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LEVERAGING EXCESS RETURN: THE CARRY TRADE AND THE CONSUMPTION-BASED CAPITAL ASSET PRICING MODEL

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ABSTRACT

In this thesis, I investigate the violation of uncovered interest rate parity in the foreign exchange market. Bias in the pricing of forward exchange rates relative to future spot exchange rates suggests there are profitable opportunities in the spot market. The carry trade is an investment strategy in which an investor borrows in a low interest rate currency and invests the proceeds in an asset denominated in a high interest rate currency like a certificate of deposit, government bond, or equity share. The positive excess returns generated by carry trades for many exchange rates in this paper contradict the uncovered interest rate parity condition. This paper uses a variant of the Consumption-Based Capital Asset Pricing Model (C-CAPM) articulated by John Cochrane to assess the predictability of carry trade excess returns. Ordinary least squares and robust regressions show that the magnitude of C-CAPM's ability to explain variation in excess returns can be strong in certain time periods, but is time-varying in general. A fixed effects univariate panel regression more clearly demonstrates that the excess returns for all of the funding currencies can have between 45% and 76% of their variation over explained by C-CAPM. The model also explains a substantial percentage of the variation in carry trades going long on one-year government bonds and large cap equity indices. The results of this paper suggest that excess returns of the carry trade are forecastable with C-CAPM, but the strength of the model's forecasting power varies across countries and time.

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Chapter 1

Introduction

One of the best professional applications of macroeconomics is creating models that determine the value of assets. This is relevant for institutions like banks and financial services companies, but it is also important for individuals who must decide how to allocate their assets throughout their life. The largest market in terms of the volume of trading is the foreign exchange market, a global decentralized market for the trading of currencies. Markets for other financial assets like equities and bonds are dependent on foreign exchange trade, so it is essential to understand the behavior of the foreign exchange market to understand other asset markets.

An investment strategy in the foreign exchange market that has gained attention recently in international finance and economics literature is the carry trade. The carry trade is an investment strategy in which an institutional investor borrows in a low interest rate currency and invests that currency in a higher-yielding asset denominated in a foreign currency like a certificate of deposit, an equity index, or a government bond. The idea behind the carry trade is that it exploits violations of uncovered interest rate parity arising from the forward premium puzzle. Namely, risk-averse investors overestimate the depreciation of high interest rate currencies in the forward market, which leads to profitable opportunities in the spot market. However, the carry trade has downside risk when a high interest rate currency depreciates, which forces investors to exit their position at the same time and causes further depreciation.

The purpose of this paper is to use a model to explain the excess returns of the carry trade over a long time horizon. In Chapter 2, I review the literature on the efficient market hypothesis, uncovered interest rate parity, the forward premium puzzle, and the carry trade itself. In Chapter 3, I outline a Consumption-Based Capital Asset Pricing Model from John Cochrane's *Asset Pricing* (2001) and explain how I will apply it to carry trade excess returns. In Chapter 4, I cite analysis of the role of the carry trade in the 2007-2008 global financial crisis with a focus on the yen carry trade. In Chapter 5, similarly, I cite analysis of the carry trade in the era of monetary policy accommodation following the global financial crisis. In Chapter 6, I describe the sources of data I used for research in this paper. In Chapter 7, I assess the empirical results utilizing ordinary least squares regressions, robust regressions, fixed effects univariate pooled panel regressions, and Hausman tests. In Chapter 8, I conclude by identifying the broader applicability of the Consumption-Based Capital Asset Pricing Model to a variety of asset classes.

Chapter 2

Literature Review

The significance of the efficient market hypothesis to the field of economics is perhaps best reflected in the announcement in 2013 that the Riksbank Prizes in Economic Sciences had been awarded to Eugene Fama and Robert Shiller, both of whom have devoted extensive research on the subject. However, the significance of the efficient market hypothesis is complemented by contemporary disagreement over its merits. Fama originated the hypothesis in his seminal 1970 paper, "Efficient Capital Markets: A Review of Empirical Work" and Shiller once called the hypothesis "one of the most remarkable errors in the history of economic thought" (Fox). The fact that substantial disagreement among economists over the efficient market hypothesis remains at present signifies the need for further research on the subject.

In Fama (1970), market efficiency is defined as the state in which prices always "fully reflect" all available information. The implication is that, if investors have a given information set at period t (Φ_t), the expected price in period t+1 of an asset ($(E(p_{j,t+1})\| \Phi_t)$ should be a function of the price of an asset in period t ($p_{j,t}$) and the expected one-period gross return ($(E(1+r_{j,t+1})\| \Phi_t)$ at time t. Fama's basic equation for asset prices is the following:

(1) $E(p_{j,t+1}\| \Phi_t) = E((1+r_{j,t+1})\| \Phi_t)p_{j,t}$

The idea underlying the efficient market hypothesis is that the current price, $p_{j,t}$, should be unaffected if Φ_t is available to all investors. The notion of an expected one-period return on an asset is characterized as a function of risk (Fama, 1970). Thus, under this hypothesis, the difference between the p_t and $(E(p_{j,t+1})\| \Phi_t)$ should be attributed to the existence of a premium which compensates an investor for assuming risk. In this context, the efficient market hypothesis dictates that assets cannot be vulnerable to arbitrage if Φ_t is equal for both parties in a trade. Even though $(E(p_{j,t+1}) \| \Phi_t)$ might not be equal to $p_{j,t}$, this is not necessarily an arbitrage opportunity because risk-averse investors demand compensation for assuming risk. This compensation is reflected in a time-varying risk premium.

Another implication of the definition of market efficiency is that there should be no trading system based only on Φ_t that can produce excess returns greater than equilibrium excess returns. The equation for expected returns in excess of equilibrium expected returns, $z_{j,t+1}$, can be stated as the following:

(2) $z_{j,t+1} = r_{j,t+1} - E(r_{j,t+1} \| \Phi_t)$

If markets are efficient, then the following must be true:

(3) $E(z_{j,t+1} \| \Phi_t) = 0$

We can define $z_{j,t+1}$ as a forecast error, the product of information not available in Φ_t. This fact indicates that the efficient markets model, specifically the random walk model, implies successive price changes (or successive one-period returns) are independent (Fama, 1970). A natural consequence of this phenomenon is that successive changes (or returns) have an identical distribution (Fama, 1970). In essence, the idea that asset prices follow random walks implies

(4) $f(r_{j,t+1} \| \Phi_t) = f(r_{j,t+1})$,

which means the entire distribution of $r_{j,t+1}$ is independent of Φ_t.

There is evidence in empirical literature that asset prices do not follow random walks. In the stock market, shares of small companies outperform the market in January (the “January effect”) and all stock prices tend to rise by more than average on the month’s final trading day (the “turn-of-the-month” effect), the day before a public holiday (the “holiday effect”), and on Friday (the “weekend” effect) (The Economist, 2013). Moreover, Shiller found that stock prices are more volatile than the efficient-market hypothesis would predict, because the hypothesis characterizes stock prices as dividends discounted at a constant rate (Fox). In a finding concerning multiple asset classes, Froot (1990) found that excess returns for stocks, bonds, and currencies are all negatively correlated with short-term interest rates: "If the U.S. short rate falls by one percentage point, the results suggest that excess returns rise by 2.488 percent" (Froot, 1990, 19).

While there has been extensive research in the relevance of the random walk model for stock markets, the finding in Meese and Rogoff (1983) that the best forecasting model for currencies was a random walk model raises important questions for asset pricing in general. In Meese and Rogoff (1983), the random walk model performed no worse than estimated univariate time series models, an unconstrained vector autoregression, or candidate structural models in forecasting major bilateral rates and the trade-weighted dollar. These models were originally tested with data from the 1970s, but Meese and Rogoff found that the models did not fit the data outside of the original sample. The out-of-sample failure of these models leads Meese and Rogoff to raise the idea that "major-country exchange rates are well-approximated by a random walk model (without drift)" (Meese and Rogoff, 1983, 21). They do, however, add that the exchange rate does not exactly or even closely follow a random walk: "However, given our finding that the random walk model almost invariably has the lowest root mean square error over all horizons and across all exchange rates, we *can* unambiguously assert that the other models do not perform significantly better than the random walk model. And while the random walk model may be as good a predictor as any of major-country exchange rates, it does not predict well" (Meese and Rogoff, 1983, 17). Yet, while it is not evident that exchange rates follow a random walk, it remains difficult to identify a specific source of market inefficiency underlying exchange rate movements. Whether such a market inefficiency is non-existent or has yet to be discovered is an open question.

The random walk model has significant implications in a body of literature that attempts to construct a general model of asset prices. Cochrane (2005) introduces a Consumption-Based Capital Asset Pricing Model (C-CAPM) in which the price of an asset is

(5) $p_t = E_t[(\beta\frac{u'(c_{t+1})}{u'(c_t)}\frac{\pi_t}{\pi_{t+1}})x_{t+1}]$,

where β is the stochastic discount factor, $u'(c_t)$ is the marginal utility of the representative consumer, π_t is the price level (i.e. CPI) of goods, and x_{t+1} is the payoff in period t+1. Cochrane's model has useful applications in determining the nature of exchange rate pricing which is detailed in the next section.

Alvarez, Atkeson, and Kehoe (2007) use a similar equation to explore the implications of assuming exchange rates follow a random walk:

(6) $p_t = \frac{1}{1+i_t} = \exp(-i_t) = \beta Et[\frac{u'(c_{t+1})}{u'(c_t)}\frac{1}{\pi_{t+1}}]$,

where $\pi_{t+1}$is the inflation rate and i_t is the logarithm of the short-term nominal interest rate $1+i_t$. They denote the product of the variables inside the expectation operator as pricing kernel m_{t+1} and, with log-normality, this implies that

(7) $i_t = E_t[-\log m_{t+1}] - \frac{1}{2}var_t[\log m_{t+1}]$

in the domestic economy, and it implies that in the foreign economy,

(8) $i_t^* = E_t[-\log m_{t+1}^*] - \frac{1}{2}var_t[\log m_{t+1}^*]$,

where i_t^* is the logarithm of the short-term nominal interest rate $1+i_t^*$. It is important to note that this relationship is only a good approximation for small values of i_t or i_t^*. In (7) and (8), m_{t+1} is the stochastic discount factor that discounts future asset prices to their present value. From (7) and (8), we can derive the expression:

(9) $i_t - i_t^* = E_t[\log m_{t+1}^* - \log m_{t+1}] - \frac{1}{2}[\mathrm{var}_t \log m_{t+1}^* - \mathrm{var}_t \log m_{t+1}]$.

The objective in Alvarez, Atkeson, and Kehoe (2007) is to form a model that contextualizes empirical data on the relationship between one-month interest rate differentials and one-month exchange rate depreciation. The central finding is that one-month interest rate differentials have no statistical relationship with one-month exchange rate changes, (Alvarez, Atkeson, and Kehoe, 2007). To illustrate this finding mathematically, we can transform (9) with the no-arbitrage condition:

(10) $m_{t+1}^* = m_{t+1}\frac{e_{t+1}}{e_t}$,

where e_t is the nominal exchange rate. From here, Alvarez, Atkeson, and Kehoe (2007) derive an equality using logs:

(11) $E_t \log e_{t+1} - \log e_t = E_t \log m_{t+1}^* - E_t \log m_{t+1}$.

When (11) is combined with (9), we obtain an expression that provides the implications of the random walk hypothesis:

(12) $i_t - i_t^* = E_t [\log e_{t+1} - \log e_t] + [\frac{1}{2} \mathrm{var}_t(\log \frac{e_{t+1}}{e_t}) + \mathrm{cov}_t(\log m_{t+1}, \log \frac{e_{t+1}}{e_t})]$

Because the empirical data suggests that exchange rates could be well approximated by random walks, this means the expected change, $E_t [\log e_{t+1} - \log e_t]$ is a constant. The implication is that when an interest rate differential changes, the conditional variance changes, rather than the conditional mean. Though this observation holds in a short horizon of one month, the average one-month interest rate differential and average one-month change in exchange rates over a long horizon of 22 years have a clear positive relationship with a slope close to 1

(Alvarez, Atkeson, and Kehoe, 2007). The implication is that the random walk model is a good approximation for exchange rate movements over short horizons, but not over long horizons.

When the assumption of risk neutrality for investors is relaxed, the existing models for asset pricing can yield insights that raise questions over market efficiency in foreign exchange rates. Namely, the risk-averse nature of investors created demand for financial instruments that allow them to hedge against risk. A forward exchange rate, f_t, allows an investor to hedge against potential losses in period t+1 by entering into a contract with another party in which he agrees to exchange one currency for another currency at a future date and a pre-determined exchange rate. In Fama (1984), an expression for the forward rate is outlined as the following:

(13) $F_t = E(S_{t+1}) + P_t$,

where $F_t = \ln f_t$, $S_{t+1} = \ln s_{t+1}$, $E(S_{t+1})$ is the expected future log of the spot rate conditional at time t, and P_t is a risk premium. Intuitively, when the expected future spot rate appreciates, an investor should want the forward rate to appreciate as well because the forward rate "is the market determined certainty equivalent of the future spot exchange rate s_{t+1}" (Fama, 1984, 320).

A topic of interest in Fama (1984) is whether the forward rate has the power to predict the future spot rate. We can begin an attempt to model this phenomenon by making an adjustment to the previous expression:

(14) $F_t – S_t = P_t + E(S_{t+1} – S_t)$

An ordinary least squares regression is useful to assess any predictive power that might exist in the forward rate. Fama's technique is to observe regressions of F_t-S_t and S_{t+1}-S_t on F_t-S_t, which effectively accomplish the same purpose as the previous expression:

(15) $F_t\text{-}S_{t+1} = \alpha_1 + \beta_1(F_t\text{-}S_t) + \varepsilon_{1,t+1}$

(16) $S_{t+1}\text{-}S_t = \alpha_2 + \beta_2(F_t\text{-}S_t) + \varepsilon_{2,t+1}$.

If β_2 is non-zero, it means that the forward rate conditional at period t has information about the spot rate observed at period t+1. Given that F_t-S_{t+1} is the sum of the premium P_t and $E(S_{t+1})$-S_{t+1}, β_1 can be non-zero if the premium component of F_t-S_t has variation that reliably appears in F_t-S_{t+1}:

(17) $$\beta_1 = \frac{cov(F_t-S_{t+1}, F_t-S_t)}{\sigma^2(F_t-S_t)} = \frac{\sigma^2(P_t)+cov(P_t, E(S_{t+1}-S_t)}{\sigma^2(P_t)+\sigma^2\big(E(S_{t+1}-S_t)\big)+2cov(P_t, E(S_{t+1}-S_t)}$$

(18) $$\beta_2 = \frac{cov(S_{t+1}-S_t, F_t-S_t)}{\sigma^2(F_t-S_t)} = \frac{\sigma^2\big(E(S_{t+1}-S_t)\big)+cov(P_t, E(S_{t+1}-S_t)}{\sigma^2(P_t)+\sigma^2\big(E(S_{t+1}-S_t)\big)+2cov(P_t, E(S_{t+1}-S_t)}$$

Intuitively, the forward rate is conditional on the information available today. In Fama (1984), we see that there is relatively high first-order autocorrelation in the forward-spot differential, F_t-S_t. This is suggestive of the existence of a bias in the pricing of the forward rate, as it consistently overestimates the depreciation of the spot exchange rate. Moreover, this observation of serial correlation contradicts the random walk model for exchange rates used in Alvarez, Atkeson, and Kehoe (2007) and Meese and Rogoff (1983).

In contrast, this first-order autocorrelation is considerably lower for F_t-S_{t+1} and S_{t+1}-S_t in the literature. These two differentials are the product of "news" which emerges between period t and period t+1. Neither the forward rate nor the spot rate at period t contain all of the information available in period t+1. Therefore, under the assumptions of the Efficient Market Hypothesis, we should expect that the autocorrelation in these differentials would be considerably lower than the F_t-S_t differential.

Another notable observation in Fama (1984) was the fact that the β_2 coefficient in (16) is not close to 1 in either of the two sub-periods: August 31, 1973-April 7, 1978 and May 5, 1978-December 10, 1982. This suggests that the forward-spot differential does not have strong predictive power over the change in spot rates. In the second sub-period, coinciding with a shift toward more flexible exchange rate regimes, the β_2 coefficient is negative for every currency in the sample. On average, the foreign currencies actually *appreciate*, contrary to the expectations of investors reflected in the forward rate.

A key assumption underlying the Efficient Market Hypothesis is that it should not be possible for an investor to reap the rewards of arbitrage opportunities because the prices of assets should incorporate all information available today. If the hypothesis is valid, this assumption should hold when it comes to borrowing in one currency and investing in another currency. An investor might choose to simultaneously borrow in a low interest rate currency and invest in a high interest rate currency because the interest differential would allow him to enjoy a gain. However, the Efficient Market Hypothesis suggests that interest rate parity should hold, meaning the expected exchange rate change should offset the gains realized from the interest rate differential. Specifically, foreign-exchange markets theoretically should not violate the covered interest rate parity condition,

(19) $i^* - i = \frac{F_t - S_t}{S_t}$,

where i* is the interest rate on a foreign currency, i is the interest rate on the domestic currency, S_t is the log of the spot exchange rate, and F_t is the log of the forward rate. The interest rates and exchange rates both are dependent on information available in period t, so market efficiency requires that equation (19) hold in practice. In fact, covered interest rate parity is generally upheld with one possible exception related to liquidity constraints during the collapse of Lehman Brothers in September 2008 discussed in Mancini-Griffoli and Ranaldo (2010).

When investors do not hedge in the forward market and engage in the carry trade, however, violations of interest rate parity—namely, uncovered interest rate parity—are often observed in literature. The carry trade refers to an investment strategy where a trader builds a short position in a low interest rate currency and a long position in a higher-yielding asset such as a stock, bond, or another currency. In this case, the trader's long position is in a high interest rate currency. The uncovered interest rate parity condition is defined as:

(20) $i^* - i = \frac{E(S_{t+1}) - S_t}{S_t}$,

where $E(S_{t+1})$ is the expected future spot exchange rate. The equation for the return of this investment when uncovered interest rate parity holds is:

(21) $\frac{E(s_{t+1})(1+i*)}{s_t(1+i)} = 1$.

Yet, Brunnermeier, Nagel, and Pedersen (2009) demonstrate that the mean gross return to this investment known as the carry trade is greater than 1. This corroborates the finding in Fama (1984) that investors' expectations inaccurately predict a depreciation of the foreign currency relative to the domestic currency, when spot exchange rates generally tend to appreciate.

There are several explanations offered in Brunnermeier, Nagel, and Pedersen (2009) for the forward premium and violations of uncovered interest rate parity. The authors argue that the strong link between currency carry and crash risk is indicative of the forward premium's role as a compensation for risk (Brunnermeier, Nagel, and Pedersen, 2009, 342). The negative skewness of carry trade returns supports this argument, as the strategy is characterized by *The Economist* as "picking up nickels in front of steamrollers" (The Economist, 2007). Brunnermeier, Nagel, and Pedersen (2009) find that currency crashes are positively correlated with increases in implied stock market volatility VIX and the TED spread, signifying that funding illiquidity can produce the negative skewness observed in carry trade returns. In their conclusion, they write that this "could be the outcome of a setting in which higher volatility leads to lower available speculator capital due to higher margins and capital requirements, inducing traders to cut back on their carry trade activity" (Brunnermeier, Nagel, and Pedersen, 2009, 342). Thus, the steep decline in carry trade returns can be self-perpetuating when traders are overleveraged and have an immediate need for the funding currency during a financial crisis. The random walk model, by definition, fails to account for such a feedback loop.

To pursue profit from the carry trade, it is essential to identify which currencies are safe haven currencies, or currencies whose demand increases in times of financial crisis. Though the U.S. dollar was generally shown in Brunnermeier, Nagel, and Pedersen (2009) to be a profitable funding currency for carry trades, Ranaldo and Söderlind (2007) find that the U.S. dollar lacks the safe haven qualities of other currencies like the Swiss franc, the Japanese yen, and the British pound. Empirically, these currencies tend to appreciate against the U.S. dollar when the S&P 500 has negative returns, U.S. Treasury bond prices increase, and currency markets become more volatile (Ranaldo and Söderlind, 13). Another important finding is that the results in Ranaldo and Söderlind (2007) suggest there is a transmission mechanism between exchange rates and other asset classes.

Farhi and Gabaix (2008) construct a calibrated model that accounts for the time-varying risk of rare disasters in certain countries and its impact across asset classes. For instance, the correlation coefficient of the change in exchange rates (in logs) and the differential between stock returns in a foreign and domestic country denominated in the domestic currency is 0.55 (Farhi and Gabaix, 2008, 33). This suggests that when the foreign currency depreciates, stocks in the foreign country generally earn higher returns than stocks in the domestic country. Meanwhile, the correlation coefficient of the change in risk reversal—defined as the implied volatility of an out-of-the-money put minus the implied volatility of an out-of-the-money call, all at 25-delta—and the aforementioned differential in stock returns is -0.49. Brunnermeier, Nagel, and Pedersen (2009) support this finding with the observation that a risk reversal tends to be positive during times of financial crisis, as the demand for put options is higher when investors expect the underlying exchange rates to fall. One implication of this finding is that profitable carry trades should then be found not just with currencies, but with stocks and bonds as the target investment well.

The comovement of assets across different classes heightens the possibility that broader sources of risk could be the source of positive carry trade returns and explain deviations from the random walk model. To assess this possibility, it is imperative to construct a model that incorporates the effect of risk on returns to the carry trade. The model outlined in the next chapter identifies global consumption variability as a broad source of risk reflected in asset pricing fluctuation. The purpose of the remainder of this paper is to test the relevance of this model to the carry trade.

Chapter 3

Model and Methodologies

Introduction to the Consumption-Based Capital Asset Pricing Model

To illustrate the effect of consumption on the prices of assets, it is useful to derive a Consumption-Based Capital Asset Pricing Model with techniques employed by Cochrane (2001). I begin to construct this model with the assumption that there is a representative consumer who must choose between consumption today, c_t, and consumption tomorrow, c_{t+1}. The representative consumer can choose to forgo some consumption today in favor of purchasing an asset at price p_t. I will denote the quantity of the asset the representative consumer purchases with the variable ξ. If the representative consumer purchases an asset today, he will receive a payoff x_{t+1} tomorrow for that asset. An initial endowment, e_t, is the level of consumption today when he purchases no assets today. The variable e_{t+1} is the level of consumption tomorrow when he purchases no assets today. In this light, I can define consumption today and consumption tomorrow as functions of exogenous variables:

(1) $c_t(e_t, p_t, \xi) = e_t - p_t\xi$

(2) $c_{t+1}(e_{t+1}, x_{t+1}, \xi) = e_{t+1} + x_{t+1}\xi$

One variable, ξ, is common to the functions for consumption today and consumption tomorrow. This suggests that the quantity of assets purchased today has an effect on both the utility of consumption today and the utility of consumption tomorrow. If I assume that the representative consumer's utility always increases when his consumption increases, I can argue that the purchase of an asset today causes the representative consumer's utility of consumption today to decrease. Given that ξ is constant over the two periods, I can also argue that the purchase of an asset today causes the representative consumer's utility of consumption tomorrow to increase.

The next step is to determine the optimal level of consumption across two periods through partial differentiation. If we take the derivative with respect to ξ for equations (1) and (2), we get $-p_t$ and x_{t+1}. Therefore, the marginal cost of purchasing one unit of an asset is p_t and the marginal benefit of purchasing one unit of an asset is x_{t+1} discounted to the present. Given that the representative consumer is rational, he should only purchase an asset if the marginal benefit is greater than the marginal cost, or if $x_{t+1} > p_t$. When such an opportunity exists, he should continue to purchase assets until the marginal benefit equals the marginal cost. It is at this point when the representative consumer has reached his optimal level of consumption. When p_t is equal to x_{t+1}, the representative consumer has maximized his utility of consumption across two periods.

The Representative Consumer's Utility Function

In this context, it is appropriate to define the representative consumer's utility function, as described in Cochrane (2001). This utility function is modeled with current and future values of consumption:

(3) $U(c_t, c_{t+1}) = U(c_t) + \beta E_t[U(c_{t+1})]$

The expectations parameter E_t is the expectation conditional on information available at time t.

The notation β used in equation (3) represents the level of impatience for the investor, and Cochrane calls it the subjective discount factor. Discounting the utility of consumption tomorrow with β accounts for the impatience by the representative consumer. It is implicit that as the rate of subjective time preference, or the rate at which a representative consumer prefers consumption today to consumption tomorrow, increases, β decreases. Therefore, the fact that a decrease in β further discounts utility of consumption tomorrow is consistent with an increasing subjective time preference for consumption today.

The Basic Consumption-Based Pricing Equation

We can use equation (3) to obtain the first-order condition for optimal consumption and portfolio choice. Given that the price of purchasing an asset today is p_t and the payoff of that asset tomorrow is x_{t+1}, we have enough information to calculate price as a function of β, $U'(c_t)$, $U'(c_{t+1})$, and x_{t+1}. When the representative consumer purchases one unit of an asset today, the following must be true:

(4) $p_t U'(c_t) = E_t[\beta U'(c_{t+1}) x_{t+1}]$

(5) $p_t = E_t[\beta(\frac{U'(c_{t+1})}{U'(c_t)}) x_{t+1}]$

Equation (4) simply states that the marginal cost of purchasing an asset must equal the marginal benefit. A component of the right-hand side of equation (5), $\beta(\frac{U'(c_{t+1})}{U'(c_t)})$, is termed by Cochrane as m_{t+1}, the stochastic discount factor. In fact, m_{t+1} is also called the marginal rate of substitution, the rate at which a representative consumer is willing to substitute a unit of consumption tomorrow for a unit of consumption today. An equivalent way of stating (5) is to say:

(6) $p_t = E_t[m_t x_{t+1}]$.

The Risk-Free Rate

The stochastic discount factor allows us to determine the price of an asset today, while an equivalent way of doing this is to use the gross risk-free interest rate, R_f. The intuition of a risk-free interest rate parallels that of the stochastic discount factor because $E(m) = \frac{1}{R_f}$. Even if there is no uncertainty, an investor still demands a risk-free rate to incentivize him to substitute consumption today for consumption tomorrow. Assuming for the time being that investors do not include a risk adjustment when they determine the equilibrium asset price, the expression for price in terms of R_f is the following:

(7) $p_t = \frac{1}{R^f} E(x_{t+1})$

Cochrane proposes that a power utility function, $U'(c_t) = c^{-\gamma}$, allows us to determine R_f in terms of β, c_{t+1}, c_t, and γ. In this particular case, we are assuming that c_{t+1} and m are independent of x_{t+1}:

(8) $R^f = \frac{1}{Et(\beta\left(\frac{Ct+1}{Ct}\right)^{-\gamma})}$

Equation (8) tells us that the risk-free rate is inversely related to β, implying that impatience creates upward pressure on the risk-free rate to incentivize consumers to substitute consumption today for consumption tomorrow.

A similar effect occurs with high consumption growth. Equation (2) demonstrates that purchasing assets today produces a payoff tomorrow that allows consumption to increase. However, equation (8) shows risk-averse investors demand a high rate to compensate for the risk they incur when consumption is expected to grow. We see that subjective time preference and risk aversion can both be drivers of interest rates.

Defining the Risk Adjustment

After introducing the concept of a risk-free rate, it is essential to adjust for the variable of risk in our asset pricing model to ensure it reflects the existence of uncertainty. Because the covariance of m and x is equal to E(mx) – E(m)E(x), and we know p = E(mx), we can use algebra to prove that the following is true:

(9) p = E(m)E(x) + cov(m, x)

Equation (7) allows us to substitute for m, and produce an equation for an asset that is not risk-free:

(10) $p = \frac{E(x)}{R^f} + cov(m, x)$

This is the same equation as (7), but with the addition of the risk adjustment, a covariance term which has implications for a Consumption-Based Capital Asset Pricing Model. We can explore these implications first by deriving a new equation that demonstrates the role of two-period consumption in asset pricing:

(11) $p = \frac{E(x)}{R^f} + \frac{cov\,(\beta u'(c_{t+1}), x_{t+1})}{u'(c_{t})}$

In our model, we assume that a representative consumer's utility of consumption has diminishing marginal returns. This means a high consumption level corresponds to a low marginal utility of consumption, and vice versa. From our equation, we see that an asset whose payoff covaries positively with future marginal utility of consumption has a higher price than an asset whose payoff covaries negatively with future marginal utility of consumption. This is because an asset whose payoff covaries positively with consumption makes consumption more volatile. The representative consumer's objective is to smooth consumption across time periods. Therefore, he is willing to pay more for an asset which has a high payoff when consumption is low than an asset which has a high payoff when consumption is high.

One-Period Bond Example

We can replicate a similar result to equation (9) using a one-period bond with a price of 1 and a return of R^i. A similar way of restating this is to use the following equation:

(12) $1 = E(mR^i)$

From here, we can substitute to derive an expression for the difference of R^i and R^f:

(13) $1 = E(m)E(R^i) + cov(m, R^i)$

$0 = \frac{E(R^i)}{R^f} - 1 + cov(m, R^i)$

$0 = \frac{E(R^i) - R^f}{R^f} + cov(m, R^i)$

$\frac{E(R^i) - R^f}{R^f} = - cov(m, R^i)$

$E(R^i) - R^f = -R^f cov(m, R^i)$

$E(R^i) - R^f = \frac{-cov(u'(c_{t+1}), R^i)}{E(u'(c_{t+1}))}$

(14) $E(R^i) = R^f - \frac{cov(u'(c_{t+1}, R^i)}{E(u'(c_{t+1}))}$

The intuition is simply that the expected return of an asset is the sum of a risk-free rate and a risk adjustment. This should be no surprise, as it is consistent with the concept of a risk adjustment we introduced in equation (9).

The Mean-Standard Deviation Frontier

The properties of asset pricing lead us to a derivation of an inequality including the excess return, $E(mR^i)$. We can derive the inequality with the following transformation of an initial expression:

$1 = E(mR^i) = E(m)E(R^i) + cov(m, R^i) = E(m)E(R^i) + \rho_{m, R^i}\sigma(R^i)\sigma(m)$

$\frac{1}{E(m)} = R^f = E(R^i) + \rho_{m, R^i}\frac{\sigma(Ri)}{E(m)}\sigma(m)$

$E(R^i) = R^f - \rho_{m, R^i}\frac{\sigma(Ri)}{E(m)}\sigma(m)$

$E(R^i) - R^f = -\frac{\sigma(m)}{E(m)}\sigma(R^i)\rho_{m, R^i}$

(15) $E(R^i) - R^f \leq -\frac{\sigma(m)}{E(m)}\sigma(R^i)$

The final expression in this transformation is an inequality because the correlation coefficient can be no greater than 1. This property is particularly useful when we study the Sharpe Ratio.

The Sharpe Ratio is the ratio between the mean excess return to standard deviation for an asset, expressed as $\frac{E(R^i)-R^f}{\sigma(R^i)}$. In essence, it is a measure for calculating risk-adjusted return. From equation (15), we can begin to construct a new expression that becomes applicable to real-world data. When we divide the left-hand side of the inequality by $\sigma(R^i)$ to create the Sharpe Ratio, we also simplify the right-hand side to $\frac{\sigma(m)}{E(m)}$. The result is the following expression that captures the slope of a theoretical mean-standard deviation frontier, the maximum of the above right-hand transformation:

$$(16)\ \left| \frac{E(R^i) - R^f}{\sigma(R^i)} \right| = \frac{\sigma(m)}{E(m)}$$

We can again use consumption growth as a proxy for the discount factor m. The power utility function, $u'(c) = c^{-\gamma}$, means that the following must be true:

$$(17)\ \left| \frac{E(R^i) - R^f}{\sigma(R^i)} \right| = \frac{\sigma\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right]}{E\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right]}$$

If we assume consumption growth is lognormal as Cochrane does, we get the following expression:

$$(18)\ \left| \frac{E(R^i) - R^f}{\sigma(R^i)} \right| = \sqrt{e^{\gamma^2 \sigma^2 (\Delta \ln c_{t+1})} - 1} \approx \gamma\sigma(\Delta \ln c)$$

The implication is that higher volatility in consumption growth—whether consumption increases, decreases—, or a higher risk aversion level γ makes the standard deviation and, consequently, the Sharpe Ratio larger. Risk-averse investors become more reluctant to purchase a relatively risky asset under either of those conditions, meaning that the price of such assets should decrease.

The Random Walk Model: Short Horizons vs. Long Horizons

The question of the relevance of risk aversion to investing depends on the time horizon over which the investor plans to hold an asset. If the horizon is short, risk is lower relative to a longer horizon, so we will ignore the effect of risk aversion in this particular situation. When investors are risk-neutral, the utility of consumption today equals the utility of consumption tomorrow. The same, of course, is true for the marginal utility of consumption across two periods. If the asset in question is a stock, the price is generally p_t and the payoff is $p_{t+1} + d_{t+1}$, where d_{t+1} is the dividend payment received tomorrow. As this example occurs across a short time horizon, it is generally reasonable to assume that there is no dividend payment tomorrow. As a result, if the time horizon is a day, we can reduce equation (4) to a much simpler equality:

(19) $p_t = E_t(p_{t+1})$

This is the same thing as saying asset prices follow a martingale. A martingale is a stochastic process where the expected value of the next value in a sequence is equal to the current value given all of the information about past values. Intuitively, this equality makes sense because an investor is assumed to be rational. If an investor expects the price of an asset to increase in value tomorrow, the rational thing to do is to purchase the asset today and realize the gains tomorrow. The effect is that the price of the asset today experiences upward pressure until it becomes the expected price tomorrow.

Of course, the right-hand side of equation (19) does not imply that p_t must equal p_{t+1} in reality. It is possible for there to be a forecast error ε_t which makes p_{t+1} different from $E_t(p_{t+1})$. We can use this information and restate p_{t+1}:

(20) $p_{t+1} = p_t + \varepsilon_{t+1}$

The gains realized by the investor are, thus, the difference between p_{t+1} and $E_t(p_{t+1})$. Equations (19) and (20) show us that the difference reduces to the following:

(21) $p_{t+1} - E_t(p_{t+1}) = \varepsilon_{t+1}$

This means that any change in an asset's price relative to its expected future price is the result of a forecast error, which is independent from the price of the asset today. If it is also true that $\sigma^2(\varepsilon_{t+1})$ is constant, then we can say asset prices follow a random walk. In this case, the price of the asset today has no information that can predict the price of the asset tomorrow. This phenomenon is the essence of the Efficient Market Hypothesis articulated in Fama (1970).

If the Efficient Market Hypothesis holds, then there is a clear way to model the prices of assets with financial data. The idea underlying the martingale model is that the best predictor of an asset price in period t+1 is the asset price in period t. Any variation in the price of an asset over two periods is the result of "news", a forecast error that is not contained in the information available to the investor today. We can empirically test the validity of this model with the following regression:

(22) $E(p_{t+1}) = \alpha + \beta(p_t) + E(\varepsilon_{t+1})$

If markets are efficient, then there should be an ordinary least squares regression where the dependent variable is the asset price in period t+1 and the β coefficient of the independent variable, the asset price in period t, should be approximately 1. Moreover, the R^2 statistic, which measures the variation in the dependent variable explained by the independent variable, should also be very close to 1 if the time horizon is one day. The size of R^2 should diminish when the time horizon is longer.

While the martingale model and its risk-neutrality assumption has relevance for short-horizon excess returns, an asset pricing model focused on long-horizon excess returns should allow investors to be risk-averse. A simple transformation of our basic equation for expected returns accomplishes this objective:

$$E_t(R_{t+1}) - R^f_t = - \frac{\text{cov}_t\,(m_{t+1}, R_{t+1})}{E_t(m_{t+1})}$$

$$E_t(R_{t+1}) - R^f_t = \frac{\sigma_t(m_{t+1})}{E_t(m_{t+1})}\sigma_t(R_{t+1})\rho_t(m_{t+1}, R_{t+1})$$

$$E_t(R_{t+1}) - R^f_t \approx \gamma_t\sigma_t(\Delta c_{t+1})\sigma_t(R_{t+1})\rho_t(m_{t+1}, R_{t+1})$$

$$(23)\ E_t(R_{t+1}) - R^f_t \approx \gamma_t\sigma_t(\Delta c_{t+1})\sigma_t(R_{t+1})\rho_t(\frac{1}{R^f_{t+1}}, R_{t+1})$$

This expression demonstrates that excess returns can be explained by changing risk— $\sigma_t(\Delta c_{t+1})$— or changing risk aversion γ. In times of high risk or when consumers are highly risk-averse, the difference between $E_t(R_{t+1}) - R_t^f$ becomes very large, suggesting that returns are positively correlated with risk and risk aversion.

In Chapter 7, I explore the extent to which variation of variables on the right-hand side of equation (23) explain variation in excess returns. If the intuition of C-CAPM is valid, these variables should influence the variation in excess returns over time. The implication of such a result would be that the model demonstrates a causal influence of risk aversion and consumption growth on the excess returns of assets.

C-CAPM, Safe Haven Currencies, and the Carry Trade

If a return was predicated solely on information available in period t, we would say that the carry trade represents an arbitrage opportunity. However, the C-CAPM model described in Cochrane (2001) and outlined earlier in this chapter allows us to explain the positive net return on the carry trade with a risk adjustment. I acknowledged earlier that C-CAPM infers that assets whose payoffs covary positively with future marginal utility of consumption are priced at a discount because a risk-averse investor wants to maximize the probability of smoothing his intertemporal consumption. A "safe haven" currency that is associated with historically low interest rates like the Japanese yen or the Swiss franc covaries positively with future marginal utility of consumption because its expected returns and risk are both low. A riskier currency in an "emerging market" associated with higher interest rates like the Brazilian real or Mexican peso covaries negatively with future marginal utility of consumption because its expected returns and risk are both high. The result is that high interest rate currencies are priced at a discount and low interest rate currencies are priced at a premium when a risk adjustment is incorporated into C-CAPM.

Concluding Section: Modeling the Carry Trade with C-CAPM

In accordance with C-CAPM, we observe that the return of a carry trade investment is defined in the following expression:

$$(24)\ E_t\left(\frac{(1+i*)s_{t+1}}{(1+i)s_t}\right) - R_t^f \approx \gamma_t \sigma_t(\Delta c_{t+1})\sigma_t\left(\frac{(1+i*)s_{t+1}}{(1+i)s_t}\right)\rho_t\left(\frac{1}{R_{t+1}^f}, \frac{(1+i*)s_{t+1}}{(1+i)s_t}\right)$$

We equate the risk-free rate at time t to the interest rate on a U.S. Treasury bill, generally considered in literature as the least risky security available to global investors. Meanwhile, the horizon over which we will explore the return on a carry trade will be three months and one year. Based on the literature and Cochrane's theoretical framework, the model should explain variations in carry trade movements fairly well. Chapter 7 of this paper will determine the strength of the statistical relationship between risk-aversion and carry trade excess returns as a means of assessing the applicability of C-CAPM.

Chapter 4

The Role of the Carry Trade in the 2007-2008 Global Financial Crisis

The global financial market turmoil in 2007 and 2008 featured a tightening of credit in the U.S. mortgage market. Several macroeconomic patterns explain how the housing bubble preceding the credit crisis unfolded. Prior to the tightening of credit, the U.S. economy had experienced a low interest rate environment because of large capital inflows from abroad, especially Asia. Brunnermeier (2009) notes that Asian countries bought U.S. securities to hedge against a depreciation of their currencies against the dollar in the aftermath of the 1997 East Asian financial crisis (Brunnermeier, 2009, 77). The movement in interest rates was strengthened by the Federal Reserve's decision to gradually lower the federal funds rate from 6.51% to 0.98% between November 2000 and December 2003 (Board of Governors). The Federal Reserve then gradually increased the federal funds rate to 5.25% by August 2006. This meant that the dollar became a desirable investment currency relative to other safe haven currencies in the period immediately prior to the global financial crisis.

The Mechanics of the Carry Trade in the 21st Century

A pattern that emerged prior to the crisis was the "originate and distribute" banking model, "in which loans are pooled, tranched, and then resold via securitization" (Brunnermeier, 2009, 78). New securities like collateralized debt obligations which formed diverse portfolios of mortgages, corporate bonds, and other assets like credit card receivables made it easier to facilitate large capital inflows from abroad. The extensive role of overseas capital inflows—

particularly those from Japan—eventually produced a weakness of the U.S. dollar at the time when credit markets began to weaken (Hattori and Shin, 2009, 377).

The Japanese yen was a popular funding currency for the carry trade prior to the crisis. This was because the Bank of Japan had held its benchmark interest rate very low since the late 1990s, also known as the Lost Decade, in response to stagnation in price level and a fall in output. *The New York Times* reported that Japanese and foreigners alike invested money in a variety of assets ranging from home loans in Budapest and Seoul to equities in Mumbai (Fackler). Moreover, Hattori and Shin (2009) argue that the carry trade not only has implications for the foreign exchange market, but that it "should be viewed within the larger context of the waxing and waning of the balance sheets of the financial intermediary sector as a whole" (Hattori and Shin, 2009, 406).

Investment banks with global reach borrowed at the much lower yen overnight rate from a Japanese bank. A Tokyo office of an investment bank would have yen liabilities to Japanese banks and yen assets against its own New York office. Foreign banks generally maintained negative net interoffice accounts (interoffice assets minus interoffice liabilities), meaning that they held a net long position in Japanese assets. This was not the case in the period leading up to the beginning of the credit crisis of 2007. In this period, yen liabilities of foreign banks dramatically increased, effectively creating a net short position in Japanese assets and producing an unprecedented net positive interoffice account. Hattori and Shin (2009) used proxies for the prices of subprime mortgages (i.e. the ABX index available from the London firm Markit) to show that the price decreases in mortgage-backed securities mirror movements in net interoffice accounts.

The deterioration of U.S. credit markets produced a "margin call" in which foreign creditors scaled back lending or demanded higher premiums to cover losses for leveraged investments. When counterparties failed to pay higher premiums, they unwound their positions in the carry trade by selling their leveraged investment and converting their investment currency back to yen to deleverage. The USDJPY exchange rate fell by more than 16% between Lehman Brothers' bankruptcy on September 15, 2008 and December 17, 2008. The EURJPY exchange rate fell by more than 21% between Lehman's bankruptcy and October 27, 2008. The depreciation of investment currencies meant that yen carry trades were no longer profitable. Additionally, the volatility in asset markets from 2007 to 2008 influenced central banks to cut interest rates, thereby further reducing the incentive to engage in the yen carry trade.

A Comparison of Financial Crises: The 1997 Asian Financial Crisis, the 1998 Russian Default Crisis, and the 2007-2008 Global Financial Crisis

A comparative analysis of financial crises sheds light on the impact of the carry trade. The 2007-08 crisis differed from two other recent crises—the Asian financial crisis of 1997 and the Russian debt default in August 1998—in places of origin, whether they were accompanied by currency crises, and the scale of contagion. The other two crises originated in emerging market economies, not the U.S. Unlike the 2007-08 crisis, the Asian and Russian crises were induced by speculative attacks on currencies with fixed exchange rate regimes, as opposed to a liquidity crisis in the U.S. banking system. In Kohler (2008), only the 2008 financial crisis featured all selected currencies depreciating sharply against the U.S. dollar, the Japanese yen, and the Swiss franc (Kohler, 2008, 41). If investors had taken a long position on emerging market assets in a carry trade, they would need to unwind this position amidst the liquidity crisis, explaining the appreciation of safe haven currencies.

Kohler (2008) provides evidence that interest rate differentials played a larger role in explaining exchange rate movements in the 2007-2008 crisis than the previous crises. The slope of an OLS regression of exchange rate depreciation and average short-term interest rates for the previous six months is positive during all three crises, but it increases over time (Kohler, 2008, 46). The coefficient on short-term interest rates increased from 0.04 to 0.54 to 2.67 between the three crises, while R^2 increases from 0.002 to 0.24 to 0.58 (Kohler, 2008, 47). This observation is consistent with the notion that carry trade activity has increased since 1997.

Chapter 5

The Carry Trade in the Era of Monetary Policy Accommodation

In contrast to the Asian and Russian financial crises in the 1990s, the 2007-08 global financial crisis yielded to a relatively quick and strong reversal of currency depreciations. Kohler (2008) argues that U.S. dollar funding shortages in the non-U.S. banking sector put temporary upward pressure on the currency (Kohler, 2008, 42). Once the U.S. Treasury Department and Federal Reserve intervened to restore liquidity to financial markets, the dollar depreciated and emerging market currencies returned approximately to their fundamental levels before September 2008. By May 2010, other developed market central banks joined Japan in keeping benchmark interest rates at historically low levels: the Federal Reserve (Fed) instituted a range of 0-0.25% in the U.S., the Bank of England (BOE) implemented a rate of 0.5%, and the European Central Bank (ECB) kept its benchmark rate at 1%. This interest rate policy was one important factor in the profitability of the carry trade, along with others.

Emerging Market Global Capital Flows

The appreciation of emerging market currencies and higher excess return on emerging market assets made the carry trade enticing once again. The International Monetary Fund stated that emerging markets received close to half of global inflows in the 2010-2013 period, compared to less than 20% from 2002 to 2008 (Sahay, et. al., 2014, 7). Emerging economies in Latin America and Asia received larger shares of global capital flows in the 2010-2013 period than the 2002-2008 period (Sahay, et. al., 2014, 7). Prices of emerging market securities like corporate bonds increased in this period and made conditions ripe for positive carry trade returns.

Nevertheless, a confluence of vulnerabilities remained and led to risk-aversion from investors. Some economies like Turkey, South Africa, Brazil, Indonesia and India incurred high inflation, high fiscal deficits, and ran high current account deficits financed by increasing levels of short-term, foreign-currency debt (The Economist, 2013). These patterns were exacerbated when commodity prices fell, affecting Brazil, South Africa, and Russia adversely. Meanwhile, the 2011-2013 recession in the Eurozone particularly hurt Central and Eastern European trading partners like Turkey, Hungary, Poland, and the Czech Republic. These events spawned a market environment less conducive to carry trade profits.

The Volatility of the Euro Carry Trade

In the aftermath of the recession, the euro faced other sources of downward pressure besides low interest rates. A sovereign debt crisis in Greece, Ireland, Spain, Italy, and Portugal led to creditors pressuring the government to adopt austerity measures. This lowered the expectations for economic growth in the Eurozone as a whole. The ECB decided to start buying government bonds of these weak Eurozone countries to prop up their funding efforts. According to *The Wall Street Journal*, institutions like French bank BNP Paribas speculated in 2010 that it would be rational for investors to go short on the euro due to these macroeconomic events (Shah, 2010). At first, this was a valid suggestion because the Eurozone entered another recession from 2011 to 2013.

However, *The Wall Street Journal* stated that futures traders entered net long positions on the euro by 2013 (Albanese, 2015). This coincided with a decline in long-term interest rates on government bonds for Eurozone nations. Investors re-entered net short positions in early 2014 due to uncertainty regarding Greece's potential exit from the Eurozone (Albanese, 2015), as well as the ECB's decision to engage in quantitative easing and set interest rates at a negative level.

The Rise of the Dollar Carry Trade

With the federal funds rate at the zero bound until December 2015, the Federal Reserve's accommodative monetary policy heightened incentives to borrow dollars since the 2007-08 global financial crisis. In Bruno and Shin (2015), it is estimated that the outstanding USD-denominated debt of non-banks outside the United States reached a total of $9.2 trillion as of September 2014, compared to $6 trillion at the beginning of 2010 (Bruno and Shin, 2015, 1). Intuitively, this could signify that emerging market investors became more sensitive to the need for dollar liquidity in the aftermath of Lehman's bankruptcy.

The findings in Bruno and Shin (2015) suggest another motivation for dollar borrowing altogether: "In our firm-level investigation of the determinants of US dollar bond issuance, we find that emerging market corporates tend to borrow more in US dollars when they already hold large cash balances, suggesting that cash needs for investment or other expenditure may not be the only motivation for bond issuance. When we examine the timing of the dollar bond issuance by EME corporates, we find that it is more prevalent during periods when the dollar carry trade is more favorable in terms of an appreciating local currency, high interest rate differential vis-à-vis the dollar, and when the exchange rate volatility is low" (Bruno and Shin, 2015, 5). The fastest increasing component of global dollar credit was the stock of corporate bonds issued by emerging market firms (Bruno and Shin, 2015, 1). The evidence suggests that the shadow banking system consisting of investment banks, hedge funds, and other non-banking financial intermediaries has become increasingly globalized since 2010 because of the carry trade.

Chapter 6

Data

The empirical section of this paper attempts to model the applicability of a Consumption-Based Capital Asset Pricing Model in forecasting long-horizon excess returns for the carry trade. In essence, the return of the carry trade is the same equation for uncovered interest rate parity, or $1 = \frac{S_{t+1}(1+i^*)}{S_t(1+i)}$, assuming that the uncovered interest rate parity condition holds. In reality, literature has shown that carry trades, on average, yield positive returns, meaning that the uncovered interest rate parity condition fails to hold. The Consumption-Based Capital Asset Pricing Model outlined earlier is designed to account for the failure of uncovered interest rate parity and forecast excess returns beyond a short time horizon.

I used a Bloomberg Terminal to obtain data history for spot and forward exchange rates, along with all other assets used for research in this paper. This paper uses five base currencies—the U.S. dollar, the Japanese yen, the Swiss franc, the euro, and the British pound—to observe the effects of the carry trade across countries.

Within each base currency, there are 34 quote currencies; a total of 35 currencies is listed, but the funding currency itself is excluded from its own base currency sample because there is no corresponding exchange rate pair. These quote currencies are divided into two groups based on their classification by MSCI as Developed Markets or Emerging Markets. The idea of this classification is to separate the currencies by their market risk. The Developed Markets subgroup consists of the following countries: United States, Canada, European Union, Denmark, Israel, Norway, Sweden, Switzerland, United Kingdom, Australia, Hong Kong, Japan, New Zealand, and Singapore. The Emerging Markets subgroup consists of the following countries: Brazil, Chile, Colombia, Mexico, Peru, Czech Republic, Egypt, Hungary, Poland, Qatar, Russia, South Africa, Turkey, United Arab Emirates, Saudi Arabia, China, India, Indonesia, South Korea, Philippines, Taiwan, and Thailand.

In Chapter 7, the paper analyzes summary statistics for 3-month carry trade returns using monthly data for these currencies quoted at the average. Later, the results section uses annual data for these currencies quoted at the average. The reason for this is that the variable of global consumption, included in the C-CAPM factor, is only available on Bloomberg at an annual frequency.

The interest rates used for the funding currencies are the London Interbank Offered Rate (LIBOR) interest rates, accessible through Bloomberg. LIBOR interest rates are a benchmark rate used by major global banks to charge each other for short-term loans. These interest rates are quoted in five different currencies. In fact, these currencies are each of the five funding currencies for the carry trades observed in this paper. This is not coincidental, as the currencies available through LIBOR are all characterized by low interest rates relative to emerging market currencies and even some other developed market currencies. Thus, these currencies are likely candidates to be funding currencies for the carry trade.

The interest rates obtained from Bloomberg for the investment currencies are the 90-day certificates of deposit (CDs) interest rates for each respective currency. Certificates of deposit are a time deposit issued by a bank that allow an individual to collect interest upon maturity, while restricting the ability of the individual to withdraw the funds on demand. In calculating the carry trade return, I used the annual average of the 90-day CD interest rate.

I also obtained historical average annual prices of large cap equity indices for all of the countries in the sample to examine carry trades that go long on a foreign currency-denominated equity index. The indices for developed market economies are the following: S&P 500 (United States), S&P/TSX Composite Index (Canada), STOXX Europe 600 (European Union), TA-100 Index (Israel), OMX 30 (Sweden), SMI (Switzerland), OMX Copenhagen 20 (Denmark), FTSE 100 Index (United Kingdom), S&P/ASX 100 Index (Australia), Hang Seng Index (Hong Kong), Nikkei 225 (Japan), S&P/NZX 50 Gross Index (New Zealand), Straits Times Index (Singapore). The indices for emerging market economies are the following: Ibovespa Index (Brazil), IPSA Index (Chile), IGBC Index (Colombia), IPC/Bolsa Index (Mexico), IGBVL Index (Peru), PX Index (Czech Republic), CASE Index (Egypt), BUX Index (Hungary), WIG Index (Poland), DSM Index (Qatar), Russia Trading System Cash Index (Russia), FTSE/JSE Top 40 (South Africa), Tadawul (Saudi Arabia), ISE-100 Index (Turkey), ADX General (United Arab Emirates), Shanghai SE Composite Index (China), NIFTY Index (India), Jakarta Stock Exchange Composite Index (Indonesia), PSE Composite Index (Philippines), KOSPI 200 Index (South Korea), Taiwan Capitalization Weighted Stock Index (Taiwan), and SET50 Index (Thailand).

Lastly, I conducted analysis on carry trades that went long on one-year government bonds denominated in a foreign currency. Some countries in the sample did not have one-year government bonds, so the regressions for carry trades with government bonds have a smaller sample size than the ones for equity indices or certificates of deposit.

Chapter 7

Results and Discussion

Overview of Results

The most striking finding among this paper's empirical results is the strength of C-CAPM in explaining excess returns of the carry trade. The profitability of the carry trade is generally positive when consumption grows and negative when there is a global recession. OLS and robust regressions show that C-CAPM's strength varies across time and countries, but yields meaningful results in all three sub-periods used in the paper. This chapter includes a fixed effects univariate pooled panel regression to control for the individual investment currency-specific effects and the time-specific effects. When the foreign currency-denominated asset is a certificate of deposit, the fixed effects univariate pooled panel regression yields an R^2 between 46% and 76% when the funding currencies are the U.S. dollar, the Japanese yen, the euro, the Swiss franc, and the British pound. The fixed effects univariate pooled panel regression is also consistently strong when the foreign currency-denominated asset is a one-year government bond or a large cap equity index. The consistent strength of the model across these funding currencies and asset classes suggest that excess returns for the carry trade are generally, but not always, predictable over a long time horizon.

The Relationship Between Interest Rates and Exchange Rates

The theoretical time-varying nature of the forward premium should be reflected in data for forward and spot exchange rates. To verify this, it is useful to assess the relationship between a country's interest rate differential vis-à-vis a safe haven currency and the change in exchange rates.

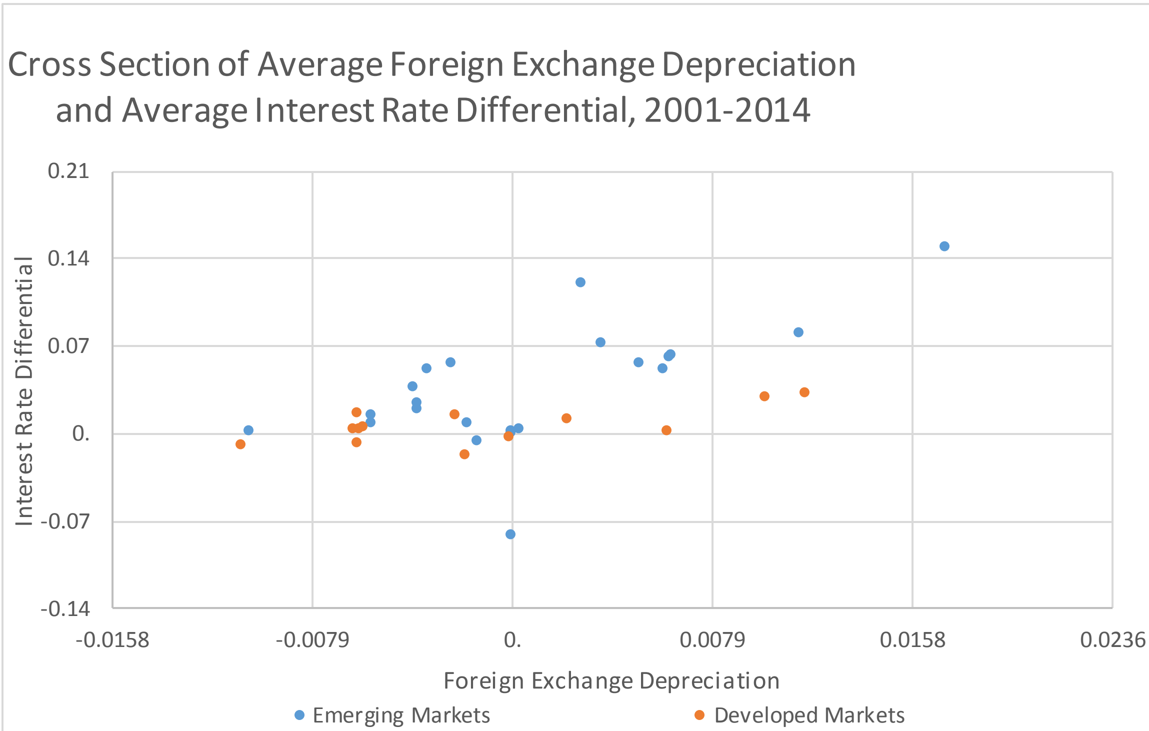

Figure 1. Scatterplot of Interest Rate Differential and Exchange Rate Differential

Figure 1 demonstrates that, over a large sample period (January 2001-October 2014), the relationship between interest rate differential and exchange rate depreciation is positive. When the average difference between a foreign country's 3-month deposit rate (alternatively, the 3-month interbank lending rate) and the 3-month U.S. LIBOR rate is high, the outcome is generally a high average depreciation by the foreign currency. The implication is that exchange rates for countries with high interest rates depreciate at a faster rate than exchange rates for countries with low interest rates. Generally, the countries labeled Developed Markets by MSCI have low interest rates and the countries labeled Emerging Markets have high interest rates.

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.58739495					
R Square	0.34503282					
Adjusted R Square	0.32518533					
Standard Error	0.00525188					
Observations	35					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	0.0004795	0.0004795	17.3842042	0.00020748	
Residual	33	0.00091021	2.7582E-05			
Total	34	0.00138971				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.002149	0.00103539	-2.0755951	0.04579992	-0.0042556	-4.253E-05
X Variable 1	0.09052111	0.02171063	4.16943691	0.00020748	0.04635049	0.13469172

Table 1. OLS Regression of ΔSt+1 on (i*- i), 2001-2014.

An ordinary least squares regression in Table 1 illustrates the quantitative relationship between interest rates and realized exchange rates. The low p-value in the regression output suggests that we can reject the hypothesis that the coefficient of (i*- i) is zero. In other words, the movements of exchange rates and interest rates are not independent. In fact, the coefficient of 0.09 means that an increase in the interest rate differential by 1% is associated with a 0.09% increase in exchange rate depreciation. Meanwhile, the relationship between exchange rate depreciation and interest rate differential is moderately strong. This is evident because the interest rate differential explains about 35% of the variation in exchange rate depreciation.

The Forward Premium and the Profitability of the Carry Trade

Though investors can hedge against exchange rate risk by agreeing on a forward rate, the question of whether there is forward bias is important because this questions the efficiency of the forward market. One way to test the predictability of future spot exchange rates is to run an ordinary least squares regression of the depreciation of the forward currency on the forward-spot differential. For this paper, this was done by using two subgroups: countries in MSCI's Emerging Market Index and countries in MSCI's Developed Market Index.

Table 2 shows the profitability of carry trades that go short on the U.S. dollar. A striking observation in Table 2 is the fact that the β coefficient is close to zero in almost every country in the sample, a glaring difference from the results in Fama (1984). The result in this paper better reflects the implications of the Efficient Market Hypothesis than the results found in Fama (1984), as the forward-spot differential now has virtually no predictive power over the spot exchange rate depreciation. The modest predictive power of the forward-spot differential that existed during Fama's sample period (1973 to 1982) appears to have vanished by the beginning of the twenty-first century.

It is striking that all of the currencies identified as safe haven currencies in Ranaldo and Söderlind (2007)—the Swiss franc, the Japanese yen, and the British pound—have a negative β in this OLS regression. This finding is intuitive because low interest currencies were found in Fama (1984) to be sold in the forward market at a discount relative to the future spot exchange rate. Taken with the existence of positive β coefficients for many emerging market countries, the negative β coefficient for developed market countries adds to the body of literature which finds investors have a forward bias in both overestimating the depreciation of low interest rate currencies and underestimating the depreciation of high interest rate currencies.

The fact that forward bias exists over a long sample period suggests that there were profitable opportunities for investors in the traditional carry trade—borrowing a low interest rate currency and investing in a low-risk asset like a certificate of deposit denominated in a high interest rate currency. Over the sample period of 2001 to 2014, I attempt to identify patterns in the behavior of carry trade returns. The funding currency in this sample is the U.S. dollar, while the investment currencies are those from emerging market economies.

In Table 3, 20 currencies out of 22 in the emerging market subgroup have a negative mean carry trade return. Meanwhile, 18 of the 22 currencies exhibit negative skewness. The emerging market currencies appear to bear higher interest rates and a forward discount as compensation for high downside risk, which is reflected in the negative skewness of the sample currencies. Given that our results indicate the forward rate overestimates the depreciation of the spot rate in the following period, the tendency seems to be that the carry trade results in positive returns for investors.

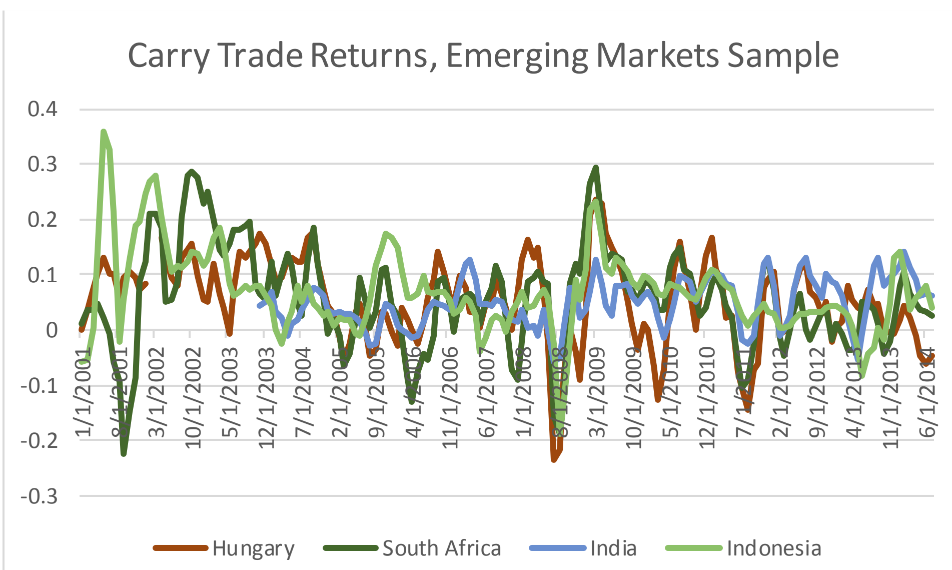

Figure 2. Carry Trade Return, Emerging Market Economies, 2001-2014.

Throughout the period of January 2001-October 2014 shown in Figure 2, many emerging market countries can generally be used as the investment currency in the carry trade and earn a positive return for investors. There are some notable exceptions in the sample period—May 2008-October 2008 and June 2011-October 2011—which correspond to the late 2000s global financial crisis and the peak of the European sovereign debt crisis. The time series graph in Figure 2 adds credence to an explanation for the negative skewness of carry trades that go long on emerging market currencies—investors adjust for the downside risk stemming from international financial crises with the forward discount.

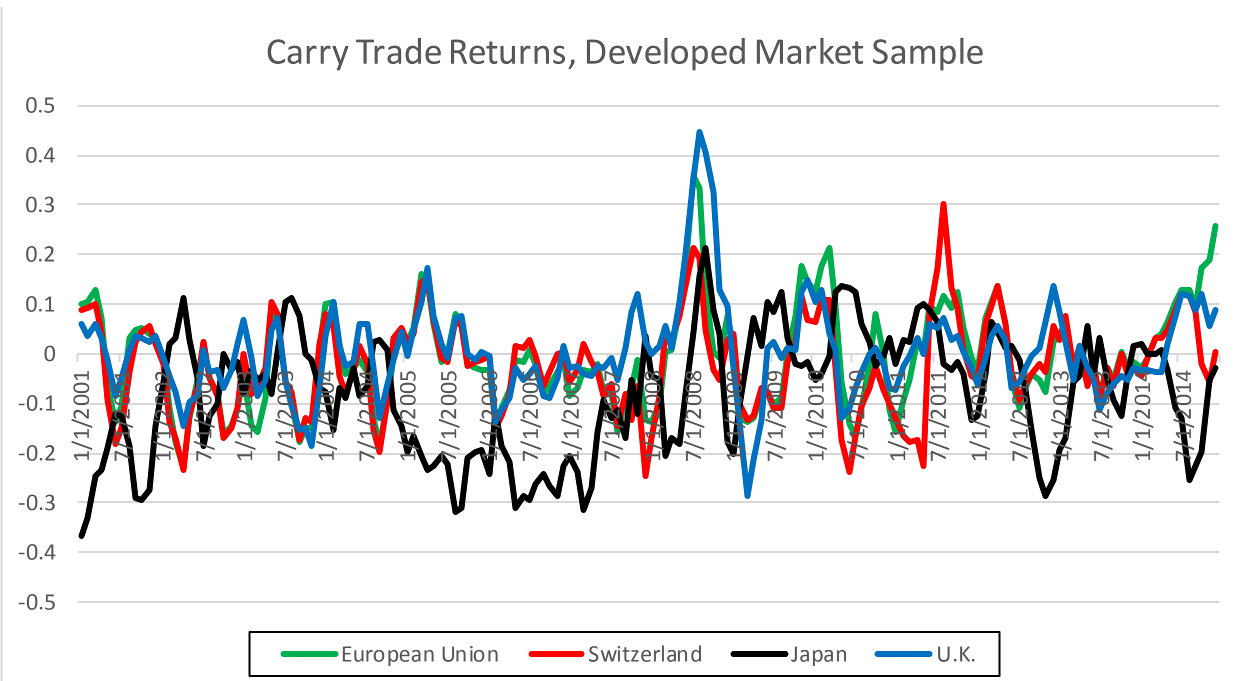

Figure 3. Carry Trade Returns, Developed Market Economies, 2001-2014.

In Figure 3, some developed market countries—the United Kingdom, the European Union, Japan, and Switzerland—produce positive returns as an investment currency in a carry trade during the 2008 global financial crisis, but generally negative returns in non-crisis times. Combined with our findings in Figure 2, Figure 3 suggests that investors engage in a “flight to quality" during global recessions. This result infers that these safe haven currencies covary negatively with global consumption, while other currencies—mostly emerging market currencies—covary positively with global consumption.

OLS and Robust Regressions

To contextualize the time-varying differences in predictive power of C-CAPM on the U.S. dollar carry trade excess returns, it is useful to conduct regressions for carry trade excess returns derived from other developed market funding currencies. In particular, I focus on excess returns from safe haven currencies.

OLS regressions displayed in Table 4 show that C-CAPM seems to capture a high amount of the variation of excess returns across some sub-periods, but not others. For instance, the OLS regression for the Japanese yen has an R^2 of 0.6113 across the full time period of 2001-2014. However, the yen's R^2 varied from 0.9743, 0.6407, and 0.0007 in the 2001-2006, 2007-2009, and 2010-2014 sub-periods respectively. One word of caution should be added when analyzing these OLS regressions. The sample size of investment currencies for each funding currency is 34, so it is possible that outliers influence the results of these regressions.

To control for the effects of outliers, I supplemented the OLS regressions with robust regressions. The results of the robust regressions suggest that, across a long time horizon, the relationship between the carry trade excess return and C-CAPM factor are modest or weak for all of the funding currencies except the Swiss franc. Across a shorter time horizon, there is noticeable time variation for the funding currencies. The U.S. dollar carry trade excess return has a strong relationship with the C-CAPM factor in the 2001-2006 sub-period (R^2 of 0.57), but a weak relationship in the 2007-2009 and 2010-2014 sub-periods (R^2 of 0.05 and 0.07 respectively).

The results are starkly different for other funding currencies from what was observed for the U.S. dollar. The Japanese yen has a weak relationship in the 2001-2006 sub-period (R^2 of 0.08), but a strong relationship in the following sub-periods with an R^2 of 0.96 and 0.84. Similarly, the euro and British pound have a weak relationship between excess return and the C-CAPM factor in the 2001-2006 sub-period, but a modestly strong relationship in the 2007-2009 and 2010-2014 sub-periods. The Swiss franc has a strong relationship between excess return and the C-CAPM factor in the sub-periods before and after the financial crisis period (R^2 of 76% and 93% respectively), but only a modest relationship during the financial crisis period (R^2 of 28%).

Different patterns are observed from output of robust regressions in Table 7 where we examine the relationship between excess return of carry trades that invest in emerging market currencies and the C-CAPM factor. The relationship between excess returns and the C-CAPM factor is generally weak in the 2001-2006 sub-period. This changed during the financial crisis sub-period (2007-2009) where the yen, the euro, and the pound all have an R^2 between 43% and 81% as funding currencies. There is a modest relationship between excess returns and the C-CAPM factor in the 2010-2014 sub-period where R^2 is between 19% and 25% for all funding currencies except the Swiss franc ($R^2 = 3\%$). Though excess returns are predictable across some of the sub-periods in the paper's sample, the extent to which these returns are predictable is time-varying.

Fixed Effects Univariate Pooled Panel Regressions: Carry Trades for CDs, Government Bonds, and Large Cap Equity Indices

An issue with the regression tests described above is that they fail to account for the effects of individual investment currencies. I account for this issue with a fixed effects univariate pooled panel regression where the group variable is individual currencies and the time variable is the sub-periods (2001-2006, 2007-2009, and 2010-2014). Table 8 shows that the fixed effects univariate pooled panel regression yields a strong relationship over a fourteen-year time horizon for all five funding currencies. The strongest regression is for the Swiss franc, which has an R^2 of 76% and the weakest is for the yen, which still has a relatively high R^2 of 46%. In Tables 10 and 12, the results for carry trades in both the Emerging Markets and Developed Markets subgroups reinforce the strength of the model.

The results in Tables 14, 16, and 18 show C-CAPM explains a substantial portion of excess returns on carry trades that go long on a foreign large cap equity index. In some cases, the p-values are higher than the α-level of .05, so it is not conclusive whether the C-CAPM factor has a positive or negative effect on excess returns. Tables 20, 22, and 24 demonstrate C-CAPM also explains a sizable portion of excess returns for carry trades that go long on government bonds. There is consistency in the strength of the model regardless of whether the investment is a certificate of deposit, government bond, or a stock index.

A Hausman test tests the null hypothesis that the coefficient for the fixed effects model and the random effects model are equal. If there is no statistical difference between the coefficients for the fixed effects and random effects model, individual specific effects are uncorrelated with regressors. In Table 9, for example, it is clear that the null hypothesis must be rejected. This means the individual countries in the sample have an effect on the regressors. These findings justify the use of the fixed effects model in determining the validity of C-CAPM.

Chapter 8

Conclusion

The variant of the Consumption-Based Capital Asset Pricing Model introduced in Cochrane (2001) has explanatory power over carry trade excess returns over a 14-year time horizon consisting of three smaller sub-periods: 2001-2006, 2007-2009, and 2010-2014. This is true regardless of the asset class or funding currency used in the carry trade. The implication of this result is C-CAPM has broad applicability to asset pricing in general.

With that being said, there are differences in the strength of the model depending on the asset class and funding currency. The results of the OLS and robust regressions suggest that there are differences in strength of C-CAPM between the sub-periods as well. It is likely that the OLS and robust regressions failed to capture individual-specific sources of movement, which would explain why the fixed effects model was more successful in explaining at least a substantial amount of the variation in carry trade excess returns for each asset class and funding currency.

Though this paper concludes that carry trade excess returns are forecastable using C-CAPM, this leaves open the question of how to forecast carry trade returns during a liquidity crisis. C-CAPM is limited in its ability to accomplish this because global consumption data is generally only available on an annual basis. It does not seem plausible that investors would be risk-neutral during a financial crisis, so the short-run martingale model outlined in Chapter 3 might not be useful. A potential follow-up to the research in this paper is the establishment of a model that can capture the effect of limited liquidity on a representative consumer and explain short-run movements in carry trade excess returns.

Appendix

Country	α	β	S(α)	S(β)	Root MSE	R^2
Colombia	0.0001986	-0.0061767	0.0045971	0.1532761	0.03551	0.0000
Mexico	0.0049532	-0.0005931	0.0067523	0.0028686	0.02587	0.0008
Czech Republic	-0.0026138	0.0239606	0.0028997	0.0302273	0.03718	0.0038
Hungary	0.0142327	0.0384619	0.0063721	0.0146783	0.04425	0.0432
Poland	-0.0015151	-0.0015418	0.0035132	0.0061575	0.03514	0.0004
Qatar	$2.02*10^{-6}$	0.0004678	0.0000119	0.0002077	0.00014	0.0338
Russia	-0.0026895	-0.002899	0.002008	0.0025574	0.01304	0.0297
South Africa	0.0109483	0.0044693	0.012446	0.0064943	0.04857	0.0098
Saudi Arabia	$6.09*10^{-6}$	0.0057235	0.0000929	0.0020098	0.00119	0.0474
Turkey	0.006615	-0.0003978	0.0054535	0.0051179	0.05008	0.0000
U.A.E.	$-2.58*10^{-6}$	0.0004593	0.000012	0.0001743	0.00015	0.0404
Philippines	-0.0008426	-0.7395264	0.0020513	3.886368	0.01733	0.0002
South Korea	-0.0007599	0.0272086	0.0031271	0.5231796	0.03354	0.0000
Thailand	-0.0005513	0.058777	0.0016756	0.0651827	0.01649	0.0049
Canada*	-0.0012858	0.0199028	0.0023104	0.0809685	0.02721	0.0004
E.U.*	0.0015371	0.0083386	0.0023357	0.0702169	0.03018	0.0001
Israel*	0.0000856	0.002365	0.0022128	0.0033406	0.02501	0.0032
Switzerland*	-0.0024123	-0.0163878	0.0034831	0.0720529	0.03141	0.0003
Denmark*	-0.0010656	0.0109596	0.0023763	0.0120164	0.02996	0.0050
Norway*	-0.0005111	-0.0037344	0.0030348	0.0038133	0.03406	0.0062
Sweden*	0.0001753	0.0095814	0.0028749	0.0076913	0.03449	0.0093
Australia*	0.0070907	-0.0823754	0.0064508	0.0994454	0.03896	0.0041
Hong Kong*	-0.000142	0.0015804	0.0001361	0.0012833	0.00134	0.0091
Japan*	0.0021729	-0.0406016	0.0031293	0.0459658	0.02776	0.0047
New Zealand*	0.0246552	-0.4058749	0.0091124	0.1641188	0.03873	0.0357
Singapore*	-0.0017221	0.0028452	0.0017397	0.0402695	0.01689	0.0000
U.K.*	0.001174	-0.0160432	0.0026062	0.0427844	0.0253	0.0009

Table 2. OLS regression for FX Depreciation on Forward-Spot Differential

Note: * denotes a developed market country, according to MSCI

Country	Mean	St Dev	Skewness	Kurtosis	Sharpe Ratio	Δs	Δi
Brazil	0.1174445	0.10595308	-0.25763398	1.6713864	1.108457882	0.002732	0.120176
Chile	0.0025543	0.07119544	-0.75680641	3.3399581	0.035876814	0.000361	0.002915
Colombia	0.060805	0.07199438	-0.54445301	2.1402182	0.8445794	-0.00235	0.056335
Mexico	0.0447285	0.05906552	-1.05601034	4.137167	0.757268456	0.006026	0.050754
Peru	0.028683	0.03219716	0.538177928	1.9059962	0.890854222	-0.00369	0.024641
Czech Rep.	0.0115903	0.06643874	-0.15453354	0.2169797	0.174451039	-0.01031	0.001285
Egypt	0.0399767	0.05343017	-1.10221039	1.9396499	0.748205438	0.011321	0.080637
Hungary	0.052575	0.08257945	-0.36074275	0.4797837	0.636660107	-0.00333	0.050522
Poland	0.0402473	0.08083482	-1.00544849	2.000795	0.497895751	-0.00389	0.03636
Qatar	-0.001475	0.01338595	-2.222797	4.8976912	-0.110193075	6.07E-06	-0.08192
Russia	0.0543888	0.10671376	-5.93787242	59.655553	0.509670125	0.006099	0.060405
South Africa	0.0560767	0.0970879	0.11420779	0.6815886	0.577587131	0.006306	0.062383
Saudi Arabia	0.002249	0.00444066	-1.1029278	6.8882657	0.506453523	3.43E-06	0.002252
Turkey	0.1355341	0.13207415	0.980333306	1.6601262	1.026196657	0.017096	0.148941
U.A.E.	0.0002566	0.00600807	-1.41994785	8.736083	0.042709881	-5E-07	0.000256
China	0.0137241	0.03659817	-0.43020972	-0.40745	0.374994638	-0.00552	0.008213
India	0.048979	0.0477711	-0.01146553	-0.232122	1.025284377	0.00505	0.05585
Indonesia	0.0685045	0.07870702	0.517728492	2.7882588	0.870373592	0.003522	0.072026
Korea	0.022691	0.05313507	-1.28953585	7.5967411	0.42704407	-0.00373	0.018963
Philippines	0.0125483	0.0412015	-0.61547854	0.5074183	0.304559974	-0.00176	0.007294
Taiwan	-0.0043166	0.03042838	-0.09569563	-0.334641	-0.141860453	-0.00132	-0.00658
Thailand	0.0188334	0.03589634	-0.36828249	0.1137569	0.524661905	-0.00548	0.013661

Table 3. Summary Statistics, Carry Trade Returns, 2001-2014. Emerging Market Economies.

2001-2014

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-32.77104	-22.53	0.000	0.9407
Japanese Yen	-30.47358	-7.09	0.000	0.6113
Swiss Franc	8.86054	3.28	0.003	0.2574
Euro	9.729295	1.07	0.291	0.0347
British Pound	4.490698	0.57	0.573	0.0100

Sub-period One: 2001-2006

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-1.265375	-0.35	0.727	0.0040
Japanese Yen	-10.55768	-34.29	0.000	0.9743
Swiss Franc	13.48882	17.60	0.000	0.9117
Euro	-12.97127	-5.69	0.000	0.5106
British Pound	-29.4644	-5.28	0.000	0.4731

Sub-period Two: 2007-2009

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-1.573896	-0.94	0.356	0.0276
Japanese Yen	17.74326	7.43	0.000	0.6407
Swiss Franc	13.04946	9.59	0.000	0.7541
Euro	-10.22171	-4.52	0.000	0.3968
British Pound	-12.70922	-4.04	0.000	0.3454

Sub-period Three: 2010-2014

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	64.5	4.74	0.000	0.4203
Japanese Yen	1.009487	0.14	0.886	0.0007
Swiss Franc	6.926973	17.39	0.000	0.9098
Euro	-11.24296	-3.47	0.002	0.2797
British Pound	-5.991421	-1.86	0.072	0.1005

Table 4. OLS Regressions, Excess Returns on C-CAPM

2001-2014

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	2.876875	1.91	0.066	0.1049656
Japanese Yen	5.656343	2.67	0.012	0.19194686
Swiss Franc	5.678728	7.39	0.000	0.65332504
Euro	-6.897785	-1.23	0.227	0.04667543
British Pound	-2.735868	-0.59	0.556	0.01091805

Sub-period One: 2001-2006

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	22.7643	6.18	0.000	0.56841287
Japanese Yen	-5.887924	-1.58	0.124	0.07724442
Swiss Franc	10.13212	9.62	0.000	0.76137029
Euro	1.180244	0.22	0.826	0.00168817
British Pound	14.68775	2.14	0.040	0.13271972

Sub-period Two: 2007-2009

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-1.181551	-1.25	0.220	0.0496474
Japanese Yen	-40.29921	-25.59	0.000	0.95620784
Swiss Franc	-5.909845	-3.31	0.003	0.28107089
Euro	-9.63089	-4.41	0.000	0.38567533
British Pound	-12.71647	-4.07	0.000	0.34837808

Sub-period Three: 2010-2014

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-1.054054	-1.51	0.141	0.07318448
Japanese Yen	-29.29617	-12.49	0.000	0.8431773
Swiss Franc	9.11983	19.33	0.000	0.92799566
Euro	-14.06268	-6.13	0.000	0.56405559
British Pound	-14.62879	-3.53	0.001	0.30090158

Table 5. Robust Regressions, Excess Returns on C-CAPM

2001-2014

Funding Currency	**Coefficient**	**t**	**Probability > |t|**	**R^2**
U.S. Dollar	-27.11115	-6.53	0.000	0.6915
Japanese Yen	-43.40863	-22.50	0.000	0.9638
Swiss Franc	5.812302	10.73	0.000	0.8647
Euro	-41.92222	-1.68	0.109	0.1087
British Pound	13.98182	0.91	0.375	0.0416

Sub-period One: 2001-2006

Funding Currency	**Coefficient**	**t**	**Probability > |t|**	**R^2**
U.S. Dollar	-15.24585	-11.51	0.000	0.8804
Japanese Yen	-10.50777	-67.87	0.000	0.9961
Swiss Franc	14.3254	33.27	0.000	0.9849
Euro	-17.31644	-29.49	0.000	0.9797
British Pound	-39.749	-8.64	0.000	0.8058

Sub-period Two: 2007-2009

Funding Currency	**Coefficient**	**t**	**Probability > |t|**	**R^2**
U.S. Dollar	-10.10994	-6.53	0.000	0.7029
Japanese Yen	-39.42894	-4.06	0.001	0.4786
Swiss Franc	-28.01931	-2.28	0.036	0.2338
Euro	-11.395352	-4.82	0.000	0.5630
British Pound	-10.18107	-2.55	0.020	0.2659

Sub-period Three: 2010-2014

Funding Currency	**Coefficient**	**t**	**Probability > |t|**	**R^2**
U.S. Dollar	-13.24705	-1.65	0.116	0.1314
Japanese Yen	-7.428548	-1.31	0.207	0.0868
Swiss Franc	9.10528	3.46	0.003	0.4135
Euro	-16.22808	-4.60	0.000	0.5402
British Pound	-15.45598	-1.38	0.184	0.0958

Table 6. OLS Regressions, Excess Returns on C-CAPM, Subgroup: Emerging Markets

2001-2014

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-14.21929	-2.25	0.037	0.21927455
Japanese Yen	4.127474	0.76	0.459	0.03086903
Swiss Franc	-2.088934	-0.34	0.737	0.00681451
Euro	-9.728681	-1.10	0.285	0.06314346
British Pound	-14.35331	-1.30	0.210	0.0857932

Sub-period One: 2001-2006

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-14.10803	-1.41	0.175	0.10525109
Japanese Yen	6.804119	0.87	0.397	0.04249272
Swiss Franc	-2.525131	-0.25	0.805	0.00391338
Euro	-10.5967	-1.27	0.221	0.08656419
British Pound	-13.70672	-1.14	0.269	0.07144055

Sub-period Two: 2007-2009

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-3.728559	-1.40	0.180	0.10296141
Japanese Yen	-32.70845	-8.35	0.000	0.81352904
Swiss Franc	-5.460079	-0.91	0.379	0.05192695
Euro	-10.55888	-4.44	0.000	0.52280648
British Pound	-17.80742	-3.55	0.002	0.42549846

Sub-period Three: 2010-2014

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-32.29933	-2.31	0.035	0.24972997
Japanese Yen	-13.16267	-1.92	0.073	0.18658116
Swiss Franc	-5.078557	-0.67	0.516	0.0287063
Euro	-20.95495	-2.01	0.061	0.1914148
British Pound	-34.06008	-2.24	0.040	0.2385392

Table 7. Robust Regressions, Excess Returns on C-CAPM, Subgroup: Emerging Markets

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	55.40519	4.93	0.000	0.5217
Japanese Yen	-4.727136	-3.13	0.003	0.4589
Swiss Franc	10.1144	10.87	0.000	0.7561
Euro	-10.04791	-7.64	0.000	0.7442
British Pound	-13.71237	-5.06	0.000	0.5988

Table 8. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, Certificates of Deposit, All Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	55.40519	52.2731	3.13209	8.469795	0.14	0.7115
Japanese Yen	-4.727136	-6.031085	1.303949	0.8914487	2.14	0.1435
Swiss Franc	10.1144	11.09381	-0.979415	0.6009138	2.66	0.1031
Euro	-10.04791	-10.60566	0.5577578	0.4648146	1.44	0.2302
British Pound	-13.71237	-13.95275	0.2403852	1.118603	0.05	0.8298

Table 9. Hausman Test, Excess Returns on C-CAPM, Certificates of Deposit, All Currencies, 2001-2014.

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	-2.894966	-1.77	0.085	0.9772
Japanese Yen	-4.727136	-3.13	0.003	0.4589
Swiss Franc	16.69747	12.01	0.000	0.8070
Euro	2.65775	0.77	0.448	0.3794
British Pound	-9.109965	-1.63	0.111	0.6071

Table 10. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, Certificates of Deposit, Emerging Market Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	-2.894966	-2.354229	0.3592634	N/A	-3.34	N/A
Japanese Yen	-4.727136	-6.031085	1.303949	0.891448	2.14	0.1435
Swiss Franc	16.69747	13.49648	3.200994	0.5911388	29.32	0.0000
Euro	2.65775	1.833711	0.8240389	1.072915	0.59	0.4425
British Pound	-9.109965	-19.50025	10.39029	3.149225	10.89	0.0010

Table 11. Hausman Test, Excess Returns on C-CAPM, Certificates of Deposit, Emerging Market Currencies, 2001-2014.

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	158.4892	8.70	0.000	0.8326
Japanese Yen	19.71969	6.61	0.000	0.7312
Swiss Franc	9.899511	6.88	0.000	0.7508
Euro	1.015908	0.38	0.705	0.3605
British Pound	-14.90652	-4.47	0.000	0.4843

Table 12. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, Certificates of Deposit, Developed Market Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	158.4892	121.9786	36.51058	14.67767	6.19	0.0129
Japanese Yen	19.71969	17.71253	2.00716	1.639655	1.50	0.2209
Swiss Franc	9.899511	10.88065	-0.9811344	0.906422	1.17	0.2791
Euro	1.015908	3.413771	-2.397863	1.134641	4.47	0.0346
British Pound	-14.90652	-11.49904	-3.407485	1.685946	4.08	0.0433

Table 13. Hausman Test, Excess Returns on C-CAPM, Certificates of Deposit, Developed Market Currencies, 2001-2014.

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	68.78296	4.00	0.000	0.4715
Japanese Yen	-0.159934	-0.07	0.943	0.2925
Swiss Franc	8.523114	8.11	0.000	0.6497
Euro	-5.418409	-1.93	0.057	0.4770
British Pound	-9.996243	-4.08	0.000	0.6978

Table 14. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, Large Cap Equity Market Indices, All Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	68.78296	71.47668	-2.69372	13.36339	0.04	0.8402
Japanese Yen	-0.159934	-2.084205	1.9242721	1.386539	1.93	0.1652
Swiss Franc	8.523114	7.891015	0.6320982	0.5495556	1.32	0.2501
Euro	-5.418409	-3.908593	-1.509816	0.9925515	2.31	0.1282
British Pound	-9.996243	-8.663212	-1.333031	N/A	-15.77	N/A

Table 15. Hausman Test, Excess Returns on C-CAPM, Large Cap Stock Market Indices, All Currencies, 2001-2014.

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	1.08974	0.79	0.441	0.7705
Japanese Yen	-12.92372	-10.85	0.000	0.8516
Swiss Franc	-12.92248	-10.84	0.000	0.8514
Euro	-8.30371	-2.41	0.020	0.2771
British Pound	-7.663779	-2.23	0.031	0.7247

Table 16. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, Large Cap Equity Market Indices, Emerging Market Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	1.08974	-1.491264	2.581004	0.5429384	22.60	0.0000
Japanese Yen	-12.92372	-14.17218	1.24846	0.7505976	2.77	0.0963
Swiss Franc	-12.92248	-14.17268	1.250197	0.7505853	2.77	0.0958
Euro	-8.30371	-7.927161	-0.3765494	2.091377	0.03	0.8571
British Pound	-7.663779	-6.454925	-1.208855	N/A	-34.19	N/A

Table 17. Hausman Test, Excess Returns on C-CAPM, Large Cap Stock Market Indices, Emerging Market Currencies, 2001-2014.

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	104.3101	3.14	0.005	0.5246
Japanese Yen	13.21866	3.96	0.001	0.5184
Swiss Franc	11.31107	22.08	0.000	0.9648
Euro	1.673174	0.36	0.721	0.7064
British Pound	-13.71237	-5.06	0.000	0.5988

Table 18. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, Large Cap Equity Market Indices, Developed Market Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	104.3101	94.53396	9.776172	25.92694	0.14	0.7061
Japanese Yen	13.21866	11.32073	1.897929	2.046858	0.86	0.3538
Swiss Franc	11.31107	10.66869	0.6423805	0.3285384	3.82	0.0506
Euro	1.673174	4.119083	-2.445908	N/A	-3.81	N/A
British Pound	-13.98563	-12.01995	-1.965682	1.381798	2.02	0.1549

Table 19. Hausman Test, Excess Returns on C-CAPM, Large Cap Stock Market Indices, Developed Market Currencies, 2001-2014.

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	89.52739	2.87	0.007	0.4519
Japanese Yen	21.01171	8.80	0.000	0.7546
Swiss Franc	10.72297	50.79	0.000	0.9897
Euro	2.983913	1.16	0.252	0.3883
British Pound	-5.870382	-1.08	0.290	0.4052

Table 20. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, One Year Government Bonds, All Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	89.52739	91.42956	-1.902174	26.52492	0.01	0.9428
Japanese Yen	21.01171	19.77657	1.235147	1.457813	0.72	0.3969
Swiss Franc	10.72297	10.42027	0.3026929	0.1230861	6.05	0.0139
Euro	2.983913	2.11527	0.8686426	0.6994446	1.54	0.2143
British Pound	-5.870382	-2.714163	-3.156219	2.784833	1.28	0.2571

Table 21. Hausman Test, Excess Returns on C-CAPM, One Year Government Bonds, All Currencies, 2001-2014.

Funding Currency	Coefficient	t	Probability > |t|	R^2
U.S. Dollar	1.08974	0.79	0.441	0.7705
Japanese Yen	-38.95748	-14.62	0.000	0.9605
Swiss Franc	11.82078	6.43	0.000	0.8649
Euro	2.983913	1.16	0.252	0.3883
British Pound	14.13637	1.55	0.137	0.4368

Table 22. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, One-Year Government Bonds, Emerging Market Currencies, 2001-2014.

Funding Currency	Fixed Coefficient (b)	Random Coefficient (B)	(b-B) Difference	Square Root Standard Error	Chi^2	$Prob>Chi^2$
U.S. Dollar	1.08974	-1.491264	2.581004	0.5429384	22.60	0.0000
Japanese Yen	-38.95748	-36.80811	-2.14937	N/A	-3.16	N/A
Swiss Franc	11.82078	13.07829	-1.257511	1.423773	0.78	0.3771
Euro	2.983913	2.11527	0.8686426	0.6994446	1.54	0.2143
British Pound	14.13637	8.545416	5.590951	6.823169	0.67	0.4126

Table 23. Hausman Test, Excess Returns on C-CAPM, One-Year Government Bonds, Emerging Market Currencies, 2001-2014.

Funding Currency	**Coefficient**	**t**	**Probability > |t|**	**R^2**
U.S. Dollar	104.3602	2.13	0.048	0.4572
Japanese Yen	21.85501	7.51	0.000	0.8039
Swiss Franc	10.71192	44.02	0.000	0.9935
Euro	13.64779	2.99	0.009	0.6143
British Pound	-11.59497	-1.64	0.121	0.3535

Table 24. Fixed Effects Univariate Pooled Panel Regression, Excess Returns on C-CAPM, One-Year Government Bonds, Developed Market Currencies, 2001-2014.

Funding Currency	**Fixed Coefficient (b)**	**Random Coefficient (B)**	**(b-B) Difference**	**Square Root Standard Error**	**Chi^2**	**$Prob>Chi^2$**
U.S. Dollar	104.3602	103.1309	1.229329	41.1851	0.00	0.9762
Japanese Yen	21.85501	20.62239	1.232615	1.658097	0.55	0.4572
Swiss Franc	10.71192	10.36292	0.3489982	0.144526	5.83	0.0157
Euro	13.64779	11.77954	1.868252	0.5206923	12.87	0.0003
British Pound	-11.59497	-7.726803	-3.868163	2.869358	1.82	0.1776

Table 25. Hausman Test, Excess Returns on C-CAPM, One-Year Government Bonds, Developed Market Currencies, 2001-2014.

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Academic Vita

Joseph Gilbert Kearns

EDUCATION

The Pennsylvania State University, University Park, PA Graduation Date: May 2016
Bachelor of Science in Economics
Concentration in Macroeconomics, Money & Banking
Minors in Business & the Liberal Arts, History

- Qualified for Dean's List in every semester to date
- Scholar in the Schreyer Honors College

PROFESSIONAL EXPERIENCE

BNY Mellon, Pittsburgh, PA June 2015-August 2015
Undergraduate Intern- Treasury Services- Credit Underwriting

- Conducted research on Treasury Services clients using corporations and municipal agencies' financial statements, as well as reports from Moody's and Standard & Poor's
- Assembled tearsheets for a credit underwriter in which I wrote about clients' corporate structure, Treasury Services risks and rationale, financial updates, and borrower and facility ratings justification
- Assigned a proposed borrower rating to a client based on my scoring of business risk and objectively determined financial risk scores

Federated Investors, Pittsburgh, PA
Summer Intern- Internal Sales Division May 2014-August 2014

- Attended training workshops on sales techniques, product updates and competitive analysis
- Worked on a P&L report of currency trades used by the company's International Fixed Income Group

LEADERSHIP EXPERIENCE

Penn State Economics Association, University Park, PA
Vice President of Education May 2015-May 2016

- Oversaw 3 committees each led by a coordinator in charge of educating the general body through oral presentations or written publications
- Presided over annual Great Debate between students and professors on illegal immigration

Print Education Committee Coordinator May 2014-May 2015

- Managed 4 associates who wrote pieces about international and domestic economic topics; Contributed writing pieces and facilitated the editing process
- Orally presented current events and news articles related to economics and finance to the general body
- Marketed my committee by overseeing redesign of Print Education website and digital marketing

Pennsylvania State University, Dept. of Economics, University Park, PA
Undergraduate Teaching Assistant August 2014-December 2014

- Directed review sessions for more than 340 students in ECON 106
- Graded course assignments and provided feedback for Professor Austin Boyle

ADDITIONAL EXTRACURRICULAR INVOLVEMENT

Penn State Investment Association, University Park, PA January 2015-May 2015
Analyst, Energy Sector

- Winner of the 2015 Spring Semester Stock Pitch Competition; presented with two other analysts to pitch a company from Industrials sector to the Nittany Lion Fund

SKILLS

- Proficient in Microsoft Office products (Excel, Word, PowerPoint, Publisher, Outlook, Access)
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