Household Consumption Heterogeneity and the Real Exchange Rate

Robert Kollmann
ECARES, Université Libre de Bruxelles & CEPR

August 2021

ECARES working paper 2021-14

ECARES
ULB - CP 114/04
50, F.D. Roosevelt Ave., B-1050 Brussels BELGIUM
www.ecares.org

Household Consumption Heterogeneity and the Real Exchange Rate

Robert Kollmann **(*)**

Université Libre de Bruxelles & CEPR

August 4, 2021

Does household heterogeneity matter for exchange rate determination? This paper tests Kocherlakota and Pistaferri's (2007) prominent heterogeneous agent model, in which the real exchange rate *perfectly* tracks relative domestic/foreign moments of cross-household consumption distributions. The evidence presented here indicates that the real exchange rate is disconnected from relative cross-household consumption moments.

Keywords: Household consumption heterogeneity; International and domestic risk sharing; Real exchange rate.

JEL codes: F36, F37, F41, F44, G15, D52

(*) I am very grateful to Narayana Kocherlakota and Luigi Pistaferri for sharing their data with me. I also thank Klaus Adam, Susana Cociuba, Ivan Faiella, Stéphane Guibaud, Urban Jermann, Narayana Kocherlakota, Sylvain Leduc, Fabrizio Perri, Ananth Ramanarayanan and Stijn Van Nieuwerburgh 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 Franklin Roosevelt, 1050 Brussels, Belgium; robert_kollmann@yahoo.com.

1. Introduction

Widely used models of the world economy postulate complete financial markets and efficient domestic and international risk sharing (see, e.g., the canonical International Real Business Cycle model of Backus et al. (1994)). With full domestic risk sharing, aggregate economic variables in a given country can be represented as being chosen by a representative household. International risk sharing entails that the ratio of domestic to foreign representative households' marginal utilities of *aggregate* consumption is proportional to the real exchange rate. This international risk sharing condition implies that a country's aggregate consumption rises, relative to foreign aggregate consumption, when the country's real exchange rate depreciates. Yet, empirically, real exchange rates are essentially uncorrelated with cross-country aggregate consumption differences (Kollmann (1991, 1995) and Backus and Smith (1993); see Devereux and Kollmann (2012) for detailed references). This "consumption-real exchange rate anomaly" is one of the major puzzles in open economy macroeconomics (Obstfeld and Rogoff (2000), Itskhoki and Mukhin (2020)).

The puzzle raises the question whether models with household heterogeneity and financial frictions can better account for the empirical dynamics of consumption and the real exchange rate. Kocherlakota and Pistaferri (2007) [KP] developed a prominent model of a two country world in which household-specific productivity (skill) shocks are only privately observable, which limits risk sharing across households.[1] The authors analyze a theoretical trading mechanism whose equilibrium allocations are (constrained) Pareto optimal, subject to incentive compatibility constraints implied by private information about individual productivity. KP show that this "private-information Pareto-optimal" (PIPO) structure entails that the real exchange rate perfectly tracks the domestic/foreign ratio of γ-th non-central moments of the cross-household distributions of consumption, where γ is the coefficient of relative risk aversion. According to this theory, household heterogeneity is hence a key determinant of the real exchange rate. Under the plausible assumption that $\gamma > 1$, the model predicts that the real exchange rate

[1] That model is an open economy version of Kocherlakota and Pistaferri's (2009) well known asset pricing theory.

is especially sensitive to changes in the consumption of the rich (right tail of the consumption distribution). [2]

KP test this prediction using monthly US and UK household-level consumption data for the period 1980-1999. The authors use the micro consumption data to construct time-series of cross-household γ-th consumption moments. Based on econometric regressions, the authors reach the conclusion that, for $\gamma \approx 5$, the UK/US ratio of cross-household consumption moments "tracks the real exchange rate well" (p.C17). This is a noteworthy claim, because empirically the real exchange rate is disconnected from ratios of domestic/foreign *aggregate* consumption, as mentioned above.

This paper assesses the empirical evidence provided by KP, using the original US and UK household consumption data employed in the KP study. I document that model error (the gap between the real exchange rate and relative domestic/foreign cross-household consumption moments) is correlated with relative UK/US industrial production and stock prices, as well as with future values of the real exchange rate. This implies a clear rejection of the heterogeneous agent theory. I furthermore use Kocherlakota and Pistaferri's (2008) idea that the fraction of aggregate consumption due to the richest households is a proxy for higher cross-household 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 heterogeneous agent theory.

The results here suggest thus that household heterogeneity, of the type highlighted by the PIPO model, fails to account for the UK/US real exchange rate. In summary, the link between the real exchange rate and consumption (heterogeneity) remains a puzzle.

2. Consumption and the real exchange rate: theory

As mentioned above, a model with full domestic and international risk sharing implies that the real exchange rate is proportional to the ratio of domestic to foreign marginal utilities of aggregate consumption. Under time-separable utility with constant relative

[2] KP also develop an alternative heterogeneous agent theory in which households cannot insure themselves at all against individual productivity shocks, as the pay-offs of all traded assets are solely contingent on aggregate shocks. In that structure, the real exchange rate is tied to the negative γ-th non-central moments of the cross-household distributions of consumption in the domestic and foreign economies; thus (for $\gamma>1$) the real exchange rate is mainly driven by the consumption of the poor (left tail of the consumption distribution). KP show that this alternative theory is rejected empirically. Thus, the present paper focuses on the PIPO theory.

risk aversion (CRRA), and risk aversion coefficient γ, this risk sharing condition implies: $e_t^{j,k}=\exp(v^{j,k})\cdot(C_t^k)^{-\gamma}/(C_t^j)^{-\gamma}$, where $e_t^{j,k}$ is 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). (A rise in $e_t^{j,k}$ is thus a depreciation of the country *j* real exchange rate.) C_t^j and C_t^k denote aggregate consumption in countries *j* and *k*, respectively. $v^{j,k}$ is a date- and state invariant term that reflects the two countries' relative wealth. In logged terms, this risk sharing condition can be expressed as:

$$\ln e_t^{j,k}=\gamma\ln(C_t^j/C_t^k)+v^{j,k}, \qquad (1)$$

i.e. the real exchange rate is predicted to be perfectly correlated with relative consumption. As discussed above, this prediction is strongly rejected empirically.

By contrast, the heterogeneous agent model (PIPO) developed by KP implies that the real exchange rate is tied to relative *cross-sectional moments* of consumption:

$$\ln e_t^{j,k}=\ln(C_{\gamma,t}^j/C_{\gamma,t}^k)+\nu_\gamma^{j,k}, \qquad (2)$$

where $\nu_\gamma^{j,k}$ is a constant term, while $C_{\gamma,t}^j$ and $C_{\gamma,t}^k$ are the γ-th non-central population moment of the cross-household consumption distribution in countries *j* and *k*, respectively, at date *t*. Assume that country *j* is inhabited by N^j households indexed by n=1,.., N^j; then, $C_{\gamma,t}^j\equiv\frac{1}{N^j}\sum_{n=1}^{N^j}(c_t^{j,n})^\gamma$ where $c_t^{j,n}$ is the consumption of household n. [3]

3. Testing the heterogeneous agent model

KP test prediction (2) with monthly US and UK household-level consumption data from the US CEX and UK FES household surveys. The sample period is 1980-1999. The household data are used by KP to construct time series of estimated cross-household

[3] When consumption risk is efficiently shared across the residents of the same country (i.e. in the absence of informational and financial frictions), individual consumption is proportional to aggregate consumption: $c_t^{j,n}=\lambda^{j,n}C_t^j$ $\forall$n, where $\lambda^{j,n}$ is a date and state-invariant term that reflects the relative wealth of household n (with $\sum_{n=1}^{N^j}\lambda_t^{j,n}=1$). Under efficient within-country risk sharing, the risk sharing conditions (2) and (1) are equivalent. However, (2) differs from (1) when within-country risk sharing is restricted (as in the PIPO structure).

consumption moments. Let $\overline{C^j_{\gamma,t}}$ be the **sample** γ–th non-central moment of the cross-household consumption distribution in country *j* at date *t*, based on the survey data.[4]

Table 1 reports the standard deviation and autocorrelation of the monthly series $\ln(\overline{C^j_{\gamma,t}}/\overline{C^k_{\gamma,t}})$ (*j*=UK, *k*=US), as well as its correlation with the logged real exchange rate $\ln(e^{j,k}_t)$, for $\gamma=1,2,..,9$. Figure 1 plots $\ln(e^{j,k}_t)$ [blue line] as well as relative cross-household consumption moments for $\gamma=1$ and $\gamma=5$: $\ln(\overline{C^j_{1,t}}/\overline{C^k_{1,t}})$ [green line] and $0.1\times\ln(\overline{C^j_{5,t}}/\overline{C^k_{5,t}})$ [red line]. (Note scaling of plotted moments for $\gamma=5$.)

These statistics and plots were *not* provided in KP's paper; they suggest that the real exchange rate is disconnected from relative cross-household consumption moments.

The standard deviation and autocorrelation of the monthly real exchange rate are 13.9% and 0.99, respectively. For $\gamma\geq 2$, the relative cross-household consumption moments are several times more volatile than the real exchange rate. Relative consumption moments are much less persistent than the real exchange rate, and negatively or weakly positively correlated with the real exchange rate. The "model error" $\ln e^{j,k}_t - \nu^{j,k}_\gamma - \ln(\overline{C^j_{\gamma,t}}/\overline{C^k_{\gamma,t}})$ is about as volatile as $\ln(\overline{C^{UK}_{\gamma,t}}/\overline{C^{US}_{\gamma,t}})$.

KP argue that for $\gamma\approx 5$ the heterogeneous agent model fits the real exchange rate. Yet, for $\gamma=5$, the relative consumption moment is 17.6 times (!) more volatile than the real exchange rate, and uncorrelated with the real exchange rate (see Figure and Table 1).

This casts doubts on the heterogeneous agent model. However, KP argue that the high volatility of $\ln(\overline{C^{UK}_{\gamma,t}}/\overline{C^{US}_{\gamma,t}})$ might reflect sampling error, and they thus use an "indirect" statistical test of condition (2). This test exploits the fact that, under the hypothesis that (2) is true, the model error solely reflects cross-household *sampling* error:

$$\Psi^{j,k}_{\gamma,t} = \ln(\overline{C^j_{\gamma,t}}/C^j_{\gamma,t}) + \ln(\overline{C^k_{\gamma,t}}/C^k_{\gamma,t}) \approx -\varepsilon^j_{\gamma,t}/C^j_{\gamma,t} + \varepsilon^k_{\gamma,t}/C^k_{\gamma,t},$$

[4] The US dataset consists of 318832 monthly household consumption observations, which corresponds to an average of 1328 households per month; the UK dataset comprises 137375 monthly observations, i.e. an average of 573 households per month. As the number of data points per period is relatively small, the sample moment $\overline{C^j_{\gamma,t}}$ may differ from the population moment $C^j_{\gamma,t}$, i.e. there may be sampling error, especially for large values of γ.

where $\varepsilon^j_{\gamma,t} \equiv \overline{C^j_{\gamma,t}} - C^j_{\gamma,t}$ is the country *j* sampling error. If $\varepsilon^j_{\gamma,t}, \varepsilon^k_{\gamma,t}$ have mean zero, the mean model error is thus (approximately) zero, under the null hypothesis.

One can thus test the theory by regressing the model error on any variable that is (plausibly) uncorrelated with household consumption sampling error. The slope coefficient of that regression should be (close to) zero, and statistically insignificant, if condition (2) is true.

KP apply this idea to the "differenced" model error. Specifically, KP regress the differenced model error on the differenced logged real exchange rate:

$$\Delta_u\{\ln e^{j,k}_t - \ln(\overline{C^j_{\gamma,t}} / \overline{C^k_{\gamma,t}})\} = b\,\Delta_u \ln e^{j,k}_t + \eta_t \ , \tag{3}$$

where $\Delta_u x_t \equiv x_t - x_{t-u}$, while η_t is a regression error. The heterogeneous agent model implies *b*=0. KP **only** consider *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.

Table 2 (Col. (2)) reports slope estimates obtained by fitting (3) to KP's data, for *u*=3 and $\gamma = 1, 2, .., 9$. 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 γ, the slope estimates are positive [negative].

This finding is the basis of KP's claim that the heterogeneous agent model "is able to account for movements in the real exchange rate" (p.C3).

It can be noted that the estimates of *b* reported in Table 2 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 the reject the hypothesis that the slope coefficient equals any other value between -7 and +7.

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

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

Col. (3) of Table 2 reports slope coefficient estimates based on regression (3) with *u*=12 (monthly time series of annual first differences), while Column (4) reports slope estimates from a regression based on variables in (log) levels:

$$\ln e_t^{j,k} - \ln(\overline{C_{\gamma,t}^j} / \overline{C_{\gamma,t}^k}) = a + b \ln e_t^{j,k} + \eta_t . \quad (4)$$

(An intercept is included in (4), to capture the term $\nu_\gamma^{j,k}$ in equation (2).) Column (5) of Table 2 reports slope coefficients based on a regression of a 12-month moving average of $\ln e_t^{j,k} - \ln(\overline{C_{\gamma,t}^j} / \overline{C_{\gamma,t}^k})$ on a 12-month moving average of the real exchange rate:

$$\tfrac{1}{12}\sum_{h=0}^{11} \{\ln e_{t-h}^{j,k} - \ln(\overline{C_{\gamma,t-h}^j} / \overline{C_{\gamma,t-h}^k})\} = a + b\tfrac{1}{12}\sum_{h=0}^{11} \ln e_{t-h}^{j,k} + \eta_t . \quad (5)$$

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 γ 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 γ, in the range considered here.[5] However the slope coefficient *b* is again estimated imprecisely when γ is large. I thus investigate next whether other regressors yield more precisely estimated slope coefficients.

3.2. Other regressors

Lags and Leads of the real exchange rate

If the heterogeneous agent 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 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 3 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

[5] The slope coefficient is negative for $\gamma > 10$, however such large values of the risk aversion coefficient are outside the range that is generally considered in macroeconomic models.

[6] $\Delta_u\{\ln e_t^{j,k} - \ln(\overline{C_{\gamma,t}^j} / \overline{C_{\gamma,t}^k})\} = \sum_{s=-12}^{s=12} b_s \Delta_u \ln e_{t-s}^{j,k} + \eta_t$ for u=3,12; $\ln e_t^{j,k} - \ln(\overline{C_{\gamma,t}^j} / \overline{C_{\gamma,t}^k}) = a + \sum_{s=-12}^{s=12} b_s \ln e_{t-s}^{j,k} + \eta_t$.

exchange rate do not enter significantly in the regression—however, for γ=1 the *contemporaneous* real exchange rate has a highly significant slope coefficient (see Table 2, 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 heterogeneous agent 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 γ considered in Table 3. In the 'levels' regressions, the p-values are all smaller than 7.4% (see Col. (4)). This again is a clear rejection of the heterogeneous agent model. The real exchange rate does *not* track the relevant relative cross-household consumption moments in the manner predicted by the theory.

Relative industrial production and stock indices

Table 4 reports slope estimates from regressions of the model error on logged relative UK/US industrial production (Panel a), and on the logged relative UK/US stock price (Panel b).

In 'levels' and 'moving averages' regressions (see Columns (4),(5) of Table 4), **relative industrial production** has negative slope coefficients, for all values of γ; 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 γ. 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 γ. This too implies rejection of the heterogeneous agent theory.

Regressions based on the consumption share of the biggest spenders

A key prediction of the heterogeneous agent theory is that the real exchange rate is linked to the right-tail of the consumption distribution (provided γ>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 $\overline{R^j_{\alpha,t}}$ 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 α % households, ranked by spending at *t*. I run these regressions:

$$\ln e_t^{j,k} = a + b\ln(\overline{R_{\alpha,t}^j}/\overline{R_{\alpha,t}^k}) + c\ln(\overline{C_{1,t}^j}/\overline{C_{1,t}^k}) + \eta_t \,, \qquad (6a)$$

$$\Delta_u \ln e_t^{j,k} = a + b\,\Delta_u \ln(\overline{R_{\alpha,t}^j}/\overline{R_{\alpha,t}^k}) + c\Delta_u \ln(\overline{C_{1,t}^j}/\overline{C_{1,t}^k}) + \eta_t \,, \text{ for u=3, 12} \qquad (6b)$$

where $\overline{C_{1,t}^j}$ is per capita consumption in country *j* (based on KP's household data). *b*>0 can be viewed as evidence for the heterogeneous agent model; a representative agent model predicts *c*>0.

Table 5 reports estimates of *b* and *c*, for $\alpha = 50\%$, 25%, 10% and 5%. The estimates of *c* are all negative; Table 5 thus confirms the rejections of representative agent models 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. Thus, there is no significant relation between the UK/US real exchange rate and relative right-tail consumption inequality. This again suggests that the heterogeneous agent model is inconsistent with the UK/US data.

4. Conclusion

The findings reported here imply a clear rejection of the heterogeneous-agent theory's real exchange rate equation. The link between the real exchange rate and consumption (heterogeneity) remains a puzzle.

Bibliography

Backus, D., and G. Smith, 1993, Consumption and Real Exchange Rates in Dynamic Economies with Non-traded Goods, Journal of International Economics 35, 297-316.

Backus, D., P. Kehoe and F. Kydland, 1994. Dynamics of the Trade Balance and the Terms of Trade: the J-Curve? American Economic Review 84, 84-103.

Devereux, M. and R. Kollmann, 2012. Symposium on International Risk Sharing. Canadian Journal of Economics 45, 373-375.

Itskhoki, O. and D. Mukhin, 2020. Exchange Rate Disconnect in General Equilibrium, forthcoming, Journal of Political Economy.

Kocherlakota, N. and L. Pistaferri, 2007, Household Heterogeneity and Real Exchange Rates, Economic Journal 117, C1-C25.

Kocherlakota, N. and L. Pistaferri, 2008, Inequality and Real Exchange Rates, Journal of the European Economic Association 6, 597-608.

Kocherlakota, N. and L. Pistaferri. 2009. Asset Pricing Implications of Pareto Optimality with Private Information. Journal of Political Economy 117, 555-590.

Kollmann, R., 1991, Essays on International Business Cycles, PhD Dissertation, Economics Department, University of Chicago.

Kollmann, R., 1995, Consumption, Real Exchange Rates and the Structure of International Asset Markets, Journal of International Money and Finance, 1995, 14, 191-211.

Newey, W. and K. West, 1987, A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix, Econometrica 55, 703-708.

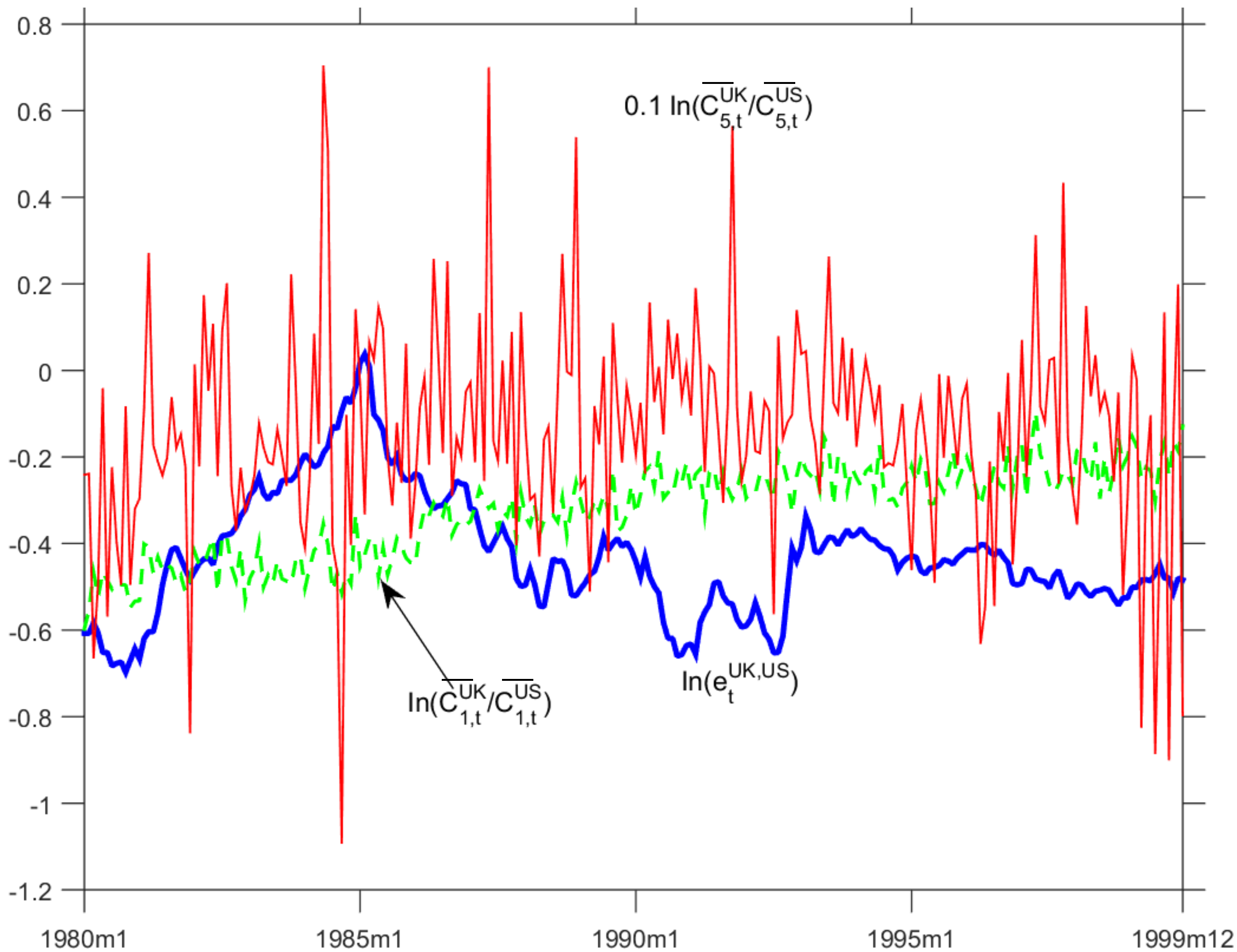

Figure 1—The Figure shows monthly time series (1980-1999) of the logged UK/US real exchange rate $\ln(e_t^{UK,US})$, and of relative UK/US cross-household consumption sample moments of orders γ=1 $[\ln(\overline{C_{1,t}^{UK}}/\overline{C_{1,t}^{US}})]$ and γ=5 $[0.1\times\ln(\overline{C_{5,t}^{UK}}/\overline{C_{5,t}^{US}})]$. **Note: plotted** $\ln(\overline{C_{5,t}^{UK}}/\overline{C_{5,t}^{US}})$ **is adjusted by factor 0.1**

Table 1. Properties of relative cross-household consumption moments and of model errors

	γ								
	1	2	3	4	5	6	7	8	9
Std. of $\ln(\overline{C^{UK}_{\gamma,t}}/\overline{C^{US}_{\gamma,t}})$	10.3%	29.7%	88.5%	166.8%	245.4%	320.2%	391.8%	461.1%	528.9%
Autocorrel. of $\ln(\overline{C^{UK}_{\gamma,t}}/\overline{C^{US}_{\gamma,t}})$	0.84	0.43	0.14	0.09	0.08	0.07	0.07	0.07	0.07
$Corr(\ln(\frac{\overline{C^{UK}_{\gamma,t}}}{\overline{C^{US}_{\gamma,t}}}),\ln(e_t^{UK,US}))$	-0.31	-0.17	-0.02	0.04	0.06	0.06	0.06	0.06	0.06
Std. of model error	19.7%	35.0%	89.9%	166.8%	244.9%	319.7%	391.2%	460.4%	528.2%

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-household $\gamma-$th consumption moment (for $\gamma=1,2,..,9$) as well as its correlation with the logged real exchange rate $e_t^{UK,US}$ (Row 3). Also shown is the standard deviation of the model error, $\ln e_t^{UK,US}-\ln(\overline{C^{UK}_{\gamma,t}}/\overline{C^{US}_{\gamma,t}})-\nu_\gamma^{UK,US}$ (Row 4).

Table 2. Slope estimates in regressions of model errors on real exchange rate

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

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)); see equations (3),(4),(5). The standard errors are of the Newey-West (1987) form (number of lags: three in Col. (2); twelve in Cols. (3) and (5); zero in Col. (4); std. errors are not sensitive to the number of lags).

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

Table 3. p-values of first 12 leads of real exchange rate

γ	Quarterly 1^{st} differences	Annual 1^{st} differences	Levels
(1)	(2)	(3)	(4)
1	0.43	0.00	0.00
2	0.09	0.01	0.00
3	0.06	0.01	0.07
4	0.04	0.00	0.07
5	0.02	0.00	0.06
6	0.02	0.00	0.04
7	0.01	0.00	0.04
8	0.01	0.00	0.03
9	0.01	0.00	0.03

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 1^{st} differences (Col. (2)), annual 1^{st} differences (Col. (3)) and levels (Col. (4)). The Wald test is based on covariance matrix of estimated coefficients of the Newey-West (1987) form (number of lags: three in Col. (2); twelve in Cols. (3); zero in Col. (4); std. errors are not sensitive to the number of lags).

Table 4. Slope estimates in regressions of model errors on additional macro variables

γ	Quarterly 1st differences		Annual 1st differences		Levels		Moving averages	
(1)	(2)		(3)		(4)		(5)	
(a) Regressions on relative industrial production								
1	0.07	(0.33)	0.14	(0.51)	-0.18	(0.25)	-0.49	(0.89)
2	0.24	(1.23)	0.39	(0.80)	**-1.29**	(0.44)	-1.56	(1.20)
3	-0.58	(4.12)	0.63	(2.09)	**-3.85**	(1.13)	**-3.42**	(1.45)
4	-4.78	(7.73)	-0.20	(3.88)	**-6.94**	(2.10)	**-5.46**	(1.95)
5	-10.64	(11.35)	-1.81	(5.70)	**-9.92**	(3.09)	**-7.35**	(2.65)
6	-16.64	(14.81)	-3.58	(7.43)	**-12.71**	(4.04)	**-9.11**	(3.39)
7	-22.32	(18.14)	-5.29	(9.05)	**-15.37**	(4.95)	**-10.81**	(4.10)
8	**-27.67**	(21.37)	-6.88	(10.69)	**-17.95**	(5.83)	**-12.47**	(4.80)
9	**-32.74**	(24.54)	-8.39	(12.26)	**-20.48**	(6.68)	**-14.12**	(5.48)
(b) Regressions on relative stock price								
1	**-0.39**	(0.08)	**-0.64**	(0.10)	**-0.97**	(0.04)	**-1.05**	(0.13)
2	**-0.86**	(0.31)	**-0.91**	(0.19)	**-1.46**	(0.10)	**-1.54**	(0.15)
3	**-1.88**	(1.07)	**-1.48**	(0.60)	**-1.90**	(0.33)	**-1.87**	(0.26)
4	**-2.76**	(2.03)	**-1.88**	(1.17)	**-2.12**	(0.65)	**-1.95**	(0.52)
5	-3.40	(2.99)	-2.14	(1.74)	**-2.26**	(0.96)	**-1.99**	(0.80)
6	-3.93	(3.91)	-2.38	(2.28)	**-2.42**	(1.26)	**-2.07**	(1.07)
7	-4.40	(4.80)	-2.62	(2.81)	**-2.62**	(1.55)	**-2.19**	(1.31)
8	-4.87	(5.65)	-2.86	(3.31)	**-2.38**	(1.82)	**-2.34**	(1.55)
9	-5.33	(6.49)	-3.11	(3.80)	**-3.05**	(2.10)	**-2.50**	(1.77)

Note—The Table reports slope coefficients in regressions of model errors (for $\gamma = 1, 2, .., 9$) 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 (number of lags: three in Col. (2); twelve in Cols. (3) and (5); zero in Col. (4); std. errors are not sensitive to the number of lags).

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 5. Regressions of real exchange rate on relative share of α % largest consumptions and on relative per capita consumption

	b	c	R^2
(1)	(2)	(3)	(4)
(i) Regression in quarterly first differences			
$\alpha = 50\%$	-0.07 (0.19)	-0.02 (0.06)	0.002
$\alpha = 25\%$	-0.01 (0.08)	-0.03 (0.07)	0.002
$\alpha = 10\%$	0.01 (0.03)	-0.04 (0.06)	0.002
$\alpha = 5\%$	0.01 (0.02)	-0.05 (0.06)	0.002
(ii) Regression in annual first differences			
$\alpha = 50\%$	-0.27 (0.54)	-0.14 (0.20)	0.01
$\alpha = 25\%$	-0.03 (0.22)	-0.18 (0.19)	0.01
$\alpha = 10\%$	-0.01 (0.10)	-0.18 (0.18)	0.01
$\alpha = 5\%$	0.02 (0.06)	-0.22 (0.18)	0.01
(iii) Regression in levels			
$\alpha = 50\%$	-0.11 (1.12)	-0.41 (0.28)	0.10
$\alpha = 25\%$	0.12 (0.45)	-0.44 (0.26)	0.10
$\alpha = 10\%$	0.13 (0.19)	-0.44 (0.25)	0.10
$\alpha = 5\%$	0.11 (0.11)	-0.45 (0.25)	0.11

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 α% 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 (number of lags: three in Panel (i); twelve in Panel (ii); zero in Panel (iii); std. errors are not sensitive to the number of lags).