Table 6 reports slope estimates from regressions of model errors based on winsorized cross-sectional moments. The Table provides further evidence against the PIPO model. The slope coefficients of relative industrial production are significant (at the 10% level or below) in the ‘levels’ regressions for $\gamma \geq 2$, and in the ‘moving averages’ regressions, for $\gamma \geq 3$. The slope estimates of the real exchange rate and of the relative stock price are statistically significant in all four regression specifications and that for almost all values of $\gamma$;\(^7\) in the ‘levels’ and ‘moving average’ regressions, those slope estimates are all significant at the 0.1% level or below.

\(^7\) In the ‘quarterly 1st differences’ regressions, the real exchange rate is not significant for $\gamma \geq 6$. 

8
5. Regressions based on the consumption share of the biggest spenders

A key prediction of the PIPO model is that the real exchange rate is linked to the right-tail of the consumption distribution (provided \( \gamma > 1 \)). Kocherlakota and Pistaferri (2008) argue that the proportion of aggregate consumption accounted for by the richest household can be used as a proxy for right-tail consumption inequality. Let \( \bar{R}^j_{a,t} \) be the fraction of total consumption in country \( j \) at date \( t \), among the households included in KP’s sample, that is accounted for by the top \( \alpha \% \) households (ranked by spending at \( t \)). I run these regressions:

\[
\ln e^{j,k}_t = a + b \ln (\bar{R}^j_{a,t}/\bar{R}^k_{a,t}) + c \ln (\bar{C}^j_{1,t}/\bar{C}^k_{1,t}) + \eta_t, \quad (6a)
\]

\[
\Delta \ln e^{j,k}_t = a + b \Delta \ln (\bar{R}^j_{a,t}/\bar{R}^k_{a,t}) + c \Delta \ln (\bar{C}^j_{1,t}/\bar{C}^k_{1,t}) + \eta_t, \quad \text{for } u=3, 12 \quad (6b)
\]

where \( \bar{C}^j_{1,t} \) is per capita consumption in country \( j \) (based on KP’s household data). \( b > 0 \) can be viewed as evidence for the PIPO model; a complete markets model predicts \( c > 0 \).

Table 7 reports estimates of \( b \) and \( c \), for \( \alpha = 50\%, 25\%, 10\% \) and \( 5\% \). The estimates of \( c \) are all negative; Table 7 is thus consistent with the rejections of the complete markets model reported in the literature. The estimates of \( b \) are positive for only half of the regressions; the estimates are numerically small and never statistically significant.\(^8\) Thus, there is no significant relation between the UK/US real exchange rate and relative right-tail consumption inequality. This again suggests that the PIPO model is inconsistent with the UK/US data.

6. Conclusion

This paper has shown that the PIPO model is inconsistent with the behavior of the UK/US real exchange rate, and with household-level consumption data for these countries. The real exchange rate does not track the relevant domestic vs. foreign cross-sectional consumption moments. The link between the real exchange rate and consumption (heterogeneity) remains a puzzle.

---

8 Kocherlakota and Pistaferri (2008) report significant slope coefficients, in panel regressions of the real exchange rates on income shares received by the richest 10% households. The consumption shares of the top households used here are relevant for testing the PIPO model (not the income shares).
Bibliography
Figure 1—The Figure shows monthly time series (1980-1999) of the logged real exchange rate $e_{t,UK/US}$ (‘RER’), and of logged relative UK/US cross-sectional consumption moments of orders $\gamma=1$ (line labeled ‘Relative UK/US Cmean’) and $\gamma=5$ (‘Relative UK/US 5th C moments’). Note: the logged real exchange rate, and logged relative mean consumption ($\gamma=1$) are both scaled by the factor 10.
Table 1. Properties of relative cross-sectional consumption moments and of model errors

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. of $\ln(C^{UK}<em>{y,t} / C^{US}</em>{y,t})$</td>
<td>10.3%</td>
<td>29.7%</td>
<td>88.5%</td>
<td>166.8%</td>
<td>245.4%</td>
<td>320.2%</td>
<td>391.8%</td>
<td>461.1%</td>
</tr>
<tr>
<td>Autocorr. of $\ln(C^{UK}<em>{y,t} / C^{US}</em>{y,t})$</td>
<td>0.84</td>
<td>0.43</td>
<td>0.14</td>
<td>0.09</td>
<td>0.08</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>$\text{Corr}(\ln(C^{UK}<em>{y,t} / C^{US}</em>{y,t}), \ln(e^{UK,US}_{t}))$</td>
<td>-0.31</td>
<td>-0.17</td>
<td>-0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Std. of model error</td>
<td>19.7%</td>
<td>35.0%</td>
<td>89.9%</td>
<td>166.8%</td>
<td>244.9%</td>
<td>319.7%</td>
<td>391.2%</td>
<td>460.4%</td>
</tr>
</tbody>
</table>

Note—The Table reports the standard deviation (Row 1) and autocorrelation (Row 2) of monthly time series (1980-1999) of the logged relative UK/US cross-sectional $\gamma$–th consumption moment (for $\gamma=1,2,\ldots,9$) as well as its correlation with the logged real exchange rate $e^{UK,US}_{t}$ (Row 3). Also shown is the standard deviation of the model error, $\ln e^{UK,US}_{t} - \ln(C^{UK}_{y,t} / C^{US}_{y,t}) - V^{UK,US}_{t}$ (Row 4).

Table 2. Fractions of periods in which $\ln e^{i,k}_{t} - \hat{V}^{i,k}_{\gamma}$ does not lie in $\alpha\%$ bootstrap confidence interval

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha = 99%$</td>
<td>60.9%</td>
<td>35.3%</td>
<td>16.4%</td>
<td>14.3%</td>
<td>10.9%</td>
<td>10.5%</td>
<td>10.5%</td>
<td>10.1%</td>
</tr>
<tr>
<td>$\alpha = 95%$</td>
<td>72.7%</td>
<td>43.3%</td>
<td>26.1%</td>
<td>21.4%</td>
<td>20.2%</td>
<td>21.0%</td>
<td>21.4%</td>
<td>21.0%</td>
</tr>
<tr>
<td>$\alpha = 90%$</td>
<td>78.2%</td>
<td>50.0%</td>
<td>33.6%</td>
<td>31.1%</td>
<td>28.6%</td>
<td>29.4%</td>
<td>29.0%</td>
<td>29.4%</td>
</tr>
<tr>
<td>$\alpha = 80%$</td>
<td>84.5%</td>
<td>59.7%</td>
<td>44.1%</td>
<td>42.9%</td>
<td>43.3%</td>
<td>43.3%</td>
<td>44.5%</td>
<td>45.4%</td>
</tr>
</tbody>
</table>

Note—The Table reports the fraction of months (1980-1999) in which the adjusted log real exchange rate $\ln e^{i,k}_{t} - \hat{V}^{i,k}_{\gamma}$ lies outside the $\alpha\%$ bootstrap confidence interval for the logged relative UK/US $\gamma$–th cross-sectional consumption moment. Bootstrap confidence intervals are constructed using the ‘modified percentile method’, i.e. the $\alpha\%$ confidence interval is the shortest interval that includes $\alpha\%$ of the simulated statistics (Davidson and MacKinnon (1993, p.766)).
### Table 3. Slope estimates in regressions of model errors on real exchange rate

<table>
<thead>
<tr>
<th></th>
<th>Quarterly 1st differences</th>
<th>Annual 1st differences</th>
<th>Levels</th>
<th>Moving averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>1</td>
<td>1.04 (0.08)</td>
<td>1.04 (0.05)</td>
<td>1.23 (0.04)</td>
<td>1.31 (0.13)</td>
</tr>
<tr>
<td>2</td>
<td>1.34 (0.45)</td>
<td>1.16 (0.21)</td>
<td>1.38 (0.13)</td>
<td>1.57 (0.27)</td>
</tr>
<tr>
<td>3</td>
<td>1.67 (1.55)</td>
<td>1.30 (0.71)</td>
<td>1.12 (0.41)</td>
<td>1.48 (0.46)</td>
</tr>
<tr>
<td>4</td>
<td>1.29 (2.97)</td>
<td>1.17 (1.36)</td>
<td>0.54 (0.77)</td>
<td>1.11 (0.75)</td>
</tr>
<tr>
<td>5</td>
<td>0.45 (4.29)</td>
<td>0.93 (2.00)</td>
<td>-0.02 (1.14)</td>
<td>0.78 (1.06)</td>
</tr>
<tr>
<td>6</td>
<td>-0.52 (5.60)</td>
<td>0.69 (2.61)</td>
<td>-0.47 (1.49)</td>
<td>0.56 (1.35)</td>
</tr>
<tr>
<td>7</td>
<td>-1.48 (6.87)</td>
<td>0.48 (3.20)</td>
<td>-0.85 (1.82)</td>
<td>0.41 (1.64)</td>
</tr>
<tr>
<td>8</td>
<td>-2.39 (8.09)</td>
<td>0.29 (3.76)</td>
<td>-1.19 (2.15)</td>
<td>0.28 (1.91)</td>
</tr>
<tr>
<td>9</td>
<td>-3.23 (9.30)</td>
<td>0.12 (4.31)</td>
<td>-1.51 (2.46)</td>
<td>0.18 (2.17)</td>
</tr>
</tbody>
</table>

Note—The Table reports slope coefficients of regressions of model errors (for $\gamma=1,2,...,9$) on the logged real exchange rate. Figures in parentheses are standard errors. The regressions are run in quarterly 1st differences (Col. (2)), annual 1st differences (Col. (3)), levels (Col. (4)), and moving averages (Col. (5)). The standard errors are of the Newey-West (1987) form; the number of lags used is three in Col. (2), twelve in Cols. (3) and (5), and zero in Col. (4).

Coefficients in **bold** font that are underlined by a **continuous [dotted]** line are significant at the 5% [10%] level (one-sided test).

### Table 4. p-values of first 12 leads of real exchange rate

<table>
<thead>
<tr>
<th></th>
<th>Quarterly 1st differences</th>
<th>Annual 1st differences</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>1</td>
<td>0.43</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>0.09</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>0.06</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>4</td>
<td>0.04</td>
<td>0.00</td>
<td>0.07</td>
</tr>
<tr>
<td>5</td>
<td>0.02</td>
<td>0.00</td>
<td>0.06</td>
</tr>
<tr>
<td>6</td>
<td>0.02</td>
<td>0.00</td>
<td>0.04</td>
</tr>
<tr>
<td>7</td>
<td>0.01</td>
<td>0.00</td>
<td>0.04</td>
</tr>
<tr>
<td>8</td>
<td>0.01</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td>9</td>
<td>0.01</td>
<td>0.00</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note—This Table is based on regressions of model errors (for $\gamma=1,2,...,9$) on the current logged real exchange rate, as well as on the first 12 lags and leads of the logged real exchange rate. The Table reports p-values of Wald tests that the first 12 leads of the logged real exchange rate all have zero coefficients. The regressions are run in quarterly 1st differences (Col. (2)), annual 1st differences (Col. (3)) and levels (Col. (4)). The Wald test is based on a covariance matrix of estimated coefficients of the Newey-West (1987) form; the number of lags used is three in Col. (2), twelve in Col. (3), and zero in Col. (4).
Table 5. Slope estimates in regressions of model errors on additional macro variables

<table>
<thead>
<tr>
<th></th>
<th>Quarterly 1st differences</th>
<th>Annual 1st differences</th>
<th>Levels</th>
<th>Moving averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>γ</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>(a)</td>
<td>Regressions on relative industrial production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.07 (0.33)</td>
<td>0.14 (0.51)</td>
<td>-0.18 (0.25)</td>
<td>-0.49 (0.89)</td>
</tr>
<tr>
<td>2</td>
<td>0.24 (1.23)</td>
<td>0.39 (0.80)</td>
<td>-1.29 (0.44)</td>
<td>-1.56 (1.20)</td>
</tr>
<tr>
<td>3</td>
<td>-0.58 (4.12)</td>
<td>0.63 (2.09)</td>
<td>-3.85 (1.13)</td>
<td>-3.42 (1.45)</td>
</tr>
<tr>
<td>4</td>
<td>-4.78 (7.73)</td>
<td>-0.20 (3.88)</td>
<td>-6.94 (2.10)</td>
<td>-5.46 (1.95)</td>
</tr>
<tr>
<td>5</td>
<td>-10.64 (11.35)</td>
<td>-1.81 (5.70)</td>
<td>-9.92 (3.09)</td>
<td>-7.35 (2.65)</td>
</tr>
<tr>
<td>6</td>
<td>-16.64 (14.81)</td>
<td>-3.58 (7.43)</td>
<td>-12.71 (4.04)</td>
<td>-9.11 (3.39)</td>
</tr>
<tr>
<td>7</td>
<td>-22.32 (18.14)</td>
<td>-5.29 (9.05)</td>
<td>-15.37 (4.95)</td>
<td>-10.81 (4.10)</td>
</tr>
<tr>
<td>8</td>
<td>-27.67 (21.37)</td>
<td>-6.88 (10.69)</td>
<td>-17.95 (5.83)</td>
<td>-12.47 (4.80)</td>
</tr>
<tr>
<td>9</td>
<td>-32.74 (24.54)</td>
<td>-8.39 (12.26)</td>
<td>-20.48 (6.68)</td>
<td>-14.12 (5.48)</td>
</tr>
</tbody>
</table>

(b) Regressions on relative stock price

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.39 (0.08)</td>
<td>-0.64 (0.10)</td>
<td>-0.97 (0.04)</td>
<td>-1.05 (0.13)</td>
</tr>
<tr>
<td>2</td>
<td>-0.86 (0.31)</td>
<td>-0.91 (0.19)</td>
<td>-1.46 (0.10)</td>
<td>-1.54 (0.15)</td>
</tr>
<tr>
<td>3</td>
<td>-1.88 (1.07)</td>
<td>-1.48 (0.60)</td>
<td>-1.90 (0.33)</td>
<td>-1.87 (0.26)</td>
</tr>
<tr>
<td>4</td>
<td>-2.76 (2.03)</td>
<td>-1.88 (1.17)</td>
<td>-2.12 (0.65)</td>
<td>-1.95 (0.52)</td>
</tr>
<tr>
<td>5</td>
<td>-3.40 (2.99)</td>
<td>-2.14 (1.74)</td>
<td>-2.26 (0.96)</td>
<td>-1.99 (0.80)</td>
</tr>
<tr>
<td>6</td>
<td>-3.93 (3.91)</td>
<td>-2.38 (2.28)</td>
<td>-2.42 (1.26)</td>
<td>-2.07 (1.07)</td>
</tr>
<tr>
<td>7</td>
<td>-4.40 (4.80)</td>
<td>-2.62 (2.81)</td>
<td>-2.62 (1.55)</td>
<td>-2.19 (1.31)</td>
</tr>
<tr>
<td>8</td>
<td>-4.87 (5.65)</td>
<td>-2.86 (3.31)</td>
<td>-2.38 (1.82)</td>
<td>-2.34 (1.55)</td>
</tr>
<tr>
<td>9</td>
<td>-5.33 (6.49)</td>
<td>-3.11 (3.80)</td>
<td>-3.05 (2.10)</td>
<td>-2.50 (1.77)</td>
</tr>
</tbody>
</table>

Note—The Table reports slope coefficients in regressions of model errors (for γ=1,2,...,9) on logged relative UK/US industrial production (Panel (a)), and on the logged relative UK/US stock price (Panel (b)). Figures in parentheses are standard errors. The regressions are run in quarterly 1st differences (Col. (2)), annual 1st differences (Col. (3)), levels (Col. (4)), and moving averages (Col. (5)). The standard errors are of the Newey-West (1987) form; the number of lags used is three in Col. (2), twelve in Cols. (3) and (5), and zero in Col. (4).

Coefficients in bold font that are underlined by a continuous [dotted] line are significant at the 5% [10%] level (one-sided test).

Industrial production (IP) series are from International Financial Statistics. Relative UK/US IP has a strong downward trend. I thus use linearly detrended logged relative IP as a regressor. Stock prices are cumulated dollar stock returns for the US and the UK, taken from Kenneth French’s website.
Table 6. Regressions results based on model errors constructed from winsorized cross-sectional moments of consumption

<table>
<thead>
<tr>
<th>γ</th>
<th>Quarterly 1st differences</th>
<th>Annual 1st differences</th>
<th>Levels</th>
<th>Moving averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>1.05</strong> (0.07)</td>
<td><strong>1.03</strong> (0.05)</td>
<td><strong>1.24</strong> (0.04)</td>
<td><strong>1.32</strong> (0.13)</td>
</tr>
<tr>
<td>2</td>
<td><strong>1.13</strong> (0.19)</td>
<td><strong>1.11</strong> (0.12)</td>
<td><strong>1.51</strong> (0.10)</td>
<td><strong>1.69</strong> (0.27)</td>
</tr>
<tr>
<td>3</td>
<td><strong>1.25</strong> (0.39)</td>
<td><strong>1.22</strong> (0.24)</td>
<td><strong>1.78</strong> (0.16)</td>
<td><strong>2.07</strong> (0.42)</td>
</tr>
<tr>
<td>4</td>
<td><strong>1.36</strong> (0.65)</td>
<td><strong>1.34</strong> (0.40)</td>
<td><strong>2.04</strong> (0.24)</td>
<td><strong>2.43</strong> (0.55)</td>
</tr>
<tr>
<td>5</td>
<td><strong>1.44</strong> (0.96)</td>
<td><strong>1.47</strong> (0.58)</td>
<td><strong>2.29</strong> (0.32)</td>
<td><strong>2.80</strong> (0.68)</td>
</tr>
<tr>
<td>6</td>
<td>1.49 (1.28)</td>
<td><strong>1.59</strong> (0.77)</td>
<td><strong>2.53</strong> (0.41)</td>
<td><strong>3.15</strong> (0.82)</td>
</tr>
<tr>
<td>7</td>
<td>1.52 (1.59)</td>
<td><strong>1.70</strong> (0.96)</td>
<td><strong>2.78</strong> (0.50)</td>
<td><strong>3.51</strong> (0.96)</td>
</tr>
<tr>
<td>8</td>
<td>1.52 (1.90)</td>
<td><strong>1.80</strong> (1.15)</td>
<td><strong>3.02</strong> (0.60)</td>
<td><strong>3.87</strong> (1.09)</td>
</tr>
<tr>
<td>9</td>
<td>1.52 (2.21)</td>
<td><strong>1.90</strong> (1.33)</td>
<td><strong>3.26</strong> (0.69)</td>
<td><strong>4.23</strong> (1.23)</td>
</tr>
</tbody>
</table>

(a) Regression of model error on real exchange rate

1 0.12 (0.32) 0.12 (0.51) -0.15 (0.25) -0.47 (0.90)
2 0.08 (0.57) -0.06 (0.62) **-0.79** (0.38) -1.26 (1.29)
3 0.04 (1.06) -0.42 (0.87) **-1.65** (0.54) -2.21 (1.70)
4 -0.02 (1.75) -0.96 (1.27) **-2.60** (0.74) **-3.19** (2.10)
5 -0.12 (2.54) -1.62 (1.74) **-3.57** (0.96) **-4.16** (2.49)
6 -0.25 (3.37) -2.31 (2.25) **-4.51** (1.20) **-5.10** (2.90)
7 -0.38 (4.20) -3.02 (2.76) **-5.43** (1.45) **-6.02** (3.30)
8 -0.52 (5.02) -3.70 (3.27) **-6.33** (1.69) **-6.93** (3.71)
9 -0.64 (5.82) -4.37 (3.77) **-7.22** (1.93) **-7.82** (4.13)

(b) Regression of model error on relative industrial production

1 -0.37 (0.07) **-0.63** (0.10) **-0.97** (0.05) **-1.05** (0.13)
2 -0.54 (0.14) **-0.72** (0.14) **-1.44** (0.07) **-1.57** (0.18)
3 -0.82 (0.27) **-0.83** (0.22) **-1.94** (0.11) **-2.12** (0.23)
4 **-1.21** (0.44) **-0.97** (0.35) **-2.43** (0.17) **-2.64** (0.29)
5 **-1.65** (0.65) **-1.10** (0.50) **-2.91** (0.24) **-3.15** (0.36)
6 **-2.11** (0.87) **-1.23** (0.66) **-3.37** (0.32) **-3.64** (0.44)
7 **-2.57** (1.09) **-1.36** (0.82) **-3.84** (0.39) **-4.12** (0.52)
8 **-3.02** (1.30) **-1.49** (0.98) **-4.29** (0.46) **-4.60** (0.60)
9 **-3.46** (1.51) **-1.61** (1.13) **-4.75** (0.53) **-5.08** (0.69)

(c) Regression of model error on relative stock price

1 -0.37 (0.07) **-0.63** (0.10) **-0.97** (0.05) **-1.05** (0.13)
2 -0.54 (0.14) **-0.72** (0.14) **-1.44** (0.07) **-1.57** (0.18)
3 -0.82 (0.27) **-0.83** (0.22) **-1.94** (0.11) **-2.12** (0.23)
4 **-1.21** (0.44) **-0.97** (0.35) **-2.43** (0.17) **-2.64** (0.29)
5 **-1.65** (0.65) **-1.10** (0.50) **-2.91** (0.24) **-3.15** (0.36)
6 **-2.11** (0.87) **-1.23** (0.66) **-3.37** (0.32) **-3.64** (0.44)
7 **-2.57** (1.09) **-1.36** (0.82) **-3.84** (0.39) **-4.12** (0.52)
8 **-3.02** (1.30) **-1.49** (0.98) **-4.29** (0.46) **-4.60** (0.60)
9 **-3.46** (1.51) **-1.61** (1.13) **-4.75** (0.53) **-5.08** (0.69)

Note—The Table reports slope coefficients in regressions of model errors, constructed using winsorized cross-sectional consumption moments (of order γ=1,2,...,9) on the logged real exchange rate (Panel (a)), on logged relative industrial production (Panel (b)), and on the logged relative stock price (Panel (c)). Figures in parentheses are standard errors.

The regressions are run in quarterly 1st differences (Col. (2)), annual 1st differences (Col. (3)), levels (Col. (4)), and moving averages (Col. (5)). The standard errors are of the Newey-West (1987) form; the number of lags used is three in Col. (2), twelve in Cols. (3) and (5), and zero in Col. (4).

Coefficients in bold font that are underlined by a continuous [dotted] line are significant at the 5% [10%] level (one-sided test).
Table 7. Regressions of real exchange rate on relative share of $\alpha$ % largest consumptions and on relative per capita consumption

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha = 50%$</td>
<td>-0.07 (0.19)</td>
<td>-0.02 (0.06)</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 25%$</td>
<td>-0.01 (0.08)</td>
<td>-0.03 (0.07)</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 10%$</td>
<td>0.01 (0.03)</td>
<td>-0.04 (0.06)</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 5%$</td>
<td>0.01 (0.02)</td>
<td>-0.05 (0.06)</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha = 50%$</td>
<td>-0.27 (0.54)</td>
<td>-0.14 (0.20)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 25%$</td>
<td>-0.03 (0.22)</td>
<td>-0.18 (0.19)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 10%$</td>
<td>-0.01 (0.10)</td>
<td>-0.18 (0.18)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 5%$</td>
<td>0.02 (0.06)</td>
<td>-0.22 (0.18)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>(iii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha = 50%$</td>
<td>-0.11 (1.12)</td>
<td>-0.41 (0.28)</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 25%$</td>
<td>0.12 (0.45)</td>
<td>-0.44 (0.26)</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 10%$</td>
<td>0.13 (0.19)</td>
<td>-0.44 (0.25)</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>$\alpha = 5%$</td>
<td>0.11 (0.11)</td>
<td>-0.45 (0.25)</td>
<td>0.11</td>
<td></td>
</tr>
</tbody>
</table>

Note—The Table reports slope estimates in regressions of the logged real exchange rate on the logged relative share of total consumption accounted for by the $\alpha$% largest consumptions (coefficient b) and on logged relative per capita consumption (coefficient c). See equations (6a) and (6b). Figures in parentheses are standard errors. The regressions are run in quarterly first differences (Panel (i)), annual first differences (Panel (ii)) and in levels (Panel (iii)). The standard errors are of the Newey-West (1987) form; the number of lags used is twelve.