Commodity Trade and the Carry Trade: A Tale of Two Countries*

Robert Ready[†], Nikolai Roussanov[‡] and Colin Ward[§]

January 15, 2015

Abstract

Persistent differences in interest rates across countries account for much of the profitability of currency carry trade strategies. The high-interest rate "investment" currencies tend to be "commodity currencies," while low interest rate "funding" currencies tend to belong to countries that export finished goods and import most of their commodities. We develop a general equilibrium model of international trade and currency pricing in which countries have an advantage in producing either basic input goods or final consumable goods. The model predicts that commodity-producing countries are insulated from global productivity shocks through a combination of trade frictions and domestic production, which forces the final goods producers to absorb the shocks. As a result, the commodity country currency is risky as it tends to depreciate in bad times, yet has higher interest rates on average due to lower precautionary demand, compared to the final good producer. Carry trade risk premium increases in the degree of specialization, and the real exchange rate tracks relative technological productivity of the two countries. The model's predictions are strongly supported in the data.

*We benefited from comments by Andy Abel, Rui Albuquerque, Dave Backus, Gurdip Bakshi, John Campbell, Mike Chernov, Ric Colacito, Max Croce, Darrell Duffie, Bernard Dumas, Xavier Gabaix, Jeremy Graveline, Robin Greenwood, Tarek Hassan, Burton Hollifield, Urban Jermann, Karen Lewis, Debbie Lucas, Hanno Lustig, Don Keim, Brent Neiman, Anna Pavlova, Bryan Routledge, Jose Scheinkman, Ivan Shaliastovich, Ken Singleton, Rob Stambaugh, Andreas Stathopoulos, Sheridan Titman, Adrien Verdelhan, Jessica Wachter, Amir Yaron, Stan Zin, and audiences at the AFA and ASSA/IEFS meetings, CEPR ESSFM Gerzensee, Duke ERID macrofinance conference, Minnesota Asset Pricing conference, Oxford-MAN Currency Trading conference, NBER SI, NBIM, SECOR, Texas Finance Festival, SED, WFA, and Wharton. Roussanov acknowledges financial support from the Iwanowski Family Research Fellowship and Wharton Global Research Initiative.

[†]Simon School of Business, University of Rochester

[‡]The Wharton School, University of Pennsylvania, and NBER

[§]Carlson School of Management, University of Minnesota

1 Introduction

A currency carry trade is a strategy that goes long high interest rate currencies and short low interest rate currencies. A typical carry trade involves buying the Australian dollar, which for much of the last three decades earned a high interest rate, and funding the position with borrowing in the Japanese yen, thus paying an extremely low rate on the short leg. Such a strategy earns positive expected returns on average, and exhibits high Sharpe ratios despite its substantial volatility. In the absence of arbitrage this implies that the marginal utility of an investor whose consumption basket is denominated in yen is more volatile than that of an Australian consumer. Are there fundamental economic differences between countries that could give rise to such a heterogeneity in risk?

One source of differences across countries is the composition of their trade. Countries that specialize in exporting basic commodities, such as Australia or New Zealand, tend to have high interest rates. Conversely, countries that import most of the basic input goods and export finished consumption goods, such as Japan or Switzerland, have low interest rates on average. These differences in interest rates do not translate into the depreciation of "commodity currencies" on average; rather, they constitute positive average returns, giving rise to a carry trade-type strategy. In this paper we develop a theoretical model of this phenomenon, document that this empirical pattern is systematic and robust over the recent time period, and provide additional evidence in support of the model's predictions for the dynamics of carry trade strategies.

The fact that carry trade strategies typically earn positive average returns is a manifestation of the failure of the Uncovered Interest Parity (UIP) hypothesis, which is one of the major longstanding puzzles in international finance. It is commonly recognized that time-varying risk premia are a major driver of carry trade profits. In fact, a longstanding consensus in the international finance literature attributed all of the carry trade average returns to *conditional* risk premia, with no evidence of non-zero *unconditional* risk premia on individual currencies throughout most of the twentieth century (e.g. see Lewis (1995)). Consequently, much of the literature has focused on explaining the conditional currency risk premia by ruling out asymmetries (e.g., Verdelhan (2010), Bansal and Shaliastovich (2012), Colacito and Croce

(2012)). However, Lustig, Roussanov, and Verdelhan (2011) show that unconditional currency risk premia are in fact substantial; indeed, they account for between a third and a half of the profitability of carry trade strategies.[1] Lustig, Roussanov, and Verdelhan (2011) argue that these returns are compensation for global risk, and the presence of unconditional risk premia implies that there is persistent heterogeneity across countries' exposures to common shocks. In this paper we uncover a potential source of such heterogeneity.[2]

We show that the differences in average interest rates and risk exposures between countries that are net importers of basic commodities and commodity-exporting countries can be explained by appealing to a natural economic mechanism: trade costs.[3] We model trade costs by considering a simple model of the shipping industry. At any time the cost of transporting a unit of good from one country to the other depends on the aggregate shipping capacity available. While the capacity of the shipping sector adjusts over time to match the demand for transporting goods between countries, it does so slowly, due to gestation lags in the shipbuilding industry. In order to capture this intuition we assume marginal costs of shipping an extra unit of good is increasing - i.e., trade costs in our model are convex. Convex shipping costs imply that the sensitivity of the commodity country to world productivity shocks is lower than that of the country that specializes in producing the final consumption good, simply because it is costlier to deliver an extra unit of the consumption good to the commodity country in good times, but cheaper in bad times. Therefore, under complete financial markets, the commodity country's consumption is smoother than it would be in the absence of trade frictions, and, conversely, the commodity importer's consumption is riskier.

[1] See also Bakshi, Carr, and Wu (2008), Campbell, Medeiros, and Viceira (2010), Koijen, Pedersen, Moskowitz, and Vrugt (2012), and Lustig, Roussanov, and Verdelhan (2013) for additional empirical evidence. Theoretical models of Hassan (2013) and Martin (2011) relate currency risk premia to country size. Stathopoulos, Vedolin, and Mueller (2012) assume an exogenous source of heterogeneity in a multi-country model with habit formation.

[2] A number of patterns of heterogeneous risk exposures have been documented empirically. In a pioneering study, Lustig and Verdelhan (2007) show that carry trade risk premia line up with loadings on the U.S. aggregate consumption growth; Lustig, Roussanov, and Verdelhan (2011) and Menkhoff, Sarno, Schmeling, and Schrimpf (2012) link these risk premia to covariances with the global stock market and foreign exchange rate volatility shocks, respectively, while Lettau, Maggiori, and Weber (2013) show that high average return strategies in currency and commodity (as well as equity) markets perform particularly poorly during large U.S. stock market declines.

[3] Trade costs have a long tradition in international finance: e.g., Dumas (1992), Hollifield and Uppal (1997). Obstfeld and Rogoff (2001) argue that trade costs hold the key to resolving several major puzzles in international economics.

Since the commodity country faces less consumption risk, it has a lower precautionary saving demand and, consequently, a higher interest rate on average, compared to the country producing manufactured goods. Since the commodity currency is risky - it depreciates in bad times - it commands a risk premium. Therefore, the interest rate differential is not offset on average by exchange rate movements, giving rise to a carry trade.

We show empirically that sorting currencies into portfolios based on net exports of finished (manufactured) goods or basic commodities generates a substantial spread in average excess returns, which subsumes the unconditional (but not conditional) carry trade documented by Lustig, Roussanov, and Verdelhan (2011). Further, we show that aggregate consumption of commodity countries is less risky than that of finished goods producers, as our model predicts.

The model makes a number of additional predictions that are consistent with salient features of the data. Commodity-currency carry trade returns are positively correlated with commodity price changes, both in the model and in the data (we provide evidence using an aggregate commodity index, which complements the result obtained by Ferraro, Rossi, and Rogoff (2011) who use individual currency and commodity price data). Moreover, the model predicts that conditional expected returns on the commodity-currency carry trade are especially high when global goods markets are most segmented, i.e. when trade costs are particularly high. We show that a popular measure of shipping costs known as the Baltic Dry Index (BDI) forecasts unconditional carry trade returns (but not their conditional component). Our model also rationalizes the evidence of carry trade predictability with a commodity price index documented by Bakshi and Panayotov (2013), since commodity prices are typically high in the model during booms, when trade costs are also high.

2 Model

2.1 Setup

There are two countries each populated by a continuum of ex ante identical households endowed with time-separable preferences over the same consumption good. The countries are spatially separated so that transporting goods from one country to the other incurs trade costs, although we abstract from shipping costs for the basic commody for tractability (introducing such costs does not alter main qualitative predictions of the model - see Appendix).

The "commodity country" has two production technologies available: one technology for producing the final (consumable) good; the other, for producing basic commodity which is an input required for production of the final good. The "producer country" only has one technology to produce the final good. Firms in both industries and in both countries are competitive. Both countries' representative households have CRRA preferences with identical coefficients of relative risk aversion γ and rates of time preference ρ. Time is continuous, and all households are infinitely-lived.

The commodity country has a linear technology for producing the commodity that is either used domestically or exported to the producer country,

$$y_{ct} = z_{ct} l_{ct},$$

where l_c is a local non-traded input (this can be thought of labor or land) and z_c is its productivity.

The commodity country has the final-good production function

$$y_{cpt} = z_{cpt}(y_{ct} - x_t)^{\alpha} l_{cpt}^{1-\alpha},$$

where z_{cp} is a productivity level and x is the quantity of commodity exported, while l_{cp} is the local non-traded input. The latter is supplied inelastically in the amount of one unit, but is perfectly substitutable between the two sectors, so that $l_c + l_{cp} = 1$.

Since the producer country imports the commodity at no cost and there is only one production technology competing for the local resources, the same production function implies its output of the final good is given by

$$y_{pt} = z_{pt} x_t,$$

where z_p is its productivity level. We assume that the producer country has an absolute (as well as comparative) advantage in producing the final good:

$$z_{pt} > z_{ct} \text{ (almost surely).}$$

Given this assumption, in the absence of trade frictions it would be optimal for the two countries to specialize, so that the commodity country only produces the basic commodity and exports all of it to the producer country, where all production of the final good is concentrated. However, most commodity-producing countries do produce at least some of the goods they consume domestically, presumably because some of these goods are too costly to import from countries that produce them more efficiently, and in fact some consumption goods are entirely non-traded. We model such trade frictions by extending the classic variable iceberg cost of Backus, Kehoe, and Kydland (1992), where each unit of the final (consumable) good shipped from the producer country to the consumer country loses a fraction

$$\tau(X_t, z_{pt}) = \frac{\kappa}{2}\frac{X_t}{z_{pt}},$$

which depends on the total amount of goods exported from the producer country to the commodity country, X_t, and the productivity in the final good producer country z_{pt}. The latter is meant to capture the dependence of trade frictions on the various short-run factors, such as available shipping capacity that cannot be adjusted quickly and is likely procyclical, as well as costs of financing trade that are likely counter-cyclical.[4]

The presence of trade frictions implies that the real exchange rate, i.e. the relative price of the same consumption bundle in the two countries, is not equal to unity. We denote this real exchange rate, expressed in the units of the producer country consumption basket per

[4]While we use "trade costs" and "shipping costs" interchangeably, in principle trade costs include a broader category of frictions than the monetary cost of freight. These could include the time delays due to port congestion, tariffs and non-tariff barriers to trade, and local distribution costs. More generally, this includes the idea that some goods are so prohibitively expensive to ship that they are essentially nontraded. An alternative would be to endow each country's consumers with a stronger preference for domestically produced consumption goods relative to foreign one, as used in international macroeconomics, e.g. by Backus, Kehoe, and Kydland (1994), and in the context of international asset pricing by, e.g., Pavlova and Rigobon (2007), Colacito and Croce (2010), and Stathopoulos (2011). We retain the classic BKK specification largely for tractability.

one unit of the commodity country consumption, by S_t.

Let p_t and p_t^* denote the price of the basic commodity in the units of the numeraire consumption good in the commodity and the producer countries, respectively. Since transporting the commodity between the two countries is costless, the law of one price holds, as the prices in the two countries are equated up to the exchange rate:

$$p_t = \frac{p_t^*}{S_t}. \tag{1}$$

2.2 Production

Given the structure of the production technologies, all firm decisions are static. Therefore, we can consider the intratemporal production decisions at a given point in time t without making specific assumptions on the dynamics of the exogenous state variables or considering the consumer problem. In this section we suppress all of the time subscripts for brevity.

In each period, the commodity country firms in the commodity sector solve

$$\max_{l_c} p z_c l_c - w l_c \Rightarrow w = p z_c,$$

that must be satisfied for the price of local nontraded input w. The final-good sector firms solve

$$\max_{x, l_{cp}} z_{cp}(z_c l_c - x)^{\alpha} l_{cp}^{1-\alpha} - p(z_c l_c - x) - w l_{cp}$$

subject to the constraint that $l_c + l_{cp} = 1$. The first-order conditions of this problem imply that

$$\frac{\alpha}{1-\alpha} z_c l_{cp} = z_c l_c - x \tag{2}$$

$$\Rightarrow l_c = \alpha + (1-\alpha)\frac{x}{z_c}, \tag{3}$$

$$l_{cp} = (1-\alpha)\left(1 - \frac{x}{z_c}\right). \tag{4}$$

This implies that the fraction of labor directed to commodity production increases with the amount of commodity exports x. The maximum ($l_c = 1$) is reached when all of the commodity endowment is exported ($x = z_c$). The same set of necessary conditions (for an interior solution) imply that the price of the commodity in the commodity country is given by

$$p = \alpha z_{cp} \left(\frac{1-\alpha}{\alpha z_c} \right)^{1-\alpha}. \tag{5}$$

Commodity price p is a decreasing function of commodity endowment and an increasing function of the domestic final good productivity. In particular, the combination of Cobb-Douglas and linear technologies imply that foreign demand for the commodity does not have a direct effect on the domestic price. However, it does determine the amount of the commodity exported to the producer country.

The producer country's final-good firm solves

$$\max_x z_p x - p^* x \tag{6}$$

$$\Rightarrow z_p = p^*. \tag{7}$$

Consequently, the goods-market no-arbitrage condition (1) implies a relationship between the real exchange rate and the relative productivities in the final good sectors of the two countries:

$$S = \frac{p^*}{p} = \frac{z_p}{\alpha z_{cp}} \left(\frac{1-\alpha}{\alpha z_c} \right)^{\alpha-1}, \tag{8}$$

which must be satisfied as long as both countries simultaneously use the commodity input to produce the final consumption good. In particular, the commodity currency appreciates in "good times" from the perspective of the final good producer, i.e. when its technology improves (or when the commodity-country domestic productivity worsens).

2.3 Dynamics

We assume that the shocks to productivity experienced by the final-good producer are permanent, its evolution following a standard geometric Brownian motion:

$$\frac{dz_{pt}}{z_{pt}} = \mu dt + \sigma dB_t.$$

To ensure stationarity of the model, we assume commodity-country productivity is cointegrated with producer-country productivity and follows a general diffusion process

$$\frac{dz_{cpt}}{z_{cpt}} = \mu_t dt + \sigma_t dB_{ct}.$$

Its drift μ_t and instantaneous volatility σ_t specified as follows so as to ensure stationarity of the relative productivity:

$$z_t \doteq \frac{z_{cpt}}{z_{pt}},$$

The assumption of comparative advantage requires $z_t < 1$; we further restrict its domain by requiring $z_t > \underline{z}$ for some $\underline{z} > 0$. We assume that the relative productivity process follows a regulated Brownian motion

$$dz_t = \mu_{zt} dt + \sigma_z dB_{zt} - dU_t + dL_t,$$

where U_t and L_t are continuous, non-decreasing processes, and dB_{zt} is independent of dB_t. L_t only increases when $z_t = \underline{z}$ and U_t only increases when $z_t = 1$. The resulting cointegration relation can be interpreted as a reduced-form representation of an economy where both countries independently, and exogenously, innovate to improve their technologies that produce the final good, but the producer country always leads the commodity country in technological advancement. We set $\mu_{zt} = \sigma_z^2/z_t$. The specification of the drift can be thought of as having the commodity country adopt ideas and technologies from the producer country, thus allowing it to catch up in technological advancement, with the effect being greater during greater differences in relative productivity. In effect, the processes dz_{cpt} and dz_{pt} become more correlated when z_t nears one. This setup makes the relative ratio of productivities vary independently of the absolute level of productivity of the producer country, z_p, which is a feature of the model that makes it particularly tractable.

Finally, we assume that the productivity in the commodity sector is constant, $z_{ct} = z_c$, so as to demonstrate clearly the role of the relative productivity in the final good sector, as well as to make the model more tractable.[5] Under this assumption we can define a constant

[5] More generally commodity supply can be modeled as a stochastic endowment cointegrated with global productivity (i.e., z_p). Such cointegrated relationship can be interpreted as a reduced form representation of

as a function of z_c, $\phi(z_c) = \alpha \left(\frac{1-\alpha}{\alpha z_c}\right)^{1-\alpha}$, so that the commodity price (in the units of the commodity country currency) is simply $p = \phi(z_c) z_{cp}$.

2.4 Complete markets and consumption risk sharing

In order to emphasize that our mechanism does not rely on any financial market imperfections, we consider consumption allocations under complete markets. This is a standard benchmark in international finance, and is reasonable at least when applied to developed countries.[6] The main implications of our model do not hinge on the complete markets assumption, but the standard setting lends both transparency and tractability to the analysis.

Under complete markets, the equilibrium allocation is identical to that chosen by a central planner for a suitable choice of a (relative) Pareto weight λ. The planner's problem is

$$V(z_{pt}, z_{cpt}) = \max_{X_s} \mathbb{E}_t \left[\int_t^\infty e^{-\rho(s-t)} \left(\frac{c_{cs}^{1-\gamma} - 1}{1-\gamma} + \lambda \frac{c_{ps}^{1-\gamma} - 1}{1-\gamma} \right) ds \right],$$

where commodity-country consumption $c_{cs} = p_s(y_{cs} - x_s) + X_s(1 - \frac{\kappa X_s}{2 z_{ps}})$ and producer-country consumption $c_{ps} = z_{ps} x_s - X_s$, subject to the constraints (5) and (8) imposed by the production side of the economy (the latter are equivalent to including choice over x_s and l_{cs} in the planner problem, since firms act competitively). As before, because the production economy here is essentially static, the planning problem collapses to a sequence of one-period problems and we henceforth ignore time subscripts.

The first-order condition of the planner's problem, which holds state-by-state for all t, implies that

$$c_c^{-\gamma} \left(1 - \kappa \frac{X}{z_p}\right) - \lambda c_p^{-\gamma} = 0. \tag{9}$$

Since the real exchange rate (here defined in the units of the producer currency per one unit of the commodity currency) is the relative price of consumption in the two countries, it is proportional to the ratio of marginal utilities of the two countries' representative consumers:

an economy where supply of the commodity is inelastic in the short run (based on the currently explored oil fields, say) but adjusts in the long run to meet the demand by the final good producers (e.g., as new fields are explored more aggressively when oil prices are high). We solve a version of such model in the Appendix.

[6] For example, Fitzgerald (2012) estimates that risk-sharing via financial markets among developed countries is nearly optimal, while goods markets trade frictions are sizeable.

$$S = \frac{1}{\lambda}\left(\frac{c_c}{c_p}\right)^{-\gamma}. \tag{10}$$

The combined equations (8) and (9) show how the exchange rate is jointly determined by the production and the consumption sides of the economy. Equation (8) states that the marginal product of the commodity is equated between the two countries, once expressed in the units of one of the country's currency (or consumption). Consequently, the real exchange rate must equal the ratio of the two countries' productivities (up to a constant):

$$S \propto \frac{1}{z}. \tag{11}$$

Equation (9) states that the relative value of the consumption good in two countries is equated up to the marginal cost of transporting it from the producer country to the commodity country. Consequently, the real exchange rate is proportional to the marginal value of one unit of the final good that has been transported from the producer to the commodity country, as is generally the case in one-good models with trade costs (e.g., see Dumas (1992), Hollifield and Uppal (1997), Verdelhan (2010)):

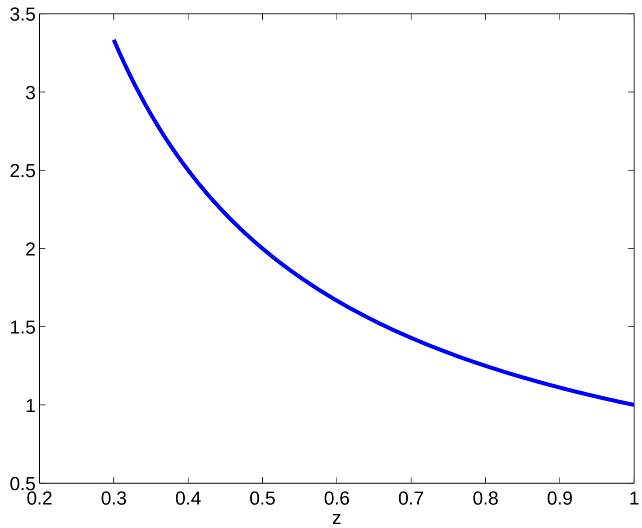
$$S = \frac{1}{\left(1 - \kappa\frac{X}{z_p}\right)}. \tag{12}$$

The first-order condition (9) combined with the law of one price for commodities (8) give an explicit solution for final good exports X:

$$X = \left(1 - \frac{p}{z_p}\right)\frac{z_p}{\kappa} = \frac{1}{\kappa}\left(z_p - \phi(z_c)z_{cp}\right).$$

This expression is very intuitive: it shows that exports of the final good are increasing (linearly) in the producer-country labor productivity, and decreasing in the final-good productivity in the commodity country. The trade cost scales down final good exports and therefore drives a wedge between the two countries' consumptions. The magnitude of this wedge depends on the relative productivity of final-good production, z, and using the first-

Figure 1: Consumption wedge



order conditions we can formally define this consumption wedge

$$\omega(z) \doteq \frac{c_p}{c_c} = \left(\frac{1-\kappa\frac{X}{z_p}}{\lambda}\right)^{-\frac{1}{\gamma}} = \left(\frac{p}{\lambda z_p}\right)^{-\frac{1}{\gamma}} = \left(\frac{\phi(z_c)}{\lambda}z\right)^{-\frac{1}{\gamma}}. \tag{13}$$

The consumption wedge measures the extent to which the producer country bears a larger share of aggregate consumption and also the risk associated with it. Because in equilibrium the producer country's consumption will be a nonlinear, scaled version of the commodity-country's consumption, the producer country will have a relatively more variable consumption stream. On average, if consumption growth rates are equal between the two countries, greater demand for precautionary savings will lead the producer country to have a relatively lower risk-free rate.

A related comment is that because the real exchange rate is positively related to the consumption wedge, $S = \frac{1}{\lambda}\omega(z)^{\gamma}$, the real exchange will comove positively with it and thus will depreciate in "bad times" for the producer country, when its relative aggregate consumption share declines.

Solving for equilibrium commodity exports x gives

$$x\left(z_p,z\right)=\frac{pz_c\omega(z)+X+X\left(1-\frac{\kappa}{2}\frac{X}{z_p}\right)\omega(z)}{z_p+p\omega(z)},$$

which can be used to compute the consumption allocations:

$$c_c=z_p\frac{z_c\phi(z_c)z+\frac{1}{2\kappa}\left(1-\phi(z_c)z\right)^2}{1+\omega(z)\phi(z_c)z} \tag{14}$$

and

$$c_p=\omega(z)c_c.$$

Commodity country consumption c_c comes from two sources: the first is domestic production of the final good, while the second consists of imports of the final good from the producer country. When z decreases, the main source of consumption for the commodity country shifts from domestic production to imports. Additionally, the consumption wedge increases, as the producer country bears an increasingly greater share of aggregate risk. This widening of the consumption wedge can be seen as a simple form of the "Dutch desease": as the 'world' price of the commodity rises, driven by the increase in foreign productivity relative to its domestic level, commodity production and exports crowd out domestic production; however, trade frictions imply that the rising imports of consumption goods are not sufficient to compensate for the decline in local production for domestic consumers.

Conversely, as z increases towards its upper limit of unity, commodity exports x decline, raising domestic production of the final good in the commodity country and shrinking the consumption wedge. In what follows we rely on the following

Lemma 1. *If there is a z_c^* given parameters $\alpha,\lambda,\kappa,\gamma$, and $\underline{z}$ such that*

$$z_c^*=\frac{1}{\kappa}\left(1-\phi(z_c^*)\underline{z}\right)\left(1+\frac{1}{2}\left(1+\phi(z_c^*)\underline{z}\right)\left(\frac{\phi(z_c^*)}{\lambda}\underline{z}\right)^{-\frac{1}{\gamma}}\right)$$

is satisfied, then $x\left(z_p,z\right)\leq z_c^*$ for all $z_p>0$ and all $z\in(\underline{z},1)$.

From here on, we restrict attention to cases where $z_c>z_c^*$ and will simply denote a member of this set of satisfactory constants as $\phi^* \in \{\phi | z_c > z_c^*\}$.

2.5 Import ratios

While our model features complete specialization, in the sense that each country only exports one type of good, the degree to which a country is an importer of final goods and an exporter of commodities, and vice versa, relative to its output, varies over time. This degree can be quantified by measuring imports of the two types of goods relative to output, with the view towards testing model's predictions in empirical work. Define the import ratio for a given country as

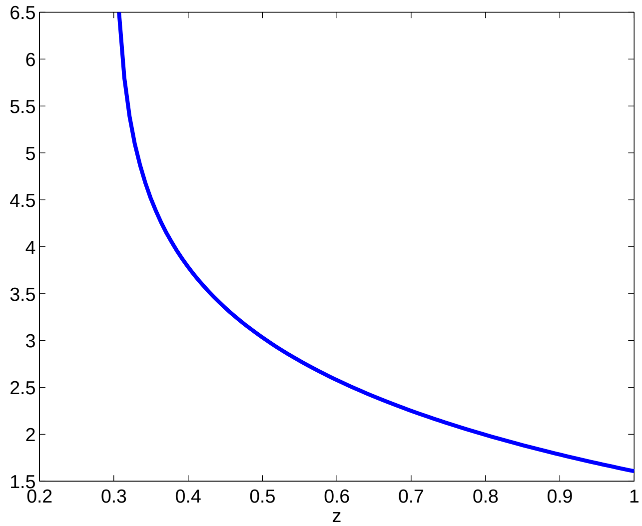
$$\frac{\text{Net Imports of Finished Goods} + \text{Net Exports of Basic Goods}}{\text{Output}}.$$

where we normalize the trade quantities in the numerator by consumption here, then we have the following:

- Commodity-country import ratio: $IR_c \doteq \frac{XS+xpS}{y_{cp}S}$
- Producer-country import ratio: $IR_p \doteq -\left(\frac{X+xpS}{y_p}\right)$

The spread of the log of these ratios ($IR_c - IR_p$) is plotted in Figure 6. The ratios do not converge to zero when $z \to 1$ because the producer country needs to import the commodity to have positive consumption. This ratio is an easily measurable empirical quantity. As a country becomes relatively more efficient at producing the final good, it becomes a net exporter of final goods, and has a lower and possibly even negative import ratio. On the other hand, as a country becomes more efficient at producing commodities, relative to its production capabilities of producing the final good, its import ratio rises. The spread between the two country's import ratios acts as a measure of relative productivity/comparative advantage, which in turn is a measure of the degree to which the country with the lower import ratio bears aggregate risk.

Figure 2: Import ratio spread: $\log(IR_c - IR_p)$



2.6 Asset pricing implications

The definition of stochastic discount factor (SDF) for the producer country is standard and with an application of Ito's lemma has the dynamics

$$\frac{d\pi_p}{\pi_p} = -\rho dt - \gamma \frac{dc_p}{c_p} + \frac{1}{2}\gamma(1+\gamma)\frac{dc_p^2}{c_p^2},$$

and the commodity country's SDF follows from our complete markets assumption, which allows it to be usefully written in terms of S and c_p.

$$\pi_c = e^{-\rho t} c_c^{-\gamma} = e^{-\rho t}\left(\frac{c_p}{\omega(z)}\right)^{-\gamma} = e^{-\rho t} c_p^{-\gamma} S\lambda$$
$$\Rightarrow \frac{d\pi_c}{\pi_c} = -\rho dt + \frac{dS}{S} - \gamma\frac{dc_p}{c_p} + \frac{1}{2}\gamma(1+\gamma)\frac{dc_p^2}{c_p^2} - \gamma\frac{dS}{S}\frac{dc_p}{c_p}.$$

The interest rate differential between the two countries is then given by

$$(r_c^f - r_p^f)dt = -\mathbb{E}_t\left[\frac{d\pi_c}{\pi_c}\right] + \mathbb{E}_t\left[\frac{d\pi_p}{\pi_p}\right] = -\mathbb{E}_t\left[\frac{dS}{S}\right] + \gamma\mathbb{E}_t\left[\frac{dS}{S}\frac{dc_p}{c_p}\right], \tag{15}$$

where the first term is the expected depreciation of the commodity currency and the second term is the risk premium. The latter can be written as

$$(r_c^f - r_p^f)dt + \mathbb{E}_t\left[\frac{dS}{S}\right] = \underbrace{\gamma\mathbb{E}_t\left[\frac{dS}{S}\frac{dc_p}{c_p}\right]}_{\text{Risk premium}}$$

By using Ito's lemma for regulated processes (see Harrison (1985, p.82)), the dynamics of the exchange rate under $\mu_z = \frac{\sigma_z^2}{z}$ are

$$\frac{dS}{S} = -\frac{dz}{z} + \frac{dz^2}{z^2} = -\frac{z}{\underline{z}^2}dL + zdU - \frac{\sigma_z}{z}dB_z. \tag{16}$$

Our selection of the drift of the process z gives the model a nice feature, which is summarized in the next lemma.

Lemma 2 (Real exchange rate follows a martingale)**.** *If $\mu_{zt} = \sigma_z^2/z_t$ then the growth of the real exchange rate is a martingale:*

$$\mathbb{E}_t\left[\frac{dS}{S}\right] = 0.$$

Because of this selection, the risk premium simply equals the interest rate differential, and, aside from the specification of standard CRRA preferences, is independent of the other features of the model. The risk premium is given by

$$\gamma\mathbb{E}_t\left[\frac{dS}{S}\frac{dc_p}{c_p}\right] = \gamma\sigma_z^2\frac{1}{z^2}\left[\frac{\frac{1}{2\kappa}(1-\phi^*z)^2}{z_c\phi^*z + \frac{1}{2\kappa}(1-\phi^*z)^2}\frac{(1+\phi^*z)}{1-\phi^*z} - \frac{1-\frac{1}{\gamma}}{1+\phi^*z\omega(z)}\right]dt. \tag{17}$$

In the special case of log utility, the risk premium, interest rate differential, and difference in the import ratio, can be signed analytically.

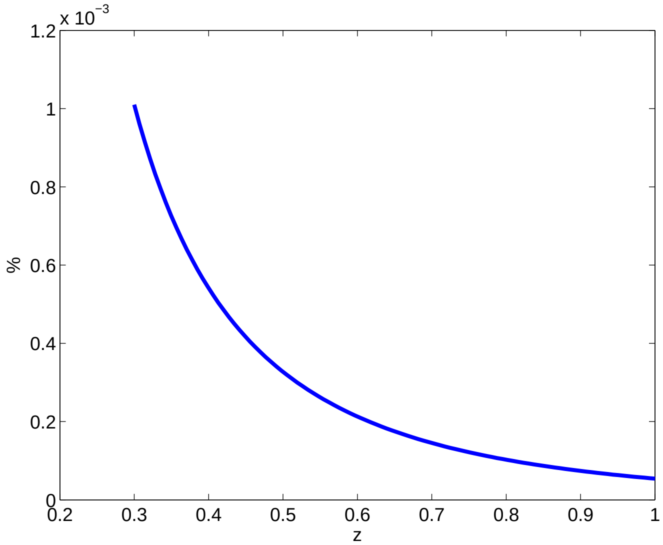
Proposition 1 (Risk premium, interest rate differential and import ratio)**.** *If the conditions of Lemma 1 above are satisfied and $\gamma = 1$, then*

1. *the risk premium and the interest rate differential are positive for all z*

2. *the spread of the import ratios $\Delta IR \doteq IR_c - IR_p$ is decreasing in z*

3. *if $\alpha \in [0, 0.8651)$ and $z_c > \max\{\frac{2}{\sqrt{5}-1}, z_c^*\}$, then the risk premium and the interest rate*

Figure 3: Carry trade risk premium



differential are decreasing in z. Thus, the spread between the import ratios is positively related to the currency risk premium and the interest rate differential.

The conditions required for the positivity of the risk premium, in addition to log utility, simply ensure that some quantity of the basic commodity is always retained to be used as input in domestic production in the commodity country. The second is a technical condition ensures that is easily satisfied for reasonable parameter values—a Cobb-Douglas labor share in final-good production over 0.1349 and a sufficient commodity production to satisfy Lemma 1 or a parametric restriction.

Both the interest rate differential and the risk premium are closely related to the import ratio. Figure 4 demonstrates that both are increasing as z falls, while the dispersion between the two countries import ratios rises. Therefore, the behavior of the *conditional* currency risk premia can be captured by the dispersion between the import ratios of the commodity country and producer country.

The risk premium is increasing in the consumption wedge, which captures the degree of endogenous risk sharing between the two countries. Risk sharing is weakest when the trade costs are high and, consequently, the consumption wedge is large. Figure 5 plots the currency risk premium against the average trade cost, illustrating the strong monotonic relationship between the two: high trade costs imply a high risk premium.

Figure 4: Relationship between interest-rate differential, risk premium, and import ratio

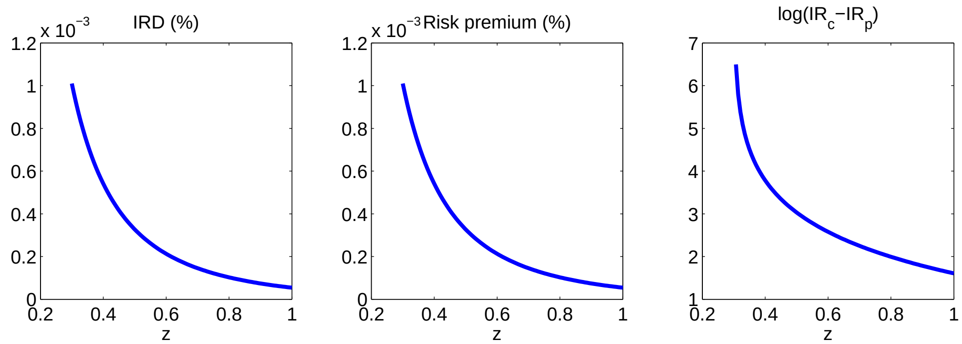
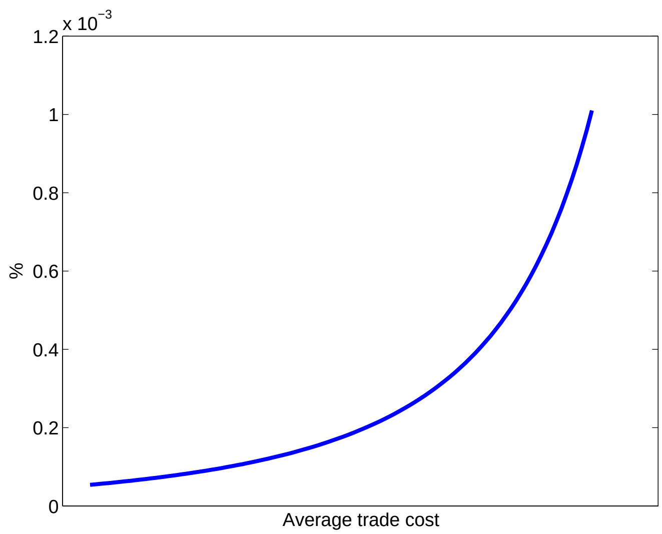


Figure 5: Carry trade risk premium



2.7 Summary of implications

The qualitative implications of the above proposition can be summarized as a set of predictions for the risk and return properties of exchange rates.

1. The final good-producing country bears more aggregate consumption risk. Therefore, it has a larger precautionary demand and lower interest rates, on average, than the commodity-producing country (since cointegration implies average consumption growth rates are the same in the long run).

2. The commodity country currency is risky, as it appreciates in good times and depreciates in bad times (i.e., when relative producer-country consumption declines). Therefore, it earns a risk premium, giving rise to a carry trade.

3. The commodity currency risk premium is increasing in spread between the import ratios of the two countries.

4. The interest rate differential and the commodity currency risk premium are both increasing in spread between the import ratios of the two countries.

5. Real exchange rates and interest rate differentials between commodity and producer country currencies are proportional to the ratio of productivities in the countries' final goods producing sectors.

6. The commodity currency exchange rate (and therefore the carry trade) is positively correlated with the (world) commodity price as well as the realized shipping costs, since they both increase in good times.

7. As high shipping costs imply lower degree of international risk sharing and therefore greater dispersion between conditional volatilities in consumption, conditional expected carry trade returns are positively correlated with trade costs.

Our model of exchange rate determination is deliberately simple and meant to highlight the mechanism leading to a carry trade: specialization combined with non-linear shipping costs. The model nevertheless makes a rich set of qualitative predictions, which we now evaluate empirically.

3 Empirical evidence

3.1 Data

Following Lustig, Roussanov, and Verdelhan (2011) we use forward and spot exchange rates to construct forward discounts (approximately equal to the interest rate differentials by the covered interest parity relation) and excess returns on currencies. Denoting log forward exchange rate one month ahead $f_t = logF_t$ and log spot exchange rate $s_t = logS_t$, both expressed in units of foreign currency per one U.S. dollar, the forward discount is equal to the interest rate differential: $f_t - s_t \approx i^\star_t - i_t$, where $i^\star$ and i denote the foreign and domestic nominal one month risk-free rates.

The log excess return rx on buying a foreign currency in the forward market and then selling it in the spot market after one month is then given by

$$rx_{t+1} = f_t - s_{t+1},$$

while the arithmetic excess return is given by

$$Rx_{t+1} = \frac{F_t}{S_{t+1}} - 1.$$

Data is provided by Barclays and Reuters and is available via Datastream. We use monthly series from February 1988 to April 2013.[7]

We use two samples in our analysis. The sample of all 35 developed and emerging countries includes: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Euro area, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom. The sub-sample of 21 developed-country currencies includes: Australia, Austria, Belgium, Canada, Denmark, Euro, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

3.2 Unconditional Average Excess Returns

Table 1 shows U.S. dollar average returns and forward discounts on the nine most actively traded currencies, collectively known as the G10 countries (the tenth currency being the U.S.

[7]While Lustig, Roussanov, and Verdelhan (2011) start their sample in 1983, very few currencies have forward discounts available in the first few years of the sample, as a number of countries, including Australia and New Zealand, undergo transition from fixed to floating exchange rates during this period. The latter countries have forward discounts available starting in 1985, but these display patterns suggesting episodes of extreme illiquidity, such as large bid-ask spreads and violations of covered interest parity relation (CIP) before 1988. Finally, the Plaza Accord of September 22, 1985 led to a large but gradual appreciation of the Deutschmark, the French Franc, and the Japanese Yen over the course of 1986 and 1987. Since these movements were largely predictable by investors it appears natural to consider unconditional strategies including these currencies starting in 1988.

dollar itself), over our sample period. Following Lustig, Roussanov, and Verdelhan (2011), we compute the average forward discount prior to 1995 and the returns after 1995. The German Deutschmark forward discount and the excess return to investing in Deutschmark forward contracts prior to 1999 are spliced with the euro variables post-1999. The table is sorted from low average returns to high average returns. What is immediately apparent is that the high return countries tended to have unconditionally high forward discounts, consistent with the unconditional carry trade strategy documented in Lustig, Roussanov, and Verdelhan (2011).

Table 1: **G10 Currency Average FX Returns and Discounts**

Country	Excess Return	Forward Discount
Japan	-1.97	-2.70
Switzerland	-0.32	-1.53
Germany/Euro	0.11	-0.15
Sweden	0.80	1.37
United Kingdom	0.92	1.81
Canada	1.66	0.65
Norway	1.99	1.81
Australia	4.02	2.71
New Zealand	4.06	3.08

Average annualized forward discounts prior to 1995 and and excess returns (without accounting for transaction costs) after 1995 for the "G-10" currencies from the perspective of a U.S. dollar investor. Germany/Euro is calculated based on the German Deutschmark prior to 1999 and the Euro post 1999. Data are monthly forward contracts from 1988 to 2012 available via Datastream.

Interestingly, this relation between average forward discounts and excess returns is not a perfectly monotonic one, in that some low return countries have high discounts. This is not necessarily surprising since factors other than expected returns (e.g. expected inflation) can have an effect on nominal interest rates, and therefore forward discounts.[8] It is clear, however, that the countries with low returns tend to be countries with advanced manufacturing economies which are also relatively resource poor. Indeed, the entire top half of the table: Germany, Japan, Sweden, Switzerland, and the UK all fit this description to some degree. In

[8]Pairwise average currency returns are only marginally statistically different from zero due to the substantial noise in bilateral exchange rate movements, consistent with evidence in Bakshi and Panayotov (2013); however, aggregating currencies into portfolios (e.g., long bottom four, short top four) reduces idiosyncratic noise and ensures robustly statistically significant average returns (as detailed in Data Appendix Table A-1).

contrast, the high return countries on the bottom half of the table tend to be large exporters of either oil (Canada and Norway) or other base agricultural or mineral commodities (New Zealand and Australia).

3.3 Import Ratios, Interest Rates, and Currency Excess Returns

In order to classify countries based on their exports we utilize the U.N. COMTRADE database of international trade flows. We use the NBER extract version of this data, available for years 1980-2000, we augment it with the original COMTRADE data for years 2001-2012 following the same methodology. The two goods in the model are a basic good, which is used as an input in production, and a final good, which is used in consumption. While this suggests a potential classification of goods as either "input" or "final" goods, there are many goods for which this classification struggles to conform to the intuition of the model. The important mechanism in the model hinges on the extra trade costs associated with shipping complex produced goods back to the commodity exporter rather than the specific use of the goods as consumption or input. For instance, New Zealand is a large exporter of many agricultural commodities, some of which (such as butter) are in their final consumable form. Likewise, New Zealand imports a large amount of sophisticated construction equipment which is produced using basic commodities (e.g., metals, energy) as an input. However, in the context of the model, a complex piece of construction equipment seems more closely related to the final good rather than the basic good, while butter is a better representation of the basic good. Moreover, the specialization assumption in the model implies that the production process in the producer country cannot be easily replicated in the commodity country, suggesting a high level of complexity for the final good. Therefore to be consistent with the model mechanism we classify goods as a basic good (i.e. a commodity) or a complex manufacturing good based on their 4-digit SITC codes. The classifications at the 2-digit level are in the appendix (Table A-2), and the full classification is available upon request.

In order to test the model's predictions we use this classification of goods and construct the empirical measure of the Import Ratio defined in Section 2.5:

$$\frac{\text{Net Imports of Complex Goods} + \text{Net Exports of Basic Goods}}{\text{Manufacturing Output}},$$

where manufacturing output is the total output in the sector that produces complex goods. As an empirical counterpart of this output we use the value added from manufacturing of "Machinery and Transport Equipment" from the U.N.'s, International Yearbook of Industrial Statistics.

This measure captures the extent to which a country specializes in the production of basic commodities, as well as the extent to which a country imports complex goods. Moreover, to the extent a country's changing composition of output and trade over time reflects its fluctuations in productivity this measure should also capture the variation in the country's productivity relative to that of its trade partners.

To test the first two implications of the model, we first examine how interest rates and currency risk premiums relates to import ratios in our cross-section of currencies. Figure 6 plots the average forward returns and discounts against the average import ratio for each country over both the Pre- and Post-Euro samples. For this figure, forward discounts and currency returns are calculated from the perspective of the US investor. In order to focus on cross-sectional differences in countries as opposed to time series changes, the per-period averages of country discounts and returns are subtracted. As the first plot shows, there is a clear relation between the import ratio and average forward discounts. Commodity countries are generally high interest rate countries, consistent with the predictions of the model. The second plot shows a similar pattern in returns, with the commodity countries earning higher returns than producer countries, again consistent with the model. Notably, the U.S. is an average country in terms of its trade composition, and also an average country in terms of forward discounts and returns.

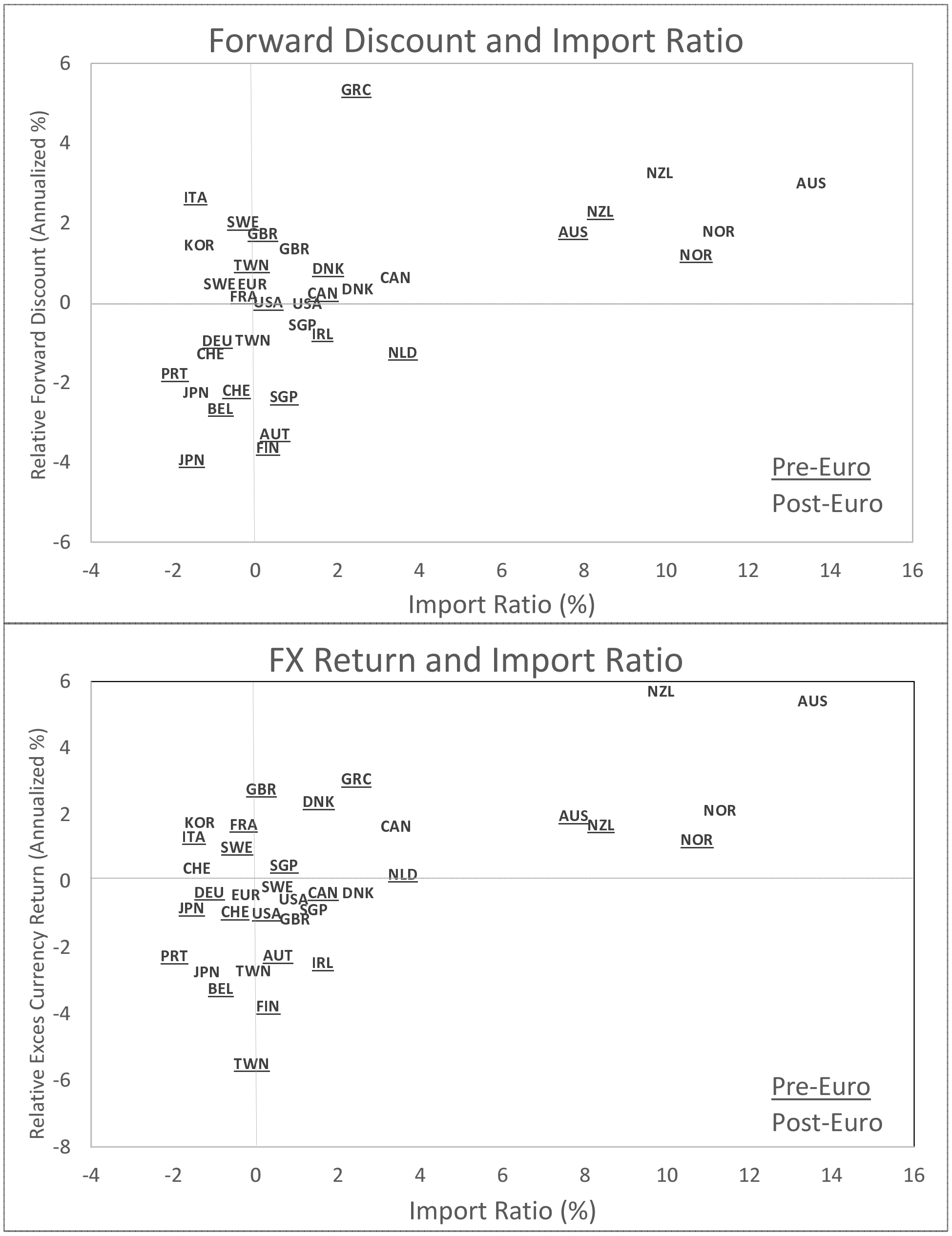
To test for statistical significance of these relations, Table 2 presents cross-sectional regression evidence that relates our import/export composition variable to the excess currency returns and forward discounts. Panel A presents results for the full sample of countries (IMF Advanced Economies) while Panel B presents the results for the G10 currencies. The left hand side of each panel presents estimates from Fama-MacBeth regressions of monthly currency excess returns on the import ratios. The right hand side of each panel presents estimates from Fama-Macbeth regressions of monthly forward discounts on import ratios. Standard errors are Newey-West with 36 months of lags to account for time-series persistence in the dependent variables.

As evidenced by the regression slope coefficients, the import ratio is a strong positive predictor of future excess returns, and is strongly correlated with contemporaneous forward discounts. As indicated by the R^2 of this regression, our trade-based variable explains a substantial portion of the cross-sectional variation in the average interest rate differentials across countries, as well as in average returns. This variation is clearly not driven entirely by country size as suggested by Hassan (2013), since the U.S. as well as the U.K. are in the middle of the distribution of the import/export variable (as well as of the average forward discount, which equals zero for the U.S. by construction). Controlling for the logarithm of country GDP in a manner similar to Hassan (2013) shows a relation between country size and and currency risk premia subsumed by the import ratios in the full sample. In the G10 country sample both variables are significant. Controlling for a lagged 3-year rolling average of log CPI changes as a measure of inflation forecast weakens somewhat the predictive power of the import ratio for the cross-section of average returns, but does not eliminate it, and inflation itself does not seem to predict future excess returns. Inflation is strongly related to forward discounts, but its inclusion leaves the coefficients on the import ratio largely unchanged and highly significant for the full sample. While the power is reduced for the G10 sample, the import ratio remains significant in all cases. This evidence is consistent with the model's prediction that the import ratio contains relevant information about the real interest rate differential and currency risk premia. For countries that experienced high inflation for a sustained period of time in our sample forward discounts are less informative about risk premia since they are dominated by expected inflation, which on average translates into depreciation of the high-yielding currency (e.g., Bansal and Dahlquist (2000)).

3.4 Real Exchange Rates and Relative Productivity

A key implication of our model mechanism is the tight link between real exchange rates and productivity differentials in the final good sectors across countries. In order to test this prediction we construct measures of real exchange rates and relative productivities for the key "commodity" and "producer" countries vis-a-vis their main trading partners (based on the imports and exports data). We consider the four commodity countries against their primary

Figure 6: Import Ratios vs. Forward Discounts and FX Returns



This figure plots forward discounts and excess FX returns against the import ratio for each country in our IMF Advanced Economies sample. The import ratio is calculated as

$$\frac{\text{Net Imports of Complex Goods} + \text{Net Exports of Basic Goods}}{\text{Manufacturing Output}},$$

Both forward discounts and FX returns are calculated from the perspective of a U.S. investor. Underlined observations are the averages for the Pre Euro period and non-underlined observations are the average of the Post Euro period. For each period both average returns and discounts are adjusted by subtracting the period mean for all countries.

Table 2: Cross-Sectional Regressions of FX Returns and Forward Discounts

Panel A: IMF Advanced Economies

	Fama-Macbeth Regressios of FX Returns					Fama-Macbeth Regressions of Forward Discounts				
VARIABLES	FX Ret	FX Ret	FX Ret	FX Ret	FX Ret	Fwd Dsct	Fwd Dsct	Fwd Dsct	Fwd Dsct	Fwd Dsct
Import Ratio	0.29*		0.25*	0.25*	0.20+	0.23**		0.23**	0.14**	0.13**
	(0.12)		(0.12)	(0.12)	(0.11)	(0.03)		(0.04)	(0.03)	(0.03)
Log GDP		-0.65**	-0.33		-0.29		-0.30**	-0.03		-0.04
		(0.25)	(0.20)		(0.21)		(0.04)	(0.06)		(0.04)
Inflation				0.22	0.20				0.29**	0.30**
				(0.21)	(0.22)				(0.04)	(0.04)
Constant	0.65	10.25*	5.17	-0.08	4.03	0.04	4.51**	0.36	-1.75**	-1.17
	(1.31)	(4.31)	(3.69)	(2.25)	(4.18)	(0.50)	(0.57)	(1.04)	(0.62)	(0.92)
Obs	4,542	4,542	4,542	4,542	4,542	4,550	4,550	4,550	4,550	4,550
R-squared	0.13	0.07	0.18	0.22	0.26	0.27	0.05	0.29	0.49	0.51
Number of Months	304	304	304	304	304	304	304	304	304	304

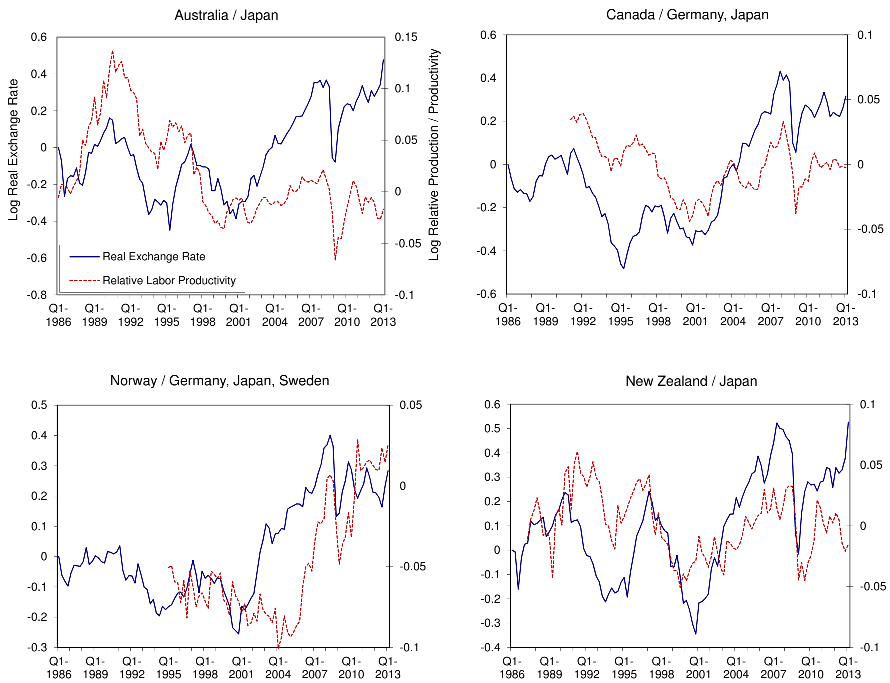
Panel B: G10 Currencies

	Fama-Macbeth Regressios of FX Returns					Fama-Macbeth Regressions of Forward Discounts				
VARIABLES	FX Ret	FX Ret	FX Ret	FX Ret	FX Ret	Fwd Dsct	Fwd Dsct	Fwd Dsct	Fwd Dsct	Fwd Dsct
Import Ratio	0.31*		0.24*	0.33**	0.20+	0.27**		0.21**	0.14**	0.07+
	(0.13)		(0.12)	(0.13)	(0.11)	(0.03)		(0.05)	(0.04)	(0.04)
Log GDP		-0.90*	-0.43		-0.55		-0.65**	-0.26*		-0.27**
		(0.42)	(0.39)		(0.41)		(0.08)	(0.11)		(0.09)
Inflation				0.14	0.12				0.32**	0.35**
				(0.23)	(0.24)				(0.06)	(0.08)
Constant	0.61	14.08*	6.88	0.50	8.67	-0.12	9.54**	3.54+	-1.99**	1.76
	(1.32)	(6.92)	(6.50)	(2.40)	(7.11)	(0.48)	(1.35)	(1.93)	(0.60)	(1.36)
Obs	3,047	3,047	3,047	3,047	3,047	3,048	3,048	3,048	3,048	3,048
R-squared	0.16	0.14	0.26	0.29	0.39	0.40	0.21	0.46	0.59	0.64
Number of Months	304	304	304	304	304	304	304	304	304	304

Newey-West Standard Errors in Parentheses
** p<0.01, * p<0.05, + p<0.10

This table shows cross-sectional regressions of FX returns and forward discounts on the Import ratio as well as log of GDP and lagged 3-year inflation. Regressions are monthly using the previous calendar year's values of the independent variables. Fama-Macbeth standard errors are calculated using the Newey-West method with 36 lags. Data are monthly from 1988 to 2012.

Figure 7: Real Exchange Rates and Relative Productivity



trading partners: Australia vs. Japan; Canada vs. Germany and Japan; New Zealand vs. Japan; and Norway vs. Germany, Japan, and Sweden.

It is difficult to construct a proxy for complex good manufacturing productivity at high frequencies, so as a proxy we use quarterly data on aggregate labor productivity from the OECD. The real exchange rate for each country is first calculated with respect to the U.S. (or equivalently any base currency) for each country i as $CPI^i \times Q^i / CPI^{US}$, where CPI data and currency values for each country are again from the OECD, where Q^i is the nominal exchange rate of country i in the units of US dollars. Countries' productivity and exchange rate series are aggregated in baskets by taking logs of the (equal weighted) geometric averages across countries. Relative productivities are then the differences of the two baskets' ("producer" and "commodity") average productivities. Figure 8 depicts the relative productivity differentials and real exchange rates for the four commodity countries and their producer country trading partners. In all of the cases the relative productivity measure appears to comove quite strongly with the real exchange rate.

Table 3.4 presents the results of regressions of the exchange rates between commodity and finished good producer-countries. Panel A presents evidence from regression of changes in average relative productivity over one or two quarters on the change in the corresponding basket real exchange rate over the same quarter, or the first quarter in the case of the two quarter specification. The latter approach is meant to capture time-aggregation of the underlying productivity series. The regression coefficients are always positive, and statistically significant in all cases with the exception of Norway. The R^2's are also quite sizeable, ranging between 5% and 20%, which suggests that relative productivity differentials comove with real exchange rates in a way consistent with our model's predictions.Panel B reports results for differences of real exchange rates and productivity ratios. While the raw regression coefficients are only robustly positive in the case of Norway vis-a-vis the group of its main trading partners, when a time trend is included, the slope coefficients are positive and highly statistically significant for the other countries, indicating strong comovement between real exchange rates and productivity differentials.

3.5 Relative Productivity and Real Interest Rate differentials

The model also predicts that the movement in the real interest rate differentials is also driven by relative productivity, since it is the only state variable. Indeed, Figure 8 demonstrates that a measure of real interest rate differentials for the pairs of countries described above, here constructed using an AR(1) specification with 5-years of lagged CPI changes to create forecasts of inflation, comoves very closely with the corresponding relative productivity variable. Table 3.5 presents corresponding regression results. For all of the countries excluding Norway, the relationship between relative productivity and real interest rate differentials is strong and significant either in innovations or in levels.

3.6 Currency portfolios sorted on Import/Export data

In order to examine the patterns of average excess returns predicted by the model, we sort all of the countries in our sample into 5 portfolios (4 for the subsample of G10 countries) using the lagged import ratio. Specifically, in the beginning of January for each year t we sort currencies based on the export ratio that is based on the trade data for the year $t-2$.

Table 3: Real Exchange Rates and Relative Labor Productivity: G10 Commodity Countries

Panel A: Innovations

	Aus vs. Jap		Can vs. Ger, Jap		Nor vs Ger, Jap, Swe		NZ vs Jap	
	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$
$\Delta RER_{t,t+1}$	0.044**	0.085*	0.051**	0.101**	0.037	0.078	0.075**	0.117**
	(0.015)	(0.034)	(0.013)	(0.029)	(0.042)	(0.071)	(0.019)	(0.039)
Constant	-0.000	-0.001	-0.001	-0.001	0.001	0.002	-0.000	-0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Obs.	111	110	91	90	75	74	105	104
R^2	0.052	0.107	0.114	0.203	0.018	0.049	0.090	0.126

Panel B: Levels

	Aus vs. Jap		Can vs. Ger, Jap		Nor vs Ger, Jap, Swe		NZ vs Jap	
	RP_t	RP_T	RP_t	RP_T	RP_t	RP_T	RP_t	RP_T
RER_t	-0.021	0.093**	0.018	0.084**	0.139**	0.013	0.030	0.070**
	(0.027)	(0.029)	(0.014)	(0.013)	(0.027)	(0.047)	(0.019)	(0.016)
Trend		-0.001**		-0.001**		0.001**		-0.001**
		(0.000)		(0.000)		(0.000)		(0.000)
Constant	0.106	-0.293**	0.151**	0.324**	0.066	0.325*	0.075*	0.255**
	(0.040)	(0.040)	(0.038)	(0.078)	(0.080)	(0.146)	(0.036)	(0.095)
Obs.	112	112	92	92	76	76	106	106
R^2	0.012	0.557	0.056	0.609	0.424	0.552	0.062	0.319

Standard errors in parentheses
** $p<0.01$, * $p<0.05$

Table shows regressions of the real exchange rate against relative levels of labor productivity. Each commodity country's exchange rate and relative productivity (the log difference of producer country and commodity country productivities) is calculated with respect to an equal weighted basked of its primary trading partners among the producer countries. Germany's exchange rate is calculated using the Euro post 1999. All exchange rates are converted to real using the relative value of the country CPI. Data are Quarterly. Panel A shows regressions of changes in relative productivity against changes in the real exchange rate. Each country includes two specifications, the first is of contemporaneous quarterly changes in relative productivity against contemporaneous changes in the real exchange rates, and the second is the sum of the contemporaneous quarter and the next quarter's change in relative productivity against this quarters change in real exchange rates to account for time-aggregation. Panel B shows regressions of levels of relative productivity against the level of the real exchange rate, both with and without and a time-trend. Newey-West standard errors with 4 lags are shown in parentheses.

Table 4: Real Interest Rates and Relative Labor Productivity: G10 Commodity Countries

Panel A: Innovations

	Aus vs. Jap		Can vs. Ger, Jap		Nor vs Ger, Jap, Swe		NZ vs Jap	
	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$	$\Delta RP_{t,t+1}$	$\Delta RP_{t,t+2}$
$\Delta RER_{t,t+1}$	0.331	0.711*	0.061	0.658*	-0.317	-0.088	0.299	0.934**
	(0.242)	(0.349)	(0.222)	(0.293)	(0.247)	(0.289)	(0.366)	(0.256)
Constant	-0.000	-0.001	-0.000	-0.001	0.001	0.002	-0.000	-0.000
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Obs.	101	101	88	88	72	72	101	101
R^2	0.016	0.043	0.001	0.065	0.015	0.001	0.014	0.080

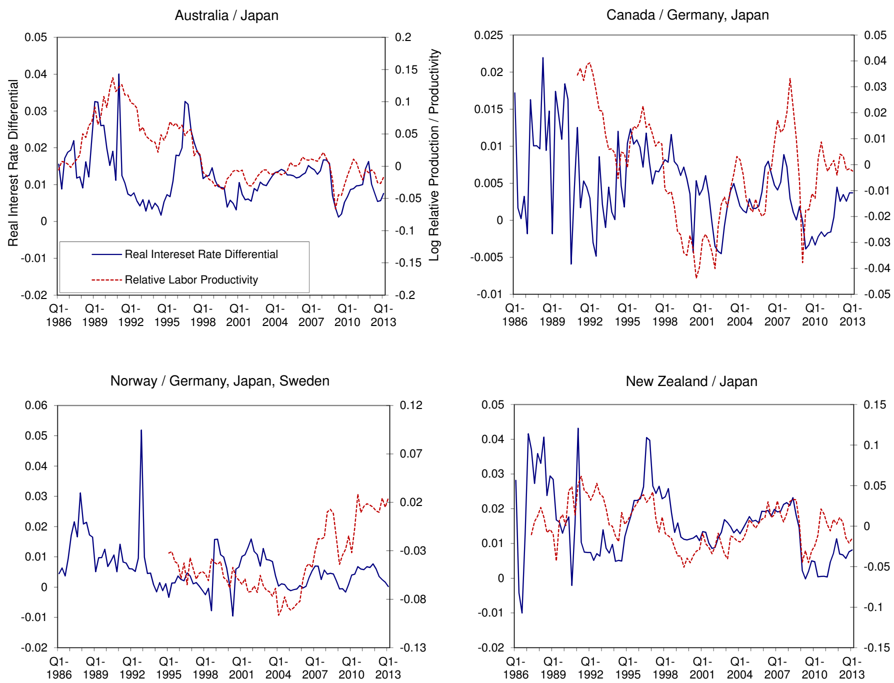
Panel B: Levels

	Aus vs. Jap		Can vs. Ger, Jap		Nor vs Ger, Jap, Swe		NZ vs Jap	
	RP_t	RP_t	RP_t	RP_t	RP_t	RP_t	RP_t	RP_t
RIR_t	2.680**	1.380**	1.607**	1.826**	-0.371	-0.283	0.805*	0.567
	(0.804)	(0.487)	(0.201)	(0.243)	(1.026)	(0.862)	(0.382)	(0.473)
Trend		-0.001**		0.000		0.001**		-0.000
		(0.000)		(0.000)		(0.000)		(0.000)
Constant	-0.012	0.069**	0.151**	0.324**	0.066	0.325*	0.075*	0.255**
	(0.040)	(0.040)	(0.038)	(0.078)	(0.080)	(0.146)	(0.036)	(0.095)
Obs.	101	101	89	89	73	73	101	101
R^2	0.181	0.626	0.486	0.503	0.003	0.500	0.076	0.124

Standard errors in parentheses
** p<0.01, * p<0.05

Table shows regressions of the relative real interest rate against relative levels of labor productivity. Each commodity country's relative interest rate and relative productivity is calculated with respect to an equal weighted basked of its primary trading partners among the producer countries as in Table 3.4. Germany's interest rate is calculated using the Euro post 1999. All interest rates are converted to real by using predicted inflation calculated using the predicted value from a rolling AR(1) regression us the last 5-years of quarterly CPI data. Newey-West standard errors with 4 lags are shown in parentheses.

Figure 8: Real Interest Rate Differentials and Relative Productivity



This is because countries report their trade statistics to COMTRADE slowly, sometimes with complete reports available only by the end of the following year.

The construction of these portfolios represents an implementable trading strategy, relying only on trade data from available at the time of portfolio formation. Average forward discounts and average returns are computed from 1988-2012.

We work with one-month forward and spot exchange rates in units of foreign currency per U.S. dollar, denoted by F_t and S_t, respectively. Using the individual currency one-month forward discounts $f_t - s_t$ (lower case letters representing logarithms) and log excess returns approximated as

$$rx_{t+1} = f_t - s_{t+1},$$

we compute the log currency excess return rx^j_{t+1} for each portfolio $j = 1, 2 \ldots, 6$ by averaging over N_j currencies in the portfolio:

$$rx^j_{t+1} = \frac{1}{N_j} \sum_{i \in N_j} rx^i_{t+1}. \tag{18}$$

Similarly, currency portfolio excess returns (in levels) RX^j are computed by averaging individual currency excess returns in levels, $RX^i = (F_t^i - S_{t+1}^i)/S_t^i$ analogously to (18). We do not take into account bid/ask spreads in the construction of these portfolios at the monthly frequency. Since our portfolios require very little rebalancing, transaction costs are likely to be small (returns based on long-horizon, e.g. one-year, forward contracts are typically similar to those obtained by rolling over shorter-horizon contracts; we report the results using one-year forward contracts with bid-ask spreads in the Data Appendix.).[9]

The results are reported in Panel I of Table 5. The results using both sorts are very similar: portfolios representing large complex good exports and basic good imports relative to their output have low average forward discounts, suggesting that they capture countries whose interest rates are typically low relative to the U.S. Conversely, portfolios with high values of commodity exports and low values of final good exports exhibit high average forward discount, indicating high average interest rates. The pattern is virtually monotonic across portfolios, especially for developed countries subsample, with differences between the highest and the lowest portfolios' average forward discounts of around 4% per annum for the basic good sort over 5% per annum for the complex good sort.

Importantly, portfolio average excess returns follow the pattern of the average forward discounts, being negative for the low portfolios and positive for the high portfolios, with the spreads in average returns between extreme portfolios close to 4% per year for both the basic good sort and the complex good sort. Thus, the differences in the average forward discounts translate almost fully into average excess returns, contrary to the UIP hypothesis. Since the sorting variables are very persistent, these differences are likely to capture unconditional rather than conditional risk premia. To facilitate comparison with traditional carry-trade strategies, we sort countries based on forward discounts at the same frequency as the import-sorted portfolios. That is, each January we sort currencies based on their forward discount vis-a-vis the U.S. dollar at the end of December. This puts the import sort on equal footing with the carry-trade sort in the sense that the information used to update the portfolios arrives at the same frequency (in both cases the portfolios are rebalanced monthly). The annual

[9]The portfolio is rebalanced to handle the introduction of the Euro. Prior to 1999 breakpoints are calculated including the component countries of the Euro as separate entities. Post 1999 the breakpoints are recalculated counting the Eurozone as a single country.

portfolio formation period departs from the traditional method of sorting currencies based on the current interest rate in each month as in Lustig, Roussanov, and Verdelhan (2011). The resulting annual sort displays somewhat less variation in average forward discounts across portfolios and a narrower spread in average excess returns that the month sort as in Lustig, Roussanov, and Verdelhan (2011). Average forward discounts and excess returns for these portfolios are shown in Panel II of Table 5. Both the spread in the average forward discounts and that in average excess returns are essentially of the same magnitude as those in the obtained using the import ratio sort in Panel I.

3.7 Explaining the carry trade with IMX factor

Lustig, Roussanov, and Verdelhan (2011) show that carry-sorted exhibit strong factor structure that implies heterogeneity in countries' SDFs exposures to a global source of risk, which is corroborated by the fact that average returns on carry portfolios line up with loadings on a common factor. If our model is a good description of such heterogeneity in risk exposures then import-sorted portfolios should exhibit similar properties. As a candidate for the risk factor capturing global SDF shocks we consider returns on a portfolio which is long the portfolio with the highest import ratio and short the lowest import ratio. We refer to this strategy as IMX (*Importers minus eXporters* of finished goods).

Table 6 present results of standard asset pricing tests using both the full sample of countries and the smaller G10 sample. Panel lists displays cross-sectional estimates of the IMX market price of risk λ_{IMX} and the corresponding SDF loading b_{IMX} using both the SDF-GMM methodology and the Fama-MacBeth approach, together with the cross-sectional pricing error tests. Panel II lists estimated time-series estimates of factor loadings β^i_{IMX} for each portfolio as well as the pricing error α^i_0, as well as the joint test statistics for the alphas. The tests show that the prices of risk and factor loadings, while imprecisely estimated (given the relatively short length of the sample) are nevertheless statistically significant using most methods and are broadly consistent in magnitudes with the mean of the IMX factor (4.53% in the full sample and 4.11% in the G10 sample. More importantly, the pricing errors are not statistically significant either individual or jointly using any method. Factor betas are essentially monotonically increasing in the import ratio. This evidence is consistent with the

Table 5: Currency Portfolios Sorted on Combined Imports/Exports Measure

Portfolio	1	2	3	4	5	1	2	3	4
	Panel I: Portfolios Sorted on Import Ratios								
	All Countries					G10 Countries			
	Forward Discount: $f^j - s^j$					$f^j - s^j$			
Mean	−0.45	−0.41	0.70	0.67	2.58	−1.93	0.42	1.24	2.52
Std	0.73	0.66	0.78	0.60	0.52	0.70	0.71	0.51	0.54
	Log Excess Return: rx^j					rx^j			
Mean	−0.95	0.36	0.84	0.96	3.76	−0.87	0.36	1.38	3.49
Std	8.57	11.11	8.42	7.73	9.67	9.56	10.80	7.08	9.69
SR	−0.11	0.03	0.10	0.12	0.39	−0.09	0.03	0.20	0.36
	Excess Return: Rx^j					Rx^j			
Mean	−0.36	1.03	1.30	1.40	4.41	−0.24	1.00	1.77	4.14
Std	8.55	11.09	8.36	7.69	9.62	9.58	10.75	7.03	9.64
SR	−0.04	0.09	0.16	0.18	0.46	−0.02	0.09	0.25	0.43
	Panel II: Portfolios Sorted on Forward Discounts								
	All Countries					G10 Countries			
	Forward Discount: $f^j - s^j$					$f^j - s^j$			
Mean	−2.30	−0.67	0.66	1.61	3.78	−2.18	−0.02	1.28	3.51
Std	0.64	0.57	0.58	0.69	0.81	0.63	0.50	0.61	0.78
	Log Excess Return: rx^j					rx^j			
Mean	−0.24	1.33	3.32	2.81	4.07	−0.28	2.80	2.58	4.24
Std	9.45	9.62	9.59	8.71	10.27	10.04	8.51	8.89	10.29
SR	−0.03	0.14	0.35	0.32	0.40	−0.03	0.33	0.29	0.41
	Excess Return: Rx^j					Rx^j			
Mean	0.33	1.91	3.86	3.32	4.79	0.38	3.27	3.08	4.96
Std	9.47	9.64	9.60	8.65	10.20	10.09	8.49	8.84	10.23
SR	0.04	0.20	0.40	0.38	0.47	0.04	0.39	0.35	0.48

This table reports average forward discounts and average (log and level) excess returns on currency portfolios sorted on the Import Ratio (panel I) and on log forward discounts (panel II). The Import Ratio is constructed by adding the level of net exports in basic goods to the level of net imports in finished goods, and then dividing by the level of manufacturing output of the country, as prescribed by the model. The rankings are updated at the end of each using the prior year's trade data or current forward discounts. Trade data are annual, from UN Comtrade (available via NBER extracts). Forward and spot exchange rate data are monthly, from Barclays and Reuters (available via Datastream). The returns do not take into account bid-ask spreads. The sample period is 2/1988 to 4/2013.

notion that the spread in average returns on import-sorted portfolios is driven by differences in exposures to a common source of risk captured by the IMX strategy.

Table 6 presents similar evidence but now using the carry-sorted portfolios as the test assets for the IMX factor. At the level of individual portfolios the factor betas exhibit the same monotonic pattern, increasing with interest rate differential. Individual pricing errors are not statistically significantly different from zero, and are jointly at only at 10% level (p-value of 9.32%) in the full sample. The implied prices of risk are somewhat larger (but not statistically significantly so). This is potentially due to the somewhat smaller spread in betas, indicating potential measurement error problems stemming either from the mismeasurement of real interest rate differentials using forward discounts or, more likely, of the import ratios constructed using trade data. This evidence broadly indicates, however, that the import-sorted and carry-sorted portfolios share a common source of risk that drives heterogeneity in average returns, consistent with the model's predictions.

3.8 Differences in risk exposure across countries

To further shed light on the underlying mechanism, we now turn to the relation between carry-trade strategies and the salient variables of the model.

The model's key prediction is that commodity country consumption is less risky than that of the final good-producing country. While our two-country model is too stylized to be taken to the data directly, we provide evidence by grouping countries that more closely resemble the two types. We form two baskets of G10 currency countries, the four "commodity countries" of Australia, Canada, New Zealand, and Norway, and the four "producer countries" of Japan, Eurozone / Germany, Sweden and Switzerland. Table 8 displays the standard deviation of quarterly consumption growth rates for the two baskets over the period 1993-2012. As the model predicts, aggregate consumption growth of final goods producers is more volatile than that of commodity producers (1.25% per annum vs. 0.88%).

The model predicts that producer country consumption is more sensitive to the global productivity shocks that are transmitted into the carry trade, rising faster in good times (when carry strategy does well) and declining in bad times (when carry trade does poorly). We can evaluate this prediction by computing the consumption betas for the commodity-

Table 6: Asset Pricing Tests: Portfolios Sorted by Import Ratio

Panel I: Risk Prices										
	All Countries					G10 Countries				
	λ_{IMX}	b_{IMX}	R^2	$RMSE$	χ^2	λ_{IMX}	b_{IMX}	R^2	$RMSE$	χ^2
GMM_1	5.71	0.65	37.71	1.16		4.70	0.43	−12.59	1.58	
	[3.23]	[0.37]			68.19	[2.89]	[0.27]			55.03
GMM_2	4.50	0.51	29.67	1.23		4.31	0.40	−13.52	1.59	
	[2.00]	[0.23]			74.92	[2.35]	[0.22]			55.59
FMB	5.71	0.65	86.92	1.16		4.70	0.43	83.98	1.58	
	[2.37]	[0.27]			73.62	[2.05]	[0.19]			48.21
	[2.39]	[0.27]			74.93	[2.05]	[0.19]			49.12
$Mean$	4.53					4.11				

Panel II: Factor Betas										
	All Countries					G10 Countries				
$Portfolio$	α_0^j	β_{IMX}^j	R^2	$\chi^2(\alpha)$	$p-val$	α_0^j	β_{IMX}^j	R^2	$\chi^2(\alpha)$	$p-val$
1	1.52	−0.36	13.18			2.03	−0.49	23.46		
	[1.70]	[0.08]				[1.80]	[0.08]			
2	0.93	0.09	0.54			1.03	0.06	0.26		
	[2.34]	[0.11]				[2.45]	[0.12]			
3	1.31	0.05	0.23			0.95	0.21	8.34		
	[1.84]	[0.09]				[1.51]	[0.08]			
4	0.63	0.20	5.06			2.03	0.51	25.60		
	[1.71]	[0.09]				[1.80]	[0.08]			
5	1.52	0.64	32.39							
	[1.70]	[0.08]								
				1.80	87.60				2.17	70.53

Notes: The panel on the left reports results for all countries in our sample. The panel on the right reports results for the G10 group of developed countries with most widely-traded currencies. Panel I reports results from GMM and Fama-McBeth asset pricing tests. Market prices of risk λ, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes stochastic discount factor loadings on the IMX strategy return. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas and alphas (pricing errors) for each of the portfolios. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1987) standard errors computed with the optimal number of lags according to Andrews (1991). The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey-West variance-covariance matrix (1 lag) for the system of equations (see **?**, p. 234). Data are monthly, from Barclays and Reuters in Datastream. The sample period is 2/1988–4/2013. The alphas are annualized and in percentage points.

currency carry trade factor IMX using both baskets. As indicated in Table 8, producer country consumption is almost twice as sensitive to the carry returns, compared to the commodity-country consumption, with IMX betas of 0.033 for the producer basket and

Table 7: Asset Pricing Tests: Portfolios Sorted by Forward Discounts

Panel I: Risk Prices										
	All Countries					G10 Countries				
	λ_{IMX}	b_{IMX}	R^2	$RMSE$	χ^2	λ_{IMX}	b_{IMX}	R^2	$RMSE$	χ^2
GMM_1	10.58	1.20	78.20	1.21		7.84	0.72	56.64	1.67	
	[7.17]	[0.81]			61.94	[4.06]	[0.38]			21.54
GMM_2	12.12	1.38	75.87	1.27		6.20	0.57	52.09	1.75	
	[4.43]	[0.50]			64.07	[3.20]	[0.30]			24.03
FMB	10.58	1.20	78.21	1.21		7.84	0.72	75.48	1.67	
	[4.21]	[0.48]			13.42	[2.56]	[0.24]			11.30
	[4.43]	[0.50]			18.19	[2.60]	[0.24]			12.99
$Mean$	4.53					4.11				

Panel II: Factor Betas										
	All Countries					G10 Countries				
$Portfolio$	α_0^j	β_{IMX}^j	R^2	$\chi^2(\alpha)$	$p-val$	α_0^j	β_{IMX}^j	R^2	$\chi^2(\alpha)$	$p-val$
1	−0.78	−0.22	4.27			0.54	−0.43	19.16		
	[1.84]	[0.08]				[1.83]	0.09			
2	−1.75	0.11	1.11			−0.63	0.11	1.36		
	[1.95]	[0.10]				[1.86]	0.08			
3	1.58	0.15	2.06			2.69	0.22	5.35		
	[1.99]	[0.09]				[1.93]	0.09			
4	2.31	0.23	5.15			3.04	0.44	16.66		
	[1.88]	[0.09]				[2.07]	0.09			
5	2.81	0.44	13.46							
	[2.16]	[0.11]								
				9.43	9.32				7.02	13.48

Notes: The panel on the left reports results for all countries in our sample. The panel on the right reports results for the G10 group of developed countries with most widely-traded currencies. Panel I reports results from GMM and Fama-McBeth asset pricing tests. Market prices of risk λ, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes stochastic discount factor loadings on the IMX strategy return. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas and alphas (pricing errors) for each of the portfolios. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1987) standard errors computed with the optimal number of lags according to Andrews (1991). The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey-West variance-covariance matrix (1 lag) for the system of equations (see **?**, p. 234). Data are monthly, from Barclays and Reuters in Datastream. The sample period is 2/1988–4/2013. The alphas are annualized and in percentage points.

0.013 for commodity countries. The short sample makes for imprecise estimates, and the high volatility of the IMX factor relative to changes in consumption growth makes for low absolute magnitudes of the betas, but the final goods producers' consumption beta is significant at the

10% level using OLS standard errors (though not significantly different from the commodity countries betas).

The small magnitudes of the consumption betas are a reflection of the well-known puzzle highlighted by Backus and Smith (1993), who show that the relative rates of consumption growth are often uncorrelated with variations in exchange rates, and to the extent that they are correlated, the correlations are often of the wrong sign. For our set of countries and over this time period we find that the sign of the correlation is consistent with the model, though the correlations are low, indicating a weaker version of the Backus-Smith puzzle.

One possible explanation for this weak relation in consumption is a peso-type problem. In this view, the low correlation between relative consumption levels and exchange rates may be an artifact of short time-series samples that include few large movements in consumption and exchange rates. As potential evidence in support of this explanation, in Section 3.9 below we consider the global recession of 2008-2009 as a case study, and find that levels of consumption growth in countries exporting manufactured goods were impacted more negatively than those of commodity-exporting countries, consistent with our model. An alternative explanation for the weak correlation between exchange rates and aggregate consumption growth rates may be financial market imperfections *within* countries. In particular, Hassan (2013) considers an economy where only a subset of households within a country participate in global financial markets as in Alvarez, Atkeson, and Kehoe (2002) (although Ramanarayanan and Cociuba (2011) show that such form of market segmentation does not necessarily solve the Backus-Smith puzzle). Finally, the Backus-Smith puzzle could be resolved within the representative-agent setting under non-separable preferences (e.g., Colacito and Croce (2011), Stathopoulos (2011)).

Another important test of the mechanism in the model is the exposure of different countries' marginal utility to shocks to global productivity. The model predicts that wealth of commodity exporting (and complex good importing) countries should have lower exposure to global economic shocks and hence IMX. While we do not observe aggregate wealth holdings, we can attempt to approximate them using equity market wealth. To this end we collect country specific MSCI equity indices for 19 developed countries. For each country we perform

Table 8: Riskiness of aggregate consumption baskets, data

Portfolio	σ	β_{IMX}
Commodity Producers	0.92	0.013
	(0.09)	(0.009)
Final Goods Producers	1.40	0.033
	(0.18)	(0.014)

This table reports summary statistics from consumption portfolios formed on a country's commodity-making or final-good-producing status. The data are quarterly and taken from the OECD. The countries for which data for consumption and forward contracts are available are ranked according to the average import export measure used in constructing IMX. The commodity and final goods producers are the top and bottom third respectively. Consumption growth is calculated as the average growth rate of consumption weighted by the GDP of each country. Annualized standard deviations are estimated using quarterly growth rates for the time period from first-quarter 1988 until fourth-quarter 2012. Consumption betas are with respect to the quarterly IMX return. Standard errors are bootstrapped for the standard deviations and OLS for the IMX Betas.

a regression of the return to the equity index on the return to IMX.

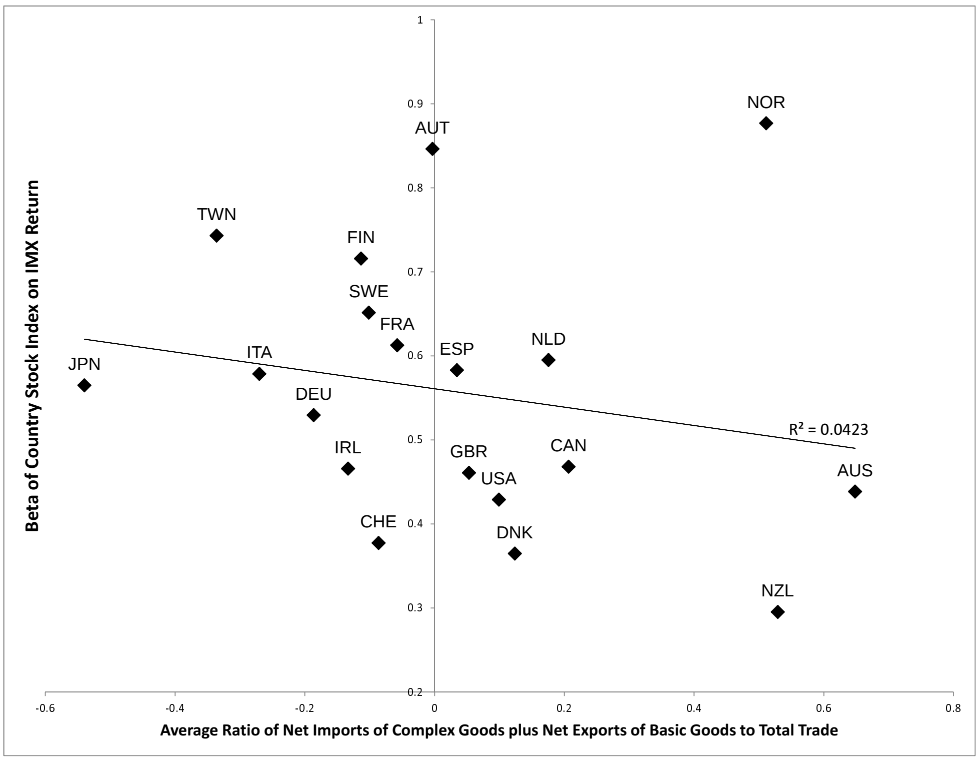
$$R^e_{j,t} = \alpha^e_j + \beta^e_j IMX_t + e_{j,t} \tag{19}$$

Figure 9 shows a graph of the β_j for each country as a function of the import-ratio of complex goods. The graph shows, that withe the notable exception of Norway, β_j tends to be a decreasing function of the import ratio. In other words, stock returns in countries which tend to be importers of these goods have less exposure to the innovations to IMX, again consistent with the predictions of the model.

3.9 Case study: the global financial crisis

As a further illustration of the model mechanisms in the data, we examine the behavior of model variables during the global financial crisis, which coincided with a dramatic decline in output, especially among final good producer countries, such as Japan, and a collapse in international trade volume (e.g. see Eaton, Kortum, Neiman, and Romalis (2011)). As Figure 10 shows, the data lines up nicely with the model predictions over this period. Panel A shows that the commodity currencies tended to depreciate relative to final good producer

Figure 9: Stock Market Betas and Import Ratios



This figure plots the betas from the regression

$$R^e_{j,t} = \alpha^e_j + \beta^e_j IMX_t + e_{j,t}$$

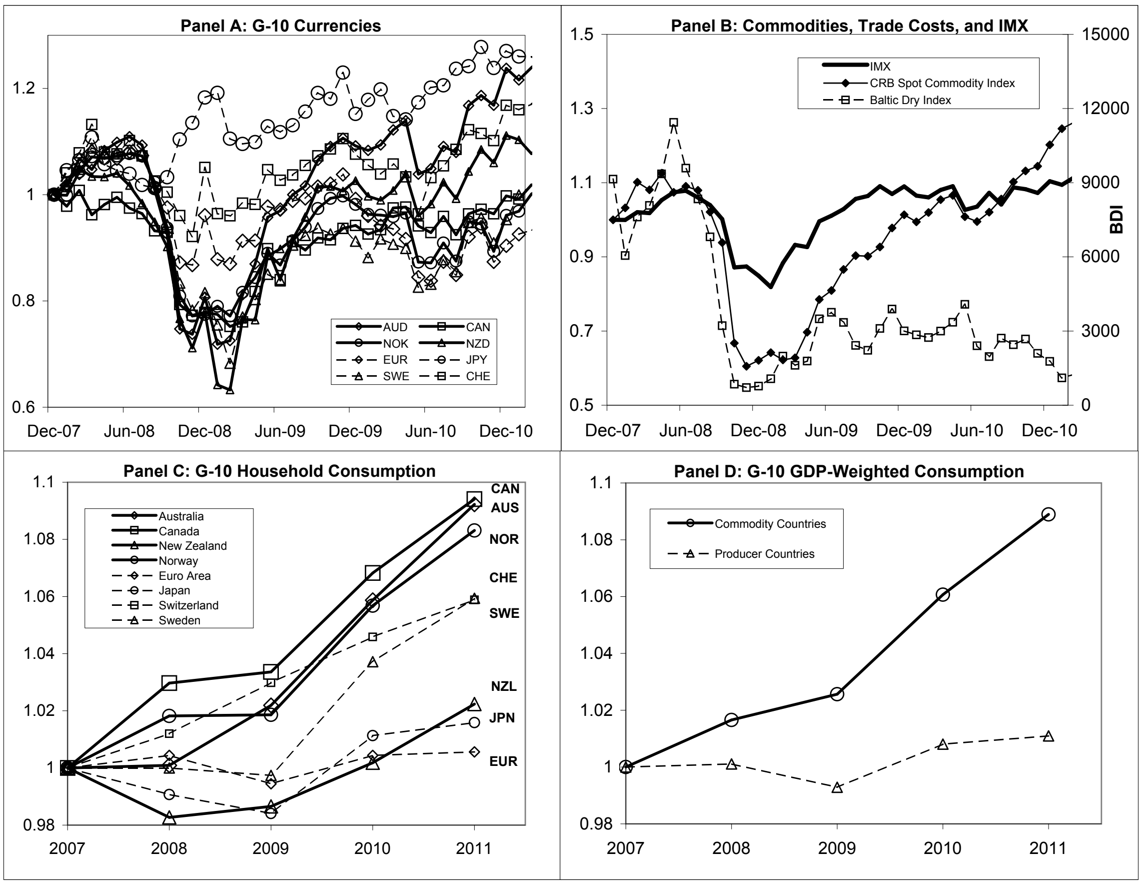
where $R_{j,t}$ is the return to the market equity index for each developed country j. Betas are plotted against each country's combined import/export ratio measure as described in Table 5. Equity returns are from global financial data. Data is monthly from 1988 to 2012, from Datastream.

currencies during the crisis. Panel B illustrates that this is reflected in a large negative return on the IMX strategy, and that this return is accompanied by large negative changes in the CRB Commodity Spot Index and the Baltic Dry Index. Perhaps most importantly, even though commodity prices were dropping during this period, Panel C shows household consumption growth of the commodity countries did not fall as severely as that of the producer countries. The outliers are two of the smaller countries, New Zealand and Switzerland. Panel D shows that a GDP-weighted basket of commodity countries' consumption growth greatly outperforms that of final goods producers during the crisis.

4 Conclusion

We present new evidence on the currency carry trade: countries that specialize in exporting basic goods such as raw commodities tend to exhibit high interest rates where as countries primarily exporting finished goods have lower interest rates on average. These interest rate differences translate almost entirely into average returns on currency carry trade strategies. We propose a novel mechanism that helps rationalize these findings: comparative advantage in production of different types of goods combined with convex trade costs and time-varying capacity of the shipping industry. Nonlinearity of the trade costs, as well as the ability of the commodity country to insure itself through domestic production, imply that the SDF of the country that is more efficient at producing the consumption good is more sensitive to productivity shocks, making its currency a "safe haven" and commodity country currency risky. Our model's empirical predictions are strongly supported in the data.

Figure 10: Currencies, Commodities, Trade Costs, and Consumption During the Crisis



Currency and economic variables during the global financial crisis. Panel A shows monthly cumulative currency returns on the four G10 "commodity countries" (Australia, Canada, New Zealand, and Norway) and the four G10 "producer countries" (Europe, Japan, Switzerland, and Sweden). Panel B shows the monthly performance of the IMX strategy as well as monthly changes in the Commodity Research Bureau All Commodity spot index and the Baltic Dry Index (BDI). Panel C shows household consumption of the eight countries, and Panel D shows the consumption growth of GDP-weighted baskets of the two country groups. All exchange rate, commodity price, and consumption variables normalized to one in December 2007. Data from Datastream and the OECD.

References

Alvarez, Fernando, Andrew Atkeson, and Patrick J. Kehoe, 2002, Money, interest rates and exchange rates with endogenously segmented markets, *Journal of Political Economy* 110(1), 73–112.

Andrews, Donald W.K., 1991, Heteroskedasticity and autocorrelation consistent covariance matrix estimation, *Econometrica* 59, 817–858.

Backus, David, Patrick Kehoe, and Finn Kydland, 1992, International real business cycles, *Journal of Political Economy* 100, 745–75.

Backus, David, and Gregor Smith, 1993, Consumption and real exchange rates in dynamic economies with non-traded goods, *Journal of International Economics* 35, 297–316.

Backus, David K, Patrick J Kehoe, and Finn E Kydland, 1994, Dynamics of the Trade Balance and the Terms of Trade: The J-Curve?, *American Economic Review* 84, 84–103.

Bakshi, Gurdip, Peter Carr, and Liuren Wu, 2008, Stochastic risk premiums, stochastic skewness in currency options, and stochastic discount factors in international economies, *Journal of Financial Economics* 87, 132–156.

Bakshi, Gurdip, and George Panayotov, 2013, Predictability of currency carry trades and asset pricing implications, *Journal of Financial Economics* 110, 139 – 163.

Bansal, Ravi, and Magnus Dahlquist, 2000, The forward premium puzzle: Different tales from developed and emerging economies, *Journal of International Economics* 51, 115–144.

Bansal, Ravi, and Ivan Shaliastovich, 2012, A long-run risks explanation of predictability puzzles in bond and currency markets, *Review of Financial Studies.*

Campbell, John Y., Karine Serfaty De Medeiros, and Luis M. Viceira, 2010, Global currency hedging, *Journal of Finance* 65, 87–121.

Colacito, R., and M. Croce, 2012, International asset pricing with recursive preferences, *Journal of Finance, forthcoming.*

Colacito, Riccardo, and Mariano M. Croce, 2010, Risk Sharing for the Long-Run: A General Equilibrium Approach to International Finance with Recursive Preferences and Long-Run Risks, *SSRN eLibrary*.

———, 2011, Risks for the long run and the real exchange rate, *Journal of Political Economy* 119, 153–182.

Dumas, Bernard, 1992, Dynamic equilibrium and the real exchange rate in a spatially separated world, *Review of Financial Studies* 5, 153–80.

Eaton, Jonathan, Samuel Kortum, Brent Neiman, and John Romalis, 2011, Trade and the global recession, Working Paper 16666 National Bureau of Economic Research.

Ferraro, Domenico, Barbara Rossi, and Kenneth S. Rogoff, 2011, Can Oil Prices Forecast Exchange Rates?, *Duke University Working Paper*.

Fitzgerald, Doireann, 2012, Trade costs, asset market frictions, and risk sharing, *American Economic Review* 102, 2700–2733.

Harrison, J. Michael, 1985, *Brownian Motion and Stochastic Flow Systems* (John Wiley & Sons: New York).

Hassan, Tarek A., 2013, Country size, currency unions, and international asset returns, *The Journal of Finance* 68, 2269–2308.

Hollifield, Burton, and Raman Uppal, 1997, An examination of uncovered interest rate parity in segmented international commodity markets, *Journal of Finance* 52, 2145–2170.

Koijen, Ralph S.J., Lasse Heje Pedersen, Tobias J. Moskowitz, and Evert B. Vrugt, 2012, Carry, Chicago Booth working paper.

Lettau, Martin, Matteo Maggiori, and Michael Weber, 2013, Conditional risk premia in currency markets and other asset classes, Working Paper 18844 National Bureau of Economic Research.

Lewis, Karen K., 1995, Puzzles in international financial markets, in G. Grossman, and K. Rogoff, ed.: *Handbook of International Economics, Vol.III* (Elsevier: Amsterdam).

Lustig, Hanno, Nikolai Roussanov, and Adrien Verdelhan, 2011, Common risk factors in currency returns, *Review of Financial Studies* 24, 3731–3777.

——— , 2013, Countercyclical currency risk premia, *Journal of Financial Economics, forthcoming.*

Lustig, Hanno, and Adrien Verdelhan, 2007, The cross-section of foreign currency risk premia and consumption growth risk, *American Economic Review* 97, 89–117.

Lyons, Richard K., 2001, *The Microstructure Approach to Exchange Rates* (MIT Press).

Martin, Ian, 2011, The Forward Premium Puzzle in a Two-Country World, *NBER Working Paper no. 17564.*

Menkhoff, Lukas, Lucio Sarno, Maik Schmeling, and Andreas Schrimpf, 2012, Carry trades and global foreign exchange rate volatility, *Journal of Finance* 67 (2), 681–718.

Newey, Whitney K., and Kenneth D. West, 1987, A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55, 703–708.

Obstfeld, Maurice, and Kenneth Rogoff, 2001, The six major puzzles in international macroeconomics: is there a common cause?, in *NBER Macroeconomics Annual 2000, Volume 15* . pp. 339–412 (MIT press).

Pavlova, Anna, and Roberto Rigobon, 2007, Asset prices and exchange rates, *Review of Financial Studies* 20, 1139–1180.

Ramanarayanan, Ananth, and Simona E. Cociuba, 2011, International risk sharing with endogenously segmented asset markets, Discussion paper.

Shanken, Jay, 1992, On the estimation of beta-pricing models, *The Review of Financial Studies* 5, 1–33.

Stathopoulos, Andreas, 2011, Asset prices and risk sharing in open economies, working paper.

———, Andrea Vedolin, and Philippe Mueller, 2012, International correlation risk, working paper.

Stokey, Nancy . , 2009, (Princeton University Press: 41 William Street, Princeton, New Jersey 08540).

Verdelhan, Adrien, 2010, A habit-based explanation of the exchange rate risk premium, *Journal of Finance* 65, 123–145.

Appendix

4.1 Additional Derivations and Proofs

Consumption dynamics

Define $\Phi(z) = \frac{z_c\phi^* z + \frac{1}{2\kappa}(1-\phi^* z)^2}{1+\phi^* z\omega(z)}$, then

$$\frac{dc_c}{c_c} = \frac{dz_p}{z_p} + \left[\frac{\phi^* z(z_c - \frac{1-\phi^* z}{\kappa})}{z_c\phi^* z + \frac{1}{2\kappa}(1-\phi^* z)^2} - \frac{\phi^* z\omega(z)\left(1-\frac{1}{\gamma}\right)}{1+\phi^* z\omega(z)}\right]\frac{dz}{z} + \frac{1}{2}\frac{\Phi''(z)}{\Phi(z)}\sigma_z^2 dt \tag{A-1}$$

$$\frac{dc_p}{c_p} = \frac{\omega'(z)}{\omega(z)}dz + \frac{1}{2}\frac{\omega''(z)}{\omega(z)}dz^2 + \frac{dc_c}{c_c} + \frac{\omega'(z)}{\omega(z)}dz\frac{dc_c}{c_c} \tag{A-2}$$

$$= -\frac{1}{\gamma}\frac{dz}{z} + \frac{1}{2}\frac{1}{\gamma}\left(\frac{1}{\gamma}+1\right)\frac{dz^2}{z^2} + \frac{dc_c}{c_c} - \frac{1}{\gamma}\frac{dz}{z}\frac{dc_c}{c_c} \tag{A-3}$$

Relative productivity

To focus on the countries' relative productivities, we project the imperfectly correlated Brownian motions dB_{ct} and dB_t onto each other, leaving a residual that is a stochastic integral with respect to an independent Brownian motion, B_{zt}: more specifically, we construct $dB_{ct} = \rho dB_{zt} + \sqrt{1-\rho^2}dB_t$. We then define z by the equation $z_p z \doteq z_{cp}$ and derive z_{cp} from here.

$$z_p z \doteq z_{cp} \tag{A-4}$$

$$dz_p z + z_p dz + dz dz_p = dz_{cp} \tag{A-5}$$

$$zz_p(\mu dt + \sigma dB) + (\mu_{zt}dt + \sigma_z dB_z + dL - dU)z_p = \mu(z_{cp})dt + \sigma(z_{cp})dB_c \tag{A-6}$$

$$= \mu(z_{cp})dt + \sigma(z_{cp})\left(\rho dB_z + \sqrt{1-\rho^2}dB\right) \tag{A-7}$$

We then need to solve a system of three equations for $\mu(z_c)$, $\sigma(z_c)$ and ρ:

$$\begin{aligned} \mu(z_c)dt &= z\mu z_p dt + \mu_{zt}z_p dt + z_p dL - z_p dU \\ \sigma(z_c)\rho &= \sigma_z z_p \\ \sigma(z_c)\sqrt{1-\rho^2} &= z\sigma z_p \end{aligned}$$

Solving this system we get $\rho = \sqrt{\frac{\sigma_z^2}{\sigma_z^2+z^2\sigma^2}}$, $\sigma(z_{cp}) = z_p\sqrt{\sigma_z^2 + z^2\sigma^2}$, and $\mu(z_{cp})dt = \mu_{zt}z_p dt + z\mu z_p dt - z_p dU + z_p dL$. The projection implies an interesting result: the processes for z_{cp} and z_p are highly correlated when their technologies for producing the final good are similar—when z_{cp} is close to z_p. To see this, when z increases, then ρ decreases, and thus the correlation between dB_c and dB, $\sqrt{1-\rho^2}$, increases. All together, we get a stochastic process z that takes values on $(\underline{z}, 1)$:

$$dz = \mu_{zt}dt + \sigma_z dB_z - dU + dL.$$

Before formally defining $U(t)$ and $L(t)$, first define $z(t)$ as the sum of an arithmetic Brownian motion $x(t) = x_0 + \int_0^t \mu_{zt}dt + \int_0^t \sigma_z dB_{zt}$ and the two regulators $U(t)$ and $L(t)$: $z(t) = x(t) - U(t) + L(t)$. Now define a stopping time T_0 as the first date when $x(t) = \underline{z}$ with initial condition $x(0) = x_0 > \underline{z}$:

$$L(t) = \begin{cases} 0, & t \leq T_0, \text{ all } \omega \\ \underline{z} - \min_{s\in[0,t]} x(s), & t > T_0, \text{ all } \omega \end{cases}$$

Thus, $L(t)$ is continuous and non-decreasing, $L(0) = 0$, and only increases if $z(t) = \underline{z}$.

Now define a stopping time T_1 as the first date when $x(t) = 1$ with initial condition

$x(0) = x_0 < 1$:

$$U(t) = \begin{cases} 0, & t \leq T_1, \text{ all } \omega \\ \max_{s\in[0,t]} x(s) - 1, & t > T_1, \text{ all } \omega \end{cases}$$

Thus, $U(t)$ is continuous and non-decreasing, $U(0) = 0$, and only increases if $z(t) = 1$.

Construction of the stochastic processes $U(t)$ and $L(t)$ for two boundaries $\underline{z} < 1$ with initial condition $x_0 \in [\underline{z}, 1]$ proceeds by induction, following Stokey (2009, p.202), and culminates in her Proposition 10.1 that states the regulated Brownian motion $z(t)$ is

$$z(t) = x(t) - U(t) + L(t), \text{ all } t,$$

where $L(t)$ and $U(t)$ are stochastic processes, and (L, U, z) have the following properties:

1. L and U are continuous and nondecreasing, with $L_0 = U_0 = 0$
2. $z(t)$ satisfies $z(t) \in [\underline{z}, 1]$, all t
3. $L(t)$ only increases when $z(t) = \underline{z}$; $U(t)$, when $z(t) = 1$

An important fact is

$$\mathbb{E}[(dz)^2] = \mathbb{E}[(dx)^2] = \sigma_z^2 dt.$$

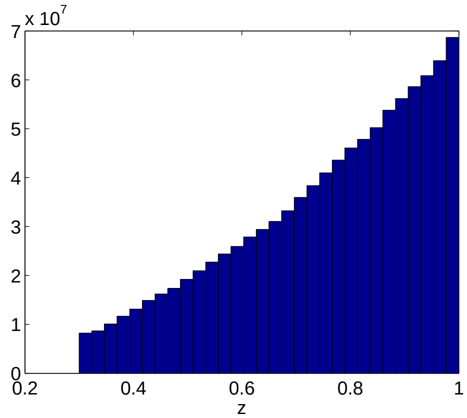
Because we specify the drift of the process to be non-constant ($\mu_z = \sigma_z^2/z$), a closed-form solution for the stationary density is unavailable. Instead, we simulate a process bounded by 0.3 and 100 million times and plot the kernel density in Figure 11. The stationary density is tilted and has more mass near the upper boundary.

Proof of Lemma 2. To do this, we fix an initial condition $z_0 \in [\underline{z}, 1]$ and define a localizing process of stopping times $0 = \tau_0 < \tau_1 < \tau_2 < \cdots \to \infty$ by

$$\tau_{n+1} = \min\{t > \tau_n | z(t) = z_0 \text{ and } z(s) = \underline{z} \text{ and } z(s') = 1, \text{ for some } \tau_n < s, s' < \tau_{n+1}\}.$$

Thus each stopping time is defined by having z_t reach each threshold, $\underline{z}$ and 1, and then to return to the initial condition z_0. Because of the boundedness of the process, each of these

Figure 11: Histogram of simulated stationary density of relative productivity shock



stopping times is finite with probability one and importantly

$$z_{\tau_n} = z_0, \text{ for all } n.$$

Because Ito's lemma for regulated processes holds for all t, we can choose $t = \tau_1$ so that $z_{\tau_1} = z_0$, and therefore an application of the lemma to the real exchange rate process S (and using $\mu_{zt} = \sigma_z^2/z_t$) gives

$$\begin{aligned} 0 &= -\int_0^{\tau_1} \frac{1}{\phi^* z^2}\left(\mu_z dt + \sigma_z dB_z + dL - dU\right) + \int_0^{\tau_1} \frac{1}{\phi^* z^3}\sigma_z^2 dt \\ &= -\frac{1}{\phi^* \underline{z}^2}\int_0^{\tau_1} dL + \frac{1}{\phi^*}\int_0^{\tau_1} dU - \int_0^{\tau_1} \frac{\sigma_z}{\phi^* z^2} dB_z, \end{aligned}$$

where the second equality uses the fact that dL is only positive when $z = \underline{z}$ and dU is only positive when $z = 1$. Taking expectations of this process conditional on our starting value for z gives

$$\frac{1}{\underline{z}^2}\mathbb{E}\left[\int_0^{\tau_1} dL \middle| S_0 = S(z_0)\right] = \mathbb{E}\left[\int_0^{\tau_1} dU \middle| S_0 = S(z_0)\right].$$

Because this equality holds for any arbitrary starting value within the boundaries, our expectation holds almost everywhere. Applying the conditional expectation operator to $\frac{dS}{S}$, given in (16) gives

$$\mathbb{E}_t\left[\frac{dS}{S}\right] = 0.$$

By definition, our localized process is a local martingale, and because the process is bounded it is a martingale. ∎

Proof of Proposition 1. First, we define for convenience a function of z

$$s(z) \doteq \frac{\frac{1}{2\kappa}(1-\phi^* z)^2}{z_c \phi^* z + \frac{1}{2\kappa}(1-\phi^* z)^2},$$

and the risk premium function

$$\varphi(z) \doteq \gamma \sigma_z^2 \frac{1}{z^2} \left[s(z) \frac{(1+\phi^* z)}{1-\phi^* z} - \frac{1-\frac{1}{\gamma}}{1+\phi^* z \omega(z)} \right].$$

Positivity of risk premium

In the case of log utility the risk premium function φ becomes

$$\varphi(z) = \sigma_z^2 \frac{1}{z^2} s(z) \frac{(1+\phi^* z)}{1-\phi^* z}. \tag{A-8}$$

We set z_c high enough such that $\phi^* < 1$ so that $s(z)$ is always positive. The risk premium, additionally, is also always positive.

Positivity of interest rate differential

To see that the interest rate differential is positive, note that since the real exchange rate process is a martingale, the interest-rate differential equals the risk premium and therefore under the same condition on ϕ^* is (almost surely) positive.

Import ratio

Even though in our model the trade cost is a pure dead weight loss, in order to be consistent with the available measures of imports and exports in our empirical work we define the import ratios omitting the losses due to trade costs and specify them as

$$IR_c \doteq \frac{XS + xpS}{y_{cp} S} \tag{A-9}$$

$$IR_p \doteq -\left(\frac{X + xpS}{y_p} \right) \tag{A-10}$$

$$\Delta IR \doteq IR_c - IR_p = \frac{\frac{1}{\kappa}(\frac{1}{\phi^* z} - 1) + x}{z_c - x} + \frac{(1-\phi^* z)\frac{1}{\kappa} + x}{x}. \tag{A-11}$$

Under log utility, the quantity of commodity exports becomes

$$x = \frac{\lambda}{1+\lambda} z_c + \frac{1}{1+\lambda} \frac{X}{z_p} \left(1 + (1 - \tau(X, z_k)) \frac{\lambda}{\phi^* z} \right) \tag{A-12}$$

$$= \frac{\lambda}{1+\lambda} \left[z_c + \frac{X}{z_p} \frac{1}{\lambda} + \frac{X}{z_p} (1 - \tau(X, z_k)) \frac{\lambda}{\phi^* z} \right] \tag{A-13}$$

and it is easy to see that

$$\frac{\partial x}{\partial z} = -\frac{\lambda}{1+\lambda} \left(\frac{\phi^*}{\kappa\lambda} + \frac{1}{2\kappa} \left(\frac{1}{\phi^* z^2} + \phi^* \right) \right) < 0 \tag{A-14}$$

So differentiating (A-11) gives

$$\frac{\partial \Delta IR}{\partial z} = \frac{\left(-\frac{1}{\phi^* z^2 \kappa} + \frac{\partial x}{\partial z} \right) (z_c - x) + \left(\left(\frac{1}{\phi^* z} - 1 \right) \frac{1}{\kappa} + x \right) \frac{\partial x}{\partial z}}{(z_c - x)^2} + \frac{\left(-\frac{\phi^*}{\kappa} + \frac{\partial x}{\partial z} \right) x - \left((1 - \phi^* z) \frac{1}{\kappa} + x \right) \frac{\partial x}{\partial z}}{x^2} \tag{A-15}$$

$$= \frac{-\frac{1}{\phi^* z^2 \kappa} (z_c - x) + \frac{\partial x}{\partial z} z_c + \left(\frac{1}{\phi^* z} - 1 \right) \frac{1}{\kappa} \frac{\partial x}{\partial z}}{(z_c - x)^2} - \frac{\frac{\phi^*}{\kappa} x + (1 - \phi^* z) \frac{1}{\kappa} \frac{\partial x}{\partial z}}{x^2}, \tag{A-16}$$

which we need to be less than zero. There are two cases in which it is: (i) $x^2 \geq (z_c - x)^2$ and (ii) $x^2 < (z_c - x)$. The first case is trivially satisfied because $\frac{1}{\phi^* z} - 1 > 1 - \phi^* z \Leftrightarrow (1 - \phi^* z)^2 \geq 0$. The second case requires making z_c "large enough", requiring the following condition to hold:

$$z_c + \left(\frac{1}{\phi^* z} - 1 \right) \frac{1}{\kappa} \left(\frac{x}{z_c - x} \right)^2 > (1 - \phi^* z) \frac{1}{\kappa}, \tag{A-17}$$

which is an easier condition to satisfy than

$$z_c > (1 - \phi^* \underline{z}) \frac{1}{\kappa}, \tag{A-18}$$

which is required by Lemma 1 and thus holds given our choice of $z_c > z_c^*$. The difference in import ratios, therefore, is monotonically decreasing in z.

Monotonicity in z of risk premium and interest rate differential

To show monotonicity, we differentiate the risk premium function with respect to z:

$$\varphi'(z) = \sigma_z^2 \left(-2\frac{1}{z^3} s(z) \frac{1+\phi^* z}{1-\phi^* z} + \frac{1}{z^2} \left(\frac{s'(z)(1+\phi^* z)(1-\phi^* z) + 2\phi^* s(z)}{(1-\phi^* z)^2} \right) \right) \tag{A-19}$$

$$= \sigma_z^2 \left(\frac{1}{z^2} s'(z) \frac{1+\phi^* z}{1-\phi^* z} - 2\frac{s(z)}{z^3(1-\phi^* z)^2}(1-\phi^* z(1+\phi^* z)) \right) < 0 \tag{A-20}$$

Because $s'(z) < 0$, This last equation holds if $1 - \phi^* z - (\phi^* z)^2 > 0$, or equivalently requiring $1 > \max_{z \in [\underline{z}, 1]} z\phi^* + z^2(\phi^*)^2 = \phi^* + (\phi^*)^2$ or equivalently $z_c > \left(\frac{2}{\sqrt{5}-1} \alpha^\alpha (1-\alpha)^{1-\alpha} \right)^{\frac{1}{1-\alpha}} \doteq F(\alpha)$, by plugging in the equation for ϕ^* and rearranging terms. This last function $F(\alpha)$ has a maximum of $\frac{2}{\sqrt{5}-1}$ on $\alpha \in [0, 0.8651)$, so we restrict our choice of α to that interval and set $z_c > \frac{2}{\sqrt{5}-1}$.

Because the growth of the real exchange rate $\frac{dS}{S}$ follows a martingale, the monotonicity of the risk premium function also implies that the interest rate differential is monotone in z as well.

∎

Data Appendix

This appendix describes the details of data construction and the robustness of empirical results.

4.1 Pairwise Returns

To show that the trading strategies are both unconditional in nature, and not driven by any one currency pair, we present the returns of currency pairs for each combination of short a final good producer currency and long a commodity country currency, as well as portfolios of all commodity countries or all producer countries. Table A-1 shows the results.

4.2 Classification of goods

We assign individual goods to "Basic" (input) and "Complex" (finished) groups based on the descriptions of 4-digit SITC (Revision 4) categories available from the U.N. Table A-2 lists classifications aggregated at a 2-digit SITC level, with the number of 4-digit sub-categories falling into each of the two groups. Detailed breakdown is available upon request.

4.3 Currency strategies and transaction costs

We investigate the effect of transaction costs on the profitability of trading strategies based on the combined export/import sort. We use bid-ask quotes for forward and spot exchange rates from Reuters. Lyons (2001) reports that bid and ask quotes published by Reuters imply bid-ask spreads that are approximately twice as large as actual inter-dealer spreads. We assume that net excess returns take place at these quotes. As a result, our estimates of the transaction costs are conservative, at least from the standpoint of a large financial institution. Since our strategy is based on sorting currencies using trade data that is available at annual frequency, a natural approach for minimizing the transaction costs is to use one-year forward contracts. Therefore, we compute returns on rolling one-year forward contracts, but in order to avoid the arbitrary choice of the starting month, we construct the portfolio returns at monthly frequency (i.e., using overlapping yearly returns). Table A-3 lists the average depreciation of

Table A-1: Pairwise Currency Strategy Returns

Long Leg		Short Leg				
		Europe / Germany	Japan	Sweden	Switzer-land	Producer Country Portfolio
Australia	Return	3.90	5.22*	3.20	4.25	4.14*
	SE	(2.41)	(3.10)	(2.34)	(2.68)	(2.33)
	SR	0.09	0.10	0.08	0.09	0.10
Canada	Return	1.82	3.14	1.12	2.17	2.06
	SE	(2.21)	(2.71)	(2.16)	(2.47)	(2.04)
	SR	0.05	0.07	0.03	0.05	0.06
Norway	Return	2.14*	3.46	1.44	2.49	2.38*
	SE	(1.23)	(2.66)	(1.36)	(1.62)	(1.31)
	SR	0.10	0.07	0.06	0.09	0.11
New Zealand	Return	3.77*	5.09*	3.07	4.12*	4.01*
	SE	(2.18)	(2.89)	(2.22)	(2.35)	(2.08)
	SR	0.10	0.10	0.08	0.10	0.11
Commodity Country Portfolio	Return	2.91*	4.22	2.21	3.26*	3.15**
	SE	(1.64)	(2.56)	(1.64)	(1.96)	(1.54)
	SR	0.10	0.10	0.08	0.10	0.12

Robust standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Excess mean returns and Sharpe ratios on pairwise and portfolio trading strategies for G10 commodity and final producer currencies. Returns are calculated using monthly forward returns for a strategy going long a commodity country currency of Australia, Canada, Norway, and New Zealand (or an equal weighted portfolio of all four), and short a producer country currency of Europe (or the German Deutschmark Pre-1999), Japan, Sweden, and Switzerland (or an equal weighted porftolio). White (1980) standard errors in parentheses. Data is 1988 to 2012, and returns do not include transaction costs.

Table A-2: COMTRADE Goods Classification

SITC	Description	Sub-categories classified as Basic	Complex
00	Live animals	13	2
01	Meat and meat preparations	14	0
02	Dairy products and eggs	10	0
03	Fish and fish preparations	12	0
04	Cereals and cereal preparations	24	0
05	Fruit and vegetables	25	1
06	Sugar, sugar preparations and honey	4	4
07	Coffee, tea, cocoa, spices and manufacs. thereof	10	5
08	Feed. Stuff for animals excl. Unmilled cereals	6	0
09	Miscellaneous food preparations	5	0
11	Beverages	0	7
12	Tobacco and tobacco manufactures	4	4
21	Hides, skins and fur skins, undressed	9	0
22	Oil seeds, oil nuts and oil kernels	14	0
23	Crude rubber including synthetic and reclaimed	5	0
24	Wood, lumber and cork	14	0
25	Pulp and paper	0	7
26	Textile fibres, not manufactured, and waste	32	0
27	Crude fertilizers and crude minerals, nes	23	0
28	Metalliferous ores and metal scrap	22	0
29	Crude animal and vegetable materials, nes	11	0
32	Coal, coke and briquettes	8	0
33	Petroleum and petroleum products	2	11
34	Gas, natural and manufactured	0	4
35	Electric energy	0	2
41	Animal oils and fats	3	0
42	Fixed vegetable oils and fats	14	0
43	Animal and vegetable oils and fats, processed	5	0
51	Chemical elements and compounds	0	28
52	Crude chemicals from coal, petroleum and gas	0	14
53	Dyeing, tanning and colouring materials	0	11
54	Medicinal and pharmaceutical products	0	8
55	Perfume materials, toilet and cleansing preptions	0	9
56	Fertilizers, manufactured	0	5
57	Explosives and pyrotechnic products	0	4
58	Plastic materials, etc.	0	28
59	Chemical materials and products, nes	0	13
61	Leather, lthr. Manufs., nes and dressed fur skins	9	5
62	Rubber manufactures, nes	2	10
63	Wood and cork manufactures excluding furniture	2	12
64	Paper, paperboard and manufactures thereof	0	15
65	Textile yarn, fabrics, made up articles, etc.	0	58
66	Non metallic mineral manufactures, nes	0	39
67	Iron and steel	8	26
68	Non ferrous metals	26	0
69	Manufactures of metal, nes	0	32
71	Machinery, other than electric	0	25
72	Electrical machinery, apparatus and appliances	0	36
73	Transport equipment	0	10
81	Sanitary, plumbing, heating and lighting fixt.	0	4
82	Furniture	0	4
83	Travel goods, handbags and similar articles	0	2
84	Clothing	0	35
85	Footwear	0	2
89	Miscellaneous manufactured articles, nes	0	39
94	Animals, nes, incl. Zoo animals, dogs and cats	2	0
95	Firearms of war and ammunition therefor	0	2

Each row represents a 2-digit Standard International Trade Classification category according to SITC Rev. 4. The classification columns show the number of 4-digit sub-categories classified as each type of good (Basic or Complex). Descriptions are from the United Nations Statistics Division.

the currencies in each portfolio, average (log) forward discount, and average excess returns with and without bid-ask spreads applied.

Table A-3: One-Year Returns on Import/Export Sorted Portfolios, All Countries

Portfolio	1	2	3	4	5	6
			Spot Change: Δs^j (without b-a)			
Mean	0.08	−0.37	−1.03	0.37	1.33	−0.50
Std	6.77	9.90	9.36	8.87	9.19	9.14
			Forward Discount: $f^j - s^j$			
Mean	−0.48	1.29	1.15	1.99	2.19	2.23
Std	1.87	2.19	2.39	2.29	1.32	1.63
			Log Excess Return: rx^j (without b-a)			
Mean	−0.56	1.66	2.18	1.61	0.86	2.73
Std	7.29	9.93	9.15	8.99	9.45	9.18
SR	−0.08	0.17	0.24	0.18	0.09	0.30
			Excess Return: rx^j (without b-a)			
Mean	0.01	2.32	2.80	2.29	1.62	3.38
Std	7.09	9.93	9.42	8.87	9.80	9.39
SR	0.00	0.23	0.30	0.26	0.17	0.36
			Net Excess Return: rx^j_{net} (with b-a)			
Mean	0.27	2.07	2.61	2.08	1.40	3.17
Std	7.16	9.93	9.39	8.84	9.78	9.38
SR	0.04	0.21	0.28	0.24	0.14	0.34
			High-minus-Low: rx^j_{net} (without b-a)			
Mean		2.31	2.79	2.28	1.61	3.37
Std		6.57	6.58	5.93	7.59	6.96
SR		0.35	0.42	0.38	0.21	0.48
			High-minus-Low: $rx^j_{net} - rx^1_{net}$ (with b-a)			
Mean		1.80	2.34	1.81	1.13	2.90
Std		6.58	6.58	5.95	7.60	6.92
SR		0.27	0.36	0.30	0.15	0.42

Note: Portfolios are rebalanced annually. Reported returns are sampled monthly with overlap. Sample is 1/1988-12/2012.