The Money Multiplier and Asset Returns

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Abstract

In recent years, we have lived through times of unprecedented money and credit creation, which has prompted a new interest in the role of money and credit in the economy. In this work, I show that the money multiplier, the ratio of a broad monetary aggregate to a narrow monetary aggregate, captures the rate of money creation in the economy and robustly predicts stock, bond and currency returns. I link the predictive ability of the money multiplier to its economic interpretations as a measure of economy-wide leverage and an alternative measure of money velocity.

First, I look at U.S. stock and bond market and show that money multipliers robustly predict stock and bond excess returns over the period January 1959 - December 2015, and are priced in cross-section of stocks. These multipliers remain statistically significant after controlling for outside money growth and other well-understood predictors of stock and bond returns.

Then I extend my analysis to currencies. I investigate short-run and long-run relationships between bilateral exchange rates and broad money multipliers of ten countries. I motivate my analysis with the quantity theory of money and find a strong long-run relationship between the exchange rate, relative money velocities, relative money supplies of the two countries and their relative output. I argue that the money multiplier can be seen as an alternative measure for money velocity, as it accounts for propensity to spend money not only on real sector goods and services but on financial assets too.

Contents

1 Introduction

In recent years, we have lived through times of unprecedented money and credit creation. This has prompted new interest in the role of money and credit in the economy and their impact on financial markets and economic fundamentals. Many theoretical models have tried to link money and credit creation to stock and bond prices; however empirical work has not. At the same time, a growing literature discusses the importance of leverage in the economy (Kiyotaki and Moore [1997], Geanakoplos [2010], Brunnermeier and Pedersen [2009], Adrian and Shin [2014] and many others), but very little work has documented the relationship between asset returns and aggregate measures of leverage and credit. The first two chapters of this work link the ideas of money creation and leverage so as to fill the gap in empirical work on predictability of stocks and bonds.

The last chapter of this work investigates how the speed of money creation across countries affects relative currency returns. Attempts to explain exchange rates with macro variables go back to monetary models of the seventies, whose empirical failures were pointed out by the seminal work of (Meese and Rogoff [1983]. Since then, one of the key negative findings on which the literature reached a certain consensus is that interest rates, prices, output and money have no success in predicting exchange rates in the short run and out-of-sample, and that a random walk is frequently found to generate better exchange rate forecasts than macro variables motivated by economic models (Rossi [2013]). However, the broad money multiplier was never considered as a predictor of exchange rates and therefore was never rejected as such in the past.

In this work, I show that money multipliers, ratios of inside money to outside money, predict asset returns. In the first two chapters, I look at the past 59 years of U.S. stock market returns and show that what matters most for stock and bond prices is the creation of inside money per dollar of outside money, rather than the quantity of money per se. In particular, I show that growth in money multipliers robustly predicts stock and bond market excess returns over the period January 1959 - December 2015 (see Table 1.1 below). These multipliers remain statistically significant after controlling for outside money growth, while the t-statistics for outside money growth itself are very low. The $\bar{R}^2$ of around 5% for quarterly data increases to up to 17% for annual data.

Table 1.1: OLS estimates from a predictive regression of log U.S. stock market excess returns (CRSP value-weighted index): $r^e_{m,t+1} = \alpha + \beta \Delta X_t + \kappa X_t + \gamma \Delta lnMB_t + \epsilon_{t+1}$. X_t is the money multiplier growth rate measured as the first difference of the log of the ratio of a broad money aggregate to the monetary base MB. $\Delta lnMB_t$ is the first difference of the log of the monetary base. I consider three monetary aggregates: M1, M2 and MZM (Money Zero Maturity). T-statistics in italics, quarterly data, 1959 Q1 - 2015 Q4.

X	β	κ	γ	$\bar{R}^2$
$^{M1}/_{MB}$	0.69	-0.09	0.27	5.90%
	2.73	*-1.18*	*0.97*	
$^{M2}/_{MB}$	0.88	-0.15	0.34	4.14%
	1.66	*-1.15*	*1.08*	
$^{MZM}/_{MB}$	0.95	-0.22	0.19	6.02%
	2.80	*-2.88*	*1.01*	

While multiplier *growth* predicts market returns positively, its *level* predicts returns negatively. When more inside money is generated per dollar of the monetary base, the multiplier increases and so, subsequently, do stock prices. However, when the level of the multiplier is high, stock prices are high and expected returns are low. Thus the money multiplier is pro-cyclical. These results are robust to controlling for inflation, stock market volatility, federal funds rate, total loan growth and some other key economic indicators, and also hold out of sample (Goyal and Welch [2008]). Furthermore, I show that changes in the multipliers are priced in the cross-section. Value stocks are more sensitive to the growth of inside money, and up to 10% of the variation of their quarterly returns is explained by variation in the money multiplier. I separately estimate the impact of inside and outside money in the cross-section and find that in all cases inside money matters more.

Chapter 2 and 3 of this work argues that the money multiplier can be interpreted as a measure of net economy-wide leverage, since it captures the total amount of credit created in the economy per dollar of cash and reserves. Traditionally, it is common to distinguish between outside money, liabilities of the central bank created by central bank fiat, and inside money, liabilities of the rest of the private banking sector, with the latter responding endogenously to the demand for money of the wider economy. In this work I document the predictive properties of their relative dynamics. I also argue that the money multiplier is a better measure of leverage than those previously considered in the literature. It accounts for netting of interbank loans as well as for synthetic leverage, such as repos and money market funds.

When more net leverage is generated in the economy, the multiplier grows, and so do stock prices. One can speculate about the exact link between the two. One possibility is that rising optimism or risk tolerance induces people to lend money to each other more easily and invest in stocks more willingly. It is also possible that there is a financial friction that results in inside money fluctuation and consequently in the fluctuation of asset prices, as in financial accelerator models (Bernanke and Gertler [1995]) or models of funding liquidity (Brunnermeier and Pedersen [2009]). My empirical findings can be reconciled with models of the leverage cycle (e.g. Geanakoplos [2010]). Independently of the underlying mechanism, variation in inside money creation forecasts market excess returns.

In this work I make a theoretical link between stock prices and the money multiplier using the margin CAPM described in Ashcraft et al. [2011] and Frazzini and Pedersen [2014]. In this model, money is created for the purpose of investing into a portfolio of stocks. Agents are born with some cash endowment, which they have to pledge against their loan together with the portfolio of stocks that they purchase. Agents differ by their leverage ratio, the aggregated level of which equals the scaled ratio of total assets held by all agents over the total value of cash pledged. Since in this economy all money is invested in risky assets, the aggregate leverage ratio equals the scaled money multiplier.

In the fourth chapter of this work, I investigate short-run and long-run relationships between bilateral exchange rates and broad money multipliers of ten countries. I motivate my analysis with the quantity theory of money and investigate a broad relationship between the exchange rate, relative money velocities, relative money supplies of the two countries and their relative output. I argue that the money multiplier can be seen as an alternative measure for money velocity, as it accounts for propensity to spend money not only on real sector goods and services, but on financial assets too. I consider two specifications for my empirical tests. The short-run dynamics are tested by regressing the first differences of exchange rates onto the first differences of the chosen macro variables. The long-run relationship is tested using the concept of cointegration and applying it using an error correction model.

Using quarterly data I show that that there is a long term relationship between the exchange rate, the two countries' money multipliers differential, and their narrow money supply and output differentials. This long term relationship holds across all countries and has strong predictive power for quarterly changes in exchange rates. At the same time, short-term deviations of the considered macro variables cannot explain the dynamics of exchange rates, neither contemporaneously nor in the near future. Thus, I find that the short run dynamics of the exchange rate can be forecast only to the extent of the reversion to the long-term equilibrium, and confirm the common literature finding that short-run fluctuations of the exchange rate are difficult to forecast using macro variables.

This paper serves several purposes and its contribution to the literature should be considered separately for the first two chapters and the last chapter. The first chapter of this work links the extensive literature on money and credit creation to models of leverage. It introduces a new measure of leverage that spans not only the financial intermediation sector, but the whole economy, thus providing a new metric for testing theories. The second chapter provides strong empirical support for these theoretical claims and demonstrates the predictive power of money multipliers for stock and bond returns in the U.S.

As such, the first two chapters contribute to several fields of the existing financial literature. It relates to the literature on the predictability of stock returns by macro variables and to the ongoing discussion about the role of money and credit in driving the economy and financial markets. It fits into a growing literature following the 'credit view', that suggests that the structure and quantities of bank credit affect real economic decisions (Mishkin [1978], Bernanke [1983] and Gertler [1988]). Currently, most empirical papers in this field look at credit and money creation in relation to the financial crisis (Congdon [2005], Schularick and Taylor [2012], Jorda et al. [2015]), or at its impact on real activity (Adrian and Shin [2010]). I look at the relationship of money and stock prices, and document the predictive power of the money multiplier for aggregated stock market returns over different time horizons and show that it is priced in cross-section. To my knowledge these empirical findings are novel. Schularick and Taylor [2012] address the link between the ratio of bank loans/assets to money balances and broad stock market indices across a range of countries. However, they also focus on periods of financial crisis and show that lagged credit growth is a significant predictor of the crisis. The empirical results presented in the current paper are the closest to Adrian et al. [2013], who look at predictability of stock and bond returns by different measures of broker-dealer leverage. While the multiplier can be interpreted as a leverage ratio, this paper emphasises the role of money creation for asset prices, and in particular, it pins down the greater importance of inside money creation relative to outside money. This newly documented empirical fact bridges the growing credit literature and classic Keynesian macroeconomics.

The majority of the credit literature focuses on the effect of credit creation alone, while this paper looks at the relative growth of inside money with respect to outside money, thus capturing the dynamics of both. King and Plosser [1984] were the first to address the difference between outside and inside money, pointing out that the former react to demand-type shocks, while the latter react more to supply-type shocks. With the growth of direct corporate lending during the past 25 years, the difference between the dynamics of inside money and outside money has become more pronounced, since demand and supply shocks often happen in different times. Thus the combination of these two very different dynamics underlines the role of efficient financial intermediation and results in strong predictive power for the multiplier.

In addition, this work adds to the growing literature that links leverage to asset prices within the CAPM framework. Adrian et al. [2014], Adrian et al. [2013] and others show that intermediary leverage explains a large portion of contemporaneous stock returns and is priced in cross-section. My approach differs from these papers, because I focus on a predictive relationship and because of the new measure of leverage that I use. Most empirical work in the literature considers margin constraints and leverage of financial intermediaries, while I look at a measure of leverage that spans the non-financial sector as well. The latter is important, since households (non sophisticated investors) hold a large share of the stock market.

The last chapter extends this analysis to ten countries and looks at the predictive power of relative money multipliers for exchange rate movements. Economic theory has tried to understand the empirical linkage between exchange rates and key macro variables for a long time. However, the nature of the relationship and its robustness are still being debated in the literature (MacDonald and Taylor [1991], Neely and Sarno [2002], Alquist and Chinn). More recently, the literature found financial variables that have an ability to forecast exchange rates (Kremens and Martin [2019], Lustig et al. [2011]), while traditional macroeconomic variables have proven especially dismal as predictive variables (Rossi [2013]).

The discussion is ongoing though. Theory of equilibrium currency pricing predicts that macroeconomic variables such as output and money supply should play an important role in forecasting currency returns. However, for the past forty years the literature has struggled to provide direct empirical evidence for that (Meese and Rogoff [1983]). Given these past failures, the task of predicting exchange rates with money multipliers seems hopeless. In the first two chapters of this work I argue that the broad money multiplier captures the dynamics of financial assets creation in the economy and thus is reactive to financial shocks. Since exchange rates are sensitive to financial shocks (Obstfeld and Rogoff [2001], Kremens and Martin [2019]), capturing those with the money multiplier gives another chance to the traditional monetary approach at exchange rate forecasting.

The universe of empirical models intended to predict exchange rates is enormous. Models that already earned their respect include interest rate parity models (Meese and Rogoff [1988]), productivity based models (Cheung et al. [2005]), purchasing power parity (Rogoff [1996]), and sticky-price and flexible price monetary models (Frenkel [1976]). In my work I do not attempt to add to this plethora of models by suggesting a new one, and merely use the quantity theory of money as a framework to test my assumption that the money multiplier can predict exchange rates, in the same way as it can predict stock and bond returns. However, my testing framework comes very close to empirical tests of classic structural monetary models of the 70s, like the flexible-price Frenkel-Bilson model (Frenkel [1976]), or the sticky price Dornbush-Frankel model (Dornbusch [1976]).

These two models stand at the origins of the monetary approach to the exchange rate forecasting and are based on the understanding that the exchange rate is the relative price of two monies, and therefore should depend on the relative demand and supply of those monies. Different monetary equilibria specifications allow to link nominal exchange rate fluctuations to movements in countries' relative money, output, interest rates and prices. The exact combination of state variables is usually motivated by a structural model, but tests were usually done in the form of a simple first difference forecasting model, since on its own structural models are usually too stylised to be taken to the data directly.

Despite the devastating critique of the monetary approach by Meese and Rogoff [1983], who showed that monetary model forecasts could not outperform a simple no-change forecast, empirical tests of exchange rate forecastability motivated by the monetary models continued. In the past 20 years, however, most of these tests relied on the concept of cointegration and error correction models (MacDonald and Taylor [1991], Chinn and Moore [2011], Du et al. [2018]).

In my work, I use the first difference predictive model to asses the short-run effects of the relative output, the money supply and the money multiplier, and I use error correction models to asses their long-run effects. One of the main contributions of this work is to suggest a new predictor of exchange rates, the broad money multiplier. It has been shown in the literature that financial shocks that move exchange rates have little effect on key macro variables like narrow money supply and output, and therefore need to be accounted for separately (Chinn and Moore [2011]). Through its money markets component the multiplier accounts for creation of financial assets in the economy and therefore captures financial market shocks that move exchange rates, but have not been accounted for previously in classic monetary models and their following extensions.

I focus on nominal exchange rates and directly address the exchange rate disconnect puzzle, one of the six major exchange rate puzzles as described by Obstfeld and Rogoff [2001], the other five being excess volatility of real exchange rates, excess reactions to interest rate differentials, excess persistence of the real exchange rate, the uncovered interest rate puzzle and the consumption correlation puzzle. The exchange rate disconnect puzzle addresses the remarkably weak short-term relationship between exchange rates and key macro variables. I find that if the relative values of money supply and output are put together with relative money multipliers into a cointegration vector, then the cointegrating residual has strong forecasting power for quarterly changes in exchange rates. I emphasise the importance of relative multiplier values for exchange rates, and their long-run relationship. I find that there is short-run predictability in the sense of reversion to the long-run trend.

The rest of this work is organised as follows. Chapter 2 discusses inside money creation and motivates the money multiplier as a proxy for economy-wide leverage, presents the margin CAPM model amended to account for inside money creation and derives theoretical predictions for empirical tests for predictability of stocks and bonds by the money multiplier. Chapter 3 presents the empirical findings following the theory of the previous chapter. Chapter 4 extends the analysis to exchange rate predictability and studies the relationship between relative money multipliers of the ten countries and their respective currency returns. Chapter 5 concludes.

2
Money Matters: The Theory

This chapter introduces the concept of the money multiplier as a measure of economy-wide leverage and presents a theoretical framework that links the money multiplier with future returns on stocks and bonds.

Using the U.S. economy as an example I discuss the differences between the measures of money supply, the notions of inside and outside money and the different macro-dynamics that they capture. I argue that the money multiplier, the ratio of inside to outside money, measures the rate at which inside money is created, reflects total demand for loans, and the depth of financial intermediation in the economy. I interpret the money multiplier as a measure of economy-wide leverage and compare it to other measures of leverage previously described in the asset pricing literature.

I use the margin CAPM of Ashcraft et al. [2011] and Frazzini and Pedersen [2014] to derive the theoretical link between the money multiplier and asset returns and derive predictions for asset return dynamics on aggregate in the cross-section. First, I show that the money multiplier predicts future market returns over a range of time horizons. In particular, I show that the expected market return is decreasing in the multiplier's levels and is increasing in the multiplier's growth rate. Second, I show that the loading on the money multiplier level and its growth rate varies in the cross-section. In particular, for stocks, the slope in front of the multiplier is higher for shares with lower market beta.

Measures of money supply, inside and outside money.

In the U.S., money supply is measured using monetary aggregates. The most narrow aggregate is the monetary base (MB). It consists of cash and reserves and measures the most liquid money in the economy. This aggregate is the only one that can be directly controlled by the central bank via either printing money, or setting the federal funds rate, and is often referred to in the literature as outside money (Hartley and Walsh [1986]). M1 and M2 monetary aggregates consider a broader definition of money and are progressively less liquid. M1 consists of currency in circulation and non-savings deposits; M2 additionally includes savings deposits and retail money market funds; money zero maturity (MZM) consists of cash, savings deposits and money market funds, both institutional and retail. The non-cash components of M1, M2 and MZM result from the lending activity of the private sector and therefore are endogenous to the economy. It is commonly referred to as inside money (Hartley and Walsh [1986], Lagos [2010]). The dynamics of U.S. monetary aggregates and their main components over the past 55 years is illustrated with Figure 2.1.[1] Table 2.1 presents descriptive statistics for all monetary aggregates and their quarterly changes. Results presented in this paper use not seasonally adjusted monetary data since the asset returns analysed in this paper are not seasonally adjusted either. However, robustness checks using seasonally adjusted monetary data show that this does not change the main results.

Table 2.1 shows that the MB grew almost 100 times from its minimum of 38.6 Billion Dollars at the beginning of 1959 to 4 Trillion at the end of 2015. M1 grew approximately 22 times, while broad monetary aggregates M2 and MZM grew about 43 and 50 times, respectively. From Figure 2.1 one can see that starting from the 1990s broad money started to grow rapidly. The share of demand deposits declined, but the share of savings deposits, financial instruments and money funds increased. At the end of 2015 MZM became larger than M2 due to a large increase in institutional money market funds.

[1] A detailed description of U.S. monetary aggregates is provided in the Appendix.

Figure 2.1: Monetary aggregates and their components. This graph shows the dynamics of the five U.S. monetary aggregates from the narrowest, the U.S. Monetary Base (MB), to the broadest, M2 and MZM, in Billions of U.S. Dollars over the period of 1959.01 - 2015.04. Data is available from the FED H.6 Money Stock Measures release, 224 quarterly data points, not seasonally adjusted, not inflation adjusted.[2]

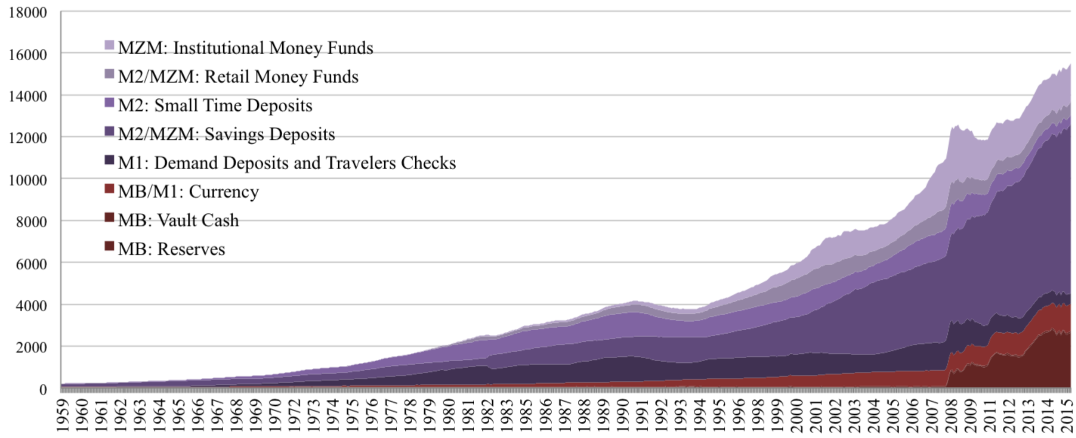


Table 2.1: Summary statistics. Part (a) presents variables' descriptive statistics estimated over the full sample period, 1959 Q1 - 2014 Q4, quarterly data. Part (b) presents the contemporaneous correlations between variables. Δ for each variable is computed as a log change of the variable's average quarterly value. σ_t and $\rho_{t,t-1}$ denote the standard deviation and the first order autocorrelation of the time series.

(a) Descriptive statistics

	$Mean$	$Median$	σ_t	Min	Max	$\rho_{t,t-1}$
MB	624.38	244.01	955.52	38.61	4076.1	0.998
M1	861.59	752.6	712.72	138.9	3093.8	1.000
M2	3558.12	2798.2	3210.96	290.2	12453.9	1.000
MZM	3424.71	2019.3	3685.46	278.2	13837.5	1.000
ΔMB	0.020	0.016	0.039	-0.071	0.425	0.330
$\Delta M1$	0.014	0.014	0.018	-0.030	0.078	0.252
$\Delta M2$	0.017	0.017	0.010	-0.008	0.046	0.317
ΔMZM	0.017	0.016	0.019	-0.036	0.145	0.370

(b) Correlation matrices

	MB	**M1**	**M2**	**MZM**
MB	1.000	0.931	0.912	0.928
M1		1.000	0.982	0.968
M2			1.000	0.993
MZM				1.000

	ΔMB	$\Delta M1$	$\Delta M2$	ΔMZM
ΔMB	1.000	0.359	0.189	0.175
$\Delta M1$		1.000	0.564	0.513
$\Delta M2$			1.000	0.679
ΔMZM				1.000

This can be explained by the growing sophistication of the financial intermediation sector and the rise of money markets. Tight financial regulation and the development of information technology led to financial innovation in the 1970s and 1980s and the increasing importance of financial markets.[3] Further advances in computer technology reduced transaction costs, thus making derivatives and other innovative financial instruments more attractive. The spread of the internet made it easier for individuals to access companies' information and reduced screening costs. This made bank loans less competitive than new types of direct financing and led to a shift of lending from traditional banks to financial markets. In the 1980s and 1990s the shadow banking sector started to grow rapidly.[4] Thus, commercial banks used to be a source of 40% of loanable funds for companies in 1974, but their share declined to 25% in 2011 (Mishkin [2007]). This in turn resulted in the increased growth of the M2 and MZM components.

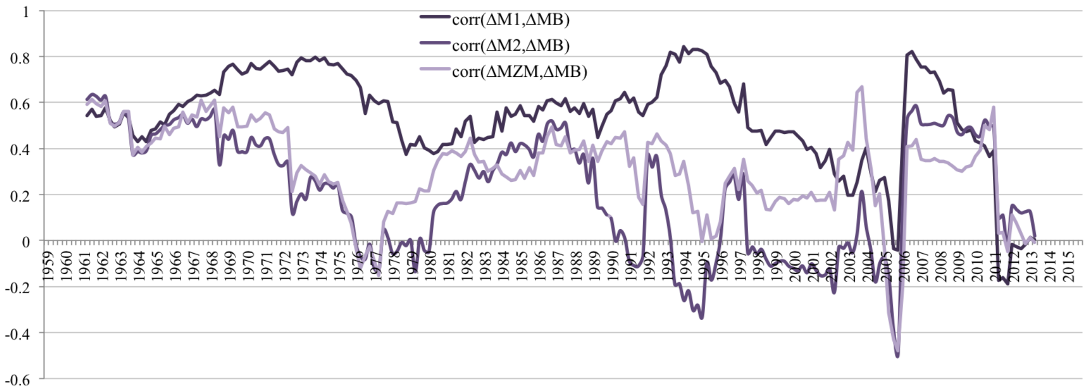
Table 2.1 part b shows less than perfect correlation between broad monetary aggregates and the MB. Given that the currency component remains the same in all aggregates, less than perfect correlation comes from the dynamics of reserves and inside money components of M2 and MZM. Both M2 and MZM build upon the M1 monetary aggregate and expand it in two different ways. M2 adds savings deposits to it, and thus its dynamics is driven by the household appetite for saving and investment. MZM adds institutional and retail money market funds, whose growth dynamics is driven by the appetite for investment coming mainly from the financial industry. Thus, correlation between the growth rates of M2 and MZM aggregates is less than perfect and the growth rate of the MZM aggregate is more significant in predicting future returns. The latter reflects greater importance of financial intermediation sector activity for asset price determination.

[3]For example, until 1980, commercial banks were prohibited from paying interest rates on checkable deposits, and were subject to an interest rate ceiling on time deposits. This made bank deposits an unattractive investment during times of high inflation or volatile interest rates. In order to stop the outflow of funds by investors seeking higher and more sensitive interest yields, commercial banks had to develop new, more risky instruments, like sweep accounts, interest rate derivatives, commercial paper, etc.

[4]In this paper I call shadow banking all the non-bank type of lending, which in the context of monetary aggregates is represented by the money market funds components of M2 and MZM.

To understand this discrepancy better, Figure 2.2 presents rolling window correlations between the growth rates of broad monetary aggregates and the monetary base. M1 co-moves the most with the MB, with the correlation level reaching above 0.8 during the mid 1990s and following the financial crisis. Average correlation between quarterly changes of M2 and MB is only 0.19, never goes above 0.6 and turns negative during the 1990s, a period of financial deregulation. It goes back up and reaches its maximum of 0.56 during the financial crisis, when financial markets got thinner and the Dodd-Frank Act imposed more stringent regulation.

Figure 2.2: This graph shows the 5 year rolling window correlation of the monthly growth rates of the three monetary aggregates, M1, M2 and MZM, over the period of 1959 Q1 - 2014 Q4. The 95% confidence bounds correspond to plus minus correlation value of 1.9. Every 5 year window includes 60 monthly observations and is measured at the mid-point of the time window considered.



Presented statistics shows the divergence of inside and outside money dynamics depending on technological advances and the regulatory climate: outside money is directly determined by the monetary authority, and inside money is fully endogenously determined by economic activity. The fact that the two types of money do not move one to one with each other implies that the degree of financial intermediation and the speed of loan creation are time-varying.

The money multiplier dynamics

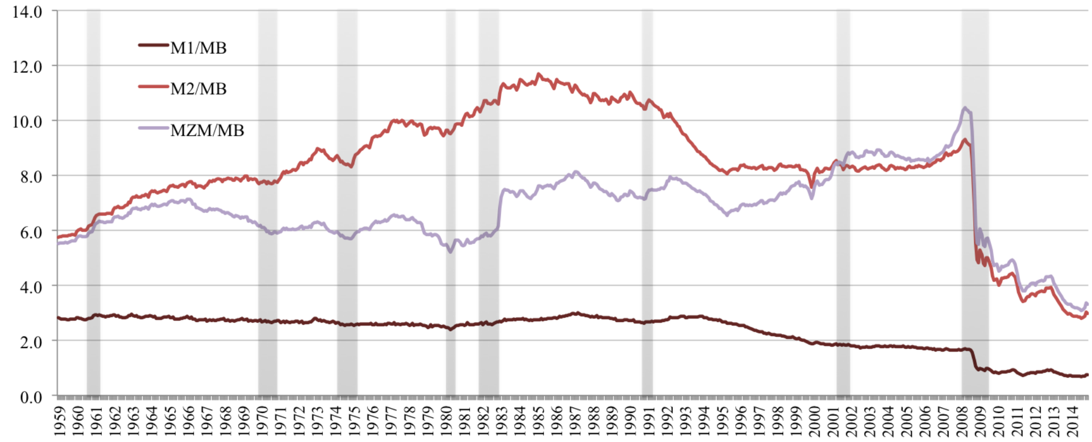
Now I look at the ratio of inside money to outside money. In this paper I refer to this ratio as the broad money multiplier. It can be computed as a ratio of a broad monetary aggregate, M1, M2 or MZM, to the monetary base. Thus, the multiplier tells how much money supply is created out of a unit of cash or reserves and shows how far money spreads in the economy. When inside money grows faster than the total supply of currency and reserves, the multiplier increases. When loan creation slows down, the multiplier shrinks.

Figure 2.3 part a. presents the dynamics of three multipliers, ${}^{M1}/_{MB}$, ${}^{M2}/_{MB}$ and ${}^{MZM}/_{MB}$, during the period 1959 Q1 - 2015 Q4, and part b presents their summary statistics. The multipliers do not exhibit a clear trend on a graph, and their average quarterly change is around zero. ${}^{M2}/_{MB}$ and ${}^{MZM}/_{MB}$ vary more over time than ${}^{M1}/_{MB}$ with corresponding standard deviations of 2.4, 1.4 and 0.9. All three multipliers are highly persistent and have autocorrelation coefficients close to one. This is due to high persistence of aggregates' levels. Multipliers' quarterly changes are positively correlated as well, but with smaller autocorrelations, 0.29 for $\Delta^{M1}/_{MB}$, 0.35 for $\Delta^{M2}/_{MB}$ and 0.37 for $\Delta^{MZM}/_{MB}$. The augmented Dickey-Fuller test rejects the null hypothesis of a unit root for all three multipliers' growth rates.

The graph of broad multipliers' dynamics has two apparent waves: (1) during the mid 1980s and (2) right before the financial crisis. The first wave can be explained by overall economic expansion and lending growth. At the same time, inflation was slowly rising. This contributed more to the expansion of broad money and did not affect the monetary base as much. The prompt growth and then decline of the multiplier during the 1980s corresponds to the U.S. savings and loan crisis. After the rise of financial innovation in the 1970s, the financial authorities removed the deposit rate ceiling from commercial banks to make them more competitive with the growing financial markets. The financial deregulation took place in 1980 and 1982, which led to an expansion of banks' balance sheets and thus an increase of the broad money supply and therefore the multiplier. One can observe a jump in the MZM multiplier at the end of 1982, which comes from the sharp increase in individual money market funds that followed the deregulation. However, new activities involved greater risks and at the end of the 1980s a series of bankruptcies reduced the total supply of loans and significantly thinned the financial intermediation sector. This, together with

Figure 2.3: Graph in part a. shows the dynamics of the M1, M2, MZM money multipliers over the period of 1959.01 - 2014.04, and table in part b. presents their descriptive statistics. The multipliers are calculated by dividing the average monthly level of a monetary aggregate by the average level of the U.S. Monetary Base (MB) for the current quarter. Δ for each variable is computed as a log change of the variable's average quarterly value. σ_t and $\rho_{t,t-1}$ denote the standard deviation and the first order autocorrelation of the time series. Shaded areas on the graph mark U.S. recessions as defined by the NBER. Time series consists of 224 quarterly data points and is adjusted for inflation.

(a) Money multipliers' dynamics.



(b) Descriptive statistics.

	Mean	*Median*	σ_t	*Min*	*Max*	$\rho_{t,t-1}$
$^{M1}/_{MB}$	2.521	2.897	0.872	0.707	3.635	0.998
$^{M2}/_{MB}$	8.826	9.072	2.418	2.830	12.125	0.995
$^{MZM}/_{MB}$	7.166	7.446	1.385	3.124	10.201	0.980
$\Delta^{M1}/_{MB}$	-0.007	-0.003	0.037	-0.348	0.098	0.285
$\Delta^{M2}/_{MB}$	-0.004	0.000	0.039	-0.381	0.096	0.348
$\Delta^{MZM}/_{MB}$	-0.003	0.000	0.040	-0.357	0.116	0.370

ensuing regulation, led to a decrease in the multiplier. Subsequently, the multiplier grew particularly fast from 2005 and up to the beginning of the financial crisis in 2007. This is mainly attributed to the growth of money market funds and the use of repurchase agreements, which in turn was a result of the growing popularity of raising short term funds from the financial markets.

There is a structural break in the multipliers' dynamics during the financial crisis, when both broad multipliers drop during the second half of 2008. The drop is due to the rapid growth of the monetary base, which almost doubled in three months, rising from \$890 billion in mid-September to \$1,740 billion at the end of December. These changes were driven by the FED's credit-oriented policies, which involved the purchase of non-Treasury securities, including commercial paper and asset-backed securities. Such purchases led to the expansion of both the asset and the liability side of the FED balance sheet and resulted in an increase in commercial banks' excess reserves held at the FED.

The money multiplier as a measure of economy-wide leverage

Why is it a proxy for leverage?

Firm's leverage is commonly defined as the ratio of total assets to equity or total debt to equity. If we talk about an individual taking a loan, then leverage is computed as a ratio of the asset value individual gets relative to the amount of down payment Geanakoplos [2010]. The leverage ratio of a bank is defined as the bank's total assets over its core capital, where the core capital is a sum of equity capital and declared reserves. Since the broad economy has a mixture of different types of agents, how would one measure economy-wide leverage?

Given that all money circulating in an economy is on the balance-sheet of a bank, or even on the balance-sheets of several banks concurrently, one can assume the economy-wide leverage ratio to be similar to the leverage ratio of a bank. In that case, the amount of aggregate credit can serve as a proxy of total assets, and total currency and reserves can be seen as core capital.

Going back to the definition of monetary aggregates, the MB consists of cash and reserves of all commercial banks that are typically on the asset side of banks' balance sheets. Broad money components of M2 and MZM, such as different types of deposits, are on the liability side of commercial banks' balance sheets. Thus, a broad money multiplier, a ratio of broad monetary aggregate to the MB, indicates the total value of deposits created in the economy per unit of cash and reserves, and can be seen as a measure of economy-wide leverage.

How does it compare to other existing proxies of leverage?

The two most common measures of leverage to be found in the literature are total loans and broker-dealer leverage. Broker dealer leverage is defined as the ratio of banks' total assets to its book equity, and is shown to predict market returns Adrian et al. [2013]. Total loans are defined as the sum of the outstanding consumer, commercial and industrial loans issued by all commercial banks in the U.S. This definition is similar to Schularick and Taylor [2012], who showed that changes in total loans predict upturns and downturns in the economy. How does the multiplier differ from these two measures and why is it better?

Broker-dealer institutions include some commercial banks, but mainly are non-depositary financial institutions, like investment banks. Broad monetary aggregates, however, include only deposits of different types held at depository institutions (which are financial institutions that obtain their funds mainly through deposits from the public, such as commercial banks, savings and loan associations, savings banks, and credit unions). Thus, broker-dealer leverage refers mainly to the shadow banking sector, and the multiplier accounts for commercial banks and money market funds. Correlations between broker-dealer leverage log growth and multiplier log growth are presented in Table 2.2, part a. Broker-dealer leverage is constructed following Adrian et al. [2014], using aggregate quarterly data on the levels of total financial assets and total financial liabilities of U.S. security broker-dealers as captured in Table L.130 of the Federal Reserve Flow of Funds. Contemporaneous correlations with growth rates of all three multipliers are very low, though significantly positive. Interestingly, the correlation of multiplier growth with broker-dealer leverage growth - one and two periods ahead - is significantly positive as well, while the reverse is not true.

Total loans, as mentioned above, include outstanding consumer, commercial and industrial loans issued by all commercial banks in the U.S. Monetary aggregates contain information about the amount of deposits in commercial banks that can serve as a proxy for the amount of loans banks make. Additionally, broad aggregates M2 and MZM also contain information about money market accounts, which serve as an important source of direct market lending. This means that money multiplier

Table 2.2: Correlations between different measures of leverage. $\Delta LevBD$ stands for quarterly log changes in broker-dealer leverage, computed as a ratio of total broker-dealer assets to their total liabilities. Data is available from the FED. ΔTL stand for quarterly log changes in total loans, computed as the sum of the outstanding consumer, commercial and industrial loans issued by all commercial banks in the U.S. 1959 Q2-2015 Q4, 227 quarterly observations. For this number of observations any correlation coefficient that is greater than 0.1. in magnitude is significantly different from 0 at the 5% confidence level.

Part a. Correlations between broker-dealer leverage and multiplier growth.

	$\Delta^{M1}/_{MBt}$	$\Delta^{M2}/_{MBt}$	$\Delta^{MZM}/_{MBt}$	$\Delta LevBD_t$
$\Delta LevBD_{t-1}$	-0.080	-0.068	0.000	-0.096
$\Delta LevBD_t$	0.200	0.244	0.251	1.000
$\Delta LevBD_{t+1}$	0.233	0.222	0.204	-0.096
$\Delta LevBD_{t+2}$	0.202	0.240	0.215	0.150

Part b. Correlations between total loans and monetary aggregates growth.

	$\Delta M1_t$	$\Delta M2_t$	ΔMZM_t	ΔTL_t
ΔTL_{t-1}	0.009	0.181	0.015	0.513
ΔTL_t	-0.106	0.004	-0.165	1.000
ΔTL_{t+1}	-0.198	0.060	-0.192	0.513
ΔTL_{t+2}	-0.033	0.138	-0.084	0.353

growth captures some of the dynamics of the direct credit as well. Furthermore, the measure of total loans can include double counting of the same loans, while monetary aggregates are net measures of lending. To illustrate this point, table 2.2 part b. presents pairwise correlations of quarterly changes in total loans and changes in broad monetary aggregates. Contemporaneous and lagged correlations are very close to zero for all three monetary aggregates and are negative for M1 and MZM aggregates.

Mechanism of loan and money creation

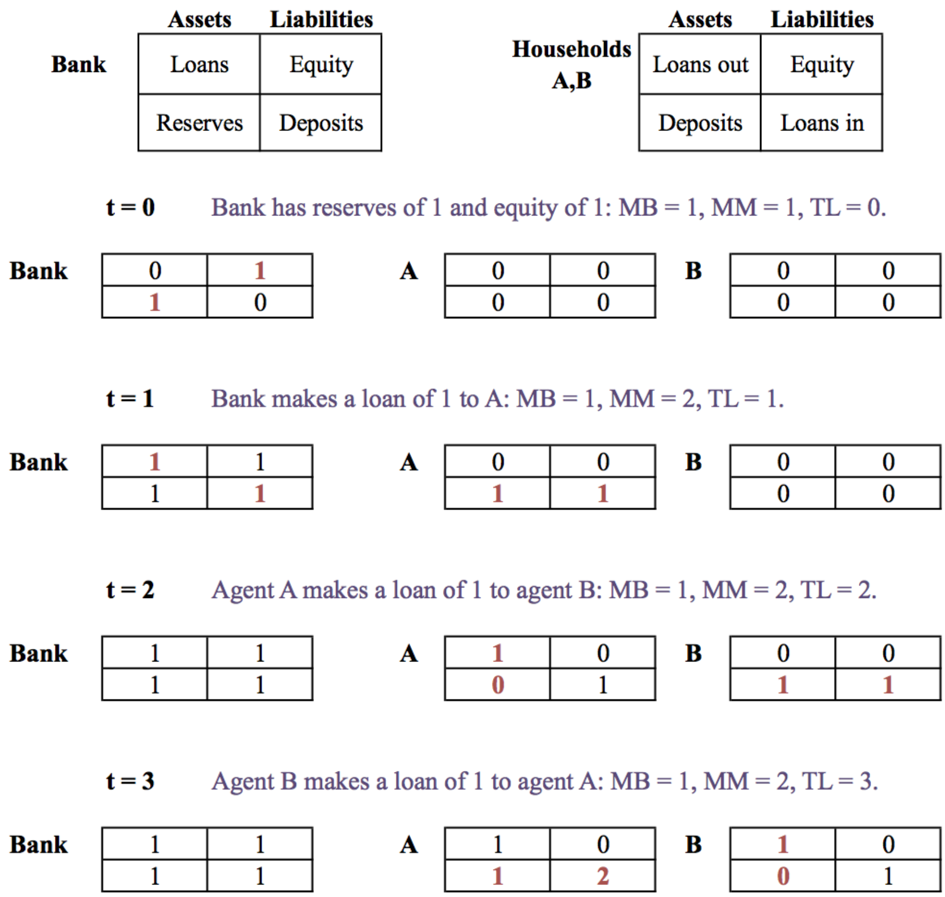
To better understand where the difference between the measure of total loans and monetary aggregates comes from, let us look in detail at the mechanism of money creation. Imagine an economy with three agents: one bank and two households, A and B. The bank has loans and reserves on the asset side of its balance sheet, and equity and deposits on the liability side. Households have loans that they provide and deposits as their assets, and have equity and loans that they take as their liability. The scheme is presented in Figure 2.4.

At the beginning of time, date $t = 0$, the bank has reserves of \$1 and equity of \$1, while the agents have nothing. Thus, in this economy the monetary base is \$1 and the money multiplier is one. Total loans are zero. Let's assume that the next day, on date $t = 1$, the bank gives a loan of \$1 to agent A by creating a deposit for her. The balance sheets of the bank and of agent A change. Yet, the monetary base of this economy remains unchanged, \$1 of broad money is created, the multiplier equals 2, and the amount of total loans is \$1. Anther day passes, and on $t = 2$ agent A decides to lend her money to agent B, who in turn deposits this money into his bank account. However, since agent A emptied her deposit, the total number of deposits in the bank is still \$1. This means that both the monetary base and the multiplier stay unchanged, but the amount of total loans increased to \$2. On the last day of this economy, date $t = 3$, agent B decides to lend his money back to agent A, and agent A deposits it back into the bank. The deposit of agent B is again empty and that of agent A is again \$1, akin to date $t = 1$. The monetary base and the multiplier again stay the same as before, but total loans have increased up to \$3.

Thus, monetary aggregates capture how the issuance of loans contributes to money creation in a whole economy. It nets out the interbank loans, thus excluding the double counting present in the measure of total loans, and other loans that do not change the aggregate net purchasing power. At the same time, the multiplier considers a broader spectrum of loans than broker-dealer leverage does.

Studying the dynamics of the money multiplier in relation to asset returns helps us better understand the effect of inside money creation on financial markets. Inside money growth contributes to an increase in economy-wide leverage, and might have the same effect on aggregate market returns as the one that firm leverage has on firm returns. At the same time money multiplier variations is an indicator of the degree of money creation in the economy, total demand for loans and overall economic activity. In that sense, the multiplier acts as a state variable and belongs to macroeconomic fundamentals.

Figure 2.4: Scheme of loan creation in an economy with three agents: one bank and two households, A and B. The first part of the scheme presents balance sheet structure of the agents. The second part presents four time periods during which different types of loans are created. MB stands for the monetary base, MM for money multiplier and TL for total loans.



Theoretical predictions

To illustrate a possible theoretical link between the money multiplier and stock returns, I use a simplified version of the margin CAPM described in Ashcraft et al. [2011] and Frazzini and Pedersen [2014]. I introduce the process of money creation through borrowing into this model and show that the broad money multiplier is a function of the economy-wide leverage. My toy model does not fully reproduce the relationships between money creation and asset returns observed in the data, and is intended as motivation for the empirical tests.

This is an OLG model with $i = (1, ..., I)$ agents born each period who live for two periods. Agents are born with wealth W_t^i, which they want to invest in a portfolio of s assets $x = (x^1, ..., x^s)'$ during the first period, in order to maximise their wealth in the last period.

Agents have quadratic utility and their maximisation problem looks as follows:

$$max_{x^i} \;\; E_t(W_{t+1}) - \frac{\gamma^i}{2} var(W_{t+1}),$$

Every agent can borrow money from a bank at a risk-free rate, r^f, in order to purchase assets. Agents are heterogeneous in their risk aversion and their ability to borrow money, which is reflected in different leverage l_t^i, that they can get from the bank. In this simple setup the leverage ratio is exogenous, but extensions of the model are possible where the leverage ratio depends on the model dynamics. Each agent has to pledge cash, the initial endowment W_t^i, and assets purchased against the amount borrowed.

The final period wealth of an agent consists of the amount of debt she has to repay and the total value of the assets she holds:

$$W_{t+1}^i = -(x^{i\prime} P_t - W_t^i)(1 + r^f) + x^{i\prime} P_{t+1},$$

where P_t and P_{t+1} are stock prices at time t and $t + 1$. Thus at time t each agent i solves:

$$max_{x^i} \;\; x^{i\prime}(E_t(P_{t+1}) - (1 + r^f)P_t) - \frac{\gamma^i}{2} x^{i\prime} \Omega_t x^i,$$

s.t.

$$\frac{1}{l_t^i} x^{i\prime} P_t \leq W_t^i.$$

where $\Omega_t = var(P_{t+1})$ is an invertible variance-covariance matrix of risky assets at time $t+1$. The funding constraint coefficient $\frac{1}{l_t^i}$ is equivalent to a margin requirement m_t^i from the original margin CAPM model. $\frac{1}{l_t^i} \leq 1$ implies that the agent leverages her position in a risky assets portfolio, $\frac{1}{l_t^i} \geq 1$ implies that the agent does not invest all of her wealth, but has to keep some of it in cash.

Solving the first-order conditions with respect to x_i we get:

$$E_t(P_{t+1}) - (1 + r^f)P_t - \gamma^i \Omega_t x^i - \frac{\lambda}{l^i} P_t = 0$$

where λ is a Lagrange multiplier that represents tightness of funding constraints depending on general economic conditions. Thus, λ is the same for all investors, while their heterogeneity is captured by l^i. The optimal vector of weights for an investor i is:

$$x^i = \frac{1}{\gamma^i}\Omega_t^{-1}\Big(E_t(P_{t+1}) - (1 + r^f + \frac{\lambda}{l^i})P_t\Big)$$

In equilibrium the total supply of assets meets the total demand: $x^* = \sum_i x^i$. Thus, the equilibrium market weights are

$$x^* = \frac{1}{\gamma}\Omega_t^{-1}\Big(E_t(P_{t+1}) - (1 + r^f + \lambda\sum_i \frac{1}{\gamma_i}\frac{1}{l_i})\ P_t\Big),$$

and $\frac{1}{l} = \sum_i \frac{1}{\gamma_i}\frac{1}{l^i} = \frac{1}{\gamma}\sum_i \frac{\gamma}{\gamma_i \frac{1}{l^i}}$ is the aggregate leverage ratio, where $\frac{1}{\gamma} = \sum_i \frac{1}{\gamma_i}$ is the aggregate risk-aversion. Since in equilibrium the funding constraint binds, the individual leverage ratio is equal to the total amount spent on risky assets over the cash pledged:

$$l_t^i = \frac{x^{i\prime}P_t}{W_t}$$

Thus the aggregate leverage ratio can be written as follows:

$$\sum_i \frac{1}{\gamma_i}\frac{1}{l_i} = \frac{1}{\gamma}\sum_i \frac{W_t^i}{\frac{\gamma_i}{\gamma}\, x^{i\prime}P_t} = \frac{1}{\gamma}\ \sum_i \frac{\widetilde{W_t}}{\frac{\gamma_i}{\gamma}\ \widetilde{x^{i\prime}P_t}}\ \frac{\sum W_t^i}{\sum x^{i\prime}P_t} = \frac{k}{\gamma}\ \frac{1}{mm_t}$$

where $\widetilde{W_t} = \frac{W_t^i}{\sum_i W_t^i}$ is the fraction of all cash in the model held by agent i, $\widetilde{x^{i\prime}P_t} = \frac{x^{i\prime}P_t}{\sum_i x^{i\prime}P_t}$ is the fraction of total asset value held by the agent i and $mm_t = \frac{\sum x^{i\prime}P_t}{\sum W_t^i}$ is the level of money multiplier at time t, the ratio of all money created in the economy via borrowing to the the total amount of cash pledged against it. $\sum_i \frac{\widetilde{W_t}}{\frac{\gamma_i}{\gamma}\ \widetilde{x^{i\prime}P_t}}$ is a positive constant which I denote with k.

Proposition 1. *The money multiplier predicts future market returns. In particular, the expected market return at $t+1$ is decreasing in the multiplier level at time t and is increasing in multiplier growth at time t:*

$$E_t(r_{t+1}^M - r^f) = \frac{k\lambda}{mm_t} + \gamma P_t' x^*\ var(r_{t+1}^M)$$

$$\frac{\partial E_t(r^M_{t+1} - r^f)}{\partial mm_t} > 0.$$

Proof of Proposition 1. From the expression of the equilibrium market weights we get the equilibrium price vector:

$$x^* = \frac{1}{\gamma}\Omega_t^{-1}(E_t(P_{t+1}) - (1 + r^f + \frac{k\lambda}{mm_t})P_t)),$$

$$P_t = (-\gamma\Omega_t x^* + E_t(P_{t+1}))/(1 + r^f + \frac{k\lambda}{mm_t}),$$

Then, the equilibrium expected return at $t+1$ on asset s is:

$$\frac{E_t(P^s_{t+1})}{P^s_t} = (1 + r^f + \frac{k\lambda}{mm_t}) + \frac{\gamma e^{s\prime}\Omega_t x^*}{P^s_t}$$

where e^s is a chooser vector for asset s.

$$E_t(R^s_{t+1}) - (1 + r^f) = \frac{\gamma}{P^s_t}\, cov(P^s_{t+1}, P'_{t+1}x^*) + \frac{k\lambda}{mm_t}$$

$$E_t(r^s_{t+1} - r^f) = \gamma P'_t x^*\, cov(r^s_{t+1}, r^m_{t+1}) + \frac{k\lambda}{mm_t}$$

$$E_t(r^m_{t+1} - r^f) = \gamma P'_t x^*\, var(r^m_{t+1}) + \frac{k\lambda}{mm_t}.$$

Taking the derivative of the market expected return with respect to the money multiplier we get:

$$\frac{\partial E_t(r^M_{t+1} - r^f)}{\partial mm_t} = -\frac{k\lambda}{mm_t^2} + \gamma\, var(r^m_{t+1})P'_t\frac{\partial x^*}{\partial mm_t}.$$

Here, changes in the money multiplier that result from changes in individual leverage ratios do not affect current prices but affect investors' weights on risky assets. An increase in the money multiplier results in a greater amount of risky investment:

$$\frac{\partial x^*}{\partial mm_t} = \frac{1}{\gamma}\Omega_t^{-1}P_t\frac{k\lambda}{mm_t^2}$$

Plugging this back into the derivative of market expected return w.r.t. the money multiplier we get:

$$\frac{\partial E_t(r^M_{t+1} - r^f)}{\partial mm_t} = \frac{k\lambda}{mm_t^2}(\Omega_t^{-1}\, var(r^m_{t+1})P'_tP_t - 1) > 0,$$

since $k = \sum_i \frac{\widetilde{W_t}}{\frac{\gamma_i}{\gamma}\widetilde{x^{i\prime}P_t}} > 0$, $\widetilde{W_t} = \frac{W_t^i}{\sum_i W_t^i}$ is the fraction of all cash held by the investor i, $\widetilde{x^{i\prime}P_t} = \frac{x^{i\prime}P_t}{\sum_i x^{i\prime}P_t}$ is the fraction of total asset value held by the investor i and $\lambda > 0$.

The times of low money multiplier levels are times when less money is lent for the purpose of stock investment. During this time, individual leverage ratios are lower, fewer stock purchases are made and stock prices go down. An increase in money multiplier implies a positive shock to funding liquidity and more weight is allocated to risky assets. This drives up the next period prices of risky assets.

Proposition 2. *Loading on the money multiplier level and on its growth rate varies across risky assets. In case of stocks, the slope in front of the multiplier is higher for stocks with lower market beta.*

$$E_t(r^s_{t+1} - r^f) = (1 - \beta^s_t)\frac{k\lambda}{mm_t} + \beta^s_t\,(E_t(r^M_{t+1}) - r^f)$$

$$\frac{\partial E_t(r^s_{t+1} - r^f)}{\partial mm_t} > 0, \qquad \frac{\partial E_t(r^i_{t+1} - r^f)}{\partial mm_t} \neq \frac{\partial E_t(r^j_{t+1} - r^f)}{\partial mm_t} \qquad for\ \ i \neq j.$$

Proof of Proposition 2.

From the expression for market return we get:

$$\gamma P_t' x^* = \frac{E_t(r^m_{t+1} - r^f) - \frac{k\lambda}{mm_t}}{var(r^m_{t+1})}.$$

Plugging this back into the expression for the return on stock s, we get:

$$E_t(r^s_{t+1} - r^f) = \frac{k\lambda}{mm_t} - \frac{cov(r^s_{t+1}, r^m_{t+1})}{var(r^m_{t+1})}\,(E_t(r^m_{t+1} - r^f) - \frac{k\lambda}{mm_t}),$$

$$E_t(r^s_{t+1} - r^f) = (1 - \beta^s)\frac{k\lambda}{mm_t} - \beta^s\,(E_t(r^m_{t+1} - r^f),$$

where $\beta^s = \frac{cov(r^s_{t+1}, r^m_{t+1})}{var(r^m_{t+1})}$ is the usual CAPM beta.

Similarly to the derivative of the market return with respect to the multiplier we find the derivative of the return on stock s with respect to the multiplier:

$$\frac{\partial E_t(r^s_{t+1} - r^f)}{\partial mm_t} = \frac{k\lambda}{mm_t^2}(\Omega_t^{-1}\,cov(r^s_{t+1}, r^m_{t+1})P_t'P_t - 1) > 0,$$

which is a function of asset s's covariance with the market and therefore is different for every asset.

In the model, money is created for the purpose of investing into a portfolio of stocks, which is a huge simplification of the reality with many more asset classes. However, the model implications hold under the assumption that the proportion of wealth allocated to a particular asset class remains the same.

3
Empirical Tests of Return Predictability With The Money Multiplier

In this section, I present the empirical tests of the return predictability of stocks and bonds by the money multiplier. I start by analysing the aggregate stock market and the cross-section of excess stock returns. I test two predictions from the theoretical model in the previous chapter and find that the money multiplier has strong statistical significance when using it to explain the time-variation of future excess market returns as well as the cross-section of stock returns. I compare the forecasting performance of the money multiplier to other well understood macro predictors of stock returns and find that it has the highest statistical significance in-sample and outperforms most of other macro predictors out-of-sample.

Next, I show that the money multiplier is priced in the cross-section of stocks using portfolios sorted on size and book-to-market and portfolios sorted on past momentum. Finally, I address the predictability of treasury and corporate bond returns by the money multiplier and find similar relationships as for stocks.

I compute market log excess returns as the difference between the log of CRSP value-weighted index returns and the log of the 1-month Treasury Bill rate. Data is obtained from CRSP. For the cross-sectional analysis I use 25 stock portfolios sorted by size and book-to-market, decile portfolios sorted on momentum and decile portfolios sorted by past investment, using data obtained from Professor Kenneth French's website[1].

The money multiplier and stock returns

First, I look at the forecasting power of the money multiplier for the time-variation of market returns, i.e. test Proposition 1 from the previous chapter. For the purpose of empirical testing, I approximate the term that contains the money multiplier as follows:

$$\frac{k\lambda}{mm_t} \approx a - b\ln(mm_t)$$

This approximation is in line with techniques suggested in Brunnermeier and Pedersen [2009] and Adrian et al. [2014]. Given this approximation, lower leverage in the economy corresponds to tighter funding constraints. Thus, I run the following one-period predictive regression of market excess returns:

$$r_{t+1}^{e,M} = \alpha + \rho^{Mx}/_{MBt} + \beta\Delta^{Mx}/_{MBt} + \epsilon_{t+1}$$

where ${}^{Mx}/_{MBt}$ and $\Delta^{Mx}/_{MBt}$ are respectively level and quarterly growth rates computed for three money multipliers, M1/MB, M2/MB and MZM/MB. Results are presented in Table 3.1, part a.

All three multipliers' levels appear in the regression with a negative coefficient. In the full sample, the M1 and M2 multipliers' levels have a coefficient that is statistically indistinguishable from zero, and only the MZM multiplier level has a t-statistic greater than two in magnitude. At the same time, the multipliers' growth rates are strongly statistically significant, have t-statistics greater than 3.4, and predict market returns with a positive sign. Looking closely at the sub-samples, one sees that the predictive power of M1/MB and M2/MB in the full sample comes solely from the last 25 years, however, the coefficient on MZM/MB is statistically significant in the early sample as well, with a t-statistic of 2.11. Adjusted R^2s are very high in the late sample for all three multipliers and vary between 9.5% and

[1] `https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html`

Table 3.1: OLS estimates from a predictive regression of log U.S. stock market excess returns (returns on CRSP value-weighted index minus 1-month T-Bill rate) one quarter ahead. Part a. estimates a regression specification with M1, M2, MZM money multipliers' levels and log changes. Part b. estimates a specification with one of the broad money multipliers' log changes, M1, M2, MZM, and log changes in the MB. Regressions are estimated using quarterly data over the whole sample period, 1959 Q1 - 2015 Q4, as well as over two sub-sample periods: 1959 Q1 - 1989 Q4 and 1990 Q1 - 2015 Q4. Quarterly data. T-statistics in italics.

(a) Multiplier level and the growth rate: $r_{t+1}^{e,M} = \alpha + \rho^{Mx}/_{MBt} + \beta\Delta^{Mx}/_{MBt} + \epsilon_{t+1}$.

	1959 - 2015			1959 - 1989			1990 - 2015		
	ρ	β	$\bar{R}^2$	ρ	β	$\bar{R}^2$	ρ	β	$\bar{R}^2$
M1	-0.08	0.25	5.07%	-0.05	0.15	0.90%	-0.03	0.34	9.44%
	-1.23	*3.71*		*-0.55*	*1.71*		*-0.36*	*3.54*	
M2	-0.10	0.23	4.34%	0.04	0.10	-0.65%	-0.14	0.35	10.44%
	-1.53	*3.40*		*0.38*	*1.08*		*-1.47*	*3.60*	
MZM	-0.15	0.27	6.79%	0.02	0.19	1.99%	-0.24	0.37	13.04%
	-2.25	*4.06*		*0.24*	*2.06*		*-2.44*	*3.80*	

(b) Multiplier growth and MB growth: $r_{t+1}^{e,M} = \alpha + \kappa\Delta^{Mx}/_{MBt} + \beta\Delta MB_t + \epsilon_{t+1}$.

	1959 - 2015			1959 - 1989			1990 - 2015		
	κ	β	$\bar{R}^2$	κ	β	$\bar{R}^2$	κ	β	$\bar{R}^2$
M1	0.33	0.11	4.69%	0.16	0.07	1.14%	0.35	0.01	9.32%
	2.32	*0.78*		*1.78*	*0.76*		*1.20*	*0.02*	
M2	0.44	0.24	3.72%	0.27	0.24	1.90%	0.38	0.05	8.50%
	1.75	*0.95*		*2.04*	*1.81*		*0.73*	*0.10*	
MZM	0.35	0.12	5.00%	0.22	0.11	2.99%	0.13	-0.20	8.14%
	2.47	*0.88*		*2.35*	*1.14*		*0.37*	*-0.58*	

12%. The sample sizes of the both samples are sufficiently large to avoid small sample bias, featuring 103 and 124 quarterly observations respectively.

These findings can be interpreted as evidence in favour of the growing importance of leverage during the last 25 years, compared to the period between the 1960s and 1990s. Since the beginning of the 90s, the time of financial deregulation and rapid financial innovation the role of financial intermediation sector for future asset prices grew. Hence, stronger significance of the variables in the late sample. To check these findings, I run individual predictive regressions of market excess returns by levels of the multipliers and separately by the multiplier growth rates and confirm my main results. Estimates for individual regressions are presented in Table 1 in the Appendix.[2]

[1]For example, interest rate swaps were introduced then.

[2]Results presented here are for nominal market excess returns, however, I run the same analysis

The negative loadings on multiplier levels suggest that at times when leverage is high, expected market returns are low. However, the multiplier growth rate predicts next quarter excess returns positively. It is possible that at times when leverage is still growing, the risk bearing capacity of the financial system is still high and funding is easy to obtain. This leads to an increase in asset purchases, and drives up asset prices. In this case, times of leverage growth correspond to times of asset price growth, but only up to the point when leverage levels become unsustainably high.

The economic significance of the multipliers is relatively small. A change of three standard deviations in multiplier growth leads to only a one standard deviation change in next quarter market returns. The descriptive statistics in Figure 2.1 show that during the sample period, quarterly multiplier growth volatility is around 0.04, while quarterly market returns are twice as volatile, $\sigma_M = 0.08$.

As already discussed in the introduction, it is the money multiplier, rather than the total money supply, which matters. I check whether stock return predictability is driven by changes in the monetary base. I run a predictive regression of market excess returns on multipliers' quarterly changes and control for quarterly changes in the MB. Results are presented in Table 3.1 part b. and show that the multiplier growth rate is significant, while the MB growth rate is not. Thus, inside money growth matters for expected market returns, and outside money growth does not.

A logical question, in this case, is whether the dynamics of inside money are driven by changes to outside money. To answer this question I run a predictive regression of multiplier changes on changes in the MB over different horizons. Results are presented in Table 3.2. I find that outside money predicts M1 and M2 multiplier growth over the following 1-3 months, and MZM multiplier growth only over 1 month. The t-statistics are greater than 2 for the respective periods of predictability. However, starting from the one quarter horizon the slope in front of the MB growth rate is statistically and economically indistinguishable from zero. Thus, outside money has only a very short term effect on inside money.

on real market excess returns and the results are very similar.

Table 3.2: OLS estimates from a predictive regression of the multipliers' growth rates by the MB growth rate: $\Delta^{Mx}/_{MBt+1} = \alpha + \beta\Delta MB_t + \epsilon_{t+1}$. Quarterly data, 1959 Q1 - 2015 Q4. Standardised coefficients. T-statistics in italics.

	1 month		**3 month**		**6 month**		**1 year**	
	β	$\bar{R}^2$	β	$\bar{R}^2$	β	$\bar{R}^2$	β	$\bar{R}^2$
M1/MB	0.11	1.80%	0.10	4.43%	0.07	1.56%	0.04	-1.08%
	3.67		*3.38*		*1.66*		*0.65*	
M2/MB	0.03	0.48%	0.03	0.90%	-0.02	0.04%	-0.08	3.46%
	2.08		*1.74*		*-1.02*		*-1.03*	
MZM/MB	0.04	0.53%	0.04	0.22%	-0.03	-0.31%	-0.10	2.74%
	2.15		*1.22*		*-0.81*		*-1.59*	

Different horizon predictability

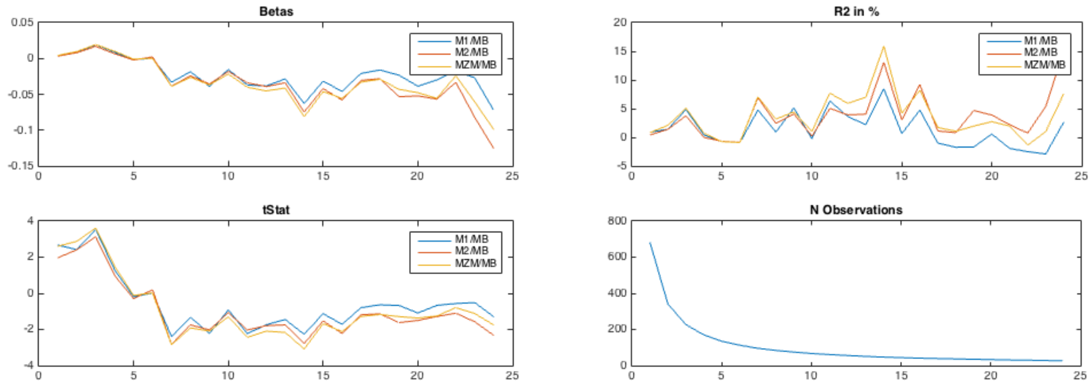
Next, I try to understand how the predictive power of the multiplier depends on the chosen horizon. I estimate a simple one-period predictive regression for different horizons, from 1 to 25 month:

$$r^e_{m,t+1} = \alpha + \beta\Delta^{Mx}/_{MBt} + \epsilon_{t+1} \tag{3.1}$$

Beta estimates, corresponding t-statistics and $\bar{R}^2$s are plotted against the chosen time horizon and presented in Figure 3.1. The figure shows that β in the above predictive regression changes its sign. Growth of the multiplier predicts market returns positively for a horizon up to three months, and negatively for all horizons beyond that.

These results are consistent with theories in which intermediaries have risk-based capital constraints, like Brunnermeier and Pedersen [2009] or Adrian and Shin [2014]. In these models leverage is a key state variable that falls in downturns due to either increased collateral requirements or due to an increase in perceived market risk. Asset prices also decrease in downturns and expected future returns become large. Thus the negative relationship between leverage growth and expected stock returns is consistent with pro-cyclical leverage. The fact that during the first quarter returns respond positively to leverage growth can be explained by rapid stock price appreciation, or may be driven by times of large shocks to leverage when the marginal value of wealth is high.

Figure 3.1: OLS estimates from a predictive regression of log U.S. stock market excess returns (CRSP value-weighted index) on multiplier growth for different time horizons: $r^e_{m,t} = \alpha + \beta \Delta X_{t-1} + \epsilon_t$, for M1, M2 and MZM multipliers. Beta coefficients, corresponding t-statistics and adjusted R^2 for each multiplier are plotted on Y axes against the time horizon on X axes. Sample period 1959:01 - 2015:12. Standardised coefficients.



The recent financial crisis is a good example of a large deleveraging in the economy, during which stock prices also fell. During this period the multiplier experienced a large drop, as excess bank reserves at the FED grew enormously. This was a result of the FED's asset purchase programs triggered by the Lehman collapse. The same event also led to a drop in stock market prices. However, further deleveraging of financial institutions exacerbated the market downturn, following the mechanism described by Brunnermeier and Pedersen [2009]. The shock to the multiplier is significantly large to be identified as a structural break. Thus, as a robustness check for all the results in this paper, I control for this structural break in the MB by introducing a dummy for the whole year of 2008. I find that the main results are not affected. Corresponding regression estimates can be found in Figure 1 and Figure 2 in the Appendix.

Comparison to other measures of leverage

Next I compare the forecasting power of the money multiplier with two measures of leverage commonly used in the literature: total loans and broker-dealer leverage. I estimate a forecasting regression of quarterly returns for three asset classes:

stocks, bonds and currency:

$$r_{Asset,t+1} = \alpha + \beta \Delta Leverage_t + \epsilon_{t+1} \quad (3.2)$$

I consider one representative instrument for each asset class: CRSP value-weighted index of common shares for stocks, CRSP fixed term index for treasuries with maturity of 10 years for bonds and a trade weighted U.S. Dollar index for currencies. The analysis is performed using log changes of quarterly data, since the broker-dealer leverage data is available only quarterly, for the period of 1973 Q1 - 2015 Q4. Results are reported in Table 3.3.

Table 3.3: OLS estimates from a predictive regression of the quarterly returns on instruments from three asset classes, stocks, bonds and currency, by the growth rate of three measures of leverage, the money multiplier (MM) measured as $\frac{M2}{MB}$, total loans (TL) and broker-dealer leverage (BD): $r^e_{Asset,t+1} = \alpha + \beta \Delta Leverage_t + \epsilon_{t+1}$. The representative asset class instruments are: CRSP value-weighted stock index incl. dividends for stocks, CRSP Fixed Term Index for 10-Year treasuries for bonds, Trade Weighted U.S. Dollar Index for currencies. Quarterly data, 1973 Q1 - 2015 Q4. T-statistics are reported in the second row of each section in italics. The last column reports adjusted R^2

Asset	Intercept	MM	TL	BD	$\bar{R}^2$
Stocks	0.03	0.56			8.0%
	3.76	*3.71*			
	0.04		-0.89		3.4%
	4.24		*-2.49*		
	0.02			0.10	1.9%
	3.10			*1.95*	
Bonds	0.00	0.26			0.7%
	-0.34	*1.82*			
	0.00		-0.05		-0.7%
	-0.27		*-0.12*		
	0.00			-0.11	1.7%
	-0.17			*-1.66*	
Currency	0.01	-0.11			2.3%
	2.94	*-2.12*			
	0.01		0.03		-0.7%
	2.23		*0.24*		
	0.01			0.03	0.9%
	2.81			*1.53*	

[2]More precisely, currency returns are represented by the Trade Weighted U.S. Dollar Index as computed by the FED (Broad, Index Jan 1997=100, Not Seasonally Adjusted); bond returns are represented by the CRSP Fixed Term Index 10-Year (Nominal terms); stock returns are represented by the CRSP value-weighted stock index incl. dividends. Leverage measures include (1) total loans, data obtained from FRED: sum of consumer and industrial loans; (2) broker-dealer leverage, computed as seasonally adjusted changes in log leverage of security broker-dealers using quarterly Flow of Funds data (`https://www.federalreserve.gov/apps/fof/DisplayTable.aspx?t=l.130`)

From Table 3.3 it can be observed that the money multiplier generally has a higher predictive ability than the other two measures of leverage for all three asset classes. All three measures have statistical significance when predicting the value-weighted stock market index, with t-statistics of 3.71, -2.49 and 1.95 on the money multiplier, total loans and broker-dealer leverage respectively, but only the money multiplier is statistically significant in predicting treasury and currency returns. While stock short term returns and bond yields are predicted by the multiplier with a positive sign, currency returns are predicted with a negative sign. The latter can be explained by the simple supply demand argument. The more broad money is created in the US, the cheaper they become relative to other currencies.

Interestingly, there is no consistency in signs between coefficients in front of the leverage measures. Stock returns load positively on the money multiplier and the broker-dealer leverage, but negatively on total loans. By construction the broad monetary aggregate M2 used is the money multiplier that is closer to the measure of total loans. However, quarterly changes in the ratio of M2 to the MB seem to have effects that more closely match those of the quarterly changes in broker-dealer leverage.

Other controls and out-of-sample forecasting

I control for some well-understood economic variables to see whether the multiplier growth rate remains an important predictor of expected market returns. In particular I control for: (1) the term yield (TY), which is computed as a difference between the 10-year Treasury note rate and the 3-month Treasury bill rate; (2) the smoothened price earnings ratio (PE); (3) the Federal funds rate (FF), to account for the monetary policy regime, which is traditionally associated with the level of money supply; (4) the volatility index (VIX) as defined by CBOE, to control for market volatility[3]; (5) the growth rate of the purchase power of money (ΔPP), computed

[3]VIX represents the implied market expectation of future volatility, so to take quarterly averages would produce a significantly smoother measure. Thus I consider the end of period values of VIX, which is also consistent with how I compute quarterly values of the multiplier. This means that the Q1 (January, February and March) VIX represents investors expectations for the month of April

as a log change in the M2 to GDP ratio; (6) the credit spread (CS), computed as the difference between the Moody's Baa corporate bond yields and the 10-year U.S. constant maturity yields; (7) the quarterly change in total loans (ΔTL), computed as the total amount of commercial, industrial and consumer loans outstanding issued by all commercial banks. Monthly data for corporate and treasury bonds, federal funds rate, GDP and total loans is available from FRED and is computed as an average of daily figures, and the quarterly value is taken at the end of the period. Data for the VIX is available from the CBOE webpage. Smoothened PE data is available from Bob Shiller's website.

I run a one-period predictive regression of market excess returns:

$$r^e_{m,t} = \alpha + \beta X_{t-1} + \epsilon_t,$$

where X_{t-1} is a vector of state variables that consists of the broad multiplier growth rate and one of the controls. Table 3.4 presents OLS estimates of this regression, t-statistics and corresponding p-values for every newly added factor, as well as for the multiplier growth rate. In this analysis I consider only the late sample of the whole available data, 1990 Q1 - 2014 Q4. Partly because VIX data is only available for this period, and partly because the multiplier appears to be more important during the last two decades, when the expansion of the financial intermediation sector was most strongly reflected in broad money growth.

Table 3.4 shows that multiplier growth remains significant at the 5% confidence level after controlling for each one of the mentioned economic indicators, while none of the control variables individually has a t-statistic high enough for the variables to be considered relevant for predicting market returns. Economic significance of the multiplier in the late sample is also higher, than of any other control variable. A change of one standard deviation in $\Delta ln^{M2}/_{MB}$ predicts a change of 0.35 standard deviations in market returns, versus a maximum of 0.13 standard deviations for other controls.[4]

[4] A change of one standard deviation in the PE ratio predicts a 0.27 standard deviation change in future returns, which is close to the number obtained for the money multiplier. However, the PE ratio is highly non-stationary, while this is not the case for $\Delta ln^{M2}/_{MB}$.

I analyse the out-of-sample performance of each of the model specifications, using the root mean squared error ($GW\Delta RMSE$) computed according to the methodology of Goyal and Welch [2008]. The chosen period of time, 1990 Q1 - 2014 Q4, contains 100 quarterly observations. I start with the in-sample period of 76 quarters and construct the out-of-sample forecast for the following 24 quarters using an expanding forecasting window.

Table 3.4: OLS estimates from a predictive regression of market excess returns: $r^e_{m,t} = \alpha + \beta X_{t-1} + \epsilon_t$, where X_{t-1} is a vector of variables different for each model specification. Variables are presented in the first row. $\Delta^{M2}/_{MB}$ is the growth of the broad money multiplier, TY is the term yield, PE is the price to earnings ratio, VIX is the level of the CBOE volatility index, FF is the federal funds rate, ΔPP is the growth rate of the purchasing power of money computed as the ratio of M3 to GDP, and CS is the credit spread, computed as the difference between Moody's BAA corporate bond yields and the 10 years US constant maturity yield. Estimates of the regression slopes are presented in the first line, t-statistics in the second and p-values in the third. The last three columns present the $\bar{R}^2$s for each model specification for the analysed period of 1990 Q1 - 2014 Q4 and the characteristics of the models' out-of-sample performance. $GW\Delta RMSE$ compares the out-of-sample forecast errors of each model with a forecast error of the sample mean, as in Goyal and Welch [2008]. For $GW\Delta RMSE$, the in-sample period are the first 76 quarters of the whole sample, for $GW\Delta RMSE*$, the in-sample period are the first 76 quarters of the whole sample.

		$\Delta^{M2}/_{MB}$	TY	PE	CPI	VIX	FF	PP	CS	ΔTL	$\bar{R}^2$	$GW\Delta RMSE$	$GW\Delta RMSE*$
	beta	0.34	0	0	0	0	0	0	0	0	10.37%	-0.0082	0.0006
Model 1	*t-stat*	*3.51*	0	0	0	0	0	0	0	0			
	p-value	0.00	0	0	0	0	0	0	0	0			
	beta	0.36	0.09	0	0	0	0	0	0	0	10.20%	-0.0101	0.0004
Model 2	*t-stat*	*3.62*	*0.90*	0	0	0	0	0	0	0			
	p-value	0.00	0.37	0	0	0	0	0	0	0			
	beta	0.41	0	-0.27	0	0	0	0	0	0	16.31%	-0.0031	0.0066
Model 3	*t-stat*	*4.26*	0	*-2.81*	0	0	0	0	0	0			
	p-value	0.00	0	0.01	0	0	0	0	0	0			
	beta	0.34	0	0	0.04	0	0	0	0	0	9.57%	-0.0172	0.0009
Model 4	*t-stat*	*3.51*	0	0	*0.37*	0	0	0	0	0			
	p-value	0.00	0	0	0.71	0	0	0	0	0			
	beta	0.35	0	0	0	0.11	0	0	0	0	10.59%	-0.0076	-0.0018
Model 5	*t-stat*	*3.66*	0	0	0	*1.11*	0	0	0	0			
	p-value	0.00	0	0	0	0.27	0	0	0	0			
	beta	0.36	0	0	0	0	-0.13	0	0	0	11.00%	-0.0081	0.002
Model 6	*t-stat*	*3.73*	0	0	0	0	*-1.30*	0	0	0			
	p-value	0.00	0	0	0	0	0.20	0	0	0			
	beta	0.30	0	0	0	0	0	-0.09	0	0	10.07%	-0.0098	0.0023
Model 7	*t-stat*	*2.87*	0	0	0	0	0	*-0.82*	0	0			
	p-value	0.01	0	0	0	0	0	0.41	0	0			
	beta	0.37	0	0	0	0	0	0	0.10	0	10.27%	-0.0207	-0.0051
Model 8	*t-stat*	*3.60*	0	0	0	0	0	0	*0.94*	0			
	p-value	0.00	0	0	0	0	0	0	0.35	0			
	beta	0.34	0	0	0	0	0	0	0	-0.09	10.32%	-0.0096	-0.0001
Model 9	*t-stat*	*3.55*	0	0	0	0	0	0	0	*-0.97*			
	p-value	0.00	0	0	0	0	0	0	0	0.33			
	beta	0.28	-0.662	-0.426	-0.373	0.400	-0.950	-0.164	-0.443	-0.093	21.82%	-0.0226	-0.0115
Model 10	*t-stat*	*2.55*	*-2.889*	*-3.655*	*-1.589*	*2.779*	*-2.794*	*-1.292*	*-2.161*	*-0.897*			
	p-value	0.01	0.005	0.000	0.116	0.007	0.006	0.200	0.033	0.372			

Tests show that none of the models beat the forecast by the mean in out-of-sample. However, these conclusions are not very robust and strongly depend on the choice of in-sample and out-of-sample periods. For example, if one considers an out-of-sample period that starts just two quarters earlier, then the results for the models' $\Delta RMSE$s look completely different. Those are presented for comparison in the last column of Table 3.4 under $GW\Delta RMSE*$. A similar analysis is produced for another broad money multiplier, MZM/MB, with very similar results and can be found in Table 2 in the Appendix.

The money multiplier and the cross-section of returns

The previous sections presented evidence that multiplier growth is a risk factor for aggregate market returns. In this section, I examine whether this risk factor is priced in the cross-section of stocks, i.e. test the predictions from Proposition 2 in the previous section.

The asset pricing equation from Proposition 2 can be tested with the following regression:

$$r_t^{e,p} = \alpha + \kappa^{Mx}/_{MBt-1} + \beta r_t^{e,M} + \epsilon_t$$

OLS estimates of this regression are presented in Table 3.5. In my analysis I standardise all variables to zero mean and unit variance, thus the regression slopes can be interpreted as a reaction of the excess return to a one standard deviation movement in the explanatory variable. All portfolios' returns load with a negative sign on the past period level of the multiplier. The economic and statistical significance of the slope is increasing in the firm's size and decreasing in the book-to-market ratio. Thus, levels of the multiplier are most significant for big growth firms.

Table 3.6 presents estimates from a one-period predictive regression (3.1) of 25 portfolios sorted on size and book-to-market by the growth rate of the M2 multiplier. Figures 3 - 4 in the Appendix present estimates of the same two regressions, but for the M1 and MZM multipliers. The observed cross-sectional patterns are the same as for M2/MB.

Table 3.5: OLS estimates from a predictive regression: $r_t^{e,p} = \alpha + \kappa^{Mx}/_{MBt-1} + \beta r_t^{e,M} + \epsilon_t$, where $r_{p,t}^e$ are returns at time t on the 25 U.S. stock portfolios formed on size and book-to-market equity, $^{Mx}/_{MBt-1}$ is the level of the M2 money multiplier at time t-1 and $r_t^{e,M}$ is the market return at time t. Quarterly data, 1959 Q1 - 2015 Q4, 228 observations. For each portfolio, the top row presents standardised regression slope coefficients, the second row presents t-statistics, the last row presents adjusted R^2s.

		Growth		**BM2**		**BM3**		**BM4**		**Value**	
		$^{M2}/_{MBt-1}$	$r_t^{e,M}$	$^{M2}/_{MBt-1}$	$r_t^{e,M}$	$^{M2}/_{MBt-1}$	$r_t^{e,M}$	$^{M2}/_{MBt-1}$	$r_t^{e,M}$	$^{M2}/_{MBt-1}$	$r_t^{e,M}$
Small	slope	-0.049	0.796	-0.051	0.822	-0.030	0.831	-0.025	0.816	-0.015	0.807
	t-stat	*-1.2*	*19.7*	*-1.3*	*21.6*	*-0.8*	*22.3*	*-0.6*	*21.1*	*-0.4*	*20.4*
	$\bar{R}^2$	63%		67%		69%		66%		65%	
ME2	slope	-0.083	0.859	-0.058	0.877	-0.040	0.886	-0.009	0.875	0.014	0.839
	t-stat	*-2.4*	*25.2*	*-1.8*	*27.3*	*-1.3*	*28.6*	*-0.3*	*27.0*	*0.4*	*23.0*
	$\bar{R}^2$	74%		77%		78%		76%		70%	
ME3	slope	-0.081	0.878	-0.065	0.914	-0.046	0.903	-0.033	0.895	-0.008	0.832
	t-stat	*-2.5*	*27.7*	*-2.4*	*33.8*	*-1.6*	*31.4*	*-1.1*	*30.1*	*-0.2*	*22.5*
	$\bar{R}^2$	77%		84%		81%		80%		69%	
ME4	slope	-0.093	0.900	-0.095	0.934	-0.071	0.931	-0.046	0.907	-0.017	0.871
	t-stat	*-3.2*	*31.3*	*-4.0*	*40.0*	*-2.9*	*38.6*	*-1.6*	*32.2*	*-0.5*	*26.5*
	$\bar{R}^2$	81%		88%		87%		82%		76%	
Big	slope	-0.114	0.922	-0.090	0.950	-0.097	0.911	-0.043	0.910	-0.028	0.846
	t-stat	*-4.5*	*37.1*	*-4.3*	*46.7*	*-3.5*	*33.7*	*-1.5*	*32.8*	*-0.8*	*23.9*
	$\bar{R}^2$	86%		91%		84%		83%		72%	

Table 3.6 shows that the slope of the estimated regression, its statistical significance and adjusted R^2 are increasing with book-to-market, however, there is no clear relationship with the firm size, as in the previous table with the multiplier level. These results do not imply that exposure to leverage risk drives the value premium, but they serve as evidence that the same factors can be driving the two. Intuitively, it is possible that companies with higher book-to-market ratios are more sensitive to changes in funding liquidity and thus load more on the leverage growth factor. At the same time, if changes in economy-wide leverage reflect changes in the broad investment opportunity set, then companies with initially more limited investment opportunities would be more susceptible to it. The latter is true for high book-to-market companies, if one treats the book-to-market ratio as a proxy for an inverse of Tobin's Q, as in Xing [2008]. Following this theory, high book-to-market companies have lower productivity levels and therefore can afford to undertake a limited number of new investment projects.

Table 3.6: OLS estimates from a predictive regression: $r^e_{p,t} = \alpha + \beta\Delta^{M2}/_{MBt-1} + \epsilon_t$, where $r^e_{p,t}$ is a return on 25 U.S. stock portfolios formed on size and book-to-market equity on the M2 multiplier changes. Quarterly data aggregated from monthly data obtained from Professor Kenneth French's website. 1959 Q1 - 2015 Q4, 228 observations. For each portfolio, the top row presents standardised regression slope coefficients, the second row presents t-statistics, the last row presents adjusted R^2s.

		BM Low	**BM2**	**BM3**	**BM4**	**BM Hi**
ME Small	β	0.114	0.116	0.152	0.197	0.208
	t-stat	*1.7*	*1.7*	*2.3*	*3.0*	*3.1*
	$\bar{R}^2$	0.82%	0.87%	1.82%	3.34%	3.76%
ME2	β	0.110	0.138	0.171	0.240	0.268
	t-stat	*1.6*	*2.1*	*2.6*	*3.6*	*4.1*
	$\bar{R}^2$	0.73%	1.42%	2.39%	5.15%	6.54%
ME3	β	0.112	0.162	0.168	0.202	0.172
	t-stat	*1.7*	*2.4*	*2.5*	*3.0*	*2.6*
	$\bar{R}^2$	0.78%	2.12%	2.31%	3.53%	2.43%
ME4	β	0.100	0.156	0.211	0.236	0.248
	t-stat	*1.5*	*2.3*	*3.2*	*3.6*	*3.8*
	$\bar{R}^2$	0.54%	1.93%	3.89%	4.97%	5.54%
ME Big	β	0.099	0.171	0.194	0.287	0.220
	t-stat	*1.5*	*2.6*	*2.9*	*4.4*	*3.3*
	$\bar{R}^2$	0.50%	2.40%	3.22%	7.56%	4.29%

The analysis of the time variation of the predictability of market returns shows that the multiplier is pro-cyclical. When the multiplier is high, expected returns are low. This is true for all horizons above two quarters, suggesting a negative relationship between the multiplier and the marginal utility of wealth. When the multiplier is high, stock prices are booming, total wealth is growing and its marginal utility is decreasing. In this case, investors will require higher compensation for holding assets that co-move more with the multiplier, and the corresponding price of risk in the cross-section of stock returns should be positive.

Table 3.7 presents estimates from Fama-MacBeth tests for 25 portfolios sorted on size and book-to-market. The table shows that all three multipliers are priced in the cross-section. The price of risk is small, but positive and statistically significant, as expected. At the same time, the intercepts are economically and statistically insignificant, which implies that all returns in excess of the risk-free rate are a compensation for systematic risk, which is well captured by multiplier growth. This result is also robust to controlling for MB growth.

Table 3.7: Estimates from Fama-MacBeth prices of risk and the corresponding t-statistics for the cross-sectional predictive regression for 25 stock portfolios sorted by size and book-to-market ratio on the multiplier growth rate.

		$\Delta^{M1}/_{MB}$	$\Delta^{M2}/_{MB}$	$\Delta^{MZM}/_{MB}$
Lambda	Mean	0.074	0.0677	0.0909
	t-stat	*2.90*	*2.37*	*2.68*
Intercept	Mean	-0.0002	0.0041	-0.003
	t-stat	*-0.03*	*0.42*	*-0.26*

Next, I run a cross-sectional analysis on momentum sorted portfolios and stock portfolios sorted by past investment. The latter is defined as a relative change in total assets of the firm. Data for both is from professor Kenneth French's data library. Cross-sectional regression estimates are summarised in Table 3.8 and the corresponding Fama-MacBeth prices of risk in Table 3.9.

While there are no clear patterns for portfolios sorted on past returns, Table 3.8, part a., there is a clear pattern for portfolios sorted on past investments, Table 3.8, part b. Slope coefficients, statistical significance, and adjusted R^2 are increasing from high to low. Thus, multiplier growth better predicts future growth of excess returns for firms with low past investments. The channel here is similar to the one for the value anomaly. Companies with low past investment are likely to have some limitation in exploiting new investment opportunities, thus they would be affected more when the number of investment opportunities decreases, or when the amount of available funding shrinks.

All cross-sectional tests presented in this section I also run controlling for the growth of the monetary base. In each case, I find that the latter is statistically insignificant in predicting future returns and is not priced in the cross-section, while the multiplier growth rate remains a priced factor.

Table 3.8: Estimates from a predictive regression of portfolio excess returns on the multiplier growth rate: $r^e_{p,t} = \alpha + \beta \Delta^{Mx}/_{MB\,t-1} + \epsilon_t$. Part a. presents estimates of this regression for 10 stock portfolios sorted on past returns, and part b. for 10 stock portfolios sorted on past investments. Past investment is defined as a past year relative change in total assets of the firm. Quarterly data aggregated from monthly data obtained from Professor Kenneth French's website. 1959 Q1 - 2015 Q4, 228 observations. For each portfolio, the top row presents standardised regression slope coefficients, the second row presents t-statistics, the last row presents adjusted R^2s.

(a) Portfolios sorted on past returns.

		Lo PRIOR	PRIOR 2	PRIOR 3	PRIOR 4	PRIOR 5	PRIOR 6	PRIOR 7	PRIOR 8	PRIOR 9	Hi PRIOR
$\Delta^{M1}/_{MB}$	β	0.158	0.208	0.176	0.209	0.198	0.161	0.144	0.188	0.221	0.176
	t-stat	*2.4*	*3.2*	*2.7*	*3.2*	*3.0*	*2.4*	*2.2*	*2.9*	*3.4*	*2.7*
	$\bar{R}^2$	2.05%	3.89%	2.66%	3.95%	3.50%	2.14%	1.62%	3.09%	4.48%	2.68%
$\Delta^{M2}/_{MB}$	β	0.108	0.164	0.139	0.182	0.166	0.119	0.104	0.171	0.196	0.152
	t-stat	*1.6*	*2.5*	*2.1*	*2.8*	*2.5*	*1.8*	*1.6*	*2.6*	*3.0*	*2.3*
	$\bar{R}^2$	0.72%	2.26%	1.49%	2.88%	2.33%	0.98%	0.63%	2.48%	3.41%	1.88%
$\Delta^{MZM}/_{MB}$	β	0.122	0.185	0.154	0.204	0.197	0.150	0.142	0.217	0.220	0.197
	t-stat	*1.8*	*2.8*	*2.3*	*3.1*	*3.0*	*2.3*	*2.1*	*3.3*	*3.4*	*3.0*
	$\bar{R}^2$	1.06%	2.97%	1.93%	3.73%	3.44%	1.82%	1.57%	4.27%	4.40%	3.43%

(b) Portfolios sorted on past investments.

		Lo PRIOR	PRIOR 2	PRIOR 3	PRIOR 4	PRIOR 5	PRIOR 6	PRIOR 7	PRIOR 8	PRIOR 9	Hi PRIOR
$\Delta^{M1}/_{MB}$	β	0.264	0.334	0.262	0.328	0.276	0.267	0.256	0.257	0.178	0.196
	t-stat	*3.9*	*5.1*	*3.9*	*5.0*	*4.1*	*4.0*	*3.8*	*3.8*	*2.6*	*2.9*
	$\bar{R}^2$	6.50%	10.69%	6.40%	10.34%	7.18%	6.70%	6.09%	6.16%	2.70%	3.38%
$\Delta^{M2}/_{MB}$	β	0.209	0.286	0.239	0.285	0.252	0.249	0.248	0.240	0.146	0.158
	t-stat	*3.1*	*4.3*	*3.5*	*4.3*	*3.8*	*3.7*	*3.7*	*3.6*	*2.1*	*2.3*
	$\bar{R}^2$	3.91%	7.72%	5.27%	7.67%	5.91%	5.76%	5.69%	5.30%	1.67%	2.03%
$\Delta^{MZM}/_{MB}$	β	0.266	0.318	0.271	0.323	0.292	0.289	0.282	0.285	0.193	0.204
	t-stat	*4.0*	*4.8*	*4.1*	*4.9*	*4.4*	*4.3*	*4.2*	*4.3*	*2.8*	*3.0*
	$\bar{R}^2$	6.60%	9.70%	6.90%	10.00%	8.08%	7.93%	7.53%	7.67%	3.26%	3.71%

Table 3.9: Estimates of Fama-MacBeth prices of risk and corresponding t-statistics for the cross-sectional predictive regression for 10 stock portfolios sorted by past returns and 10 portfolios sorted by past investments on the multiplier growth rate.

		(a) Portfolios sorted on past returns			**(b) Portfolios sorted on past investments**		
		$\Delta^{M1}/_{MB}$	$\Delta^{M2}/_{MB}$	$\Delta^{MZM}/_{MB}$	$\Delta^{M1}/_{MB}$	$\Delta^{M2}/_{MB}$	$\Delta^{MZM}/_{MB}$
Lambda	**mean**	0.0999	0.1594	0.2211	0.058	0.0538	0.0616
	t-stat	*3.71*	*5.23*	*5.26*	*2.09*	*1.77*	*1.88*
Intercept	**mean**	-0.0081	-0.0136	-0.0292	0.027	0.0298	0.0254
	t-stat	*-0.89*	*-1.48*	*-2.48*	*0.87*	*0.96*	*0.80*

The money multiplier and bond returns

In this subsection, I look at the predictability of treasury and corporate bond returns by the money multiplier. Treasury returns are returns on 1,2,5,7,10,20 and 30 year constant maturity Treasury notes. Corporate bond returns are returns on Moody's seasoned Aaa and Baa corporate bond indices. Data is available from FRED.

Table 3.10 provides estimates from a predictive regression of the excess returns on two corporate bond portfolios, of Aaa and of Baa rated bonds, with multipliers levels and growth rates. Aaa bond returns are better predicted by the multiplier than Baa returns across sub-samples: the multipliers' β has higher statistical and economic significance in the regression for Aaa bonds than in a regression for Baa bonds, and the corresponding $\bar{R}^2$ is higher. For both corporate portfolios, multiplier growth predicts returns positively in the early sample and negatively in the late sample. In the late sample, an increase of one standard deviation in the MZM multiplier results in a 0.26 standard deviations decrease in excess returns on Aaa portfolio and a 0.18 decrease in excess returns on Baa portfolio.

Table 3.11 presents estimates from the same predictive regression, but for Treasury notes with fixed maturities. In the full sample M2 and MZM multiplier growth is statistically significant for predicting excess returns for treasuries of all maturities, i.e. they have t-statistics of a magnitude greater than 2. M1 multiplier growth is statistically significant only for 3, 5 and 7 year Treasury returns. Looking at the regression estimates in the sub-samples, one notices that all the predictive power of the multiplier growth rate in the full sample comes from the past 30

Table 3.10: The table presents OLS estimates of the predictive regression of corporate bond excess returns by levels of three different money multipliers and by their quarterly changes: $r^e_{cb,t} = \alpha + \beta X_{t-1} + \epsilon_t$. Part a. presents estimates for Aaa bond portfolio, and part b. for Baa portfolio. Estimates are computed for the full sample period of 1959 Q1 - 2015 Q4, as well as for two sub-sample periods, 1959 Q1 - 1989 Q4 and 1990 Q1 - 2015 Q4. Standardised coefficients.

Part a. Aaa bonds.

	1959 Q1 - 2015 Q4			1959 Q1 - 1989 Q4			1990 Q1 - 2015 Q4		
X	β	$t-stat$	$\bar{R}^2$	β	$t-stat$	$\bar{R}^2$	β	$t-stat$	$\bar{R}^2$
$^{M1}/_{MB}$	-0.516	*-8.90*	25.81%	0.583	*7.85*	33.17%	-0.680	*-9.62*	47.54%
$^{M2}/_{MB}$	-0.707	*-14.63*	48.63%	-0.536	*-6.99*	28.17%	-0.679	*-9.50*	46.91%
$^{MZM}/_{MB}$	-0.240	*-3.64*	5.17%	0.535	*6.98*	28.15%	-0.490	*-5.73*	23.97%
$\Delta^{M1}/_{MB}$	-0.112	*-1.65*	0.76%	0.043	*0.47*	-0.64%	-0.084	*-0.85*	-0.27%
$\Delta^{M2}/_{MB}$	-0.179	*-2.68*	2.68%	0.195	*2.19*	3.00%	-0.228	*-2.36*	4.33%
$\Delta^{MZM}/_{MB}$	-0.116	*-1.73*	0.87%	0.198	*2.23*	3.16%	-0.262	*-2.75*	6.11%

Part b. Baa bonds.

	1959 Q1 - 2015 Q4			1959 Q1 - 1989 Q4			1990 Q1 - 2015 Q4		
X	β	$t-stat$	$\bar{R}^2$	β	$t-stat$	$\bar{R}^2$	β	$t-stat$	$\bar{R}^2$
$^{M1}/_{MB}$	-0.502	*-8.59*	24.44%	0.569	*7.58*	31.61%	-0.650	*-8.81*	43.12%
$^{M2}/_{MB}$	-0.691	*-14.00*	46.43%	-0.508	*-6.50*	25.25%	-0.666	*-9.13*	44.89%
$^{MZM}/_{MB}$	-0.238	*-3.62*	5.10%	0.560	*7.47*	30.97%	-0.498	*-5.83*	24.64%
$\Delta^{M1}/_{MB}$	-0.066	*-0.97*	-0.03%	0.062	*0.69*	-0.44%	0.003	*0.03*	-1.00%
$\Delta^{M2}/_{MB}$	-0.141	*-2.09*	1.48%	0.212	*2.39*	3.71%	-0.154	*-1.56*	1.41%
$\Delta^{MZM}/_{MB}$	-0.062	*-0.92*	-0.07%	0.266	*3.05*	6.38%	-0.182	*-1.88*	2.43%

years, i.e. during the period of growing financial intermediation and sophistication of the banking sector. One big difference between the predictability results for the bond market and the stock market is that predictability is high for monthly changes but vanishes for quarterly changes.

Figure 3.2 presents OLS estimates over various time horizons, from 1 to 25 months, from a predictive regression of 5-year Treasury returns on changes in the money multiplier. The slopes of the regression, corresponding t-statistics and adjusted R^2s are plotted against time horizons used in the regression. Over a one-month horizon, all three multipliers are statistically significant in forecasting future Treasure excess returns, but only the M2 multiplier remains statistically significant for all horizons, i.e. the t-statistic is always greater than 2 in magnitude. M2 multiplier growth of one standard deviation predicts a decline in Treasury returns of 0.15 standard deviations over the next month, a decline of 0.25 standard deviations over the following two quarters and a decline of 0.4 standard deviations over the next year.

Table 3.11: OLS estimates of the predictive regression of excess returns on Treasury constant maturity: $r^e_{TN,t} = \alpha + \beta X_{t-1} + \epsilon_t$, $r^e_{TN,t}$ monthly excess return on CRSP fixed maturity indices, constructed from Treasury notes with 1,2,5,7,10,20 and 30 year maturities. Estimates are computed for the full sample period of 1959:01 - 2015:12, as well as for two sub-sample periods, 1959:01 - 1989:12 and 1990:01 - 2015:12. The first row for each model specification presents the standardised regression coefficients, the second row presents t-statistics, the third adjusted R^2s.

Full sample

	1 year	**3 years**	**5 years**	**7 years**	**10 years**	**20 years**	**30 years**
$\Delta^{M1}/_{MB}$	-0.069	-0.087	-0.105	-0.114	-0.072	-0.045	-0.063
	-1.79	*-2.27*	*-2.77*	*-2.99*	*-1.87*	*-1.16*	*-1.65*
	0.3%	0.6%	1.0%	1.2%	0.4%	0.1%	0.3%
$\Delta^{M2}/_{MB}$	-0.069	-0.081	-0.096	-0.116	-0.077	-0.079	-0.106
	-1.79	*-2.12*	*-2.52*	*-3.04*	*-2.01*	*-2.06*	*-2.77*
	0.3%	0.5%	0.8%	1.2%	0.5%	0.5%	1.0%
$\Delta^{MZM}/_{MB}$	-0.067	-0.083	-0.092	-0.114	-0.080	-0.075	-0.098
	-1.74	*-2.16*	*-2.39*	*-2.98*	*-2.09*	*-1.95*	*-2.55*
	0.3%	0.5%	0.7%	1.1%	0.5%	0.4%	0.8%

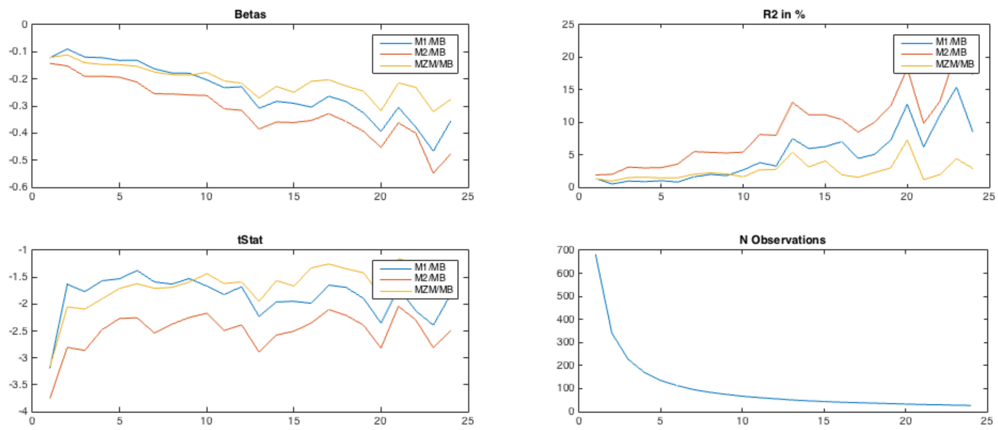
Early sample

	1 year	**3 years**	**5 years**	**7 years**	**10 years**	**20 years**	**30 years**
$\Delta^{M1}/_{MB}$	-0.030	-0.039	-0.035	-0.060	-0.029	0.041	0.021
	-0.58	*-0.75*	*-0.66*	*-1.16*	*-0.55*	*0.78*	*0.40*
	-0.2%	-0.1%	-0.2%	0.1%	-0.2%	-0.1%	-0.2%
$\Delta^{M2}/_{MB}$	-0.007	-0.021	-0.027	-0.066	-0.006	-0.012	-0.053
	-0.13	*-0.39*	*-0.51*	*-1.27*	*-0.11*	*-0.22*	*-1.01*
	-0.3%	-0.2%	-0.2%	0.2%	-0.3%	-0.3%	0.0%
$\Delta^{MZM}/_{MB}$	-0.042	-0.054	-0.031	-0.071	-0.031	-0.010	-0.034
	-0.81	*-1.03*	*-0.59*	*-1.37*	*-0.60*	*-0.19*	*-0.64*
	-0.1%	0.0%	-0.2%	0.2%	-0.2%	-0.3%	-0.2%

Late sample

	1 year	**3 years**	**5 years**	**7 years**	**10 years**	**20 years**	**30 years**
$\Delta^{M1}/_{MB}$	-0.170	-0.177	-0.180	-0.172	-0.109	-0.107	-0.128
	-3.03	*-3.16*	*-3.22*	*-3.06*	*-1.92*	*-1.88*	*-2.26*
	2.6%	2.8%	2.9%	2.6%	0.9%	0.8%	1.3%
$\Delta^{M2}/_{MB}$	-0.189	-0.174	-0.161	-0.170	-0.125	-0.131	-0.157
	-3.37	*-3.09*	*-2.85*	*-3.03*	*-2.21*	*-2.31*	*-2.78*
	3.2%	2.7%	2.3%	2.6%	1.2%	1.4%	2.1%
$\Delta^{MZM}/_{MB}$	-0.152	-0.155	-0.155	-0.166	-0.124	-0.133	-0.159
	-2.69	*-2.75*	*-2.76*	*-2.95*	*-2.20*	*-2.35*	*-2.82*
	2.0%	2.1%	2.1%	2.4%	1.2%	1.4%	2.2%

Figure 3.2: OLS estimates from a predictive regression of log excess returns on Treasury 5 year fixed maturity CRSP index on the multiplier growth rate for different time horizons: $r^e_{TN5,t} = \alpha + \beta \Delta X_{t-1} + \epsilon_t$, for M1, M2 and MZM multipliers. Beta coefficients, corresponding t-statistics and adjusted R^2s for each multiplier are plotted on the Y-axes against the time horizon on the X-axes. Sample period 1959:01 - 2015:12. Standardised coefficients.



These results are also consistent with theories of pro-cyclical leverage and the mechanism described earlier for stock markets. However, there is one difference. Multiplier growth predicts changes in expected stock returns positively for one quarter ahead, and negatively for all horizons beyond two quarters. I associate it with the fact that growing leverage indicates good times for financial markets when funding can be easily obtained and used for asset purchases. Since bonds are less risky investments, they experience fewer demand fluctuations associated with good and bad times than stocks do. Thus the relationship between leverage and expected bond returns is always negative. When leverage is high, markets are saturated and bond prices are high, meaning that expected returns are low.

4
The Money Multiplier and Currency Returns

In previous chapters, I addressed the predictability of returns on financial assets that represent a claim on a stream of future cashflows and therefore have an intrinsic value of their own. I showed that within a country, the time-series and cross-sectional variation of returns on these assets can be explained by the country money multiplier. In this chapter, I will look at currencies, whose value can only be determined relative to value of other currencies. I show that in case of assets priced in relative terms, it is the differential of the country pair's multipliers that explains the time-variation of asset returns. I do not attempt to derive a fully specified asset pricing model that would link country money multipliers to exchange rate returns, but use a simple long term identity to motivate my empirical investigation.

In particular, I look at the exchange rates of nine countries, UK, Japan, Canada, New Zealand, Australia, Switzerland, Sweden, Norway, Denmark, with the U.S. and find broad patterns of long term predictability using money multiplier variables. I motivate my analysis with the quantity theory of money identity and investigate a broad relationship between exchange rates, velocities, money supplies and real outputs of country pairs. I argue that the money multiplier can be interpreted as an alternative measure for money velocity, as it accounts for the propensity to spend money not only on real sector goods and services, but on financial assets, too.

Using quarterly data I estimate a first difference model and an error correction model. I show that that there is a long term relationship between exchange rates, money multipliers, narrow money supplies and relative GDPs. This long term relationship holds across all countries and has strong predictive power for quarterly changes in exchange rates. At the same time, short-term deviations of the considered macro variables cannot explain the dynamics of exchange rates, neither contemporaneously nor in the near future. Thus, I find that the short run dynamics of the exchange rate can be forecast only to the extent of the reversion to the long-term equilibrium, and confirm the common literature finding that short-run fluctuations of the exchange rates are difficult to forecast using macro variables (Obstfeld and Rogoff [2001], Rogoff and Stavrakeva [2008], Neely and Sarno [2002], Rossi [2013]).

Motivation

The quantity theory of money specifies the long-run relationship between money supply, velocity, the price level and real output. It is an identity and has been used to describe the evolution of the price level as a function of money supply, most recently in work focusing on the long-term effects of quantitative easing.

$$MV = PY,$$

Economic theory suggests that real exchange rates are a driver of capital flows. We can define the real exchange rate as

$$RER = NER\frac{P^*}{P},$$

where NER is the nominal exchange rate, the price of one unit of the foreign currency in the home currency or the amount of home currency that can be bought with one unit of foreign currency. P is the consumer price level in the home country and P^* is the consumer price level in the foreign country. RER is the real exchange rate, which represents the price of the consumer basket in the foreign country, relative to its price in the home country. Increases in NER and RER indicate a nominal and real depreciation of the home currency, respectively.

With this, and the quantity theory of money, it is possible to link the nominal exchange rate to the relative velocities of money, money supplies, real GDPs and the real exchange rate:

$$NER = RER\frac{MV/Y}{M^*V^*/Y^*}$$

where M is money supply, V is the velocity of money and Y is real output. To make this model empirically implementable and easily tractable I take logs of both sides of the equation:

$$ner = rer + m + v - y - m^* - v^* + y^*$$
$$ner = rer + (m - m^*) + (v - v^*) - (y - y^*) \tag{4.1}$$

where lower case letters denote the natural logarithm of variables written in upper case letters. Taking the first differences one gets:

$$\Delta ner_t = \Delta rer_t + (\Delta m_t - \Delta m_t^*) + (\Delta v_t - \Delta v_t^*) - (\Delta y_t - \Delta y_t^*) \tag{4.2}$$

Thus, the nominal exchange rate is a function of the relative differences in money supplies, relative real output levels and relative money velocities. Δrer_t can be seen as a part of an error term, since the real exchange rate has to adjust for variations in the macro variables, law of one price assumptions, market inefficiencies and trade policies, to name a few.

Two specifications of this theoretical prediction are estimated in this paper. An error-correction specification is used to assess the effects of macro variables on exchange rates in the long run, while a first-difference specification is employed to estimate the effects of the explanatory variables on exchange rates in the short run.

These two specifications entail different implications for the interactions between exchange rates and their determinants.

Each of the variables in question is highly persistent, therefore a simple regression in levels would produce biased t-statistics. To correct for this, I estimate a cointegration vector and use the resulting cointegration residual in an error correction model to explicitly account for long-run interactions of the model variables in the exchange rate forecast.

The first differences model emphasises the effects of changes in the macro variables on exchange rates. If the state variables are cointegrated, then the error correction specification should be more efficient and should produce better forecasts.

The money multiplier and the velocity of money

Money velocity is usually understood to mean how often each unit of currency, such as the U.S. dollar, is used to buy goods or services during a given period of time, with a focus on the real economy. If the velocity of money is increasing, then more transactions per unit of currency are occurring between individuals. A more efficient financial sector should, therefore, enable agents to use each unit of currency more frequently, thereby leading to an increase in the velocity of money.

Based on this definition the velocity is usually measured as a ratio of a nominal Gross Domestic Product (NGDP) to some measure of money supply, usually M1 or M2:

$$V_t = \frac{NGDP_t}{M1_t}$$

Across most countries, M1 usually denotes the money supply of currency in circulation. In the U.S. that would include notes and coins, traveler's checks, demand deposits, and checkable deposits. A decrease in the velocity of M1 might indicate that fewer short-term consumption transactions are taking place, where short-term transactions can be thought of as consumption made on an everyday basis. The broader M2 component usually includes M1 in addition to saving deposits. In the U.S., M2 includes savings deposits, certificates of deposit less than USD 100

000, and money market deposits of individuals, in addition to M1. Thus, comparing the velocities of M1 and M2 provides some insight into how quickly agents in the economy are spending and how quickly they are saving.

The classic definition of money velocity does not account for any sort of financial assets or home equity. However, spending of this sort accounts for a great part of money distribution in the economy and foregoing these items completely might lead to incorrect conclusions about money velocity. A good example is the period of quantitative easing (QE). QE is the process of electronic creation of central bank liabilities that are used to purchase financial assets rather than real assets. Given the nature of the assets, this newly created money might never translate into transactions involving real goods and services. The classic measure of money velocity will not reflect these money flows, however, money was created and money was spent.

Thus, if one considers money velocity as the rate at which money moves through the real sector, then the previously used measure is a fair description. However, the economy does not only consist of a real sector. If one wants to measure the rate at which money flows through the economy as a whole, then the measure needs rethinking. In times of rapid financial innovation, monetary transactions moved far away from simply spending money on real sector goods and services. The amount of money spent on financial assets and the speed at which money is spent has real affects on the economy, which are not yet fully understood, but are already acknowledged by both the economics and finance literatures Fieldhouse et al. [2018], Ramey and Zubairy [2018].

In previous chapters, I discussed that broad money in the economy is created to be immediately spent. Thus, looking at how much broad money is created per unit of currency can give an indication of the overall spending in the economy. In this chapter, I refer to the ratio of broad money to a unit of currency as the money multiplier [1]. In particular, for each country I consider the broadest monetary aggregate available, that is directly comparable among countries. In case of the

[1] In previous chapters, I consider the multiplier as a ratio of broad money to the monetary base (MB), which includes reserves in addition to currency in circulation. In this chapter I switch from the MB to M1, as this monetary aggregate is available for a larger set of countries than the MB.

U.S., I focus on the MZM (money with zero maturity) monetary aggregate. It is the broadest component of money supply and consists of the supply of financial assets redeemable at par on demand: notes and coins in circulation, traveler's checks, demand deposits, other checkable deposits, savings deposits, and all money market funds. Therefore looking at the velocity of money as a ratio of MZM to M1 directly shows how much savings and money market funds have been created in the economy per unit of currency.

If new money market funds are created through funding from existing financial institutions, MZM increases through the proliferation of liabilities in the financial sector. Therefore the ratio of MZM to M1 can be seen as a proxy of the rate at which financial assets are exchanged, per unit of currency in circulation.

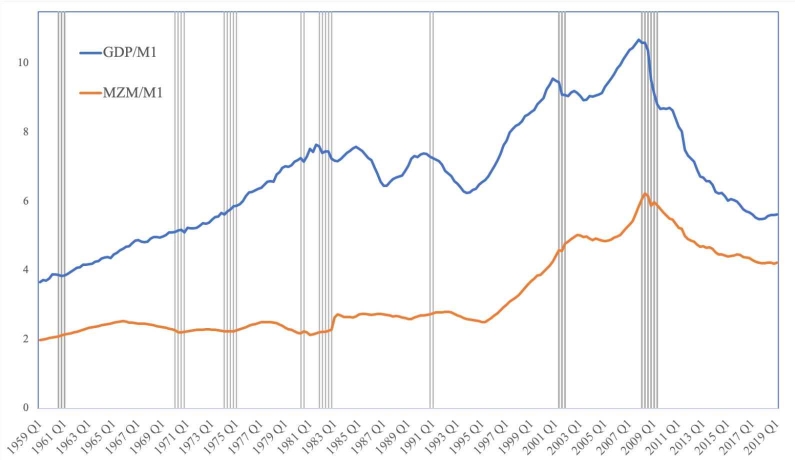
To illustrate how the dynamics of the money multiplier compare to the dynamics of a classic money velocity measure I plot two time series for the U.S. in Figure 4.1. Part a. of Figure 4.1 compares the levels of the two measures for the U.S. and part b. compares their quarterly growth rates. Visually the behaviour of the two series is quite similar. In terms of the numerator, the dynamics of GDP is known to closely follow the dynamics of broad money in the U.S.. In addition, both measures have the same monetary aggregate, M1, in the denominator.

Table 4.1 reports correlations between levels and correlations between quarterly changes in money velocity and broad money multipliers for ten countries. Correlations are computed for the maximum period of time available for each country. For the period between 1959 Q1 and 2019 Q1, the correlation between the level of the money multiplier, $\frac{MZM}{M1}$, and the velocity of money, $\frac{GDP}{M1}$, is 0.68 in the U.S., but the correlation of their quarterly growth rates is only 0.29. For comparison, the narrower multiplier, $\frac{M2}{M1}$, has a higher correlation with the traditional money velocity measure: 0.91 in level and 0.72 in growth rate space.

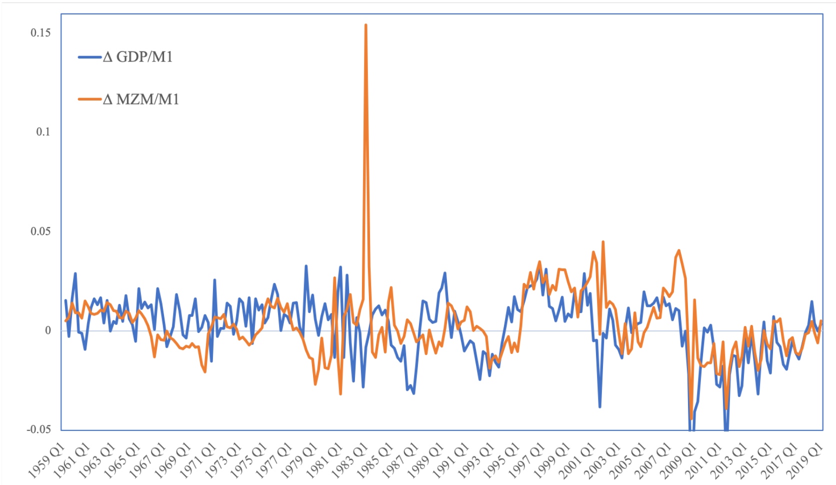
The main difference between $\frac{MZM}{M1}$ and $\frac{M2}{M1}$ is that the MZM monetary aggregate accounts for a broader range of financial instruments. In particular, it includes institutional market funds. The difference in correlations with a traditional

Figure 4.1: Plot of the U.S. broad money multiplier dynamics and the velocity of money. The multiplier is defined as a ratio of a broad monetary aggreate MZM to a narrow monetary aggregate M1, $\frac{MZM}{M1}$. Money velocity measure as a ratio of the Gross Domestic Product over M1 monetary aggregate, $\frac{GDP}{M1}$. Part a. compares levels of the two variables, while Part b. compares quarterly growth rates. Grey ares indicate NBER recessions on quarterly basis. All variables are in nominal terms and are seasonally adjusted. Quarterly frequency.

(a) The U.S. money multiplier and money velocity (levels)



(b) The U.S. money multiplier and money velocity (growth rates)



measure of money velocity illustrates the amount of extra information about money circulation in the economy added by using a broader money multiplier.

While the U.S. broad money multiplier behaves broadly similar to the traditional measure of money velocity, that is not the case for all countries studied in this chapter. Figure 4.2 compares the time series of the money multiplier and money velocity for each country. Money velocity is only greater than the broad money multiplier for the U.S and Australia. For the remainder of the cross section of the

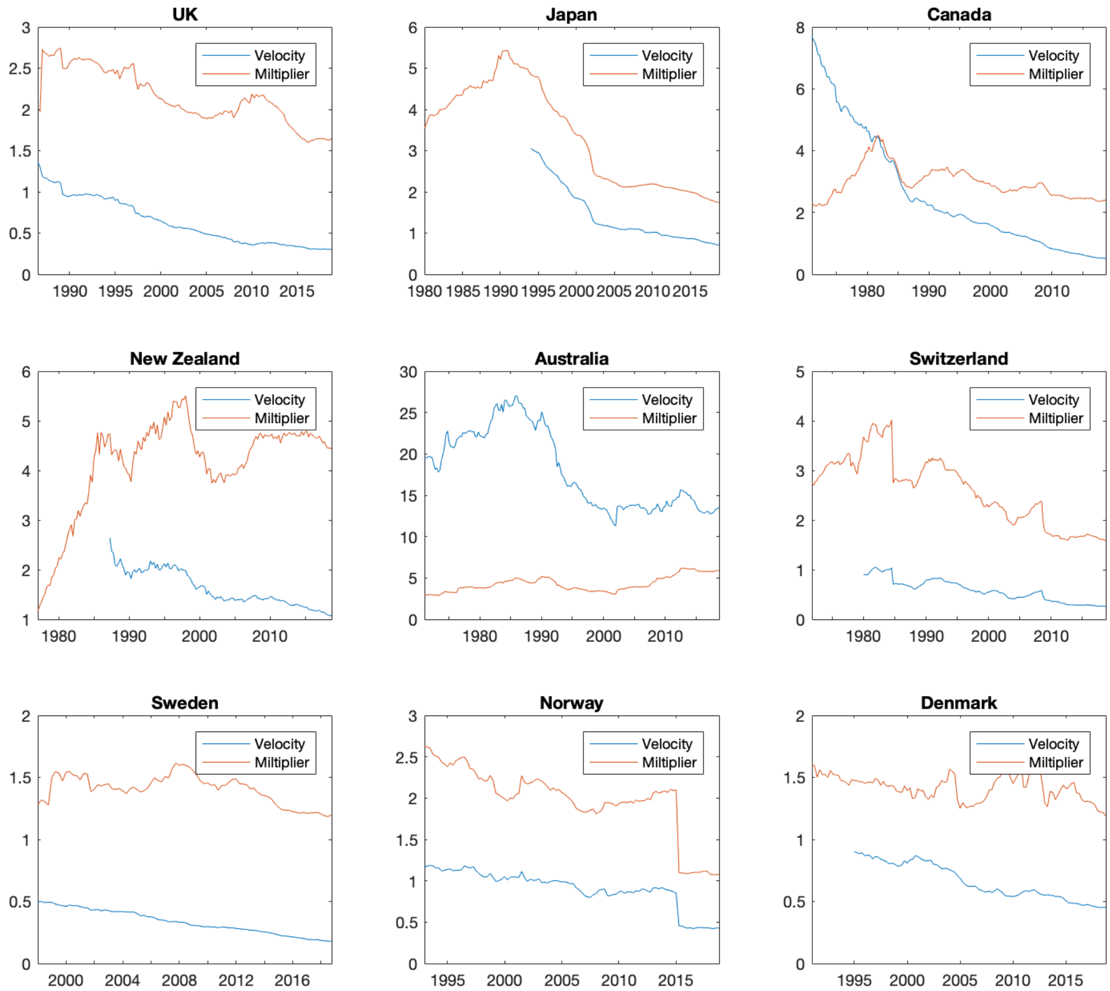
Table 4.1: Correlations between money velocity and the money multiplier for ten countries. The multiplier is defined as the ratio of the broad monetary aggregate, M3 (MZM in case of the U.S.), to a narrow monetary aggregate, M1, $\frac{M3}{M1}$. Money velocity is measured as a ratio of the Gross Domestic Product to the M1 monetary aggregate, $\frac{GDP}{M1}$. The first column reports correlations between levels of the two variables, the second column presents correlations between their quarterly changes. All variables are in nominal terms and are seasonally adjusted. The frequency is quarterly.

	$corr(\frac{M3}{M1}, \frac{GDP}{M1})$	$corr(\Delta\frac{M3}{M1}, \Delta\frac{GDP}{M1})$
UK	0.89	-0.01
Japan	1.00	0.83
Canada	0.20	0.69
New Zealand	0.26	0.71
Australia	-0.07	0.76
Switzerland	0.99	0.95
Sweden	0.54	0.37
Norway	0.98	0.90
Denmark	0.23	0.22
US	0.68	0.29

sample, the opposite is the case. This implies that the total amount of broad money supply is higher than the level of nominal GDP in these countries. Correlations between the level of money velocity and the multiplier varies from close to zero for Australia to almost one for Japan. Correlations in changes vary between close to zero for the U.K. and 0.95 for Switzerland.

Those differences are interesting in their own right, but are related to the dynamics of the country's GDP relative to the country's broad money supply, which is outside the scope of this paper. The conclusion from this descriptive analysis is that the broad money multiplier can be seen as a proxy for the velocity of money and, depending on the country, this proxy can deviate substantially from the classic measure of money velocity.

Figure 4.2: Dynamics of the broad money multiplier and the velocity of money for nine countries. The multiplier is defined as the ratio of the broad monetary aggregate, M3 (MZM in case of the U.S.), to a narrow monetary aggregate, M1, $\frac{M3}{M1}$. Money velocity is measured as a ratio of the Gross Domestic Product to the M1 monetary aggregate, $\frac{GDP}{M1}$. All variables are in nominal terms and are seasonally adjusted. The frequency is quarterly.



Data

In this work I examine the behaviour of U.S. dollar-based exchange rates of British pound, Japanese yen, Canadian dollar, New Zealand dollar, Australian dollar, Swiss franc, Swedish krona, Norwegian krone and Danish krone. The choice of countries is driven by the availability of directly comparable monetary data. Monetary aggregates are usually computed by each country individually with little international standards agreed. More and more countries track their broad money supply nowadays, however a 20 year reliable history of monetary data is only available for a few countries.

I proxy the velocity of money by the money multiplier and the output by nominal GDP. The money multiplier is computed as the ratio of a broad monetary aggregate to a narrow monetary aggregate. In previous chapters I used the multiplier of the monetary base to the broad money. Since the monetary base data is available for a small set of countries, in this chapter I define the multiplier as a ratio of M3 aggregate to M1 aggregate.

Data for monetary variables and the output for all countries apart from the U.S. is drawn from the OECD database [2]. The M3 aggregate is used as a measure of broad money and includes currency, deposits with an agreed maturity of up to two years, deposits redeemable at notice of up to three months and repurchase agreements, money market fund shares/units and debt securities up to two years. The M1 aggregate is a measure of narrow money and includes currency in circulation, banknotes and coins, and overnight deposits.

U.S. data is sourced from the St. Louis Fed FRED Economic Database [3]. I use Money Zero Maturity as a measure of broad money and M1 as a measure for narrow money. Monetary data is available at a monthly frequency, while GDP data is only available at quarterly frequency.

If one was interested in an analysis at monthly frequency, one could use indicators of industrial production as a measure of output, which are available at a monthly

[2] https://data.oecd.org/

[3] https://fred.stlouisfed.org/

frequency for most of the countries. However, even industrial production is only available quarterly for New Zealand and Australia. Additionally, GDP is a broader measure of economic activity compared to industrial production, and therefore matches the output definition in the quantity theory of money more closely. Thus, in my analysis I opt for a larger set of countries instead of a higher frequency analysis.

Figure 4.3: Plot of broad money multipliers in ten different countries. The multiplier is defined as the ratio of the broad monetary aggregate, M3, to the narrow monetary aggregate, M1. The frequency is monthly.

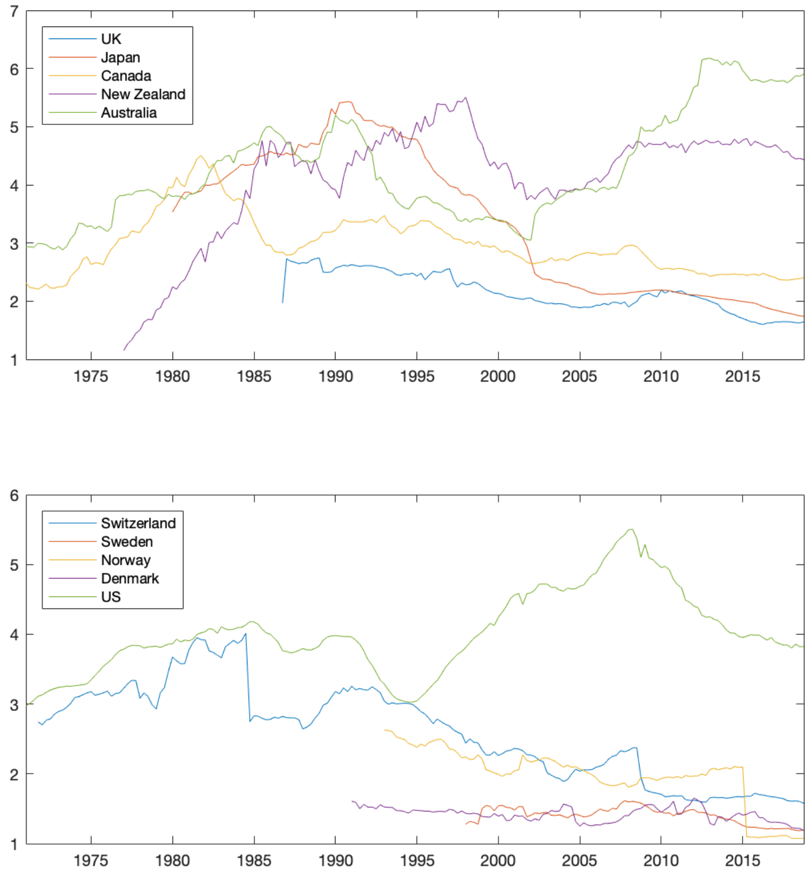


Figure 4.3 compares broad money multipliers across ten countries. The largest multipliers are observed in the U.S, Australia and New Zealand and vary between 4 and 5. The Japanese multiplier has a comparable magnitude prior to the early 1990s, before declining afterwards. The smallest money multipliers are observed in Sweden, Denmark, Norway, and in the UK.

Short-term dynamics

While the quantity theory of money is often interpreted as a long-run relationship, it is an identity and therefore holds at all points in time. Naturally, the first step in this analysis is therefore to assess the ability of the money multiplier to explain contemporaneous changes in the nominal exchange rate.

Contemporaneous relationships

To analyse the effects of money multipliers on exchange rates in the short run I test Eq 4.2 using the following two regression specifications:

$$\Delta ner_t = \alpha + \beta_1 \Delta m_t + \beta_2 \Delta m_t^* + \beta_3 \Delta v_t + \beta_4 \Delta v_t^* + \beta_5 \Delta y_t + \beta_6 \Delta y_t^* + \nu_t, \quad (4.3)$$

$$\Delta ner_t = \alpha + \gamma_m (\Delta m_t - \Delta m_t^*) + \gamma_v (\Delta v_t - \Delta v_t^*) + \gamma_y (\Delta y_t + \Delta y_t^*) + \nu_t, \quad (4.4)$$

where ner_t represents the nominal exchange rate at time t between a home country and the U.S. which plays the role of the foreign country in my analysis, m_t and m_t^* is the money supply in the home and foreign country respectively, measured by the M1 monetary aggregate; v_t and v_t^* is the velocity of money in the home and foreign country, measured by the corresponding money multipliers (the ratios of broad to narrow money), $\frac{M3}{M1}$; y_t and y_t^* is output in the home and foreign country, measured by respective GDPs. All variables are at quarterly frequency and Δ indicates a quarterly change.

Regression 4.3 allows coefficients to be estimated independently, thereby implying that foreign and domestic macro variables can have different effects on the exchange rate. Regression 4.4 restricts coefficients and focuses on the impact of the difference of the home macro variables from their foreign counterparts. Going forward, these specifications are referred to as the unrestricted and the restricted model, respectively.

Intuitively, one would expect countries with higher money supply and higher money velocity to have cheaper currencies. A higher relative money supply for a given relative real output, implies a higher price level and therefore a cheaper currency, ceteris paribus. A higher relative velocity implies that for a given level of relative nominal output, less currency is needed per transaction, thereby leading to a reduction in the value of the currency.

In my analysis, I quote exchange rates as a price of one USD in the foreign currency. Thus, I expect the coefficients of the US money supply and the US multiplier to have a negative sign, while the corresponding coefficients of the foreign country variables should have a positive sign. Since these regressions study the effects of quarterly changes in macro variables on the exchange rate, I do not expect the coefficients to be close to one, as predicted by Eq. 4.2, as that identity is set for the long run dynamics, not for the short run deviations. In addition, nominal GDP and the money multiplier are not perfect proxies for output and the velocity of money.

OLS estimates for the unrestricted model and its restricted counterpart are presented in Tables 4.2 and 4.3 respectively. For both models signs vary with respect to the prediction and it is difficult to establish a pattern of statistical significance. Both in the restricted and the unrestricted model, monetary variables appear significant at the 3%-10% levels for Japan, New Zealand, Australia and Switzerland. The GBPUSD exchange rate is sensitive to the money ratios only in the unrestricted model. The exchange rates of Canada, Sweden, Norway and Denmark show no sensitivity to any of the macro variables and have a negative adjusted R^2. These results show that the identity in Eq. 4.2 does not have strong empirical support in the short-run.

Japan, Australia, New Zealand and Switzerland have the highest adjusted R^2 across both models and have loadings on the monetary variables that are statistically significant and economically meaningful. All four of these currencies are seen as 'safe havens' and are included in many trading benchmarks and strategies, for example FX carry strategies, alongside the USD. Thus, their sensitivity to changes in money balances might be due to a latent variable that captures changes in global economic conditions, which might not affect the Canadian and Scandinavian currencies as much.

Predictive relationships

The original identity is contemporaneous, but as a robustness exercise I also estimate forecasting regressions. The home currency is likely to be affected by changes in the home money supply, home money velocity and home output contemporaneously. Moreover, there are likely to be secondary effects coming from similar changes in the foreign country. For example, U.S. monetary policy has been shown to affect not only the U.S Dollar, but other currencies as well: there are spillovers from U.S. policy. However, smaller countries will need time to adjust to the shifts in U.S. policies. To assess the reaction of exchange rates to previous quarter changes of the underlying macro variables, I estimate two regressions similar to those in Eq. 4.3 and 4.4 but using lagged changes of the independent macro variables:

$$\Delta ner_t = \alpha + \beta_1 \Delta m_{t-1} + \beta_2 \Delta m^*_{t-1} + \beta_3 \Delta v_{t-1} + \beta_4 \Delta v^*_{t-1} + \beta_5 \Delta y_{t-1} + \beta_6 \Delta y^*_{t-1} + \nu_t,$$

$$\Delta ner_t = \alpha + \gamma_m(\Delta m_{t-1} - \Delta m^*_{t-1}) + \gamma_v(\Delta v_{t-1} - \Delta v^*_{t-1}) + \gamma_y(\Delta y_{t-1} + \Delta y^*_{t-1}) + \nu_t,$$

The OLS estimates are presented in Tables 4.4 and 4.5 for the unrestricted and restricted models respectively. The predictive power is inconsistent over different countries and overall is higher for the unrestricted model, as would be expected. Adjusted for the number of variables in the regression, lagged changes in money supply, money velocity and output explain from -2.8% up to 11.9% in the quarterly dynamics of the exchange rates. The model has the highest adjusted R^2 of 7.2%, 11.9% and 5.5% for the unrestricted model for the exchange rates of New Zealand, Sweden and Norway with the U.S. Dollar respectively.

Monetary variables individually are statistically significant for Australia and the U.K., while the relative values of the money velocity and money supply are only statistically significant for New Zealand. Overall, similarly to the contemporaneous regressions, there is no consistent pattern across countries, which confirms the common literature finding about poor exchange rate predictability in the short run.

Table 4.2: Table presents OLS estimates of the unrestricted regression: $\Delta ner_t = \alpha + \beta_1 \Delta m_t + \beta_2 \Delta m_t^* + \beta_3 \Delta v_t + \beta_4 \Delta v_t^* + \beta_5 \Delta y_t + \beta_6 \Delta y_t^* + \nu_t$, where ner_t is the nominal exchange rate, the price of one U.S. Dollar in the home currency, m_t is the money supply measured by the M1 monetary aggregate, v_t is the velocity of money, measured by the money multiplier, $\frac{M3}{M1}$, y_t is output measured by nominal GDP. Asterisks denotes variables of the foreign country, the U.S. in this case. Δ indicates a quarterly change. The first line in each country block presents the coefficient estimates, the second row presents t-statistics and the third row presents p-values.

		α	Δv_t	Δv_t^*	Δm_t	Δm_t^*	Δy_t	Δy_t^*	R^2_{adj}
UK	ΔFX_t	0.01	0.01	-0.12	-0.10	-0.64	0.97	-0.86	2.7%
		0.60	*0.09*	*-0.19*	*-0.59*	*-1.12*	*1.92*	*-1.11*	
		0.55	0.93	0.85	0.56	0.26	0.06	0.27	
Japan	ΔFX_t	-0.02	-0.07	2.06	-0.14	1.61	0.87	-0.19	0.9%
		-0.92	*-0.03*	*2.21*	*-0.08*	*2.02*	*1.39*	*-0.19*	
		0.36	0.97	0.03	0.93	0.05	0.17	0.85	
Canada	ΔFX_t	0.00	-0.04	-0.13	-0.01	0.19	0.07	0.15	-0.4%
		-0.57	*-0.25*	*-0.48*	*-0.06*	*0.74*	*0.24*	*0.54*	
		0.57	0.80	0.63	0.95	0.46	0.81	0.59	
New Zealand	ΔFX_t	0.03	0.22	-1.04	0.41	-1.33	0.57	-2.43	7.6%
		2.03	*0.89*	*-1.49*	*1.66*	*-2.07*	*1.73*	*-3.07*	
		0.04	0.38	0.14	0.10	0.04	0.09	0.00	
Australia	ΔFX_t	0.00	0.54	-0.20	0.29	-0.07	-0.32	0.42	0.1%
		-0.34	*2.17*	*-0.40*	*1.18*	*-0.15*	*-0.98*	*0.90*	
		0.73	0.03	0.69	0.24	0.88	0.33	0.37	
Switzerland	ΔFX_t	-0.02	-0.86	0.79	-0.47	0.67	-0.41	1.27	2.2%
		-1.71	*-1.67*	*1.36*	*-1.32*	*1.30*	*-0.66*	*2.06*	
		0.09	0.10	0.18	0.19	0.19	0.51	0.04	
Sweden	ΔFX_t	-0.02	-0.02	-0.26	0.22	0.36	-0.85	1.40	-2.5%
		-0.68	*-0.08*	*-0.25*	*0.45*	*0.40*	*-0.84*	*1.27*	
		0.50	0.94	0.80	0.65	0.69	0.41	0.21	
Norway	ΔFX_t	-0.02	-0.07	0.41	0.02	0.74	0.14	0.76	-2.9%
		-1.00	*-0.15*	*0.47*	*0.08*	*0.95*	*0.51*	*0.77*	
		0.32	0.88	0.64	0.94	0.34	0.61	0.45	
Denmark	ΔFX_t	-0.02	-0.04	0.26	-0.08	0.59	0.18	1.07	-3.6%
		-0.92	*-0.26*	*0.29*	*-0.26*	*0.77*	*0.30*	*1.15*	
		0.36	0.80	0.77	0.80	0.44	0.76	0.25	

Table 4.3: Table presents OLS estimates of the restricted regression: $\Delta ner_t = \alpha + \gamma_m(\Delta m_t - \Delta m_t^*) + \gamma_v(\Delta v_t - \Delta v_t^*) + \gamma_y(\Delta y_t + \Delta y_t^*) + \nu_t$, where ner_t is the nominal exchange rate, the price of one U.S. Dollar in the home currency, m_t is the money supply measured by the M1 monetary aggregate, v_t is the velocity of money, measured by the money multiplier, $\frac{M3}{M1}$, y_t is output measured by nominal GDP. Asterisks denotes variables of the foreign country, the U.S. in this case. Δ indicates a quarterly change. The first line in each country block presents the coefficient estimates, the second row presents t-statistics and the third row presents p-values.

		α	$\Delta v_t - \Delta v_t^*$	$\Delta m_t - \Delta m_t^*$	$\Delta y_t^* - \Delta y_t^*$	R^2_{adj}
		0.00	0.04	-0.13	-0.84	1.5%
UK	ΔFX_t	*-0.57*	*0.40*	*-1.03*	*-1.74*	
		0.57	0.69	0.31	0.08	
		0.00	1.45	1.18	-0.73	2.6%
Japan	ΔFX_t	*-0.39*	*1.92*	*1.79*	*-1.26*	
		0.70	0.06	0.08	0.21	
		0.00	0.04	0.16	0.02	-0.8%
Canada	ΔFX_t	*0.86*	*0.26*	*0.96*	*0.10*	
		0.39	0.80	0.34	0.92	
		0.00	-0.23	-0.38	-0.80	5.9%
New Zealand	ΔFX_t	*-0.24*	*-1.00*	*-1.70*	*-2.61*	
		0.81	0.32	0.09	0.01	
		0.00	-0.51	-0.28	0.30	1.4%
Australia	ΔFX_t	*0.40*	*-2.13*	*-1.29*	*0.99*	
		0.69	0.03	0.20	0.32	
		-0.01	0.70	0.40	0.86	3.0%
Switzerland	ΔFX_t	*-1.63*	*1.90*	*1.43*	*1.72*	
		0.11	0.06	0.16	0.09	
		0.00	0.00	0.25	0.90	-1.3%
Sweden	ΔFX_t	*-0.02*	*0.02*	*0.84*	*1.09*	
		0.98	0.98	0.40	0.28	
		0.00	-0.15	-0.13	-0.12	-2.2%
Norway	ΔFX_t	*0.46*	*-0.40*	*-0.55*	*-0.44*	
		0.65	0.69	0.59	0.66	
		0.00	0.01	0.14	0.01	-2.7%
Denmark	ΔFX_t	*0.66*	*0.05*	*0.67*	*0.02*	
		0.51	0.96	0.50	0.98	

Table 4.4: Table presents OLS estimates of the unrestricted predictive regression: $\Delta ner_t = \alpha + \beta_1 \Delta m_{t-1} + \beta_2 \Delta m^*_{t-1} + \beta_3 \Delta v_{t-1} + \beta_4 \Delta v^*_{t-1} + \beta_5 \Delta y_{t-1} + \beta_6 \Delta y^*_{t-1} + \nu_t$, where ner_t is the nominal exchange rate, the price of one U.S. Dollar in the home currency, m_t is the money supply measured by the M1 monetary aggregate, v_t is the velocity of money, measured by the money multiplier, $\frac{M3}{M1}$, y_t is output measured by nominal GDP. Asterisks denotes variables of the foreign country, the U.S. in this case. Δ indicates a quarterly change. The first line in each country block presents the coefficient estimates, the second row presents t-statistics and the third row presents p-values.

		α	Δv_{t-1}	Δv^*_{t-1}	Δm_{t-1}	Δm^*_{t-1}	Δy_{t-1}	Δy^*_{t-1}	R^2_{adj}
		-2.57	0.08	1.13	0.10	1.35	0.40	0.48	1.3%
UK	ΔFX_t	*-1.60*	*0.72*	*1.79*	*0.56*	*2.34*	*0.78*	*0.62*	
		0.11	0.47	0.08	0.58	0.02	0.44	0.54	
		-2.95	0.78	-0.02	0.91	0.52	0.37	1.36	-1.1%
Japan	ΔFX_t	*-0.68*	*0.40*	*-0.02*	*0.53*	*0.64*	*0.59*	*1.30*	
		0.50	0.69	0.98	0.60	0.52	0.56	0.20	
		1.57	-0.04	-0.41	-0.10	-0.38	-0.19	0.54	0.6%
Canada	ΔFX_t	*2.80*	*-0.24*	*-1.45*	*-0.45*	*-1.52*	*-0.61*	*1.93*	
		0.01	0.81	0.15	0.65	0.13	0.54	0.05	
		-0.35	-0.50	0.83	-0.40	1.19	0.75	-0.53	7.2%
New Zealand	ΔFX_t	*-0.19*	*-2.04*	*1.18*	*-1.61*	*1.83*	*2.28*	*-0.66*	
		0.85	0.04	0.24	0.11	0.07	0.02	0.51	
		2.56	-0.25	-0.55	-0.27	-0.94	0.32	0.15	1.8%
Australia	ΔFX_t	*2.77*	*-1.01*	*-1.10*	*-1.11*	*-2.16*	*0.97*	*0.34*	
		0.01	0.31	0.27	0.27	0.03	0.33	0.74	
		1.63	-0.51	0.29	-0.46	-0.10	-0.60	0.74	0.6%
Switzerland	ΔFX_t	*1.13*	*-0.97*	*0.50*	*-1.29*	*-0.19*	*-0.94*	*1.19*	
		0.26	0.33	0.62	0.20	0.85	0.35	0.24	
		5.24	-0.08	-1.56	-0.64	-1.28	-2.91	2.26	11.9%
Sweden	ΔFX_t	*2.06*	*-0.38*	*-1.55*	*-1.45*	*-1.49*	*-2.95*	*2.18*	
		0.04	0.70	0.12	0.15	0.14	0.00	0.03	
		-0.41	-0.48	0.26	-0.23	0.39	0.63	0.83	5.5%
Norway	ΔFX_t	*-0.21*	*-1.09*	*0.31*	*-0.92*	*0.52*	*2.40*	*0.86*	
		0.84	0.28	0.76	0.36	0.60	0.02	0.39	
		0.66	-0.18	-0.68	-0.07	-0.41	0.76	0.92	3.7%
Denmark	ΔFX_t	*0.32*	*-1.36*	*-0.79*	*-0.26*	*-0.55*	*1.31*	*1.02*	
		0.75	0.18	0.43	0.80	0.59	0.19	0.31	

Table 4.5: Table presents OLS estimates of the predictive restricted regression: $\Delta ner_t = \alpha + \gamma_m(\Delta m_{t-1} - \Delta m^*_{t-1}) + \gamma_v(\Delta v_{t-1} - \Delta v^*_{t-1}) + \gamma_y(\Delta y_{t-1} + \Delta y^*_{t-1}) + \nu_t$, where ner_t is the nominal exchange rate, the price of one U.S. Dollar in the home currency, m_t is the money supply measured by the M1 monetary aggregate, v_t is the velocity of money, measured by the money multiplier, $\frac{M3}{M1}$, y_t is output measured by nominal GDP. Asterisks denotes variables of the foreign country, the U.S. in this case. Δ indicates a quarterly change. The first line in each country block presents the coefficient estimates, the second row presents t-statistics and the third row presents p-values.

		α	$\Delta v_{t-1} - \Delta v^*_{t-1}$	$\Delta m_{t-1} - \Delta m^*_{t-1}$	$\Delta y^*_{t-1} - \Delta y^*_{t-1}$	R^2_{adj}
		1.00	-0.07	0.00	-0.38	-1.5%
UK	ΔFX_t	*226.98*	*-0.69*	*-0.02*	*-0.78*	
		0.00	0.49	0.98	0.44	
		1.01	-0.26	-0.14	-0.19	-2.8%
Japan	ΔFX_t	*88.83*	*-0.33*	*-0.20*	*-0.31*	
		0.00	0.74	0.84	0.75	
		1.00	-0.12	-0.11	0.34	0.2%
Canada	ΔFX_t	*325.70*	*-0.82*	*-0.65*	*1.38*	
		0.00	0.41	0.52	0.17	
		1.00	0.54	0.56	-0.76	7.2%
New Zealand	ΔFX_t	*206.68*	*2.40*	*2.54*	*-2.47*	
		0.00	0.02	0.01	0.01	
		1.00	0.12	-0.03	-0.12	-0.9%
Australia	ΔFX_t	*217.93*	*0.50*	*-0.12*	*-0.38*	
		0.00	0.62	0.91	0.70	
		0.99	0.47	0.42	0.66	0.6%
Switzerland	ΔFX_t	*192.09*	*1.25*	*1.48*	*1.29*	
		0.00	0.21	0.14	0.20	
		0.99	0.02	0.21	2.80	10.6%
Sweden	ΔFX_t	*144.46*	*0.09*	*0.75*	*3.48*	
		0.00	0.93	0.46	0.00	
		1.00	0.34	0.15	-0.69	5.2%
Norway	ΔFX_t	*193.81*	*0.90*	*0.68*	*-2.68*	
		0.00	0.37	0.50	0.01	
		1.00	0.15	0.01	-0.59	-0.2%
Denmark	ΔFX_t	*198.01*	*1.11*	*0.04*	*-1.04*	
		0.00	0.27	0.97	0.30	

Long-term dynamics

To assess the long-run relationship between exchange rates and macro fundamentals in my model I use the concept of cointegration, i.e. I test whether variables have a common stochastic trend to which they revert in the long run. Most of the literature uses the Johansen methodology to test for cointegration, since it allows to test for more than one cointegrating relationship.

However, if this approach suggests that there is more than one cointegrating relationship for a given vector of macro variables, it is difficult to decide in favour of a particular cointegrating vector. In the current case, the cointegrating relationship is known as it directly follows from the quantity theory of money identity. Thus, in my test for cointegration I follow the simple two-step Engel-Granger procedure.

For the first step, I estimate the cointegrating relationships between the exchange rate and the corresponding macro variables for each country. For the second step, I compare the long- and the short-run effects of the macro variables on the exchange rates using an error correction model.

In my analysis, I consider two models of exchange rate dependency on money supply, money velocity and output of the two countries. In the first model I do not impose any restrictions on the variable coefficients and thus consider a state vector of variables $Y = (ner, v, v^*, m, m^*, y, y^*)$ and the following cointegration relationship:

$$ner_t = \beta_0 + \beta_1 v_t + \beta_2 v_t^* + \beta_3 m_t + \beta_4 m_t^* + \beta_5 y_t + \beta_6 y_t^* + \epsilon_t \tag{4.5}$$

where v_t and v_t^* is the velocity of money in the home country and in the US, proxied by the respective money multipliers, $(\frac{M3}{M1})_{Country}$ and $(\frac{M3}{M1})_{US}$; m_t and m_t^* are the home country and the US money supplies, measured by the respective M1 aggregates; and y_t and y_t^* are the country and the US outputs measured by each country's nominal GDP levels.

In the second model, I impose coefficient restrictions in line with the theoretical motivation and test whether it is the difference in the home and the US macro variables that is driving the exchange rate dynamics. Thus, I consider the state vector $Y = (ner, v - v^*, m - m^*, y - y^*)$ and the following cointegration relationship:

$$ner_t = \gamma_0 + \gamma_v(v_t - v_t^*) + \gamma_m(m_t - m_t^*) + \gamma_y(y_t - y_t^*) + \epsilon_t \tag{4.6}$$

where $v_t - v_t^*$ is the log ratio of money velocity in the home country and in the US, $m - m^*$ is the log ration of the home country and the US money supply and $y - y^*$ is the ratio of the two countries' outputs.

Unit root tests

Before starting with the EG procedure I explore statistical properties of the raw time series. For variables to be cointegrated each one of them has to be an I(1) process. Thus, I perform ADF tests on each variable / combination of variables that will be used in the cointegration vectors. I consider ADF specifications augmented with different numbers of lagged difference terms, between one and ten lags, and report the number of lags that corresponds to a specification with the smallest BIC criteria.

I test all variables using two variants of the ADF test: with and without a time-trend. The ADF test fails to reject the H0 of a unit root against at least one of the test variants for all tested variables. Tables 4.6 reports the ADF test's t-statistics for variables from the model with unrestricted coefficients, i.e. it tests money multipliers, M1 aggregates and GDP levels of each country for the presence of the unit root. Table 4.7 shows the log ratios of the respective variables of the home country and the U.S. Interestingly, all of the variables from Table 4.7 appear to be highly persistent, too, which might be explained by the fact that all of these variables are slow moving.

Cointegration vectors

Once it has been established that each state variable is integrated for all countries, I estimate the cointegration relationship individually for each country. The EG methodology exploits the main idea behind the cointegration phenomena: if

Table 4.6: Results of the ADF tests of the state vector variables $Y = (ner, v, v^*, m, m^*, y, y^*)$ of the exchange rate model with unrestricted coefficients. T-statistics are presented for the ADF test specification with the time trend. The column labelled 'lags' shows the optimal number of lags used in the standard DF test based on the BIC criteria.

	Series	t-stat	pVal	cVal	Lags		Series	t-stat	pVal	cVal	Lags
FX	UK	-2.54	0.11	-2.87	1	GDP	UK	2.11	1.00	-2.88	10
	Japan	-2.36	0.15	-2.87	8		Japan	-1.82	0.38	-2.89	10
	Canada	-1.88	0.35	-2.87	1		Canada	0.68	0.99	-2.88	1
	New Zealand	-1.90	0.34	-2.87	1		New Zealand	4.04	1.00	-2.89	5
	Australia	-1.99	0.30	-2.87	1		Australia	5.18	1.00	-2.88	1
	Switzerland	-3.94	0.00	-2.87	1		Switzerland	-0.62	0.86	-2.88	1
	Sweden	-1.59	0.48	-2.87	2		Sweden	0.05	0.96	-2.89	10
	Norway	-2.25	0.19	-2.87	1		Norway	1.74	1.00	-2.88	10
	Denmark	-2.31	0.17	-2.87	1		Denmark	-0.28	0.92	-2.90	10
							US	2.99	1.00	-2.88	10
$\frac{M3}{M1}$	UK	-0.93	0.77	-2.87	1	$M1$	UK	1.82	1.00	-2.89	10
	Japan	-0.32	0.92	-2.87	6		Japan	1.60	1.00	-2.88	10
	Canada	-1.48	0.53	-2.87	3		Canada	3.85	1.00	-2.88	7
	*New Zealand	0.90	0.90	-1.94	1		New Zealand	8.47	1.00	-2.88	1
	Australia	-0.46	0.90	-2.87	1		Australia	3.56	1.00	-2.88	1
	Switzerland	-0.66	0.85	-2.87	1		Switzerland	2.12	1.00	-2.88	10
	Sweden	-0.90	0.78	-2.87	1		Sweden	1.44	1.00	-2.90	10
	Norway	-0.85	0.80	-2.87	1		Norway	1.43	1.00	-2.89	10
	Denmark	-2.34	0.16	-2.87	1		Denmark	0.49	0.99	-2.89	10
	US	-1.72	0.42	-2.87	3		US	1.39	1.00	-2.88	10

Table 4.7: Results of the ADF tests of the state vector variables $Y = (ner, v - v^*, m - m^*, y - y^*)$ of the exchange rate model with unrestricted coefficients. T-statistics are presented for the ADF test specification with the time trend. The column labelled 'lags' shows the optimal number of lags used in the standard DF test based on the BIC criteria.

	Series	t-stat	pVal	Val	Lags		Series	t-stat	pVal	cVal	Lags
FX	UK	-2.54	0.11	-2.87	1	$GDP_{Cntr} - GDP_{US}$	UK	-1.60	0.47	-2.88	1
	Japan	-2.36	0.15	-2.87	8		Japan	0.69	0.99	-2.89	1
	Canada	-1.88	0.35	-2.87	1		Canada	3.70	1.00	-2.88	1
	New Zealand	-1.90	0.34	-2.87	1		New Zealand	-1.01	0.73	-2.89	1
	Australia	-1.99	0.30	-2.87	1		Australia	-0.61	0.86	-2.88	1
	Switzerland	-3.94	0.00	-2.87	1		Switzerland	1.69	1.00	-2.88	1
	Sweden	-1.59	0.48	-2.87	2		Sweden	1.19	1.00	-2.89	1
	Norway	-2.25	0.19	-2.87	1		Norway	-1.31	0.60	-2.88	1
	Denmark	-2.31	0.17	-2.87	1		Denmark	0.54	0.99	-2.89	1
$\frac{M3}{M1}_{Cntr} - \frac{M3}{M1}_{US}$	UK	-1.44	0.54	-2.89	2	$M1_{Cntr} - M1_{US}$	UK	-1.16	0.66	-2.88	1
	Japan	-0.82	0.81	-2.88	2		Japan	-1.31	0.60	-2.88	2
	Canada	-1.62	0.46	-2.88	3		Canada	-0.73	0.83	-2.88	1
	New Zealand	-2.43	0.13	-2.88	4		New Zealand	-0.87	0.79	-2.88	1
	Australia	-0.70	0.84	-2.88	2		Australia	-0.99	0.74	-2.88	1
	Switzerland	-0.92	0.77	-2.88	1		Switzerland	-1.45	0.54	-2.88	1
	Sweden	-1.02	0.72	-2.90	1		Sweden	-1.55	0.50	-2.90	1
	Norway	-2.03	0.28	-2.89	1		Norway	-2.22	0.20	-2.89	1
	Denmark	-1.57	0.48	-2.89	3		Denmark	-1.56	0.49	-2.89	2

variables are cointegrated, it is possible to construct a linear combination of them that is stationary.

Thus, I estimate the unrestricted coefficients model from Eq 4.5 for each country and test the residual of this regression, ϵ_t, for the presence of a unit root. I do the same for the model with restricted coefficients from Eq 4.6. Long-run relationships between the exchange rates and the macro variables in question for each country are presented in Tables 4.8 and 4.10 for the unrestricted and restricted models respectively. Tables 4.9 and 4.11 present the results of the ADF test of the models' residuals, for the unrestricted and restricted models respectively, where I test $H0 : \gamma = 0$ against $H1 : \gamma < 0$ in the regression

$$\Delta\epsilon_t = \gamma\epsilon_{t-1} + \delta_1\Delta\epsilon_{t-1} + \delta_2\Delta\epsilon_{t-2} + ... + \delta_p\Delta\epsilon_{t-p} + \nu_t.$$

Based on the ADF tests it follows that the hypothesis of a unit root is strongly rejected for all currency pairs, and thus, one can consider each currency pair to be cointegrated with the respective vector of macro variables. This result on its own is quite remarkable. The unrestricted model has seven variables in the cointegration vector, which is a relatively large number for this sort of analysis. The restricted model has four variables, but three of them represent differences in levels of home and foreign country macro variables. Thus, not only exchange rates have a common stochastic trend with the velocity of money, the money supply and the output of the respective countries, there is also a common long-term dynamic with the relative differences in these macro variables.

The model prescribes that if the home money supply or the home velocity of money is high, then the price of the home currency is low and nominal exchange rate is high. In other words, one needs more units of the home currency to purchase one dollar. While if home output is high, then the price of the home currency is high too and exchange rates are low. The version of the model with unrestricted coefficients allows the exchange rate to load differently on home and foreign macro variables, while the restricted version of the model implies that exchange rates react to the difference in the home and foreign macro variables.

Table 4.8: OLS estimates of the long-run relationship between the exchange rates of a home country to the USD and macro variables from the unrestricted model: $ner_t = \beta_0 + \beta_1 v_t + \beta_2 v_t^* + \beta_3 m_t + \beta_4 m_t^* + \beta_5 y_t + \beta_6 y_t^* + \epsilon_t$. The cointegration vector is estimated for each country individually using quarterly data. v represents the money velocity, measured with $\frac{M3}{M1}$, m is the country's money supply measured by $M1$ and y is the output measured with the country's nominal GDP.

Series		**Estimate**	**Tstat**	**pVal**		**Estimate**	**Tstat**	**pVal**
Const	UK	0.18	0.31	0.76	Switzerland	1.83	4.75	0.00
$\frac{M3}{M1}_{Cntr}$		0.23	2.32	0.02		-0.09	-1.39	0.17
$\frac{M3}{M1}_{US}$		0.18	2.23	0.03		0.32	4.30	0.00
$M1_{Cntr}$		-0.78	-1.34	0.18		-1.15	-2.59	0.01
$M1_{US}$		0.23	0.38	0.71		2.00	3.08	0.00
GDP_{Cntr}		1.50	1.05	0.30		-2.78	-4.68	0.00
GDP_{US}		-0.86	-0.53	0.60		-0.01	-0.02	0.99
Const	Japan	-153.59	-3.23	0.00	Sweden	7.97	2.16	0.03
$\frac{M3}{M1}_{Cntr}$		-21.88	-3.27	0.00		0.28	0.21	0.84
$\frac{M3}{M1}_{US}$		18.19	2.38	0.02		3.51	4.20	0.00
$M1_{Cntr}$		-109.03	-2.51	0.01		8.05	2.47	0.02
$M1_{US}$		167.51	3.61	0.00		23.21	3.94	0.00
GDP_{Cntr}		370.07	11.28	0.00		-11.96	-1.34	0.18
GDP_{US}		-195.47	-3.78	0.00		-32.41	-4.75	0.00
Const	Canada	0.06	0.34	0.73	Norway	13.63	6.33	0.00
$\frac{M3}{M1}_{Cntr}$		-0.07	-2.80	0.01		-5.85	-7.94	0.00
$\frac{M3}{M1}_{US}$		0.23	4.41	0.00		3.55	7.60	0.00
$M1_{Cntr}$		-3.86	-9.31	0.00		-11.62	-6.25	0.00
$M1_{US}$		4.51	8.74	0.00		33.01	9.69	0.00
GDP_{Cntr}		0.66	0.92	0.36		-2.73	-1.15	0.25
GDP_{US}		-0.89	-1.56	0.12		-31.99	-5.73	0.00
Const	New Zealand	0.95	4.13	0.00	Denmark	0.76	0.45	0.66
$\frac{M3}{M1}_{Cntr}$		-0.02	-0.70	0.49		-2.67	-3.98	0.00
$\frac{M3}{M1}_{US}$		-0.13	-2.72	0.01		3.12	6.43	0.00
$M1_{Cntr}$		-1.14	-2.53	0.01		-8.31	-4.08	0.00
$M1_{US}$		-1.09	-2.70	0.01		24.40	8.11	0.00
GDP_{Cntr}		4.42	7.92	0.00		13.29	1.71	0.09
GDP_{US}		-1.89	-6.05	0.00		-32.49	-3.90	0.00
Const	Australia	0.19	1.11	0.27				
$\frac{M3}{M1}_{Cntr}$		0.09	1.59	0.11				
$\frac{M3}{M1}_{US}$		0.00	0.04	0.97				
$M1_{Cntr}$		0.28	0.37	0.71				
$M1_{US}$		0.98	1.73	0.08				
GDP_{Cntr}		-7.23	-7.51	0.00				
GDP_{US}		6.60	11.50	0.00				

Table 4.9: ADF tests of the cointegration residual from the unrestricted model: $ner_t = \beta_0 + \beta_1 v_t + \beta_2 v_t^* + \beta_3 m_t + \beta_4 m_t^* + \beta_5 y_t + \beta_6 y_t^* + \epsilon_t$ for nine countries, using quarterly data.

Series	T stat	pVal	Critical val
UK	-4.03	0.00	-1.94
Japan	-3.88	0.00	-1.94
Canada	-2.16	0.03	-1.94
New Zealand	-3.64	0.00	-1.94
Australia	-3.82	0.00	-1.94
Switzerland	-4.21	0.00	-1.94
Sweden	-2.92	0.00	-1.94
Norway	-3.61	0.00	-1.94
Denmark	-3.58	0.00	-1.94

Table 4.10: OLS estimates of the long-run relationship between the exchange rates of a home country to the USD and macro variables from the restricted model: $ner_t = \gamma_0 + \gamma_v(v_t - v_t^*) + \gamma_m(m_t - m_t^*) + \gamma_y(y_t - y_t^*) + \epsilon_t$. The cointegration vector is estimated for each country individually using quarterly data. v represents the money velocity, measured with $\frac{M3}{M1}$, m is the country's money supply measured by $M1$ and y is the output measured with the country's nominalGDP. Variables without asterisks represent home countries, while variables with an asterisk represent the US.

Series		**Estimate**	**Tstat**	**pVal**		**Estimate**	**Tstat**	**pVal**
Const	UK	1.35	11.43	0.00	Switzerland	1.62	10.76	0.00
$v - v^*$		-0.08	-1.58	0.12		0.19	3.71	0.00
$m - m^*$		-0.40	-1.01	0.31		-0.06	-0.08	0.93
$y - y^*$		4.41	2.83	0.01		0.70	1.15	0.25
Const	Japan	26.65	2.24	0.03	Sweden	14.02	9.46	0.00
$v - v^*$		-32.07	-6.29	0.00		2.33	4.71	0.00
$m - m^*$		-274.13	-6.01	0.00		12.21	2.88	0.01
$y - y^*$		182.16	7.04	0.00		9.56	4.16	0.00
Const	Canada	1.03	21.33	0.00	Norway	8.07	12.40	0.00
$v - v^*$		-0.13	-6.90	0.00		0.27	1.48	0.14
$m - m^*$		-3.71	-12.59	0.00		5.06	3.30	0.00
$y - y^*$		-0.66	-4.04	0.00		-5.09	-2.31	0.02
Const	New Zealand	0.76	43.63	0.00	Denmark	1.99	3.03	0.00
$v - v^*$		0.11	5.67	0.00		-1.62	-6.36	0.00
$m - m^*$		1.77	7.44	0.00		-14.55	-8.47	0.00
$y - y^*$		1.81	6.49	0.00		6.02	2.34	0.02
Const	Australia	0.60	16.75	0.00				
$v - v^*$		0.26	12.56	0.00				
$m - m^*$		1.43	10.72	0.00				
$y - y^*$		-8.02	-18.63	0.00				

Table 4.11: ADF tests of the cointegration residuals, ϵ from the restricted model $ner_t = \gamma_0 + \gamma_v(v_t - v_t^*) + \gamma_m(m_t - m_t^*) + \gamma_y(y_t - y_t^*) + \epsilon_t$ for nine countries, using quarterly data.

Series	T stat	pVal	Critical val
UK	-3.02	0.00	-1.94
Japan	-2.47	0.01	-1.94
Canada	-2.37	0.02	-1.94
New Zealand	-2.52	0.01	-1.94
Australia	-3.65	0.00	-1.94
Switzerland	-2.35	0.02	-1.94
Sweden	-2.49	0.01	-1.94
Norway	-1.91	0.05	-1.94
Denmark	-3.14	0.00	-1.94

Based on this intuition, in the unrestricted version I expect the home money multiplier, home money supply and the U.S. GDP to have a positive sign, while other variables should have a negative sign. Table 4.8 shows that Japan, Canada and Denmark have signs in line with the prediction. Three countries, Switzerland, Norway and the UK, show minor deviation in signs. The remaining three countries, New Zealand, Australia and Sweden have cointegration vector signs different from what is predicted by the model.

Table 4.8 also reports the t-statistics and the p-values of each variable in the cointegration vector. Even though on their own t-statistics and the p-values are biased towards higher statistical significance, their values are still useful to see the relative importance of each variable in the long-run relationship. Only for Denmark and Japan all variables of the cointegration vector are statistically significant, and the rest of the countries show no particular pattern in variables that have stronger effects on the long-run relationship.

There are several possible reasons for this deviation from the model prediction. First, it is possible that the proxies that I am using for the velocities of money and countries' output are not perfect. One could try and fix that by including another variable in the equation to compensate for the missing macroeconomic force. Second, it is possible that the time frequency of the variable adjustment is chosen wrongly and/or is time varying throughout the history. Third, exchange rate markets are highly speculative and thus are subject to a lot of noise unrelated to the underlying macroeconomic forces.

In the restricted version of the model, I expect exchange rates to load positively on differences in the velocity of money and on differences in the money supply, and to load negatively onto differences in output. If a home country has a higher money velocity than the U.S., or higher money supply than the U.S., the price of the home currency should drop relative to the price of the U.S. dollar and exchange rates should increase. Table 4.10 shows that the long-term relationship has signs as expected for Australia and Norway, and has them completely switched for the U.K., Japan and Denmark.

There could be idiosyncratic reasons for all three of these countries: the U.K. has a relatively large financial sector (measured by assets over nominal GDP), so may well be affected by factors outside the model. Japan has had unconventional monetary policies in place for much of the past three decades, which could have skewed financial asset prices away from fundamentals. The Danish krona is pegged to the Euro, and is therefore not free to adjust to Denmark specific macroeconomic changes.

Thus, restricting coefficients fixes the sign problem for some countries, such as Australia and Norway, and introduces a sign problem for others, like Japan and Denmark. Overall, considering both specifications only the UK and Sweden seem to not fit the model at all.

Error correction model

Having established that the system is indeed cointegrated for each country and for both model specifications, I estimate an error correction model (ECM), which governs short deviations of the state variables from the stochastic trend:

$$\Delta Y_t = B_0 + B_{lt} LT_{t-1} + B_1 \Delta Y_{t-1} + \mu_t$$

where $Y = (ner, v, v^*, m, m^*, y, y^*)$ for the unrestricted model and $Y = (ner, v - v^*, m - m^*, y - y^*)$ for the restricted model. B_0 is a vector of constants, or a linear time-trend, and B_1 is a matrix of coefficients in front of the lagged vector of state variables. The ECM can be augmented to allow past short-run deviations to also influence present short-run deviations. I choose to use only one lag of changes in the state variables, because earlier changes in money supply, money velocity and the output will be incorporated into the previous period's changes in the exchange rate, which is already part of the vector of independent variables. B_{lt} is a vector of coefficients in front of the long-term component, which represents the speed of adjustment to the long-run trend and LT is the deviation from the long-term trend, also known as the error correction term. In case of the unrestricted model LT takes the following form:

$$LT = ner_t - \beta_0 + \beta_1 v_t + \beta_2 v_t^* + \beta_3 m_t + \beta_4 m_t^* + \beta_5 y_t + \beta_6 y_t^*$$

In case of the ECM for the model with restricted coefficients, LT takes the following form:

$$LT = ner_t - \gamma_0 + \gamma_v(v_t - v_t^*) + \gamma_m(m_t - m_t^*) + \gamma_y(y_t - y_t^*).$$

In both cases, $LT_{t-1} = \epsilon_{t-1}$. Therefore I insert the cointegration vector residual into the main ECM equation, such that the equation is linear in its coefficients and OLS can be used to estimate it.

Thus, an error correction model describes the short-run dynamics of the state variables and combines the long-term effects of the state variables in the form of the cointegration residual and their short-term effects in the form of the lagged quarterly changes. Coefficient estimates of the ECM are presented in Tables 4.12 and 4.13 for the unrestricted and restricted models respectively.

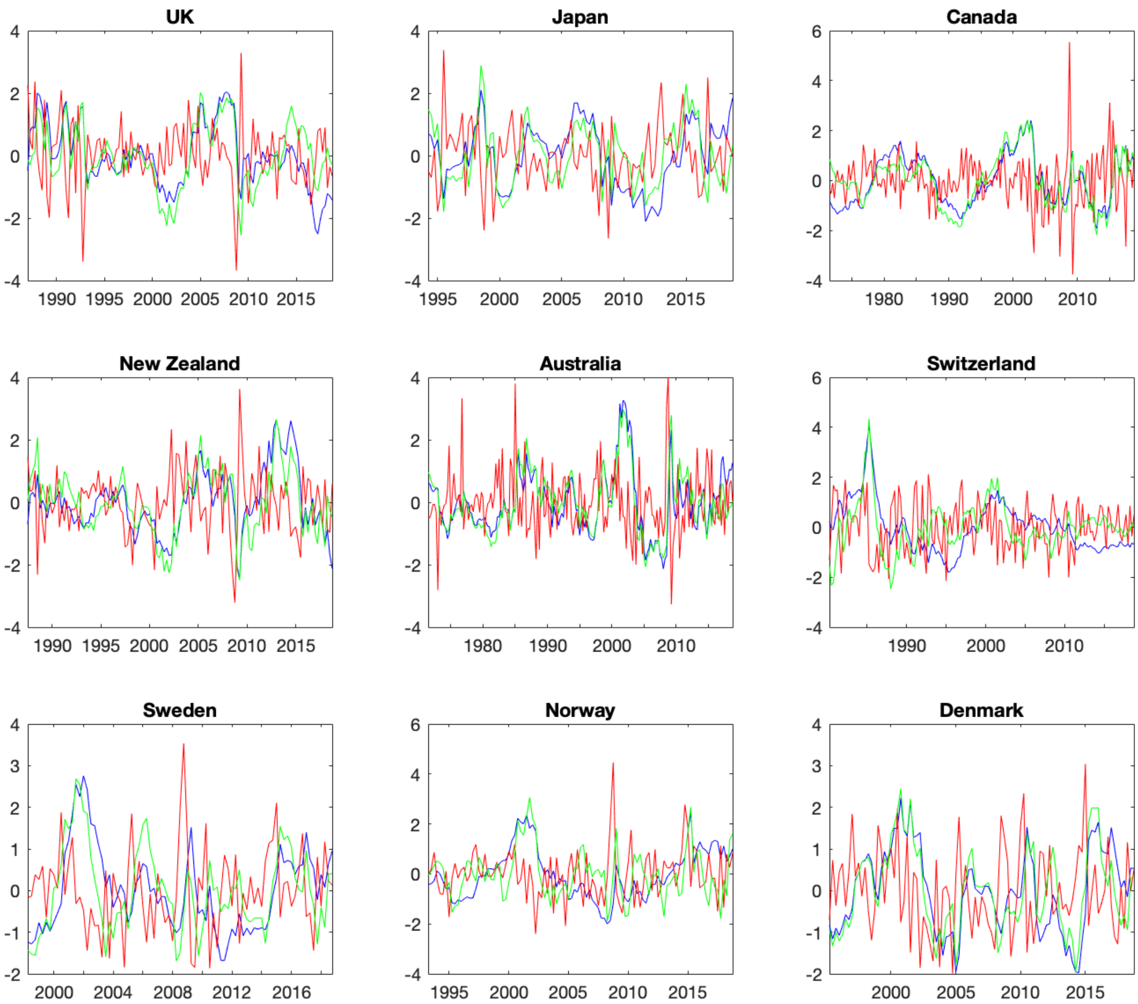
To illustrate the relationship between the quarterly growth rate of the exchange rates and the cointegration residuals, I plot their standardised time series in Figure 4.4. In the same figure I compare the dynamics of the cointegration residual from the restricted and unrestricted model specifications. The two seem to behave very similarly for almost all the countries, which means that the imposition of the model restrictions did not significantly alter the relationship between the variables. Even without the restrictions the relationship was close to the one as suggested by the model's intuition. From the figures it is visible at which points in time the two cointegration residuals grow apart from each other and thus, when the unrestricted model deviates from the theoretical prediction. For example, for the UK the only deviation happens after 2010, in Switzerland between 1990 and 2000, as well as after 2010, and Swedish cointegration residuals deviate the most during the post-crisis years. At the same time the long-term relationships of Australia, Canada and Denmark from the two model specifications move in lockstep throughout the available history.

From Figure 4.4 it is also clear that there is a strong negative relationship between the quarterly currency returns and the cointegration residuals for all countries. The residual also appears to precede quarterly deviations for all countries. Thus, based on the graphs alone, I expect the changes in the FX to load significantly and with a negative sign, onto cointegration residuals. However, currency returns are much more volatile than the residual, which can have an impact on the predictability. Excess volatility of the exchange rate over and beyond volatility levels explained by underlying macro variables is a well-documented phenomena, but literature does not offer a consensus explanation for it Rossi [2013]. One of the more prominent economic theories is that markets for traded goods that tie down the exchange rates are not fully integrated and are highly segmented due to varying trading costs. Combined with nominal price rigidities this can produce an excessive response of exchange rates to macro shocks Obstfeld and Rogoff [2001].

Tables 4.12 and 4.13 show that the cointegration residual is indeed a strong predictor of quarterly changes in the exchange rates. In both model specifications, ΔFX_t loads negatively on ϵ_{t-1} with the coefficient being statistically significant, with t-statistics between -1.82 and -4.38 in magnitude.

Most regressions have high R^2s which, however, vary a lot in magnitude between the countries. The unrestricted version of the error correction model explains 18.2%, 15.9% and 13.6% of the variation in quarterly exchange rates in New Zealand, the U.K. and Japan respectively. However, it explains only 1.2% of the exchange rate dynamics in Norway and 2% of the exchange rate dynamics in Sweden. The two

Figure 4.4: This figure plots the quarterly changes of the exchange rates (in red) for each country against the cointegration residuals from the restricted (blue) and unrestricted (green) models. All time-series are standardised to zero mean and unit variance.



big outliers are Norway in the restricted model, and Denmark in the unrestricted model with t-stats of -1.09 and -1.72 respectively on the cointegration residual and negative adjusted R^2s. This sort of instability of model performance across countries is common for all models presented in the literature so far.

In terms of quarterly changes in other macro variables, only the previous lag of the exchange rate appears to be systematically statistically significant. Some monetary variables appear to be statistically significant only for New Zealand, Australia and Switzerland in either of the two model specifications. Output is statistically significant only for the UK and New Zealand both in the restricted and unrestricted model. The expected signs in front of the short term components are straight forward to judge in the ECM, as there is an interaction with a long-term component.

Overall, the predictive power of the long term component is much stronger than from the short-term dynamics of the underlying state variables. This is in line with the literature consensus, that the short term deviations in the exchange rate are the hardest to forecast Obstfeld and Rogoff [2001], Rossi [2013]. The long term dynamics of exchange rates is driven by the equilibrium relationship between the money multipliers, money supplies and outputs of the two countries. The speed of convergence is small in magnitude, but highly statistically significant, which implies a slow but consistent reversion to the long term equilibrium. Given the low significance of the short-term components, it seems fair to suggest that adjusted R^2s are driven by the cointegration residual and would be even higher if the short-term components were to be removed from the regression.

Table 4.12: OLS estimates of the first equation of the ECM model $\Delta Y_t = B_0 + B_{lt}\epsilon_{t-1} + B_1\Delta Y_{t-1} + \mu_t$, where ϵ_{t-1} is a cointegration residual for the unrestricted model. $Y = (ner, v, v^*, m, m^*, y, y^*)$ is a vector of state variables, where ner is the nominal exchange rate measured as a price of one USD in the home currency, v and v^* are the velocities of home and foreign money measured by the respective country's money multipliers, m and m^* are the home and foreign money supply measured by M1 monetary aggregates, and y and y^* are the home and foreign country's output measured by GDP. Δ represents a quarterly change. All variables are in logs. The sample period depends on the data availability and varies for each country (see Data section).

		Const	ϵ_{t-1}	ΔFX_{t-1}	$\Delta\frac{M3}{M1}_{Cntr,t-1}$	$\Delta\frac{M3}{M1}_{US,t-1}$	$\Delta M1_{Cntr,t-1}$	$\Delta M1_{US,t-1}$	$\Delta GDP_{Cntr,t-1}$	$\Delta GDP_{US,t-1}$	R^2_{adj}
	Coef	0.00	-0.14	0.20	-0.06	-0.38	0.00	-0.78	0.92	-0.47	15.9%
ΔFX_tUK	***tstat***	*0.31*	*-4.38*	*2.32*	*-0.61*	*-0.64*	*-0.01*	*-1.45*	*1.95*	*-0.65*	
	pval	0.76	0.00	0.02	0.54	0.52	0.99	0.15	0.05	0.52	
	Coef	-0.01	0.00	0.11	0.91	1.65	0.79	1.14	0.40	-0.54	13.6%
ΔFX_tJapan	***tstat***	*-0.70*	*-3.93*	*1.07*	*0.50*	*1.88*	*0.49*	*1.52*	*0.67*	*-0.56*	
	pval	0.48	0.00	0.29	0.62	0.06	0.62	0.13	0.50	0.58	
	Coef	0.00	-0.06	0.18	-0.12	0.02	-0.10	0.19	0.21	0.11	4.2%
ΔFX_tCanada	***tstat***	*-0.43*	*-2.55*	*2.46*	*-0.70*	*0.05*	*-0.46*	*0.77*	*0.70*	*0.40*	
	pval	0.67	0.01	0.01	0.48	0.96	0.65	0.44	0.49	0.69	
	Coef	0.02	-0.26	0.23	0.34	-0.72	0.50	-1.03	0.32	-1.52	18.2%
ΔFX_tNew Zealand	***tstat***	*1.21*	*-3.54*	*2.71*	*1.45*	*-1.08*	*2.12*	*-1.68*	*1.02*	*-1.92*	
	pval	0.23	0.00	0.01	0.15	0.28	0.04	0.10	0.31	0.06	
	Coef	0.00	-0.10	0.18	0.51	-0.23	0.30	0.08	-0.34	0.05	8.8%
ΔFX_tAustralia	***tstat***	*-0.06*	*-3.90*	*2.52*	*2.11*	*-0.46*	*1.27*	*0.17*	*-1.08*	*0.12*	
	pval	0.95	0.00	0.01	0.04	0.65	0.21	0.86	0.28	0.91	
	Coef	-0.02	-0.09	0.16	-0.90	0.91	-0.47	0.83	-0.36	1.28	10.2%
ΔFX_tSwitzerland	***tstat***	*-1.97*	*-3.69*	*2.02*	*-1.81*	*1.62*	*-1.35*	*1.67*	*-0.60*	*2.14*	
	pval	0.05	0.00	0.04	0.07	0.11	0.18	0.10	0.55	0.03	
	Coef	-0.01	-0.02	0.25	-0.06	-0.35	0.06	0.14	-0.44	1.19	2.0%
ΔFX_tSweden	***tstat***	*-0.44*	*-1.82*	*1.95*	*-0.24*	*-0.33*	*0.13*	*0.15*	*-0.43*	*1.10*	
	pval	0.66	0.07	0.05	0.81	0.74	0.90	0.88	0.66	0.27	
	Coef	-0.02	-0.03	0.23	0.33	0.29	0.24	0.51	0.05	0.86	1.2%
ΔFX_tNorway	***tstat***	*-1.05*	*-2.21*	*1.94*	*0.68*	*0.34*	*0.90*	*0.65*	*0.18*	*0.87*	
	pval	0.30	0.03	0.06	0.50	0.74	0.37	0.52	0.86	0.38	
	Coef	-0.02	-0.02	0.19	-0.03	0.42	-0.14	0.71	0.34	0.99	-1.0%
ΔFX_tDenmark	***tstat***	*-1.02*	*-1.72*	*1.66*	*-0.24*	*0.47*	*-0.47*	*0.92*	*0.55*	*1.08*	
	pval	0.31	0.09	0.10	0.81	0.64	0.64	0.36	0.58	0.28	

Table 4.13: OLS estimates of the first equation in the ECM model $\Delta Y_t = B_0 + B_{lt}\epsilon_{t-1} + B_1 \Delta Y_{t-1} + \mu_t$, where ϵ_{t-1} is a cointegration residual for the restricted model. $Y = (ner, v, v^*, m, m^*, y, y^*)$ is a vector of state variables, where ner is the nominal exchange rate measured as a price of one USD in the home currency, v and v^* are the velocities of home and foreign money measured by the respective country's money multipliers, m and m^* are the home and foreign money supply measured by M1 monetary aggregates, and y and y^* are the home and foreign country's output measured by GDP. Δ represents a quarterly change. All variables are in logs. The sample period depends on the data availability and varies for each country (see Data section).

		Const	Cointegration residual	ΔFX_{t-1}	$\Delta \frac{M3}{M1}_{Cntr,t-1} - \Delta \frac{M3}{M1}_{US,t-1}$	$\Delta M1_{Cntr,t-1} - \Delta M1_{US,t-1}$	$\Delta GDP_{Cntr,t-1} - \Delta GDP_{US,t-1}$	R^2_{adj}
	Coef	0.00	-0.08	0.21	-0.05	0.19	0.83	9.4%
ΔFX_t UK	***tstat***	*-0.72*	*-3.16*	*2.41*	*-0.48*	*1.55*	*1.80*	
	pval	0.47	0.00	0.02	0.63	0.12	0.07	
	Coef	-0.01	0.00	0.05	-1.35	-0.94	0.58	9.1%
ΔFX_t Japan	***tstat***	*-0.55*	*-2.95*	*0.51*	*-1.84*	*-1.46*	*1.04*	
	pval	0.58	0.00	0.61	0.07	0.15	0.30	
	Coef	0.00	-0.04	0.19	-0.11	-0.20	-0.02	4.0%
ΔFX_t Canada	***tstat***	*0.83*	*-2.40*	*2.60*	*-0.71*	*-1.18*	*-0.06*	
	pval	0.41	0.02	0.01	0.48	0.24	0.95	
	Coef	0.00	-0.16	0.23	0.21	0.35	0.72	13.3%
ΔFX_t New Zealand	***tstat***	*-0.26*	*-2.78*	*2.66*	*0.97*	*1.63*	*2.42*	
	pval	0.80	0.01	0.01	0.33	0.11	0.02	
	Coef	0.00	-0.08	0.19	0.44	0.21	-0.27	8.8%
ΔFX_t Australia	***tstat***	*0.36*	*-3.54*	*2.59*	*1.84*	*0.95*	*-0.91*	
	pval	0.72	0.00	0.01	0.07	0.34	0.36	
	Coef	-0.01	-0.03	0.12	-0.81	-0.45	-0.67	6.7%
ΔFX_t Switzerland	***tstat***	*-1.48*	*-2.51*	*1.51*	*-2.23*	*-1.66*	*-1.35*	
	pval	0.14	0.01	0.13	0.03	0.10	0.18	
	Coef	0.00	-0.02	0.23	-0.11	-0.22	-0.64	6.2%
ΔFX_t Sweden	***tstat***	*0.03*	*-2.40*	*2.06*	*-0.49*	*-0.76*	*-0.80*	
	pval	0.98	0.02	0.04	0.63	0.45	0.43	
	Coef	0.00	-0.01	0.16	0.20	0.16	0.07	-1.5%
ΔFX_t Norway	***tstat***	*0.37*	*-1.09*	*1.49*	*0.51*	*0.70*	*0.27*	
	pval	0.71	0.28	0.14	0.61	0.49	0.79	
	Coef	0.00	-0.02	0.18	-0.03	-0.15	0.16	1.4%
ΔFX_t Denmark	***tstat***	*0.67*	*-2.09*	*1.67*	*-0.22*	*-0.74*	*0.28*	
	pval	0.51	0.04	0.10	0.83	0.46	0.78	

Impulse response functions

In the following analysis I focus on the version of the above ECM model with restricted coefficients and use it to describe the dynamic response of the system to the unobservable structural shocks. The model follows a first order VAR and describes a joint evolution of the vector of macro variables:

$$Z_t = AZ_{t-1} + \epsilon_t, \quad \epsilon_t \sim N(0, \Sigma) \tag{4.7}$$

where Z_t is a five-element state vector, with the exchange rate being its first element, the cointegration residual being the second element, money multiplier differences being the third, and money supply and nominal GDP differences being the forth and fifth elements of Z_t. Matrix A is a companion matrix of the VAR coefficients and ϵ_t is a vector of correlated innovations; Σ is the innovations' variance-covariance matrix.

The model can easily be generalised to include more lags, since any high-order VAR can always be transformed into a first-oder VAR via a companion form. The ordering of the state variables is important since it is based on the shock transmission through the system, and thus represents the order in which the state variables are known to the market.

I use impulse response functions to assess the effect of a structural shock on the long run dynamics of the model. An impulse-response function (IRF) describes the evolution of the variable of interest along a specified time horizon after a shock at a given moment in time. To illustrate the role of impulse responses, consider the Wold representation, also known as the moving average representation, of the vector of the covariance stationary vector of state variables Z_t .

$$Z_t = \epsilon_t + A\epsilon_{t-1} + A^2\epsilon_{t-2} + A^3\epsilon_{t-3} + ... + A^t\epsilon_0$$
$$Z_t = \sum_{i=0}^{i=t} A^i\epsilon_{t-i}.$$

Computing impulse responses requires the orthogonality of structural shocks, so that one can consider the effects of each shock in isolation. Since ϵ_t is a vector of correlated innovations, following a common approach, I assume that ϵ_t is a reduced-form vector of innovations that is equal to a mixed combination of some structural shocks u_t:

$$\epsilon_t = Bu_t, \quad u_t \sim N(0, I)$$

where B is a (5×5) matrix and u_t is a (5×1) column vector containing the structural shocks. The moving average representation of my model is:

$$Z_t = u_t + Cu_{t-1} + C^2 u_{t-2} + C^3 u_{t-3} + ... + C^t u_0$$
$$Z_t = \sum_{i=0}^{i=t} C^i u_{t-i},$$

where the coefficients in front of the structural shocks defined as $C = AB$ are the responses of variables in Z to the unit shocks. The generic matrix C_j within the moving average representation can be interpreted as follows:

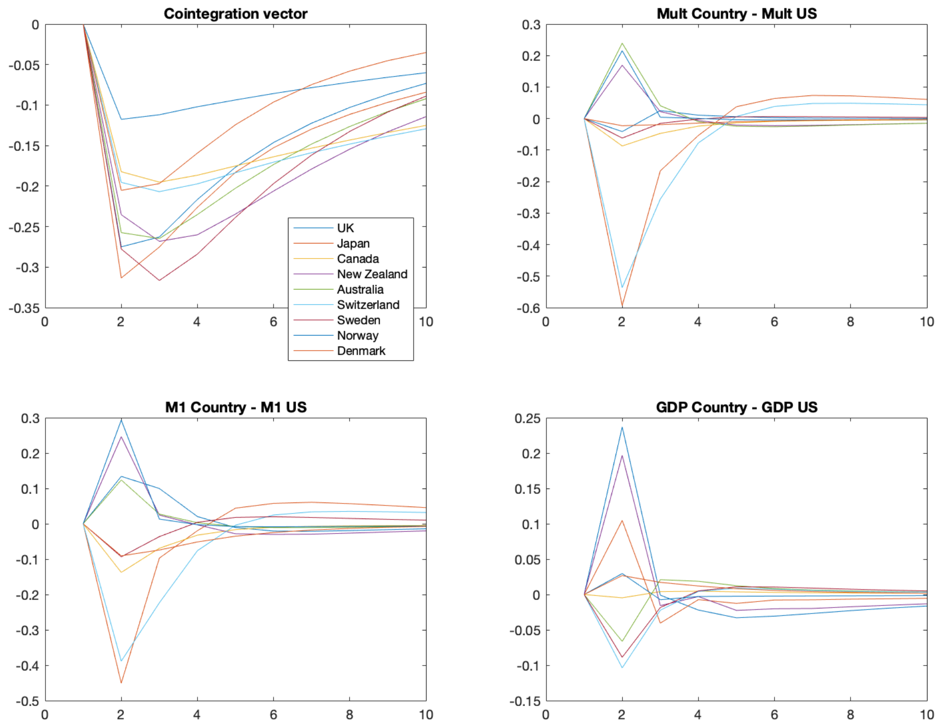
$$C_s = \frac{\partial Z_{t+s}}{\partial u_t},$$

where the element i, j of matrix C_s represents the impact of a shock hitting the j-th variable of the system at time t on the i-th variable of the system at time $t + s$. Thus, an impulse-response function plot of C_{t+s} for all $s = 0, ..., H$ (where H is the time horizon of the plot) depicts the response of each variable in the state vector Z_{t+s} for all s after a unit variance shock at time t. Impulse response analysis allows to differentiate between permanent and transitory shocks to the system and helps understand the co-movement of the state variables.

For the purpose of plotting impulse response functions, I standardise all state variables to zero mean and unit variance, and re-estimate matrix A using OLS. Thus, the only remaining challenge is to find matrix B, which depends on the identification restrictions. I follow the original approach of Sims (1981), which relies on the ordering of the variables, and set $B = \Sigma^{\frac{1}{2}}$, i.e. B is equal to the lower triangular matrix obtained from the Choleski decomposition of the VAR's innovations' covariance matrix.

Impulse response functions of the exchange rates to shocks in four state variables are presented in Figure 4.5. The first graph in Figure 4.5 compares the responses of the exchange rates of nine countries to a shock to the corresponding cointegration residual. The second graph compares the exchange rates' reactions to a shock to the relative money multiplier and the third and fourth graphs plot the exchange rates' responses to shocks to the relative money supply and to the shock in the relative output respectively. Only the impulse response of the shock to the cointegration residual is consistent across all countries and lasts for more than 10 quarters. A one unit structural shock to the cointegration vector yields a fall of 0.1 to 0.3 units in the exchange rates (price of the US dollar in the home currency) over the following two quarters. By the end of the 10th quarter the negative impact is still present and varies between -0.25 to -0.15 units. Shocks to other macro variables of the model have less consistent and more contemporaneous effects on exchange rates that almost fully disappear after four quarters.

Figure 4.5: Impulse response functions of the exchange rate, the price of one USD in local currency, for ten time steps / quarters onto the unit shock to four state variables: the cointegration residual, the difference between the country's money multiplier and the U.S.'s money multiplier, the difference between the country's monetary aggregate M1 and the U.S.'s monetary aggregate, M1, and the difference between the country's GDP and the U.S. GDP.



5
Conclusion

Asset return predictability by macro variables is a popular topic in both the finance and economics literature. The strength of the empirical evidence, however, depends on the asset class. A range of macro variables has been linked to expected returns of stocks and bonds, however, predictability of exchange rates by the same macro variables has not received convincing empirical support yet.

This work contributes to the literature by suggesting a new macro predictor for a range of asset classes, the money multiplier. I compute the money multiplier as the ratio of a broad monetary aggregate to a narrow monetary aggregate, which corresponds to the ratio of inside to outside money in the economy, and show that it robustly predicts future expected returns of stocks, bonds and currencies. I link the predictive ability of the multiplier to its economic interpretation as a measure of economy-wide leverage.

In particular, I show that the multiplier growth rate significantly and robustly predicts stock market excess returns on aggregate and in the cross-section. In addition, it predicts bond returns for a range of bond maturities and over a range of horizons. I demonstrate that changes in the money multiplier are a priced risk factor in the cross-section of stock returns. I motivate my empirical findings for stocks and bonds using the margin CAPM model of Adrian et al. [2014], into which I incorporate the mechanism of loan creation. The choice on margin CAPM model to motivate my results is not final and is mainly driven by it's elegance and flexibility at the same time. The task of incorporating money into stochastic discount factor is a difficult one and a properly specified model that does so is yet to be written. This however, lies outside of the scope of this work. The main idea behind my research is to simply show that money creation has a predictive relationship with asset prices and to give a potential explanation of this phenomenon. I argue that money in nowadays economy is created in a form of credit and loans and thus is tightly link to the concept of leverage. I use margin CAPM to show that this explanation is plausible and that the money multiplier can be seen as a measure of the economy-wide leverage.

The case of currencies I address separately. Currency is an asset that can only be priced relative to other assets, namely currencies from other countries, and therefore the multiplier differential has to be used as a predictor of currency returns. I consider a set of ten countries and study the price of one dollar in terms of nine other currencies. I motivate my analysis of currency returns predictability using the identity from the quantity theory of money. Combining it with the definition of real exchange rates results in an empirical specification similar to that of classic monetary models of the 1970s, the brontosaurus of exchange rate modelling. Despite former unsuccessful attempts of the economic literature to empirically link exchange rates to monetary variables, I show that the money multiplier differential has a strong long-term relationship with exchange rates, narrow money supply differentials and output differentials of country pairs. Econometrically, this long-term relationship is captured with a cointegration vector.

I show that the cointegration residual is strongly significant when forecasting quarterly changes in exchange rates and its sign is consistent across currency pairs despite the fact that their cointegration relationships differ from each other. Thus, I show that the money multiplier is important in forecasting currency returns, vis-a-vis the reversion to the long-term trend.

In the context of exchange rate predictability I show that the money multiplier can be seen as a proxy for money velocity in the economy. I argue that it is a broader proxy compared to the usual definition of money velocity, since it accounts not only for real sector money circulation, but also for multiplication of financial assets and therefore for the circulation of money in the financial sector.

The two economic interpretations of the money multiplier offered in this work are not exactly the same, but they are inherently linked. In the past few decades a large part of money spending in the economy took place in the financial sector and was highly leveraged. Thus, in an economy with a deep layer of financial intermediation the amount of leverage created would be proportional to the amount of money spent in the economy. The drivers behind both money creation in the financial sector and economy-wide leverage are the usual suspects, for example real business cycle variables and financial shocks.

As a proxy for the level of economy-wide leverage, the money multiplier may serve as an indicator of the risk-bearing capacity of the financial system, tightness of margin constraints that are so difficult to observe, and generally, can be used as a state variable for dynamics induced by financial frictions. In this paper, I do not argue that the multiplier drives asset returns, but merely show its strong forecasting power. It is likely that the multiplier reacts to the same endogenous changes in the economy that affect asset prices. Since the multiplier is determined by the amount of money that has actually been borrowed in the economy, it can be seen as an indicator of funding liquidity, a state variable that otherwise is not easy to capture.

The multiplier has very different dynamics compared to other common measures of leverage, like broker-dealer leverage or total loans. Compared to the former, the multiplier also considers loans made by a different financial intermediary, commercial banks, and partly accounts for direct market lending too, due to its money market funds component. Compared to total loans, the multiplier excludes double counting of the same loans and therefore represents net lending in the economy.

I also show that the multiplier is different from the traditional measure of money velocity, and the difference varies from country to country. Remarkably, countries in which the two variables are related the most in their levels, the US and the UK, exhibit very low correlation between the two variables' growth rates. I attribute it to the difference in the dynamics of the real economy and the financial sector, because the latter is unaccounted for by the usual money velocity measure. Thus, the bigger the financial sector in the economy, the stronger is the discrepancy between the dynamics of the money multiplier and classic money velocity measure.

Empirical predictions obtained in this paper for stock and bond excess returns are consistent with theories of risk based funding constraints that generate procyclical leverage as a state variable (Geanakoplos [2010], Brunnermeier and Pedersen [2009], Adrian and Shin [2014]). When the multiplier is high, expected returns are low. Thus the general mechanism that relates changes in the multiplier to expected returns is similar to that in models of financial intermediaries' leverage. Agents adjust the risk exposure of their asset portfolios based on broad economic conditions. This affects demand for assets and thereby their equilibrium price. However, when dealing with broker-dealer leverage one considers risk exposures of financial intermediaries, a very specific type of economic agent, subject to constraints arising from agency problems. Looking at the broad money multiplier allows assessing changes in investors' risk exposure more generally: it unites borrowing by financial and private sector in one measure. Therefore the multiplier is a better indicator of changes in the marginal utility of wealth in different states of the economy. It serves as a macroeconomic state variable, that characterises the agents' aggregate response to changes in the investment opportunity set.

Appendices

U.S. Monetary Aggregates and their components

The definition and the composition of different monetary aggregates varies across countries. Since this paper focuses on the U.S. economy, I use the definition of monetary aggregates provided by the Federal Reserve Bank. MB, M1, M2, MZM and M3 are progressively more inclusive measures of money with the narrowest component being the adjusted monetary base (MB). The monetary base is defined as those liabilities of the monetary authorities that households and firms use as media of exchange and that depository institutions use to satisfy statutory reserve requirements and to settle interbank debts. In the United States, this includes currency (including coin) held outside the Treasury and the Federal Reserve Banks (referred to as currency in circulation) plus deposits held by depository institutions at the Federal Reserve Banks. The demand of public onto these liquid assets allows the monetary authority to control the prevailing money market interest rate.[1]

M1 includes funds that are readily accessible for spending, i.e. the most liquid forms of money. It consists of (1) currency outside the U.S. Treasury, the Federal Reserve Banks, and the vaults of depository institutions, (2) travellers checks of nonbank issuers, (3) demand deposits, and (4) other checkable deposits, which consist primarily of negotiable order of withdrawal accounts at depository institutions and credit union share draft accounts.

M2 includes a broader set of financial assets held primarily by households. M2 consists of M1 plus (1) savings deposits (which include money market deposit accounts), (2) small-denomination time deposits (time deposits in amounts of less than $100,000) issued by financial institutions, and (3) balances in retail money market mutual funds (funds with initial investments under $50,000), net of retirement accounts.

M3 consists of M2 and (1) all other certificates of deposits (large time deposits, institutional money market mutual fund balances), (2) deposits of eurodollars and

[1]Details about the measurement of the Monetary Base can be found in the Appendix. The MB data is adjusted for the effects of changes in statutory reserve requirements on the quantity of base money held by depositories.

(3) repurchase agreements. Monitoring of M3 was discontinued in March 2006, because M3 "does not appear to convey any additional information about economic activity that is not already embodied in M2 and has not played a role in the monetary policy process for many years".[2], [3]

MZM stands for money zero maturity and is calculated by the Federal Reserve Bank of St. Louis. It equals M2 minus small-denomination time deposits, plus institutional money market mutual funds (that is, those included in M3 but excluded from M2). The aggregate itself was proposed by Motley [1988].

The multiplier levels and growth rates and market excess returns

Table 1: Table presents OLS estimates of the predictive regression of market premium by levels of three different money multipliers and separately by their quarterly changes. Estimates are computed for the full sample period of 1959 Q1 - 2015 Q4, as well as for two subsample periods, 1959 Q1 - 1989 Q4 and 1990 Q1 - 2015 Q4.

	Full sample: 1959 Q1 - 2015 Q4			Early sample: 1959 Q1 - 1989 Q4			Late sample. 1990 Q1 - 2015 Q4		
	b	**tStat**	$\bar{R}^2$	**b**	**tStat**	$\bar{R}^2$	**b**	**tStat**	$\bar{R}^2$
$^{M1}/_{MB}$	-0.036	*-0.53*	-0.32%	-0.040	*-0.44*	-0.66%	0.003	*0.03*	-1.00%
$^{M2}/_{MB}$	-0.052	*-0.77*	-0.18%	0.021	*0.23*	-0.78%	-0.084	*-0.84*	-0.30%
$^{MZM}/_{MB}$	-0.088	*-1.31*	0.32%	0.044	*0.49*	-0.63%	-0.154	*-1.53*	1.32%
$\Delta^{M1}/_{MB}$	0.234	*3.53*	4.86%	0.151	*1.68*	1.48%	0.341	*3.54*	10.23%
$\Delta^{M2}/_{MB}$	0.208	*3.13*	3.76%	0.094	*1.04*	0.06%	0.327	*3.39*	9.41%
$\Delta^{MZM}/_{MB}$	0.238	*3.62*	5.09%	0.188	*2.11*	2.76%	0.316	*3.27*	8.75%

Predictability over different horizons with crisis dummy

Controls and out-of-sample predictability for MZM/MB

[2]http://www.federalreserve.gov/releases/h6/discm3.htm

[3]In my analysis I use the time series provided by OECD: "Main Economic Indicators - complete database"

Figure 1: OLS estimates from a predictive regression of log U.S. stock market excess returns (CRSP value-weighted index) that includes a crisis dummy for the whole year of 2008. Quarterly data, 1959 Q1 - 2015 Q4. Standardised coefficients.

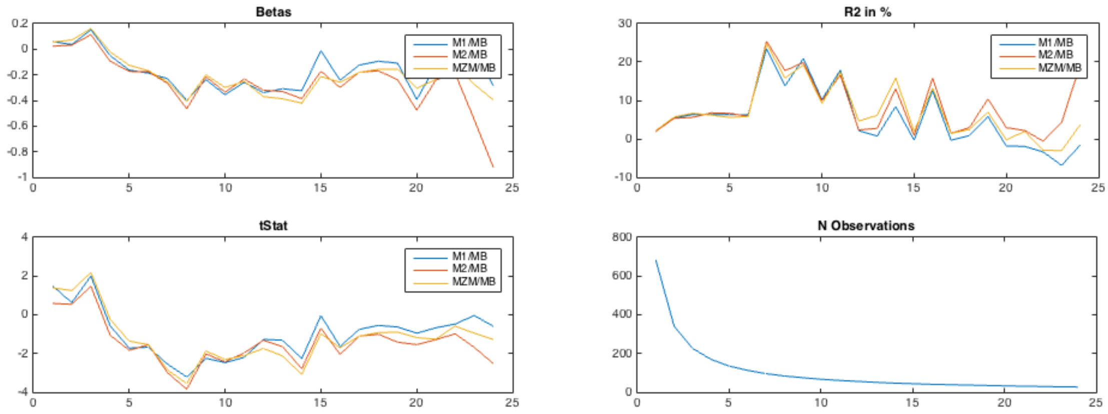


Figure 2: OLS estimates from a predictive regression of log U.S. stock market excess returns (CRSP value-weighted index) that includes a crisis dummy for the whole year of 2008 and an interaction term. Quarterly data, 1959 Q1 - 2015 Q4. Standardised coefficients.

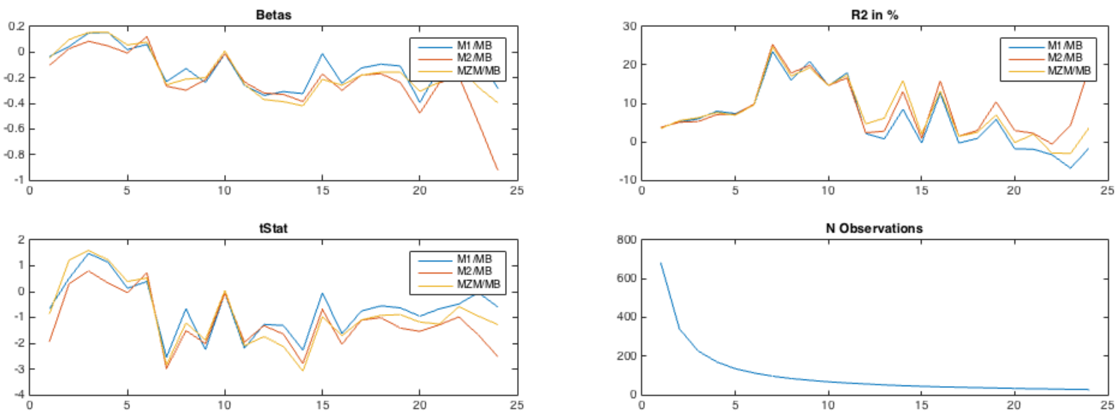


Table 2: OLS estimates from a predictive regression of market excess returns: $r^e_{m,t} = \alpha + \beta X_{t-1} + \epsilon_t$, where X_{t-1} is a vector of variables different for each model specification. Variables are presented in the first row. $\Delta^{MZM}/_{MB}$ - growth of the broad money multiplier, TY is the term yield, PE - price earnings ratio, VIX - level of the CBOE volatility index, FF - federal funds rate, ΔPP - the growth rate of purchase power of money computed as the ratio of the level of the M3 to the GDP level, and CS - the credit spread, computed as the difference between Moody's BAA corporate bond yields and the 10 years US constant maturity yield. Estimates of the regression slopes are presented in the first line, t-statistics in the second and p-values in the third. Last three columns present $\bar{R}^2$ for each model specification for the analysed period of 1990 Q1 - 2014 Q4 and characteristics of models' out-of-sample performance. $GW\Delta RMSE$ compares out-of-sample forecast errors of each model with a forecast error of the sample mean, as in Goyal and Welch [2008]. For $GW\Delta RMSE$ in-sample period is the first 76 quarters of the whole sample, for $GW\Delta RMSE*$ in-sample period is the first 76 quarters of the whole sample.

		$\Delta^{MZM}/_{MB}$	TY	PE	CPI	VIX	FF	PP	CS	ΔTL	$\bar{R}^2$	$GW\Delta RMSE$	$GW\Delta RMSE*$
	beta	0.32	0	0	0	0	0	0	0	0	9.29%	-0.0015	-0.0014
Model 1	*t-stat*	*3.35*	*0*	*0*	*0*	0	0	0	0	0	0		
	p-value	0.00	0	0	0	0	0	0	0	0	0		
	beta	0.35	0.11	0	0	0	0	0	0	0	9.52%	-0.0008	-0.0008
Model 2	*t-stat*	*3.54*	*1.12*	*0*	*0*	0	0	0	0	0	0		
	p-value	0.00	0.26	0	0	0	0	0	0	0	0		
	beta	0.39	0	-0.25	0	0	0	0	0	0	14.29%	0.0052	0.0045
Model 3	*t-stat*	*4.04*	*0*	*-2.60*	0	*0*	0	0	0	0	0		
	p-value	0.00	0	0.01	0	0	0	0	0	0	0		
	beta	0.34	0	0	0.08	0	0	0	0	0	8.96%	-0.0003	-0.0002
Model 4	*t-stat*	*3.44*	*0*	*0*	*0.80*	0	0	0	0	0	0		
	p-value	0.00	0	0	0.43	0	0	0	0	0	0		
	beta	0.33	0	0	0	0.10	0	0	0	0	9.32%	-0.0079	-0.0075
Model 7	*t-stat*	*3.47*	*0*	*0*	0	*1.02*	0	0	0	0	0		
	p-value	0.00	0	0	0	0.31	0	0	0	0	0		
	beta	0.37	0	0	0	0	-0.17	0	0	0	11.08%	0.0005	0.0004
Model 8	*t-stat*	*3.74*	*0*	*0*	0	0	*-1.73*	0	0	0	0		
	p-value	0.00	0	0	0	0	0.09	0	0	0	0		
	beta	0.28	0	0	0	0	0	-0.11	0	0	9.43%	0.0019	0.0022
Model 9	*t-stat*	*2.74*	*0*	*0*	0	0	0	*-1.08*	*0*	*0*	0		
	p-value	0.01	0	0	0	0	0	0.28	0	0	0		
	beta	0.35	0	0	0	0	0	0	0.09	0	9.10%	-0.005	-0.0044
Model 10	*t-stat*	*3.44*	*0*	*0*	0	0	0	*0*	*0.89*	*0*	0		
	p-value	0.00	0	0	0	0	0	0	0.38	0	0		
	beta	0.32	0	0	0	0	0	0	0	-0.09	9.19%	-0.0024	-0.0025
Model 9	*t-stat*	*3.38*	*0*	*0*	0	0	0	*0*	*0*	*-0.94*	0		
	p-value	0.00	0	0	0	0	0	0	0	0.35	0		
	beta	0.28	-0.674	-0.419	-0.351	0.433	-1.051	-0.187	-0.495	-0.093	22.69%	-0.0047	-0.0045
Model 10	*t-stat*	*2.70*	*-2.950*	*-3.698*	-1.473	3.107	-3.022	*-1.536*	*-2.494*	*-0.908*	0		
	p-value	0.01	0.004	0.000	0.144	0.003	0.003	0.128	0.015	0.366	0		

Cross-sectional results for M1/MB and MZM/MB

Table 3: OLS estimates from a predictive regression: $r_t^{e,p} = \alpha + \kappa^{Mx}/_{MBt-1} + \beta r_t^{e,M} + \epsilon_t$, where $r_{p,t}^e$ are returns at time t on the 25 U.S. stock portfolios formed on size and book-to-market equity, $^{Mx}/_{MBt-1}$ is the level of the M1 money multiplier at time t-1 in Part (a) and the level of the MZM money multiplier at time t-1 in Part (b) of the Table, $r_t^{e,M}$ is market return at time t. Quarterly data, 1959 Q1 - 2015 Q4, 228 observations. For each portfolio, top row presents standardised regression slope coefficients, second row presents t-statistics, last row presents adjusted R^2.

Part (a)

		Growth		BM2		BM3		BM4		Value	
		$^{M1}/_{MBt-1}$	$r_t^{e,M}$	$^{M1}/_{MBt-1}$	$r_t^{e,M}$	$^{M1}/_{MBt-1}$	$r_t^{e,M}$	$^{M1}/_{MBt-1}$	$r_t^{e,M}$	$^{M1}/_{MBt-1}$	$r_t^{e,M}$
Small	slope	-0.031	0.796	-0.051	0.822	-0.040	0.831	-0.023	0.817	-0.013	0.807
	t-stat	*-0.8*	*19.6*	*-1.3*	*21.6*	*-1.1*	*22.3*	*-0.6*	*21.1*	*-0.3*	*20.4*
	$\bar{R}^2$	63%		67%		69%		66%		65%	
ME2	slope	-0.077	0.859	-0.064	0.877	-0.048	0.887	-0.009	0.875	0.018	0.839
	t-stat	*-2.2*	*25.2*	*-2.0*	*27.4*	*-1.5*	*28.6*	*-0.3*	*27.0*	*0.5*	*23.0*
	$\bar{R}^2$	74%		77%		78%		76%		70%	
ME3	slope	-0.075	0.879	-0.064	0.914	-0.061	0.904	-0.032	0.895	-0.036	0.833
	t-stat	*-2.3*	*27.6*	*-2.3*	*33.8*	*-2.1*	*31.6*	*-1.1*	*30.1*	*-1.0*	*22.5*
	$\bar{R}^2$	77%		84%		82%		80%		69%	
ME4	slope	-0.092	0.901	-0.091	0.935	-0.052	0.931	-0.032	0.907	-0.019	0.871
	t-stat	*-3.2*	*31.3*	*-3.8*	*39.9*	*-2.1*	*38.3*	*-1.1*	*32.1*	*-0.6*	*26.5*
	$\bar{R}^2$	81%		88%		87%		82%		76%	
Big	slope	-0.091	0.923	-0.090	0.951	-0.058	0.911	-0.029	0.910	-0.016	0.846
	t-stat	*-3.6*	*36.5*	*-4.4*	*46.8*	*-2.1*	*33.1*	*-1.0*	*32.7*	*-0.4*	*23.8*
	$\bar{R}^2$	86%		91%		83%		83%		72%	

Part (b)

		Growth		BM2		BM3		BM4		Value	
		$^{MZM}/_{MBt-1}$	$r_t^{e,M}$	$^{MZM}/_{MBt-1}$	$r_t^{e,M}$	$^{MZM}/_{MBt-1}$	$r_t^{e,M}$	$^{MZM}/_{MBt-1}$	$r_t^{e,M}$	$^{MZM}/_{MBt-1}$	$r_t^{e,M}$
Small	slope	-0.009	0.795	-0.013	0.820	0.009	0.831	0.017	0.817	0.030	0.808
	t-stat	*-0.2*	*19.6*	*-0.3*	*21.4*	*0.2*	*22.2*	*0.4*	*21.1*	*0.8*	*20.4*
	$\bar{R}^2$	63%		67%		69%		66%		65%	
ME2	slope	-0.046	0.856	-0.022	0.875	0.011	0.886	0.021	0.876	0.051	0.841
	t-stat	*-1.3*	*24.9*	*-0.7*	*27.1*	*0.4*	*28.4*	*0.6*	*27.0*	*1.4*	*23.1*
	$\bar{R}^2$	74%		77%		78%		76%		70%	
ME3	slope	-0.048	0.875	-0.028	0.912	0.006	0.903	0.009	0.895	0.034	0.833
	t-stat	*-1.5*	*27.3*	*-1.0*	*33.3*	*0.2*	*31.2*	*0.3*	*30.0*	*0.9*	*22.5*
	$\bar{R}^2$	77%		83%		81%		80%		69%	
ME4	slope	-0.051	0.897	-0.040	0.931	-0.048	0.928	0.006	0.906	0.000	0.871
	t-stat	*-1.7*	*30.7*	*-1.6*	*38.7*	*-1.9*	*38.1*	*0.2*	*32.0*	*0.0*	*26.4*
	$\bar{R}^2$	81%		87%		87%		82%		76%	
Big	slope	-0.081	0.917	-0.061	0.946	-0.065	0.907	-0.038	0.908	-0.012	0.845
	t-stat	*-3.1*	*36.1*	*-2.9*	*45.4*	*-2.3*	*33.0*	*-1.3*	*32.6*	*-0.3*	*23.8*
	$\bar{R}^2$	85%		90%		83%		83%		72%	

Table 4: Estimates of the predictive regression: $r^e_{p,t} = \alpha + \beta\Delta^{M1}/_{MBt-1} + \epsilon_t$ for 25 U.S. stock portfolios formed on size and book-to-market equity. Part (a) presents estimates for the M2 multiplier growth and Part (b) for MZM multiplier growth. Quarterly data aggregated from monthly data obtained from Kenneth French website. 1959 Q1 - 2015 Q4, 228 observations. For each portfolio, top row presents standardised regression slope coefficients, the second row presents t-statistics, the last row presents adjusted R^2.

Part (a).

		Low	**BM2**	**BM3**	**BM4**	**High**
Small	β	0.157	0.170	0.207	0.255	0.284
	t-stat	*2.3*	*2.5*	*3.1*	*3.9*	*4.4*
	$\bar{R}^2$	1.94%	2.37%	3.72%	5.88%	7.39%
ME2	β	0.145	0.186	0.218	0.284	0.327
	t-stat	*2.2*	*2.8*	*3.3*	*4.3*	*5.1*
	$\bar{R}^2$	1.60%	2.92%	4.15%	7.38%	9.94%
ME3	β	0.150	0.206	0.211	0.253	0.239
	t-stat	*2.2*	*3.1*	*3.2*	*3.8*	*3.6*
	$\bar{R}^2$	1.74%	3.68%	3.86%	5.76%	5.09%
ME4	β	0.133	0.190	0.252	0.275	0.292
	t-stat	*2.0*	*2.8*	*3.8*	*4.2*	*4.5*
	$\bar{R}^2$	1.26%	3.05%	5.74%	6.89%	7.83%
Big	β	0.110	0.189	0.227	0.306	0.270
	t-stat	*1.6*	*2.8*	*3.4*	*4.7*	*4.1*
	$\bar{R}^2$	0.72%	3.02%	4.53%	8.66%	6.68%

Part (b).

		Low	**BM2**	**BM3**	**BM4**	**BM High**
Small	β	0.152	0.162	0.203	0.241	0.248
	t-stat	*2.3*	*2.4*	*3.1*	*3.7*	*3.8*
	$\bar{R}^2$	1.82%	2.14%	3.59%	5.24%	5.58%
ME2	β	0.146	0.178	0.208	0.269	0.285
	t-stat	*2.2*	*2.7*	*3.2*	*4.1*	*4.4*
	$\bar{R}^2$	1.63%	2.66%	3.81%	6.63%	7.55%
ME3	β	0.149	0.199	0.210	0.224	0.204
	t-stat	*2.2*	*3.0*	*3.2*	*3.4*	*3.1*
	$\bar{R}^2$	1.74%	3.46%	3.87%	4.50%	3.65%
ME4	β	0.139	0.198	0.236	0.253	0.251
	t-stat	*2.1*	*3.0*	*3.6*	*3.9*	*3.8*
	$\bar{R}^2$	1.44%	3.42%	5.01%	5.82%	5.74%
Big	β	0.140	0.203	0.224	0.294	0.237
	t-stat	*2.1*	*3.1*	*3.4*	*4.5*	*3.6*
	$\bar{R}^2$	1.48%	3.61%	4.47%	8.00%	5.11%

Bibliography

Tobias Adrian and Hyun Song Shin. Liquidity and leverage. *Journal of Financial Intermediation*, 19(3):418 – 437, 2010.

Tobias Adrian and Hyun Song Shin. Procyclical Leverage and Value-at-Risk. *Review of Financial Studies*, 27(2):373–403, 2014.

Tobias Adrian, Emanuel Moench, and Hyun Song Shin. Leverage asset pricing. Technical report, 2013.

Tobias Adrian, Erkko Etula, and Tyler Muir. Financial intermediaries and the cross-section of asset returns. *The Journal of Finance*, 69(6):2557–2596, 2014.

Ron Alquist and Menzie D. Chinn. Conventional and unconventional approaches to exchange rate modelling and assessment. *International Journal of Finance & Economics*, 13(1):2–13.

Adam Ashcraft, Nicolae Garleanu, and Lasse Heje Pedersen. Two monetary tools: Interest rates and haircuts. *NBER Macroeconomics Annual*, 25(1):143–180, 2011.

Ben S. Bernanke. Non monetary effects of the financial crisis in the propagation of the great depression. *The American Economic Review*, 73(3):257–276, 1983.

Ben S. Bernanke and Mark Gertler. Inside the Black Box: The Credit Channel of Monetary Policy Transmission. *Journal of Economic Perspectives*, 9(4):27–48, 1995.

Markus K. Brunnermeier and Lasse Heje Pedersen. Market liquidity and funding liquidity. *Review of Financial Studies*, 22(6):2201–2238, 2009.

Yin-Wong Cheung, Menzie D. Chinn, and Antonio Garcia Pascual. Empirical exchange rate models of the nineties: Are any fit to survive? *Journal of International Money and Finance*, 24(7):1150 – 1175, 2005.

Menzie d. Chinn and Michael J. Moore. Order flow and the monetary model of exchange rates: Evidence from a novel data set. *Journal of Money, Credit and Banking*, 43(8):1599–1624, 2011.

Tim Congdon. Money and Asset Prices in Boom and Bust. pages 1–142, 2005.

Rudiger Dornbusch. Expectations and Exchange Rate Dynamics. *Journal of Political Economy*, 84(6):1161–1176, December 1976.

Wenxin Du, Alexander Tepper, and Adrien Verdelhan. Deviations from covered interest rate parity. *The Journal of Finance*, 73(3):915–957, 2018.

Andrew J Fieldhouse, Karel Mertens, and Morten O Ravn. The Macroeconomic Effects of Government Asset Purchases: Evidence from Postwar U.S. Housing Credit Policy. *The Quarterly Journal of Economics*, 133(3):1503–1560, 01 2018.

Andrea Frazzini and Lasse Heje Pedersen. Betting against beta. *Journal of Financial Economics*, 111(1):1 – 25, 2014.

Jacob A. Frenkel. A monetary approach to the exchange rate: Doctrinal aspects and empirical evidence. *The Scandinavian Journal of Economics*, 78(2):200–224, 1976.

John Geanakoplos. *The Leverage Cycle*, pages 1–65. University of Chicago Press, April 2010.

Mark Gertler. Financial structure and aggregate economic activity: An overview. *Journal of Money, Credit and Banking*, 20(3):559–588, 1988.

Amit Goyal and Ivo Welch. A comprehensive look at the empirical performance of equity premium prediction. *Review of Financial Studies*, 21(4):1455–1508, 2008.

Peter R. Hartley and Carl E. Walsh. Inside money and monetary neutrality. Working Paper 1890, National Bureau of Economic Research, April 1986.

Oscar Jorda, Moritz Schularick, and Alan M. Taylor. Leveraged bubbles. *Journal of Monetary Economics*, 76(S):S1–S20, 2015.

Robert G. King and Charles I. Plosser. Money, credit, and prices in a real business cycle. *The American Economic Review*, 74(3):363–380, 1984.

Nobuhiro Kiyotaki and John Moore. Credit Cycles Nobuhiro Kiyotaki. *The Journal of Political Economy*, 105(2):211–248, 1997.

Lukas Kremens and Ian Martin. The quanto theory of exchange rates. *American Economic Review*, 109(3):810–43, March 2019.

Ricardo Lagos. *Inside and Outside Money*, pages 132–136. Palgrave Macmillan UK, London, 2010. ISBN 978-0-230-28085-4.

Hanno Lustig, Nikolai Roussanov, and Adrien Verdelhan. Common Risk Factors in Currency Markets. *The Review of Financial Studies*, 24(11):3731–3777, 08 2011.

Ronald MacDonald and Mark P. Taylor. The monetary approach to the exchange rate: Long-run relationships and coefficient restrictions. *Economics Letters*, 37 (2):179 – 185, 1991. ISSN 0165-1765.

Richard Meese and Kenneth Rogoff. Empirical exchange rate models of the seventies: Do they fit out of sample? *Journal of International Economics*, 14:3–24, 1983. See also "The Failure of Empirical Exchange Rate Models: No Longer New, But Still True," Economic Policy Web Essay, September 2001.

Richard Meese and Kenneth Rogoff. Was it real? the exchange rate-interest differential relation over the modern floating-rate period. *The Journal of Finance*, 43(4):933–948, 1988.

Frederic S. Mishkin. The household balance sheet and the great depression. *The Journal of Economic History*, 38:918–937, 12 1978.

Frederic S Mishkin. *The economics of money, banking, and financial markets.* Pearson education, 2007.

Brian Motley. Should M2 be Redefined? *Review, Federal Reserve Bank of San Francisco*, (Winter):33–51, 1988.

Christopher J. Neely and Lucio Sarno. How well do monetary fundamentals forecast exchange rates? *The Federal Reserve Bank of St. Luis Review*, pages 51–74, Sep 2002.

Maurice Obstfeld and Kenneth Rogoff. *The Six Major Puzzles in International Macroeconomics: Is there a Common Cause?*, pages 339–390. MIT Press, Cambridge, MA, 2001.

Valerie A. Ramey and Sarah Zubairy. Government spending multipliers in good times and in bad: Evidence from us historical data. *Journal of Political Economy*, 126(2):850–901, 2018.

Kenneth Rogoff. The purchasing power parity puzzle. *Journal of Economic Literature*, 34:647–68, 1996.

Kenneth Rogoff and Vania Stavrakeva. The continuing puzzle of short-horizon exchange rate forecasting. 2008. NBER Working Paper No. 14071, June 2008.

Barbara Rossi. Exchange rate predictability. *Journal of Economic Literature*, 51 (4):1063–1119, 2013.

Moritz Schularick and Alan M. Taylor. Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008. *American Economic Review*, 102(2):1029–61, April 2012.

Yuhang Xing. Interpreting the value effect through the q-theory: An empirical investigation. *Review of Financial Studies*, 21(4):1767–1795, 2008.