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RESEARCH DISCUSSION PAPER

Trade Costs and Some Puzzles in International Macroeconomics

Luke Willard

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Economic Research Department
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Economic Publications: ecpubs@rba.gov.au

Abstract

Obstfeld and Rogoff (2001) argue that trade costs provide at least part of the explanation for a number of puzzles in international macroeconomics. Using data on imports to the United States from developed economies, this paper investigates whether trade costs are associated with correlations associated with three of these puzzles: the Feldstein-Horioka saving-investment puzzle; the purchasing power parity real exchange rate persistence puzzle; and the international consumption correlation puzzle. In general there is some evidence in support of Obstfeld and Rogoff's argument, though the parameters are often imprecisely estimated.

JEL Classification Numbers: F00, F3, F4

Keywords: consumption smoothing, Feldstein-Horioka puzzle, purchasing power puzzle, trade

Table of Contents

TRADE COSTS AND SOME PUZZLES IN INTERNATIONAL MACROECONOMICS

Luke Willard

1. Introduction

The international macroeconomics literature has identified a number of key puzzles which are associated with empirical correlations. One, called the Feldstein-Horioka puzzle, is why domestic investment is correlated with domestic saving when, in a world with open capital markets, savings should flow to countries with the greatest investment opportunities. For example, in the sample of developed economies used in this paper, there is a correlation between annual investment and saving of 0.47 when theory would predict a low correlation.[1] Another, called the purchasing power parity (PPP) puzzle, is why the real exchange rate is very persistent despite the relative flexibility implied by high nominal exchange rate volatility.[2] For example, Froot and Rogoff (1995) and Rogoff (1996) find that it takes over three years for a deviation from PPP to be reduced by one-half in developed economies. A third puzzle, called the international consumption correlation puzzle, is why, in a world of international trade and capital flows, financial instruments (or other mechanisms) have not developed so as to better help consumption smoothing in the face of country-specific shocks. Some theories suggest that countries should smooth consumption such that every country's consumption is perfectly correlated with world consumption.[3]

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1 This puzzle was originally described by Feldstein and Horioka (1980). More recent work by Obstfeld and Rogoff (1996) and Feldstein (2005) suggests that the extent of the puzzle has lessened but the puzzle is still important. The correlations in Table 1 suggest that the extent of the correlation has fallen from about 0.6 to 0.3.

2 Taylor (2000) argues that it is generally difficult to test for deviations from PPP. Even if one is uncomfortable characterising the correlations discussed in this paper as puzzles, it is useful to know the extent to which they can be accounted for by trade costs for the purposes of better understanding and predicting economic developments.

3 For example, see the discussion in Chapter 6 of Obstfeld and Rogoff (1996). In this paper, I put aside concerns that have been raised about how the low consumption correlation is only a puzzle under a set of strong assumptions (such as that the amount of leisure does not affect the marginal utility of consumption), as a number of these assumptions are fairly standard in the macroeconomic literature.

In a seminal paper in international macroeconomics, Obstfeld and Rogoff (2001) argue that trade costs could explain these puzzles (as well as some other puzzles, such as the extent of the bias towards consuming domestically produced goods and the bias towards domestic shares in equity portfolios). While trade costs provide a natural explanation for why individuals consume a relatively high share of domestically produced goods, this paper seeks to assess the extent to which the data suggest that trade costs can explain the Feldstein-Horioka, PPP and international consumption correlation puzzles. In essence, Obstfeld and Rogoff suggest that trade costs for goods can cause phenomena that are similar to financial market imperfections, which are natural explanations for both the Feldstein-Horioka and consumption correlation puzzles.[4] With financial market imperfections, global savings do not necessarily flow to the most profitable investments, which would explain the high correlation of domestic investment and saving. Similarly, financial market imperfections due to trade costs may also lessen the extent of consumption smoothing across countries. Trade costs also explain why the same good may not cost the same amount in different countries and so provides a natural explanation of deviations from PPP (see the discussion in Dumas 1992).[5]

The contribution of this paper is to assess the plausibility of the trade-cost explanation for these three puzzles within a simple empirical analysis which is consistently applied across each of the puzzles. Some existing literature looks at whether trade costs can explain the potentially related puzzle of the home bias in portfolio holdings (Coeurdacier 2006 and van Wincoop and Warnock 2006). Other work has found evidence between the home bias in portfolio holdings and the international consumption correlation puzzle (Sørensen *et al* 2005). Other related literature looks at the channels of consumption smoothing such as the role of government spending (Asdrubali, Sørensen and Yosha 1996, for example).

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4 Trade costs imply that a country's consumption patterns can affect prices, and, therefore, expected changes in consumption patterns can affect interest rates. Trade costs can also affect incentives for portfolio diversification and the ability to share risks internationally since payments to foreigners can only be made in the form of traded goods. Fazio, MacDonald and Melitz (2005) also suggest that trade costs can explain the Feldstein-Horioka puzzle because of the differential between consumption and output prices.

5 Some of the controls used later in the panel data regressions could be viewed as ways of trying to control for other possible explanations of the puzzles. This is particularly relevant for the Feldstein-Horioka puzzle for which a number of explanations already exist (though Obstfeld and Rogoff 2001 describe them as not thoroughly convincing).

The extent to which trade costs might explain these three puzzles in macroeconomics is interesting in a number of respects. It would aid in the prediction and interpretation of movements in the real exchange rate, investment and consumption. For example, if trade costs play a role in these puzzles and continue to decline, it would be expected that real exchange rates would tend to adjust to shocks more quickly, domestic investment and saving would become less closely related and consumption would become smoother (at least to the extent of not responding to domestic shocks). It is also likely to change the way in which shocks that influence the real exchange rate influence the rest of the economy.[6]

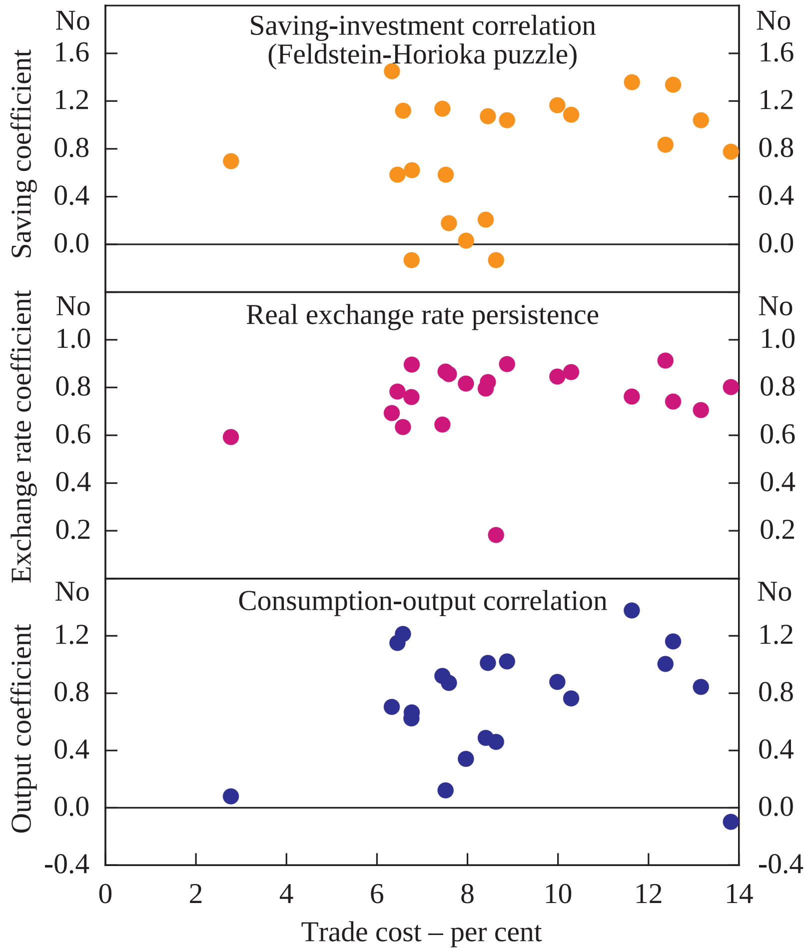
Perhaps as importantly, if there is evidence that trade costs explain the consumption correlation puzzle, it would suggest that lower trade costs may not only raise welfare by enabling greater opportunities to benefit from comparative advantage, but also by facilitating consumption smoothing. Similarly, if trade costs explain the Feldstein-Horioka puzzle, it suggests that lowering trading costs will help saving flow to where investment returns are higher.

To preview the results, I find some evidence that trade costs appear to play a role in each of the three puzzles for the developed economies in the sample, though sometimes the relationships are imprecisely estimated and trade costs appear to only explain certain aspects of the correlations (which are indicative of the puzzles). Figure 1 summarises these results. The horizontal axes show a measure of trade costs for each country's imports into the US. The trade costs are expressed as a percentage of the free-alongside-ship (FAS) cost. FAS cost is closely related to the more commonly cited free-on-board (FOB) cost, which includes loading costs. On the vertical axis, the top panel of Figure 1 plots a measure of the correlation between investment and saving for each country (obtained by regressing investment on saving, both as a percentage of GDP). The positive relationship suggests that lower trade costs are associated with a smaller Feldstein-Horioka puzzle (a lower correlation between investment and saving). The middle panel of Figure 1 plots trade costs against a measure of real exchange rate persistence within each country – based on the coefficient of regressing the real exchange rate on the first period lag of the exchange rate. The bottom panel of Figure 1 plots trade costs against a measure of the correlation between domestic

[6] Also, if the real exchange rate becomes less persistent it may be easier to determine what drives real exchange rate movements (see Obstfeld and Rogoff 1996).

output and consumption.[7] These positive relationships support Obstfeld and Rogoff's (1996) theory. Later it will be argued that trade costs play an economically significant role in explaining the Feldstein-Horioka and PPP puzzles.

Figure 1: Trade Costs and the Puzzles



The rest of the paper is structured as follows. The main empirical methods used are described in Section 2. Section 3 presents the data and the main results. Some results examining whether capital restrictions play a role are presented in Section 4. Section 5 presents results using an alternative measure of trade costs and provides some additional checks of robustness. Section 6 discusses in more detail those aspects of the correlations which trade costs appear to be able to explain. Brief conclusions are drawn in Section 7.

7 The regressions estimated for Figure 1 are the equivalent of Equations (1), (3) and (4) below without the trade-cost terms and with a constant instead of the fixed effects.

2. Method and Data

Obstfeld and Rogoff (2001) present a series of simple models in which a percentage of the good is lost in transport to argue that trade costs can explain these three puzzles. The estimation approach used in this paper uses panel data (across countries and time) to examine the link between trade costs and various measures of the extent of these puzzles (for example, a higher correlation between saving and investment for the Feldstein-Horioka puzzle).

The approach involves running regressions similar to those seen in the existing literature about these puzzles, but also including terms relating to trade costs, which are proxied by cost data based on US imports. These data are used because, firstly, it seems to be close to what Obstfeld and Rogoff's model suggests is most relevant (costs that cause a wedge between prices faced by locals and foreigners).[8] Secondly, it is one of the few reliable sources for trade costs (Hummels and Lugovskyy 2006).[9]

To examine whether trade costs play a role in the Feldstein-Horioka puzzle, variations of the following regression are run on data from 1974–2001:

$$\frac{I_{it}}{Y_{it}} = \delta_{1i} + \phi_1 \frac{S_{it}}{Y_{it}} + \gamma_1 \frac{S_{it}}{Y_{it}} f_{it} + \theta_1 f_{it} + e_{1it} \qquad (1)$$

8 Plausibly, other factors affecting prices faced by foreigners (compared to locals) – such as non-tariff barriers and intranational transportation costs – are positively correlated with the measure used. To the extent that they are uncorrelated, the coefficients estimated may be biased towards zero and may explain the insignificance of some of the statistical results below. Anderson and van Wincoop (2004) provide a rich discussion of issues relating to trade costs such as their measurement.

9 Analysis of the 1999 data from the IMF *Direction of Trade Statistics* (DOTS) confirms that these statistics are not a reliable source from which to infer trade costs. In particular, it is not uncommon for the cost insurance and freight (CIF) measure of trade to be less than the FOB measure of the same trade flow, implying a negative trade-weighted trade cost for some countries (even after adding 10 per cent to costs for Australia and Canada, where imports are reported FOB rather than CIF). As the US is the most significant economy in the world, it seems reasonable to think that US costs are likely to be a reasonable proxy for costs applying to a significant portion of world trade. This issue will be discussed further below.

where: t is a year index; i is a country index; I is investment; S is saving; and Y is output. f captures the average transport costs for shipments originating in country i to the US in year t (using data on US merchandise imports from Feenstra 2005). f is defined as the average percentage trade cost including insurance, derived as CIF (cost, insurance and freight) plus duties minus the FAS value (all expressed as a percentage of the FAS value). Results are also reported for measures excluding duties. Apart from the Feenstra trade data, much of the data used in the analysis comes from the World Bank *World Development Indicators*. This source provides a reasonably standardised collection of cross-country data. However, as with all cross-country data sets, there are likely to be concerns about the reliability of the data and their comparability across countries. The inclusion of fixed effects can be viewed as a way of controlling for some of these cross-country differences. A summary of the key data is provided in Table 1; details about the data and how the variables are defined are provided in Appendix A.[10]

In short, the regression describes investment as depending upon: (a) country fixed effects (to capture potentially relevant factors that may be relatively invariant over time); (b) saving; (c) saving interacted with trade costs (to allow for the investment-saving relationship to vary with trade costs); and (d) trade costs (as trade costs may be associated with lower investment).

If trade costs provide at least a partial explanation of the puzzle, γ_1 would be expected to be positive. If γ_1 is positive and ϕ_1 is not statistically different from zero, the results could be interpreted as suggesting that trade costs explain all of the puzzle. However there are a number of reasons why this is unlikely. For example, in real business cycle models with complete markets and no trade costs, shocks can lead to a co-movement of investment and saving. Some of the results in Kehoe and Perri (2002) seem consistent with this.[11]

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10 The regressions are generally estimated with dummies using least squares. This will yield reliable estimates if the number of countries is sufficiently large, which I am assuming is true here.

11 Obstfeld and Rogoff (1996, ch 3) provide additional reasons why trade costs may explain only part of the puzzle. However, the regression results below may, to some extent, control for these other potential explanations of the puzzle, like demographic change, via decade fixed effects.

One possible concern about estimating a regression like Equation (1) is that with the country fixed effects, the parameters of interest (for example, γ_1 and ϕ_1) are estimated from a small fraction of the variation in the independent variable (in this case, investment). There is some evidence that this is true.[12] To some extent, the issue is that there is a trade-off between estimating with fewer fixed effects (such as estimating with just country fixed effects) and estimating with more fixed effects (such as with country-decade fixed effects). The former approach may reduce the extent of multicollinearity and is likely to be more informative as it estimates fewer parameters from the same number of observations (assuming the equations are not misspecified). The latter is likely to be more immune from arguments that other factors not included in the regression could explain the apparent correlation between investment and saving.

I also compare the results from estimating Equation (1) to the regression excluding the interaction and trade-cost terms. If trade costs can account for much of the puzzle, the coefficient on investment should be much smaller in a regression of Equation (1) than in the regression without trade-cost terms.

For the purchasing PPP, variations of the following regressions are estimated:

$$\log(RER_{it}) = \delta_2 + \phi_2 \log(RER_{it-1}) + \gamma_2 \log(RER_{it-1}) f_{it} + \theta_2 f_{it} + e_{2it} \qquad (2)$$

$$RER_{it} = \delta_3 + \phi_3 RER_{it-1} + \gamma_3 RER_{it-1} f_{it} + \theta_3 f_{it} + e_{3it} \qquad (3)$$

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[12] The concern is that there is a close-to-linear relationship between the main variables of interest (for example, saving interacted with trade costs) and the other right-hand-side variables. A fair amount of this multicollinearity is due to the relationship between the interaction term and trade costs. As discussed in Deaton (1997), a concern could be that including fixed effects (and other controls) increases the noise-to-signal ratio in the independent variable of interest, potentially making the estimates appear insignificant even if the underlying relationship between trade costs and the puzzle is important. The insignificance of some coefficients is consistent with this.

where *RER* is a real exchange rate index. Here, country fixed effects are not included because to do so in the presence of a lagged dependent variable would result in biased estimates.[13]

If trade costs are a contributor to the PPP puzzle, the coefficient on the third term, γ_2, is expected to be positive, indicating that higher trade costs increase the persistence of the real exchange rate and decrease the speed of convergence. The model is estimated in both logs, Equation (2), and levels, Equation (3). The former has the advantage of reducing the influence of some observations that are extreme, which may be due to the real exchange rate being poorly measured.[14]

To examine the effect of trade costs on the international consumption correlation puzzle, variations of the following regression are estimated:

$$\log\left(\frac{C_{it}}{C^*_t}\right) = \delta_{4i} + \phi_4 \log\left(\frac{GDP_{it}}{GDP^*_t}\right) + \gamma_4 \log\left(\frac{GDP_{it}}{GDP^*_t}\right) f_{it} + \theta_4 f_{it} + e_{4it} \qquad (4)$$

where: *C* and *GDP* are consumption and output per capita; and *C** and *GDP** are world consumption and output per capita (in real US dollars).[15] Under a simple model of complete insurance, the growth rate of every individual's consumption could be expected to be equal. In this case, the growth rate of national consumption per capita should equal the growth rate of world consumption per capita;

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[13] As mentioned previously, Taylor (2000) has discussed how this type of regression is not necessarily inconsistent with PPP. However, a number of authors, including Imbs *et al* (2005), estimate a linear model similar to Equation (2) and treat the coefficient on the first lag of the exchange rate as indicative of the extent of the PPP puzzle. Even if this is not informative about the PPP puzzle, the results indicate the persistence of the real exchange rate. As the real effective exchange rate is arguably the most relevant for developments in the economy, it is the focus of the analysis, though some robustness checks are done with bilateral real exchange rates.

[14] An alternative approach could be to include trade-cost terms in some of the popular non-linear models such as Exponential Smooth Transition Autoregressive (often referred to as ESTAR; see, for example, Kilian and Taylor 2001). Kilian and Taylor's results provide mixed evidence of whether trade (which is likely to be related to trade costs) explains the speed of adjustment. Countries for which shocks to the real exchange rate have relatively short half-lives (France, Germany, Italy and the United Kingdom) trade less, considering the size of their economy, than two of the other economies in the sample (Canada and Switzerland), but more than the only other country in the sample (Japan).

[15] This specification is similar in spirit to the one in Sørensen *et al* (2005).

alternatively, the ratio of national consumption per capita and world consumption per capita should be constant.[16] So, if there is no consumption correlation puzzle (that is, there is complete risk sharing), all terms in Equation (4) except the country fixed effects should have coefficients which are equal to zero. Alternatively, with no risk sharing, consumption should move in line with national income (or output). If trade costs explain all of the puzzle, the coefficient on the third term should be positive and the coefficient on the second term should be zero.

I also estimate a version using consumption and output measured in PPP terms. Such PPP measures may be more appropriate as they value goods according to common international prices, however, there is no readily available measure of world output on this basis, so I include year fixed effects in order to capture the effect of these omitted terms.

One potential concern with estimating Equation (4) is that it ignores the possibility that the consumption puzzle is explained by consumption of non-tradable goods like housing. There is some evidence that non-tradables can explain the consumption correlation puzzle (Lewis 1996). Partly due to data availability and partly to examine how much of the puzzle can be explained by trade costs alone, my analysis does not take into account the role of non-tradables.

3. Main Results

Table 1 indicates that trade costs have tended to decline over time and there is substantial variation in trade costs across countries. The level and trends in average trade costs are broadly consistent with other studies, which also imply that trade costs have declined at least since the 1980s (see, for example, Hummels 1999).

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[16] In an economy with a fixed population, where all individuals have identical preferences with constant relative risk aversion, each individual will consume a constant share of world consumption each period (see Obstfeld and Rogoff 1996). This implies that individual consumption growth will be the same across individuals in each time period. Hence, national per capita consumption growth should equal world per capita consumption growth. The specification of Equation (4) has been driven by a desire to use a similar regression to that of Equations (1) to (3), while being similar to previous statistical examinations of the extent of complete insurance (for example, Townsend 1994, chapter 5 of Obstfeld and Rogoff 1996 and Sørensen *et al* 2005).

Table 1: Summary Statistics

	1974–1981	1982–1991	1992–2001
Trade costs (CIF compared to FAS) (per cent)			
Average	7	6	4
Standard deviation	3	2	2
Maximum	16	13	10
Minimum	2	1	0
Trade costs (also including duties) (per cent)			
Average	12	9	6
Standard deviation	5	3	3
Maximum	57	16	14
Minimum	4	2	1
Other variables			
Investment (per cent of GDP) average	26	23	21
Standard deviation	4	4	3
Saving (per cent of GDP) average	24	23	23
Standard deviation	5	4	5
Ln(output/output world) average	1.3	1.4	1.4
Standard deviation	0.4	0.4	0.4
Ln(cons/cons world) average	1.3	1.4	1.4
Standard deviation	0.3	0.4	0.3
Ln(GDP(PWT)) average	9.6	9.8	10.0
Standard deviation	0.2	0.2	0.2
Ln(consumption(PWT)*100) average	13.7	13.8	14.0
Standard deviation	0.2	0.2	0.2
Capital controls average	0.8	0.6	0.1
Investment and saving correlation	0.58	0.63	0.30
Real exchange rate and one year lag correlation	0.85	0.94	0.80
Consumption and output regression coefficient	0.84	0.79	0.64

Notes: These are summary statistics where each observation is country-year. There are 168 observations on trade costs for 1974–1981, 210 for 1982–1991 and 210 for 1992–2001. The number of observations used for calculating the investment and real exchange rate correlations are: 168 and 116, respectively, for 1974–1981; 210 for 1982–1991; and 210 for 1992–2001. Note that as the subsequent regression analysis includes a constant, using Ln(Consumption(PWT)*100) will be equivalent to using Ln(Consumption(PWT)). PWT indicates the Penn World Table per capita PPP data. The last row reports results controlling for country fixed effects.

Also there is some evidence that the investment-saving correlation and the strength of the consumption-output correlation have both decreased over time, consistent with trade costs falling.

3.1 Feldstein-Horioka Puzzle

Table 2 reports the estimates for the investment equation. Each row reports the coefficients from a single regression; results for a wide variety of specifications and samples are reported, providing evidence of the robustness of the results.

Proceeding from the top of Table 2, I first report the two regressions that are the focus of my analysis. The first regression estimates Equation (1) with trade-cost terms (including duties), while the second regression excludes trade costs. With trade costs, the interaction term is positive and statistically significant though the saving coefficient is not zero, suggesting that trade costs are only a partial explanation of the puzzle. The extent to which trade costs can account for the puzzle is indicated by the lower coefficient on saving in the model with trade costs compared to the coefficient without (0.19 versus 0.44). Though it is of less interest, the coefficient on trade costs is negative and significant.[17]

Results for a variety of reasonable alternative specifications are as follows. The third and fourth regressions include country-decade fixed effects (which can lead to better estimates if it is believed that the relationship between investment and saving may vary within the same country over time, say, because of productivity shocks). As the theory only describes trade costs in a simple way, it is reassuring that the results estimated using this regression are similar to those in the first two rows. The fifth row reports the results where the trade-cost measure does not include duties. The results are similar to the first row.

[17] For a number of the regressions estimated in this paper, I allowed for serial correlation of the errors by estimating Newey-West standard errors. However, they led to similar results and so are not reported.

Table 2: Investment – Equation (1)

Model with country fixed effects

	Trade-cost measure	Specification	Saving	Interaction term	Trade cost
1	With duties	Baseline specification	0.19* (0.09)	0.04* (0.01)	–0.40* (0.18)
2	Without trade costs	Baseline specification	0.44* (0.07)	na	na
3	With duties	With country-decade fixed effects	0.35* (0.08)	0.035* (0.008)	–0.69* (0.16)
4	Without trade costs	With country-decade fixed effects	0.61* (0.06)	na	na
5	No duties	Baseline specification	0.15 (0.08)	0.07* (0.01)	–0.73* (0.24)
6	With duties	Weighted by population	0.56	0.006	0.22
7	With duties	Weighted by GDP	0.63	–0.002	0.42
8	With duties	With additional control[(a)]	1.88 (1.20)	0.04* (0.01)	–0.45* (0.19)
9	With duties	Robust regression[(b)]	0.49* (0.05)	0.02* (0.005)	–0.10 (0.11)
10	No duties	Trade cost average of whole sample	–0.12 (0.10)	0.14* (0.02)	na
11	With duties	Trade cost average of whole sample	–0.18 (0.11)	0.10* (0.01)	na
12	With duties	IV (lagged costs as instruments)[(c)]	0.58 (0.38)	–0.007 (0.04)	0.95 (1.25)
13	With duties	Alternative investment measure	0.17* (0.09)	0.02* (0.01)	–0.10 (0.23)
14	With duties	With productivity and demographic controls	0.18* (0.09)	0.02* (0.01)	–0.25 (0.15)

Notes: Robust standard errors are reported in parentheses. There are 588 observations used to estimate the results in the first row. * indicates significance at the 5 per cent level. 'na' signifies no available estimate either because the terms are not included in the regression or because the variable is co-linear with the fixed effects.

(a) Additional control is log distance interacted with the main independent variable (here, saving).

(b) Calculated using Stata's rreg command.

(c) According to Stock-Yogo critical values, the instruments are not weak.

The sixth and seventh regressions estimate Equation (1), but weighted by population and GDP (which could reduce measurement error problems and may be more appropriate if one is more interested in the result among larger, more populated economies).[18] These results provide weaker evidence that trade costs play a role in the puzzle.

The eighth regression is estimated with log distance (from the US) interacted with saving (the main independent variable) included in the regression, as well as the standard monetary measure of trade costs. This is designed to examine whether the results are sensitive to the inclusion of other variables that may measure trade costs (at least with the largest economy in the world). One motivation for including this variable is to examine whether the main trade-cost variable may be picking up the effects of trade costs specific to the US. It is notable that the monetary trade cost-saving interaction term remains positive and significant (suggesting monetary trade costs play a role). However, the coefficient on saving becomes larger (though it is statistically indistinguishable from zero). This regression suggests that once a rich enough set of trade-cost measures are included, the positive correlation between saving and investment disappears.

The ninth regression reports the results using a robust regression procedure which seeks to downplay the role of potential outliers. This regression has similar results to the baseline specification, though the coefficient on saving is larger. Rows 10 and 11 report the results of using average trade costs over the sample as the measure of trade costs. This could help eliminate measurement error and so may yield better estimates. Consistent with this, the estimate on the interaction term is larger in this specification, at least compared to the baseline specification.

The twelfth row reports the results using instrumental variables (IV), where the lagged trade costs are used as an instrument. IV estimation is motivated by the trade-cost measure providing a noisy measure of the actual trade cost. Using an instrument (that is, lagged trade costs) can potentially resolve this problem by

[18] For all regression results using weighting, I have used Stata's *pweight* option. This reweights assuming that the weight is the inverse of the probability that the observation is included due to sampling design. For the point estimates, the results seem robust to the reweighting method used. I have not reported standard errors as the results are sensitive to the weighting method used and the most appropriate method is debatable.

essentially providing a better measure of trade costs (see Hayashi 2000, ch 3).[19] However, the standard errors are large (as is common with IV estimation), suggesting that this method does not provide very informative results. The thirteenth row reports results using an alternative measure of investment (using gross fixed capital formation instead of gross capital formation). The fourteenth row reports results with demographic and productivity controls (proxied by GDP growth).[20] The latter is motivated by Taylor (1994), who finds evidence that demographic and productivity changes account for some of the puzzle, consistent with demographic and productivity changes affecting both investment and saving.

In summary, the regression results in Table 2 generally suggest that there is evidence that increased trade costs are associated with a larger correlation between investment and saving (as indicated by the tendency for the coefficient on the interaction term to be positive and significant). Even so, trade costs can explain some, but not all, of the Feldstein-Horioka puzzle, since the coefficient on saving tends to be typically lower in the model with transaction costs than the one without, though it remains positive and significant.

3.2 PPP Puzzle

Tables 3 and 4 present estimates from a similar set of regressions with the real exchange rate as the dependent variable and the lagged exchange rate as the main independent variable. They show that the coefficient for the trade-cost interaction term is of the correct sign (positive), though it is typically insignificant. The negative coefficient on the trade-cost term suggests that countries with higher trade costs have lower real exchange rates (perhaps consistent with a need to have a more competitive exchange rate to compensate for higher trade costs). It is

[19] Using IV assumes that noise in the instrument, lagged trade cost, is uncorrelated with the noise in the regressor, current trade costs, which seems plausible.

[20] Unlike Taylor (1994), relative prices are not included as controls as they may be related to the relative prices faced by locals and foreigners.

noticeable that the lagged real exchange rate coefficient is somewhat smaller compared to models without trade costs.[21]

The last three rows of Table 4 present results that use some alternative estimation methods and/or data that have been used in the existing literature. Specifically, row 14 reports results controlling for country fixed effects. Row 15 uses bilateral monthly real exchange rate data between the US and some European countries where prices are particular sub-components of the CPI index. This is designed to address the concern that the PPP puzzle is an artefact of using aggregated prices (see Imbs *et al* 2005).[22] The data for this come from Imbs' website. The last row uses monthly bilateral real exchange rates with the US. These last three rows suggest that the exchange rate is highly persistent and do not suggest a role for trade costs to explain the puzzle.

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[21] There is mixed evidence on time-series properties of the main economic series, but there are some theoretical reasons for thinking they may be stationary and hence the regression results being informative. In the context of Tables 3 and 4, a potential concern is that the real exchange rate may have a unit root. The existing literature suggests that it is difficult to distinguish between a unit root and a persistent stationary process and that, using very long runs of data, there is evidence that real exchange rates are stationary (see discussion in Schnatz 2006). Also, if the real exchange rate does have a unit root, then it suggests that it is not mean-reverting, which seems at odds with the characterisation of the puzzle – that the exchange rate just takes longer than expected but does revert to the mean. Potentially, some of the investment and consumption regressions I conduct could be viewed as robustness checks in case my baseline regressions are misleading due to the time series being non-stationary.

[22] The results are estimated using the mean group estimator used by Imbs *et al* (2005) and discussed in Pesaran and Smith (1995), which allows for country fixed effects. The use of country fixed effects is likely to be less problematic for rows 15 and 16 as they use monthly and quarterly data, which are more frequent.

Table 3: Real Exchange Rate – Levels Equation (3)

Model with no fixed effects

	Trade-cost measure	Specification	Lagged real exchange rate	Interaction term	Trade cost
1	With duties	Baseline specification	0.81* (0.08)	0.005 (0.009)	–0.56 (0.92)
2	Without trade costs	Baseline specification	0.86* (0.03)	na	na
3	With duties	Decade fixed effects	0.80* (0.08)	0.01 (0.01)	–0.7 (0.9)
4	Without trade costs	Decade fixed effects	0.86* (0.03)	na	na
5	No duties	Baseline specification	0.80* (0.06)	0.01 (0.01)	–1.18 (1.01)
6	With duties	Weighted by population	0.73	0.02	–1.93
7	With duties	Weighted by GDP	0.68	0.03	–2.58
8	With duties	With additional control[(a)]	–0.25 (0.99)	0.003 (0.02)	–0.24 (1.47)
9	With duties	Robust regression[(b)]	0.81* (0.04)	0.01* (0.005)	–1.07* (0.47)
10	No duties	Trade cost average of whole sample	0.83* (0.09)	0.007 (0.016)	–0.67 (1.64)
11	With duties	Trade cost average of whole sample	0.80* (0.10)	0.009 (0.012)	–0.98 (1.24)
12	With duties	With four lags of first difference of lagged RER	0.82* (0.06)	0.007 (0.006)	–0.73 (0.65)

Notes: Robust standard errors are reported in parentheses. There are 536 observations used to estimate the results in the first row. * indicates significance at the 5 per cent level. 'na' signifies no available estimate either because the terms are not included in the regression or because the variable is co-linear with the fixed effects.

(a) Additional control is log distance interacted with the main independent variable.

(b) Calculated using Stata's rreg command.

Table 4: Real Exchange Rate – Logs Equation (2)

Model with no fixed effects

	Trade-cost measure	Specification	Lagged RER	Interaction term	Trade cost
1	With duties	Baseline specification	0.80* (0.07)	0.008 (0.008)	–0.04 (0.04)
2	Without trade costs	Baseline specification	0.88* (0.03)	na	na
3	With duties	Decade fixed effects	0.79* (0.07)	0.01 (0.01)	–0.04 (0.04)
4	Without trade costs	Decade fixed effects	0.88* (0.03)	na	na
5	No duties	Baseline specification	0.80* (0.06)	0.01 (0.01)	–0.07 (0.04)
6	With duties	Weighted by population	0.69	0.02	–0.11
7	With duties	Weighted by GDP	0.62	0.03	–0.14
8	With duties	With additional control[(a)]	–0.03 (0.96)	0.008 (0.012)	–0.04 (0.06)
9	With duties	Robust regression[(b)]	0.84* (0.04)	0.007 (0.004)	–0.03 (0.02)
10	No duties	Trade cost average of whole sample	0.87* (0.07)	0.001 (0.013)	–0.004 (0.06)
11	With duties	Trade cost average of whole sample	0.85* (0.09)	0.004 (0.010)	–0.02 (0.05)
12	With duties	IV (lagged costs as instruments)[(c)]	1.20* (0.13)	–0.03* (0.01)	0.16* (0.06)
13	With duties	With four lags of first difference of lagged RER	0.80* (0.06)	0.011 (0.007)	–0.05 (0.03)
14	With duties	Estimated in first differences using IV (country fixed effects)[(c)]	1.09* (0.20)	–0.0001 (0.0003)	0.001 (0.001)
15	With duties	Using Imbs *et al* monthly data	0.96	–0.001	0.0009
16	With duties	Using quarterly bilateral data and country fixed effects	0.96* (0.02)	0.0007 (0.002)	–0.002 (0.008)

Notes: Robust standard errors are reported in parentheses. There are 536 observations used to estimate the results in the first row. * indicates significance at the 5 per cent level. 'na' signifies no available estimate either because the terms are not included in the regression or because the variable is co-linear with the fixed effects.

(a) Additional control is log distance interacted with the main independent variable.

(b) Calculated using Stata's rreg command.

(c) Based on Stock-Yogo critical values, the instruments are not weak.

3.3 International Consumption Correlation Puzzle

Tables 5, 6 and 7 provide evidence about whether trade costs play a role in the international consumption correlation puzzle. The first two tables use data calculated using exchange rate measures (with consumption including government spending). Table 5 uses only country fixed effects (that is, it estimates Equation (4), the preferred specification), while Table 6 includes decade-country interactions. Both Tables 5 and 6 report a set of results based on consumption including the statistical discrepancy in case some hard-to-estimate components of consumption are in the discrepancy. Also, in rows 14 and 15 of Table 5, results are reported using consumption (excluding government spending) and including demographic controls. The last regression is similar to Townsend (1994), which includes demographic controls. The results from these regressions can be viewed as further robustness checks.

Table 7 is based on PPP data (with consumption excluding government spending). Rather than using measures of world output and consumption (which are included in Equation (4)), it includes year fixed effects to capture these omitted variables. In some sense this specification could be viewed as allowing for a weaker form of global risk sharing. For example, it may be that there is perfect risk sharing among OECD countries (rather than the world as a whole), in which case these regressions should find an interaction term that is equal to zero. Rows 11 and 12 include results with consumption including government spending and demographic controls respectively.[23]

Tables 5–7 generally report an interaction coefficient which is positive, though often insignificant. In general, the introduction of trade-cost terms do not substantially change the size of the coefficient on the output term, suggesting that trade costs do not play a big part in the consumption correlation puzzle. This might be because non-tradables lead to a correlation between domestic consumption and output. The estimates for the interactive coefficient using trade costs averaged over the whole sample (which may eliminate measurement error) tend to be positive, significant and are often larger than the estimates obtained using other regressions.

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[23] Row 13 of Table 5 reports the results of running a regression similar to those reported in Table 7 (that is, a regression of log consumption per capita on log output per capita with year and country fixed effects).

Table 5: Consumption – Equation (4)

Exchange rate measure (including government spending) – country fixed effects

	Trade-cost measure	Specification	Output	Interaction term	Trade cost
1	With duties	Baseline specification	0.70* (0.04)	0.0001 (0.0002)	–0.000 (0.003)
2	Without trade costs	Baseline specification	0.70* (0.03)	na	na
3	No duties	Baseline specification	0.65* (0.04)	0.005 (0.003)	–0.010* (0.004)
4	With duties	Consumption including statistical discrepancy	0.43* (0.04)	0.012* (0.002)	–0.006 (0.003)
5	With duties	Weighted by population	0.86	–0.0005	–0.0025
6	With duties	Weighted by GDP	0.83	–0.0029	0.0000
7	With duties	With additional control[(a)]	0.70* (0.03)	0.0018 (0.0013)	0.11* (0.02)
8	With duties	Robust regression[(b)]	0.79* (0.02)	0.0082* (0.001)	–0.013* (0.001)
9	No duties	Trade cost average of whole sample	0.46* (0.04)	0.066* (0.009)	na
10	With duties	Trade cost average of whole sample	0.36* (0.04)	0.057* (0.006)	na
11	With duties	IV (lagged costs as instrument)[(c)]	0.70* (0.11)	0.001 (0.005)	–0.0008 (0.01)
12	With duties	Estimated in first differences	0.64* (0.04)	–0.0002 (0.001)	0.0003 (0.001)
13	With duties	Year dummies and regression of log(C) on log(Y)	0.63* (0.04)	0.005* (0.002)	–0.044* (0.014)
14	With duties	Consumption (excluding government spending)	0.67* (0.03)	0.0002 (0.0002)	0.001 (0.002)
15	With duties	Including demographic controls	0.61* (0.03)	0.0024* (0.0012)	–0.0001 (0.001)

Notes: Robust standard errors are reported in parentheses. There are 588 observations used to estimate the results in the first row. * indicates significance at the 5 per cent level. 'na' signifies no available estimate either because the terms are not included in the regression or because the variable is co-linear with the fixed effects.

(a) Additional control is log distance interacted with the main independent variable.

(b) Calculated using Stata's rreg command.

(c) Based on Stock-Yogo critical values, the instruments are not weak.

Table 6: Consumption – Equation (4)
Exchange rate measure (including government spending) –
decade-country fixed effects

	Trade-cost measure	Specification	Output	Interaction term	Trade cost
1	With duties	Baseline specification	0.72* (0.03)	–0.001 (0.001)	0.001 (0.001)
2	Without trade costs	Baseline specification	0.72* (0.03)	na	na
3	No duties	Baseline specification	0.67* (0.03)	0.005 (0.003)	–0.010 (0.004)
4	With duties	Consumption including statistical discrepancy	0.47* (0.03)	0.009 (0.002)	–0.008* (0.002)

Notes: Robust standard errors are reported in parentheses. * indicates significance at the 5 per cent level. 'na' signifies no available estimate either because the terms are not included in the regression or because the variable is co-linear with the fixed effects. There are 588 observations used to estimate the results in the first row.

Also, it can be seen from the results reported in Tables 5 and 7 that the results are generally not sensitive to whether consumption includes government spending or not. This suggests that government spending does not play a major role in reducing the consumption correlation puzzle in either high- or low- trade-cost countries.

In Tables 2–7, it is noticeable that when an additional control is included (that is, the inclusion of an interaction term between the main independent variable and log distance from the US), the main independent variable often becomes insignificant and/or negative. As log distance is a measure of trade costs, this could be viewed as suggesting that with a richer or more complete set of measures of trade costs, the apparent puzzles can be explained.

One potential concern with the above results is that the interaction term may just be capturing a trend decline in the puzzle over time (as trade costs have tended to decline over time). The inclusion of an additional interaction term between a time trend and the main independent variable provides mixed evidence on this (results not shown). The interaction term between trade costs and the main independent variable remains positive for the investment and log real exchange rate equation, while it becomes negative for some specifications of the consumption equation.[24]

Table 7: Consumption Smoothing – Equation (4)

PPP measure (excluding government spending) – country and year fixed effects

	Trade-cost measure	Specification	Output	Interaction term	Trade cost
1	With duties	Baseline specification	0.70* (0.04)	0.005 (0.003)	–0.05 (0.03)
2	Without trade costs	Baseline specification	0.74* (0.04)	na	na
3	No duties	Baseline specification	0.72* (0.04)	0.004 (0.006)	–0.04 (0.05)
4	With duties	Weighted by population	0.88	0.0005	–0.006
5	With duties	Weighted by GDP	0.88	0.0042	–0.042
6	With duties	With additional control[(a)]	–0.25 (0.20)	0.005 (0.003)	–0.05 (0.03)
7	With duties	Robust regression[(b)]	0.66* (0.02)	0.015* (0.002)	–0.15* (0.01)
8	No duties	Trade cost average of whole sample	0.70* (0.03)	0.014* (0.005)	na
9	With duties	Trade cost average of whole sample	0.65* (0.03)	0.018* (0.004)	na
10	With duties	IV (lagged costs as instrument)[(c)]	0.68* (0.06)	0.009* (0.004)	–0.08* (0.04)
11	With duties	Consumption (including government spending)	0.53* (0.03)	0.002 (0.02)	–0.14* (0.02)
12	With duties	Including demographic controls	0.65* (0.04)	0.003 (0.003)	–0.029 (0.029)

Notes: Robust standard errors are reported in parentheses. There are 588 observations used to estimate the results in the first row. * indicates significance at the 5 per cent level. PPP regressions include year fixed effects which effectively controls for the level of 'world' output despite a world output measure being unavailable. 'na' signifies no available estimate either because the terms are not included in the regression or because the variable is co-linear with the fixed effects.

(a) Additional control is log distance interacted with the main independent variable.

(b) Calculated using Stata's rreg command.

(c) Based on Stock-Yogo critical values, the instruments are not weak.

[24] Some analysis I conducted including developing countries provides less evidence that trade costs play a role in the puzzles, though there was some evidence for the investment equation. This may be because, for these countries, my proxy for trade costs less accurately reflects true trade costs.

4. Capital Controls

Another potential explanation for the three puzzles could be capital-market restrictions. Lewis (1996) argued that such restrictions could explain the lack of consumption risk sharing and Engel (2000) suggests that many of the puzzles may be explained by allowing for financial market imperfections. The following regression explores whether capital-market restrictions could play a role together with trade costs in explaining the Feldstein-Horioka puzzle:

$$\begin{aligned}\frac{I_{it}}{Y_{it}} &= \delta_{1i} + \phi_1 \frac{S_{it}}{Y_{it}} + \gamma_1 \frac{S_{it}}{Y_{it}} f_{it} + \theta_1 f_{it} + \varpi_1 K_{it} \\ &+ \varpi_2 K_{it} f_{it} + \varpi_3 K_{it} f_{it} \frac{S_{it}}{Y_{it}} + \varpi_4 K_{it} \frac{S_{it}}{Y_{it}} + e_{1it}\end{aligned} \tag{5}$$

where K is a dummy variable equal to 1 when a country has capital controls and zero otherwise (based on IMF data). If the puzzle is due to an interaction of the role of trade costs and capital controls, then the relevant interaction coefficient, ϖ_3, will be positive. As can be seen from Table 1, many countries removed capital controls during the sample period, with around 80 per cent of observations having capital controls early in the sample but only about 10 per cent having it towards the end.

Table 8 presents the results of investment, the real exchange rate and consumption equations using a variety of specifications. The middle column reports the coefficient ϖ_3 in Equation (5) or its analogue, while the last column reports the coefficient γ_1 or its analogue. The coefficient ϕ on the main independent variable (saving, the lag of the real exchange rate or output) appears in the left-hand column and tends to be positive and significant, suggesting that a puzzle still exists even after controlling for trade costs and capital controls. The coefficient γ_1 is still positive, indicating that even in the absence of capital controls, trade costs still appear to play a role in explaining the puzzle.

Table 8: Trade Costs, Capital Controls and the Puzzles

Dependent variable, fixed effects	Main independent variable (saving, exchange rate or output)	Interaction of capital control, trade cost and main independent variable	Interaction of trade cost and main independent variable
Investment country effects	0.23* (0.09)	–0.01 (0.01)	0.02* (0.01)
Investment country-decade effects	0.33* (0.11)	0.02 (0.02)	0.03* (0.01)
Investment country and year effects	0.06 (0.09)	–0.03 (0.01)	0.03* (0.01)
RER no fixed effects	0.74* (0.09)	–0.04 (0.02)	0.01 (0.01)
RER decade effects	0.71* (0.09)	–0.04 (0.02)	0.02 (0.01)
RER year effects	0.72* (0.10)	–0.04 (0.03)	0.02 (0.01)
Log(RER) no fixed effects	0.71* (0.07)	–0.04* (0.02)	0.02* (0.01)
Log(RER) decade effects	0.69* (0.10)	–0.04* (0.02)	0.02 (0.01)
Log(RER) year effects	0.70* (0.10)	–0.04 (0.02)	0.02 (0.01)
Consumption country effects (including government spending)	0.77* (0.05)	0.01* (0.004)	–0.01* (0.004)
Consumption country effects (excluding government spending)	0.68* (0.04)	–0.001 (0.004)	–0.005 (0.03)
Consumption (PWT) country and year effects (excluding government spending)	0.60* (0.05)	–0.01 (0.01)	0.010 (0.01)
Consumption (PWT) country and year effects (including government spending)	0.51* (0.04)	–0.01* (0.01)	0.020* (0.005)

Notes: Robust standard errors are reported in parentheses. 568 observations are used to estimate the investment equations, 519 the exchange rate equations and 568 the consumption equations. * indicates significance at the 5 per cent level.

5. Further Robustness Checks

In this section I examine a number of further checks of the robustness of my results. First I use a different measure of trade costs obtained by running the following regression:

$$f_{kit} = \alpha_k + \beta_{is} + \varepsilon_{kit} \tag{6}$$

where f_{kit} captures the average transport costs for shipments of good k to the US originating in country i at time t. Here, goods are disaggregated to the Standard International Trade Classification (SITC) revision 2, 3-digit level (again using Feenstra 2005). The betas are allowed to vary across countries and decades (which are indicated with the subscript s) and provide estimates of the transport costs for each country over time.

The regression attributes some of the trade cost to a commodity-specific effect (as some goods are likely to be more expensive to transport than others) while allowing there to be an effect that varies across time and across countries (represented by the betas), which captures in some sense the underlying transaction costs for the country. While this is a direct and intuitive way of attempting to calculate transportation costs, there are a number of reasons why it may be problematic. For example, it assumes a specific, though not implausible, assumption about functional form. However, Appendix B provides some evidence that this trade-cost measure may be reasonable.

The results from using estimates of betas as an alternative measure of trade costs in Equations (1) to (4) are reported in Table 9. The table provides support for trade costs explaining all three puzzles, since the interaction term is of the right sign in all specifications and similar in magnitude to estimates provided in Section 3 of the paper. Similar results are obtained if trade costs are assumed to follow a country-specific trend.

Up to this point I have been using trade-cost measures with the US as the proxy for general trade costs (largely due to data availability and reliability). There are a number of ways I attempt to assess whether this is likely to be affecting my results.

Table 9: Trade Costs and Macro Puzzles
Alternative approach to measuring trade costs, including duties

Model	Main independent variable (saving, exchange rate or output)	Interaction term	Fixed effects
Investment	–0.03	0.03	Country
Investment	–0.02	0.05	Decade-country
Log(real exchange rate)	0.79	0.007	None
Log(real exchange rate)	0.75	0.010	Decade
Consumption (including government spending)	0.61	0.004	Country
Consumption (excluding government spending)	0.59	0.006	Country
Consumption (PPP) (excluding government spending)	0.60	0.011	Country and year
Consumption (PPP) (including government spending)	0.35	0.02	Country and year

First, it is possible that by using trade costs with the US I may be able to describe well countries that are significant trading partners with the US, but poorly describe other countries. To assess this I run some of the simpler regressions using only a sub-sample of countries that trade substantially with the US – Australia, Canada, Japan and New Zealand (Table 10).[25] Compared to the whole sample, arguably this sample suggests that trade costs provide a less convincing explanation for the puzzles; for the investment equation the interaction coefficient is insignificant and for one of the consumption equations it is negative. Alternatively, estimating the same regressions without these countries that trade highly with the US (that is, estimating for the European economies which tend to trade more amongst themselves) leads to results somewhat consistent with those of the full sample – the interaction term in the investment and the consumption (PPP) equations are positive and significant and the interaction term in the consumption (exchange rate) equation is also positive. However, the interaction term in the real exchange rate equation is negative and insignificant. This provides some evidence about the extent to which the main results are being driven by countries that trade substantially with the US.

[25] These countries have 20 per cent or more of their developed economy trade with the US (based on IMF DOTS for 1999).

Table 10: Trade Costs and Macro Puzzles

Countries that trade substantially with the US; trade costs include duties

Model	Main independent variable (saving, exchange rate or output)	Interaction term	Fixed effects
Investment	0.91* (0.12)	–0.02 (0.01)	Country
Investment	0.63* (0.20)	0.02 (0.02)	Country-decade
Log(real exchange rate)	0.67* (0.14)	0.03 (0.01)	None
Log(real exchange rate)	0.53* (0.20)	0.04* (0.02)	Decade
Consumption (including government spending)	0.86* (0.05)	–0.02* (0.003)	Country
Consumption (excluding government spending)	0.91* (0.06)	–0.01 (0.005)	Country
Consumption (PPP) (excluding government spending)	0.91* (0.04)	0.01* (0.003)	Country and year
Consumption (PPP) (including government spending)	0.78* (0.04)	0.02* (0.004)	Country and year

Notes: Robust standard errors reported in parentheses. * indicates significance at the 5 per cent level. Country sample: Australia, Canada, Japan and New Zealand.

As a second way to assess whether my results may be affected by their reliance on US import costs, I examine whether the extent of trade (as a share of GDP), in place of trade costs, effects the qualitative results. The idea behind this approach is that higher trade costs are likely to be reflected in lower openness and so openness may be a good and more broadly based indicator of trade costs. Moreover, it may also be better able to capture the extent of non-tradables, which are likely to lead to deviations between prices faced by locals and foreigners. Table 11 provides some further support to trade costs explaining part of the puzzles. The results indicate that the more open the economy the less extreme the puzzle (as the interaction term is negative).

Table 11: Openness and Macro Puzzles

Model	Main independent variable (saving, exchange rate or output)	Interaction term	Fixed effects
Investment	0.68* (0.09)	–0.0006 (0.001)	Country
Investment	0.75* (0.09)	–0.002* (0.001)	Country-decade
Log(real exchange rate)	0.97* (0.06)	–0.002* (0.001)	None
Log(real exchange rate)	0.97* (0.06)	–0.003* (0.001)	Decade
Consumption (including government spending)	0.90* (0.03)	–0.003* (0.0003)	Country
Consumption (excluding government spending)	0.83* (0.04)	–0.002* (0.0004)	Country
Consumption (PPP) (excluding government spending)	0.89* (0.03)	–0.002* (0.0004)	Country and year
Consumption (PPP) (including government spending)	0.91* (0.03)	–0.002* (0.0003)	Country and year

Notes: Trade-cost measure includes duties for all specifications. Robust standard errors reported in parentheses. * indicates significance at the 5 per cent level. Openness measure is openness (exports plus imports all over GDP) in constant prices from Penn World Table.

6. What Aspects of the Puzzles Do the Trade Costs Explain?

The above results suggest that it is possible to find some evidence that trade costs are associated with correlations that have been linked with three puzzles in international macroeconomics. Important issues are: (a) whether trade costs appear to explain much of these correlations; and (b) whether there are only certain aspects of the correlations that trade costs explain.

The first issue can be addressed by comparing the coefficient on the main independent variable in the models with and without trade-cost controls. The correlation (or more precisely the regression coefficient) between saving and investment in the data (controlling only for fixed effects) is 0.44, but the results suggest that after also controlling for trade costs, this correlation falls to 0.19. This suggests that trade costs can account for about half of the puzzle. For the real exchange rate, the estimates suggest that accounting for trade costs can reduce the correlation with the lagged real exchange rate from about 0.9 to 0.8. The coefficient estimates imply that if trade costs were to fall to zero, the half-life of shocks to the real exchange rate would fall from about five to three years. So, for the Feldstein-Horioka and PPP puzzles, trade costs appear to explain around half of the puzzles. Trade costs appear to explain little of the consumption correlation puzzle with the preferred specification suggesting that accounting for trade costs has no effect on the correlation between a country's relative consumption and its relative output, with the correlation remaining stable at about 0.7 for the exchange rate measure.

Table 12 provides information for addressing whether there are only certain aspects of the correlations that trade costs explain by summarising results for different controls. It can be seen that while trade costs play a role in some specifications, they play a minimal role in others. For example, in cross-sectional regressions of investment on saving (similar to the original specification of Feldstein-Horioka), including trade-cost controls *increases* the extent of the puzzle. This provides further evidence that trade costs are unlikely to be a complete explanation of the puzzles. However, to the extent that theory suggests that other factors are likely to contribute to the correlation, this may not be surprising. For example, cross-country differences in financial systems and developments may explain why countries with high saving rates may also have high rates of investment.

Table 12: Aspect of Puzzles and Trade Costs

Dependent variable	Sign and significance of interaction term	Fraction of puzzle accounted for	Specifications (fixed effects)
Investment	Negative	na	Cross-section
Investment	Positive significant	0.2	Panel (none)
Investment	Positive significant	0.6	Panel (country)
Investment	Positive significant	0.4	Panel (country-decade)
Investment	Positive significant	0.3	Panel (country year)
Log(real exchange rate)	Positive insignificant	0.4	Panel (none)
Log(real exchange rate)	Positive insignificant	0.4	Panel (decade)
Log(real exchange rate)	Positive insignificant	0.4	Panel (year)
Log(real exchange rate) Monthly data	Positive insignificant	0.3	Panel (country)
Log(real exchange rate) Bilateral quarterly data	Negative	na	Panel (country)
Log(real exchange rate) Imbs et al monthly data	Negative	na	Mean group estimator
Consumption	Positive insignificant	0.0	Panel (country)
Consumption	Negative	na	Panel (country-decade)
Consumption	Positive significant	0.0	Panel (country year)
Consumption (excluding government spending)	Positive insignificant	0.0	Panel (country)
Consumption (PPP)	Positive insignificant	0.0	Panel (country year)
Consumption (PPP) (including government spending)	Positive insignificant	na	Panel (country year)

Notes: Fraction explained is based on difference between coefficients or implied real exchange rate half-life. 'na' is reported where the interaction term is negative or if coefficient with trade controls is larger than without.

7. Conclusions

Using panel data for a set of developed economies, this paper summarises the link between trade costs and three important puzzles in international macroeconomics. It provides evidence that the Feldstein-Horioka saving-investment puzzle and the PPP puzzle are partially explained by trade costs. The signs of coefficient estimates imply that higher trade costs are associated with a stronger relationship between investment and savings and a more persistent exchange rate. The size of the coefficients implies that these effects are economically important, with trade costs accounting for something like half of each puzzle. However, the relationship is generally statistically significant only for the Feldstein-Horioka puzzle. While there is some evidence for a link between trade costs and the consumption correlation puzzle, it is more mixed and trade costs appear to explain little of this puzzle.

Additional analysis suggests that the effect of trade costs is somewhat robust to the inclusion of measures of capital controls in the regressions. Also, it is worth noting that the trade-cost measure used here is likely to be an imperfect measure of actual trade costs and so this approach may understate the relationship between these puzzles and trade costs.

It is important to recognise that, at best, trade costs appear to only explain certain aspects of the puzzles or correlation. Moreover, as there is little evidence of trade costs explaining the consumption correlation puzzle and arguably fragile evidence of it explaining the PPP puzzle, more work needs to be done to understand how trade costs relate to these puzzles. One plausible argument is that all three puzzles should be linked because they are in some sense connected to issues of financial market imperfections. The developing theoretical literature on trade costs and some of the other puzzles in international macroeconomics (such as Coeurdacier 2006) may provide further insights into the nature of the relationships and how to better understand them empirically.

Appendix A: Notes on Data

The following variables were used in the analysis:

1. Final consumption expenditure (2000 US$, converted using exchange rates) from *World Development Indicators* (World Bank) (transformed into per capita terms using GDP and GDP per capita data). This includes household final and general government final consumption expenditure. Tables 5 and 6 each include a regression which includes the statistical discrepancy in the consumption measure.

2. GDP per capita (2000 US$, converted using exchange rates) from *World Development Indicators* (World Bank).

3. Investment (gross capital formation as a percentage of GDP) from *World Development Indicators* (World Bank).

4. Real effective exchange rate (value in 2000 indexed to be 100) from *World Development Indicators* (World Bank). Available from 1975. Because of this and the regressions including the lagged real exchange rate, the analysis for this is limited to 1976–2001.

5. Saving (gross domestic saving as a percentage of GDP) from *World Development Indicators* (World Bank).

6. Trade-cost data: US imports FAS, CIF and duties by SITC 5-digit code, country and year from 1974 to 2001 from <http://cid.econ.ucdavis.edu/data/sasstata/usiss.html>. The data have been aggregated to the 3-digit level. For all of the analysis I have dropped problematic observations such as where trade costs or FAS costs are negative. FAS cost is measured by the custom value. Before 1989, the FAS (customs value) and CIF numbers are reported directly. After 1988, the CIF numbers are calculated as the sum of FAS and charges. Trade costs without duties are the percentage CIF is above FAS. Trade costs with duties include duties as well. The percentages are approximated using the natural log function. Note that similar trade-cost data are not available for US exports. FAS cost does not include loading costs while FOB cost does.

7. Trade-related data from Glick and Rose (2002). This included information about distance and geography used in some of the analysis. These data are available from Rose's website (<http://faculty.haas.berkeley.edu/arose/>). Glick and Rose's data are only available up to 1997.

8. Capital restrictions data from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions. Data for Switzerland are not available over the whole sample.

9. Penn World Table versions of consumption and output. Output is real GDP per capita (Layspeyres) in 2000 constant prices and consumption is derived from consumption share for this series. These measures are in PPP.

In addition, some analysis used demographic and real GDP data from the *World Development Indicators* (such as the last row of Table 2, where some observations were lost in calculating GDP growth as a proxy for productivity). Also, some analysis used bilateral (with respect to the US) real exchange rates based on data used by Imbs *et al* (2005), and bilateral real exchange rates with respect to the US, calculated from national sources.

The analysis is for Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom (the United States is not part of our sample as it is not covered by United States import data). Note that because of data availability, the sample varies somewhat across regressions. Because the Glick and Rose data do not include data after 1997, the coverage of information on bilateral trade and free trade agreements is more limited in the more recent sample. Also, the Glick and Rose data are not comprehensive (for example, it has few observations for Belgium). However, it is unclear how this would bias the results and it seems likely that the Glick and Rose data should be relatively comprehensive given the available data sources.

Appendix B: Plausibility of Alternative Trade-cost Measure

One way of checking the plausibility of the trade-cost estimates derived using equation (6) is to regress the beta estimates on distance and time and other variables that affect trade costs. The coefficient on distance from the US is expected to be positive. Another check is to see whether trade costs explain the extent of trade by running the regression:

$$\log(Trade_{USit}) = \delta_5 + \gamma_5 \beta_{is} + \kappa X_{it} + e_{5it} \tag{B1}$$

where $Trade_{USit}$ is bilateral trade between the US and country i at time t (from Glick and Rose 2002), X are the possibly relevant controls in gravity models (like distance and other terms capturing geography). If the betas are only capturing trade costs, it would be expected that the coefficient on the second term would be negative.

Figure B1 suggests that the estimated betas are generally similar to the more standard direct measure of trade costs. Table B1 provides further evidence that the betas plausibly capture trade costs. Panel A reports a large positive correlation between the direct measure of trade cost and the calculated estimate. It also reports a positive and significant relationship between the estimated beta and an observable related to trade costs (distance from the US). Panel B reports coefficients from a regression of the betas from Equation (6) on a range of variables common to gravity models of trade. It indicates that distance for the US and being an island is associated with higher betas, and a regional trade agreement (with the US) and having a common border (with the US) reduces beta. Sharing a common language with the US (i.e., speaking English) does not seem to have an effect on beta. Panel C indicates that the estimated betas are negatively related to the extent of trade with the US. (The results in Tables 9 and B1 are generally robust to the two potential outliers which can be seen in Figure B1.)

In summary, Figure B1 and Table B1 suggest that there is a reasonable relationship between the fitted measures of trade cost (beta) with both the actual money trade cost used in Section 3 and factors related to trade with the US, suggesting the betas are at least capturing factors related to US trade costs. To the extent that the US is a significant country in the world economy, trade costs with the US may be a good indicator of overall trade costs.

Figure B1: Trade Cost and Estimated Trade Cost

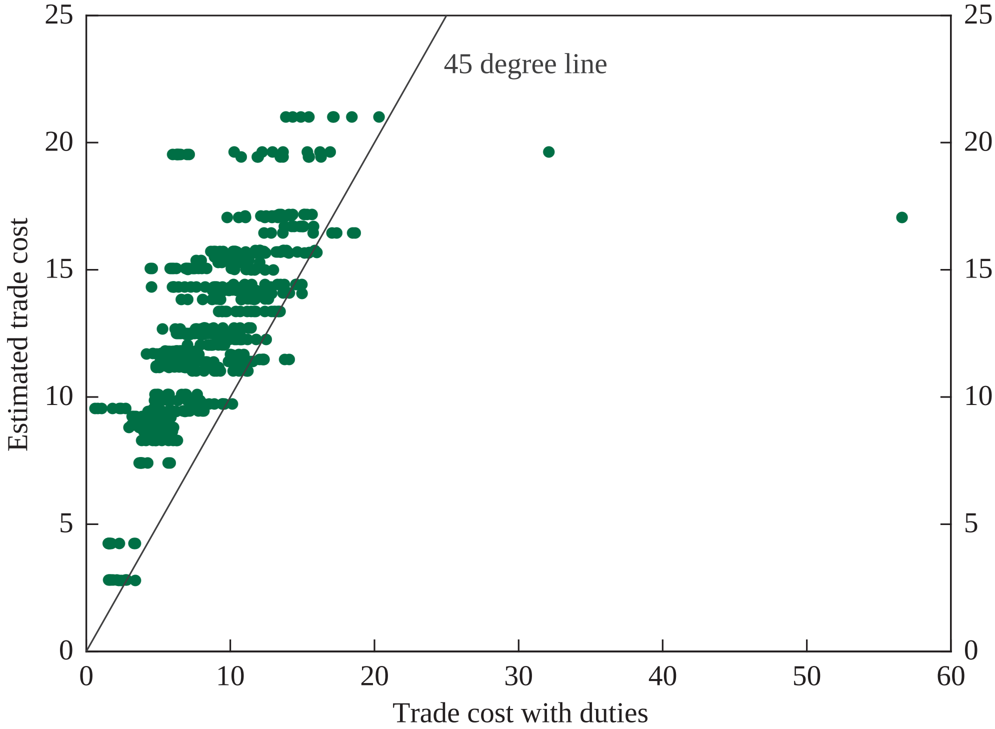

Table B1: Trade Costs and Betas

	Trade cost with duty
Panel A	
Correlation between trade costs and betas	0.69
Coefficient from regressing beta on log of bilateral distance	5.4*
	(0.4)
Panel B	
Regression of beta on multiple variables	
Log distance	1.7
	(0.9)
Common border	–5.4*
	(1.1)
Island	1.5*
	(0.5)
Land-locked	–1.1*
	(0.3)
Common language	0.1
	(0.3)
Regional trade agreement	–2.6*
	(0.5)
Panel C	
Coefficient from regressing log(bilateral trade) on beta	–0.26
Coefficient from regressing log(bilateral trade) on beta[(a)]	–0.78

Notes: Robust standard errors in parentheses. The first-stage regression (Equation (5)) was estimated using 113 580 observations (where an observation is a country-year-commodity type). The correlation in the top cell was calculated from 588 observations (where an observation is a country-year). * indicates significance at the 5 per cent level.

(a) Additional controls are whether share border, whether an island, whether land-locked, whether share a common language, whether in a regional trade agreement, log distance, 'decade' dummies and the interaction between decade dummies and log distance.

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