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On the Performance Drivers of U.S. Treasury Inflation-Protected Securities

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Abstract: With the alarming federal deficit and persistent execution of expansionary monetary policy, inflation risk has become a serious concern for U.S. financial market participants. Many investors are confronted with a choice between Nominal Treasuries and Treasury Inflation-Protected Securities (TIPs) in making asset allocation decisions. Using monthly data on the Barclays Capital U.S. TIPs Index and Nominal Treasury Index from March 1997 to November 2008, this paper examines the comparative performances of TIPs and Nominal Treasuries as two asset classes, and uses a structural vector autoregressive (VAR) model to examine the key drivers underlying the return performance on each asset class. Empirical results show that the returns on TIPs and Treasuries are both negatively driven by the changes in the level and term spread of interest rates, but their responses to the change in the quality spread (as measured by the BAA and AAA corporate bond yield spread) and the inflation rate are completely different. A higher quality spread tends to drive up the Treasury return but drive down the TIPs return. A higher inflation rate tends to drive down the return on Nominal Treasuries but has little impact on the TIPs return. Treasuries tend to outperform TIPs during periods dominated by increasing concern for credit and liquidity risks, but TIPs tend to outperform Treasuries during highly inflationary environments.

JEL Classification: D53, E31, G19
Keywords: Inflation Risk, Treasury Inflation-Protected Securities (TIPS).

1. Introduction

With the alarming federal deficit and persistent execution of expansionary monetary policy since the outbreak of the global financial crisis, intermediate-term

and long-term inflation has become a serious concern for U.S. financial market participants. Many investors are confronted with a choice between Nominal Treasuries and Treasury Inflation-Protected Securities (TIPs) in making asset allocation decisions. Using monthly data on the Barclays Capital U.S. TIPs Index and Nominal Treasury Index from March 1997 to November 2008, this paper examines the characteristics and drivers of the return performance on each of these two asset classes and the return spread between the two.

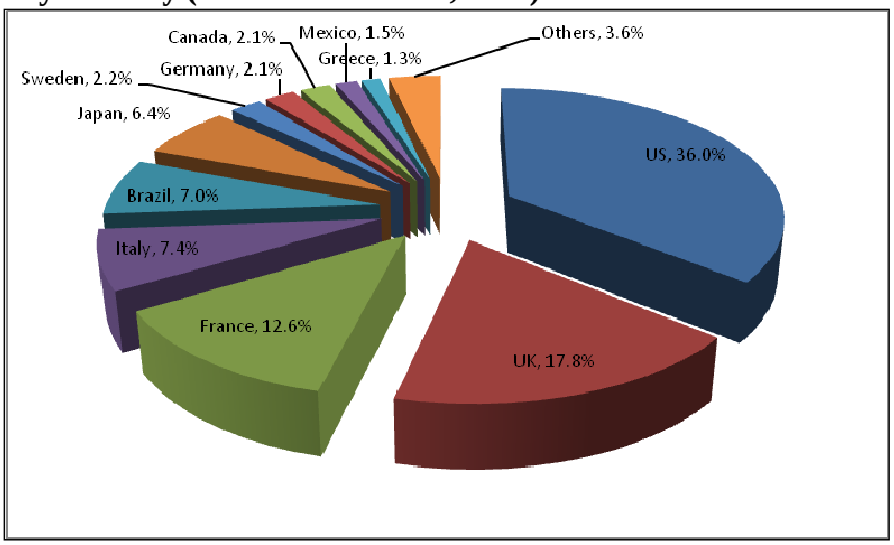
The face value and coupon payment of an inflation-linked bond (ILB) are typically adjusted periodically to compensate investors for inflation risk. The world's first government ILB was issued by the U.K. back in 1981, known as the inflation-linked Gilts. In 1997, the U.S. government issued its first ILBs named Treasury Inflation-Protected Securities (TIPs). Other prominent ILB issuers include Australia (1985), Canada (1991), Sweden (1994), New Zealand (1995), France (1998), Greece (2003), Italy (2003), Japan (2004), and Germany (2006). The world government ILB market has grown dramatically from $145 billions in Dec. 1997 to $1.34 trillion in November 2008. Although the U.S. TIPs market is newer relative to those of U.K., Canada, Sweden, and New Zealand, it currently has the largest market value in the world government ILB market. Chart 1 shows that, as of November 2008, the U.S. TIPs market represents the largest share (36.0%) of the world ILB market, followed by U.K. (17.8%), France (12.6%), Italy (7.4%) and Japan (7.0%). Chart 2 illustrates the dramatic growth of the U.S. TIPs market from March 1997 to November 2008, in terms of absolute market value and relative size to the Nominal Treasuries. As of November 2008, there are 26 issues of TIPs outstanding with a market value of $483 billions, equivalent to 17.4% of the $2.703 trillions outstanding nominal Treasury notes and bonds.

TIPs were designed to provide protection against inflation by paying a fixed coupon rate over an inflation-adjusted principal. The coupon payment and underlying principal of TIPs are automatically adjusted with inflation. The inflation accrual to the principal is linked to the Consumer Price Index lagged by a quarter. At maturity, investors are paid the inflation-adjusted principal or the original principal, whichever is greater. From an investor's perspective, TIPs provide two major benefits. They serve as an explicit hedge against the erosion of purchasing power from inflation; they offer portfolio diversification benefits due to their low correlation with other asset classes. From the issuer's perspective, they allow for better matching of interest payments with the inflation-linked revenues that the

issuer generates.

Chart 1

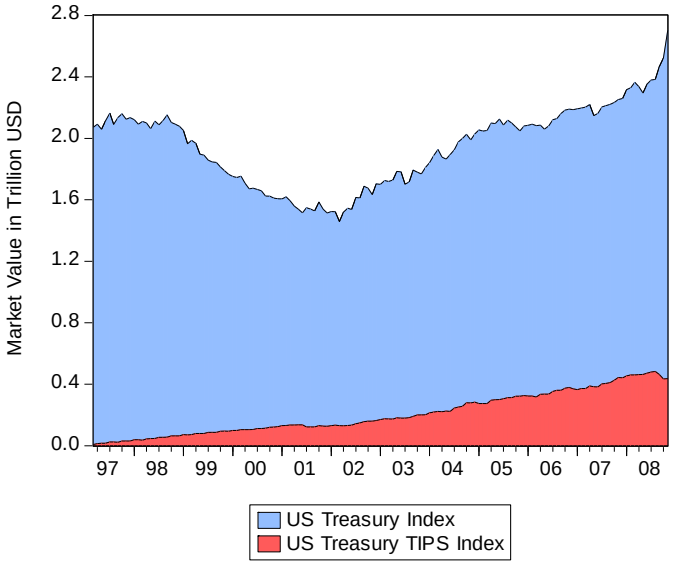
Market Value Weights in the Global Government Inflation-Linked Bonds Market by Country (as of November 30, 2008)



Source: Barclays Capital Global Government Inflation-Linked Bond Index

Chart 2

Market Value of U.S. Nominal Treasuries versus TIPs (Mar. 1997 to Nov. 2008)



Source: Barclays Capital U.S. Treasury Index and TIPs Index.

Since their inception in 1997, TIPs have attracted considerable interest from investors, policy makers and researchers. Previous research on TIPs has focused on three major areas. One has been on the information content, information risk premium, and inflation forecasting based on TIPs market trading (see Brian [2000], Shen and Corning [2001], Chu, Pittman and Yu [2005], Grishchenko and Huang [2008], and D'Amico, Kim and Wei [2008]). The second has focused on the determination of price, yield and duration of TIPs as a unique group of Treasury securities with explicit inflation protection (see Rudolph-Shabinsky and Trainer [1999], Jarrow and Yildirim [2003], and Jacoby [2007, 2008]). The third has dealt with the performance of TIPs as an asset class and its role in a nominal portfolio (Lucas and Quek [1998], Kothari and Shanken [2004], Roll [2004], Hunter and Simon [2005], and Arak and Rosenstein [2006]). This paper extends this third line of research. It uses the entire history of TIPs index data to examine the performance of TIPS as an investment asset class and, more importantly, to reveal the drivers underlying the performance of TIPS, the first study to do so.

Earlier studies on TIPS have been confronted with two issues. First, there are data limitations. For example, the study by Lucas and Quek [1998] on TIPs performance is limited to the first two years of data, from 1997 to 1998. Kothari and Shanken [2004] and Roll [2004] examine the performance of TIPs in a portfolio setting using data from 1997 to 2003. Hunter and Simon [2005] perform a conditional assessment of the risk and return on TIPs and conventional Treasuries using data from 1997 to 2001. Not only do these studies rely on a short time series, but they also use individual TIPs issues rather than the more comprehensive TIPs index**.**

In this study, I utilize monthly data on the well-respected Barclays Capital U.S. TIPs index and other Barclays Capital fixed income indices from March 1997 to November 2008 to examine the performance of TIPs relative to Nominal Treasuries and other asset classes. In doing so, I uncover the financial and economic drivers of the return performance on TIPs. Although previous studies have examined the TIPs return and yield performance, none has studied the drivers of TIPs performance as an asset class.

Since TIPs is a fixed income asset class, interest rates should certainly play an important role in shaping their return dynamics. The changes in the level and term structure of interest rates should negatively affect both TIPS and Nominal Treasury returns due to the discount rate effect. I use the yield change in three-month Constant

Maturity Treasury (CMT) to capture movements in the short-term risk-free rate (RFSD), and the change in yield spread between the ten-year and three-month CMTs to capture movements in the interest rate term structure (TSD).

During credit crunch periods, investors tend to flee to quality and liquidity, and as a result, Treasury prices soar. The bond quality spread, as measured by the difference between Moody's BAA and AAA corporate bond yields, contains a credit risk premium and also a liquidity premium. The change in quality spread (QSD) should be positively related to the Nominal Treasury return. As for the return on TIPs, I expect three possible driving forces to coexist. First, the flight to quality may positively affect the return on TIPs since they are also credit-risk free securities issued by the U.S. government. Second, since TIPs are associated with much lower liquidity relative to Nominal Treasuries,[1] a higher liquidity premium could lead to a negative relationship between QSD and TIPs return. Third, the widening of the quality spread is often associated with weaker economic conditions and lower inflation expectations, which could also lead to a negative relationship between the QSD and the return on TIPs. As a result, the characterization of the dynamic effect of QSD on TIPs return should be of great interest to investors.

Since the coupon payments and principal on TIPs are both indexed to inflation, I expect the TIPs return to be unaffected by the inflation rate. In contrast, higher inflation should lead to a lower real yield and imply a lower return on Nominal Treasuries. I use the twelve-month percentage change on the U.S. CPI-U (INF) to measure the inflation rate.

Ang and Piazzesi (2003) find that real activity variables such as growth in industrial production and change in unemployment rate can serve as important explanatory variables for the dynamics of the yield curve. I include the growth in industrial production (IPG) and change in unemployment rate (UERD) in the endogenous variable list to see if these two real activity variables have any impact beyond those already contained in the financial variables such as inflation rate and changes in short-rate, term structure spread, and quality spread.

A structural vector autoregressive (VAR) model is used to examine important drivers for the return performance on TIPs. Although the VAR model has been used

[1] According to the Federal Reserve Bank of New York and the U.S. Treasury Department, the average daily trading volumes of TIPs and Nominal Treasuries from 1998 to 2008 were $4.6 billion and $249.0 billion, respectively. During this ten-year period, the average daily turnover ratio of TIPs is 1.7%, much lower than the 11.0% average daily turnover ratio for Nominal Treasuries.

extensively in the finance literature (see, e.g., Lee [1992], Campbell and Ammer [1993], Ang and Piazzesi [2003], Xu and Fung [2005], and Xu [2007]), this approach has not been used for TIPs research. In a reduced form of VAR, each endogenous variable in the system is modeled as a function of the *lagged* values of all the endogenous variables in the system, and the error terms may be correlated with one another. In a *structural* form of VAR, restrictions are placed on the *contemporaneous* relations between the endogenous variables to allow for the identification of uncorrelated/independent structural shocks. One general approach to structural VAR identification is the *Cholesky* decomposition proposed by Sims [1980], which restricts the variable higher in the ordering to have no contemporaneous effect on the variables lower in the ordering. From the structural VAR model, I am able to decompose the forecast variance of TIPs return into components that can be explained by each of these variables. The structural VAR also permits an investigation into the extent to which a variable drives the TIPs return and promotes an understanding as to how the TIPs return responds to shocks in various factors over time. The empirical results help illuminate the dynamic relationships between the TIPs return and these driving forces.

In what follows, section II discusses the data. Section III examines the return, risk, and correlation of TIPS as an asset class, in comparison with Nominal Treasuries and other major asset classes. Section IV analyzes the performance drivers of TIPs and Nominal Treasuries using a structural vector autoregressive (VAR) model. Section V summarizes the empirical findings and discusses their implications.

2. Data

Barclays inflation-linked bond indices provide investors with accurate benchmarks for performance measurement of ILBs (see Barclays Capital [2004]). The indices cover the world's major government inflation-linked bond markets, including U.S., U.K., France, Italy, Brazil, Japan, Sweden, etc. I use the Barclays U.S. Government inflation-linked bond index to measure the performance on U.S. TIPs. Total returns, real yields and average durations on the Barclays TIPs index were obtained from the Barclays Capital. The data cover 141 months, from the inception month of the TIPs index (March 1997) to the latest available month (November 2008) at the time of this study. This represents the most complete data time series available on TIPs research. It is also the first empirical study to use

comprehensive TIPs index data (instead of individual TIPs issues) to allow for a better characterization of TIPs as an asset class.

Another major source of data is from the Barclays fixed income indices (rebranded from the Lehman Brothers Family of Fixed Income Indices since Barclays Capital's acquisition of Lehman Brothers in September 2008, see Lehman Brothers [2008] and Barclays Capital [2008]). I use monthly data on the price return, coupon return, nominal yield, average maturity, and average coupon rate from the rebranded Lehman TIPs index to supplement the data from the Barclays original TIPs index. Total return data, provided by both the Barclays original TIPs index and the Barclays rebranded Lehman TIPs index are largely consistent. Since both TIPs indices are now under the Barclays family of indices, I will refer the merged TIPs index data as one single source for all future discussions.

To compare the performance of TIPs with Nominal Treasuries and other major fixed income asset classes, I use the Barclays rebranded Lehman Family of Fixed Income Indices, including the Treasury index (T), investment-grade corporate bond (CI) index, high-yield corporate bond (CH) index, agency mortgage-backed securities (MBS) index, Home-Equity Asset-backed Securities (AHE) index, Credit-Card Asset-backed Securities (ACR) index, Aaa rated Commercial Mortgage-backed Securities (CMA) index, and Baa rated Commercial Mortgage-backed Securities (CMB) index. Monthly data during the same period (March 1997 to November 2008) on these indices were also obtained from Barclays Capital. In addition, monthly data on the total return of S&P 500 and Russell 3000 stock indices were obtained from Bloomberg.

Finally, data on the three-month and ten-year constant maturity treasury (CMT) yields, Aaa and Baa corporate bond yields, consumer price index, industrial production, and unemployment rate were all obtained from the Federal Reserve Economic Database. These data were used to compute financial and real economy variables that serve as potential drivers of TIPs return performance.

3. Performance of TIPs as an Asset Class

Table 1 provides the comparative summary statistics for the constituents of the Barclays Treasury index and TIPs index. The average maturity is 11.3 years for the TIPs index and 8.3 years for the Treasury index. The average duration on the TIPs index (8.7 years) is also higher than that of the Treasury index (5.4 years). With the

inflation-indexed feature, TIPs have an average coupon rate that is 2.6% lower than that of the Nominal Treasuries. The market value, outstanding amount, and number of issues represented by the TIPs index are considerably smaller relative to the Nominal Treasury index. However, as discussed in the first session, the relative market value size of TIPs to Treasuries has grown from zero in January 1997 to 17.4% in November 2008, demonstrating the growing importance of TIPs.

Table 2 provides comparative summary statistics on the yields and returns on the Barclays Treasury index and TIPs index. During the sample period, the TIPs nominal yield (with a mean of 5.4%) is statistically higher than the Treasury nominal yield (with a mean of 4.6%). The relative higher nominal yield of TIPs is persistent across the first half and second half of the sample period. Unlike the Treasury's original intention to lower borrowing costs through the issuance of TIPs, these results seem to indicate that the TIPs are indeed associated with higher borrowing costs. The real yield on TIPs (i.e., nominal yield adjusted for inflation) is averaged at 2.8% with a low standard deviation of 0.88%, consistent with the inflation-protected nature of TIPs.

From an asset class perspective, total return is the most important performance measurement. Investors often find yield to maturity to be an unsatisfactory indicator of total return because it assumes that the security is held until maturity and that all cash flows received prior to maturity are reinvested at the yield. Total return, which is also called the holding period return, measures what investors can earn from a security over a specified holding period, and it is the most commonly used measure of return for all securities (stocks, bonds, etc). Total return on TIPs is computed as the sum of the price return and coupon return for each monthly period. Table 2 shows that the average monthly price return, coupon return and total return on TIPs are 0.23%, 0.26%, and 0.49%, respectively. The coupon return and total return on TIPs are 0.19% and 0.06% lower than those on the Nominal Treasuries, while the price return on the TIPs is about 0.13% higher than that on the Nominal Treasuries. The difference in the coupon return on TIPs and the Nominal Treasuries is statistically significant, but insignificant for the differences in the price return or total return between the two groups.

Table 1

Summary Statistics on the Constituents of Barclays Capital U.S. Nominal Index and U.S. TIPs Index

Period	Stat	MAT_T	MAT_I	DUR_T	DUR_I	COU_T	COU_I	MV_T	MV_I	OUT_T	OUT_I	NOI_T	NOI_I
Whole Period (Mar. 1997 -Nov. 2008)	Mean	8.301	11.308	5.417	8.666	5.810	3.210	1.947	0.207	1.787	0.195	133.738	11.908
	Median	8.414	11.345	5.367	8.788	5.656	3.472	2.028	0.170	1.840	0.150	131.000	10.000
	Max	9.900	14.571	6.222	10.370	7.084	3.727	2.703	0.483	2.374	0.470	173.000	26.000
	Min	6.733	6.667	4.724	5.761	4.424	2.271	1.460	0.007	1.331	0.007	107.000	1.000
	Stdev	1.018	1.854	0.353	0.878	0.956	0.513	0.261	0.137	0.262	0.129	19.714	7.127
First Half (Mar. 1997 -Dec. 2002)	Mean	9.176	12.117	5.555	8.769	6.720	3.622	1.813	0.092	1.656	0.089	141.986	6.014
	Median	9.169	12.914	5.554	9.014	6.851	3.643	1.753	0.099	1.683	0.104	143.000	7.000
	Max	9.900	14.571	6.222	10.370	7.084	3.727	2.164	0.164	2.009	0.144	173.000	10.000
	Min	8.157	6.667	4.724	5.761	5.686	3.375	1.460	0.007	1.331	0.007	107.000	1.000
	Stdev	0.448	2.148	0.359	1.128	0.357	0.098	0.236	0.043	0.235	0.040	22.361	2.590
Second Half (Jan. 2003 -Nov. 2008)	Mean	7.439	10.511	5.281	8.564	4.913	2.804	2.080	0.321	1.916	0.300	125.606	17.718
	Median	7.248	10.406	5.223	8.563	4.877	2.660	2.087	0.323	1.958	0.304	125.000	17.000
	Max	8.828	12.695	6.049	9.659	5.656	3.587	2.703	0.483	2.374	0.470	142.000	26.000
	Min	6.733	8.717	4.850	7.323	4.424	2.271	1.700	0.170	1.469	0.150	107.000	10.000
	Stdev	0.596	1.015	0.291	0.517	0.237	0.424	0.213	0.095	0.221	0.098	12.220	5.100

Notes: MAT: Average Maturity; DUR: Average Duration; COU: Average Coupon Rate; MV: Market Value in Trillion USD; OUT: Outstanding Face Value in Trillion USD; NOI: Number of Issues included in the Index. _T refers to the U.S. Treasury Index, while _I refers to the U.S. Treasury TIPs Index. The summary statistics are based on monthly data on the Barclays Capital U.S. Treasury Index (_T) and U.S. Treasury TIPs Index (_I) from March 1997 to November 2008.

Table 2

Summary Statistics on the Yields and Returns on Barclays Capital U.S. Treasury Index and U.S. TIPs Index

Period	Stat	Y_T	Y_I	RY_I	Y_T-RY_I	R_T	R_I	R_T-R_I	PRR_T	PRR_I	CUR_T	CUR_I
Whole Period (Mar. 1997 -Nov. 2008)	Mean	4.555	5.400	2.807	1.748	0.549	0.489	0.060	0.105	0.230	0.444	0.259
	Median	4.625	5.314	2.549	1.859	0.560	0.542	-0.033	0.121	0.248	0.413	0.269
	Max	6.730	9.159	4.287	3.144	5.307	4.744	-2.145	4.968	4.469	0.567	0.329
	Min	2.026	2.838	1.220	-1.351	-4.393	-8.691	8.581	-4.777	-8.881	0.329	0.171
	Stdev	1.149	1.182	0.882	0.716	1.343	1.667	1.250	1.338	1.661	0.073	0.046
First Half (Mar. 1997 -Dec. 2002)	Mean	5.299	5.872	3.589	1.710	0.671	0.631	0.040	0.160	0.331	0.511	0.300
	Median	5.555	5.875	3.669	1.829	0.626	0.564	0.081	0.137	0.271	0.519	0.302
	Max	6.730	7.747	4.287	3.144	2.868	3.581	-1.853	2.307	3.296	0.567	0.329
	Min	2.982	3.765	2.337	0.451	-2.552	-2.669	2.489	-3.013	-2.940	0.410	0.267
	Stdev	0.972	1.003	0.423	0.641	1.273	1.121	0.914	1.271	1.120	0.038	0.014
Second Half (Jan. 2003 -Nov. 2008)	Mean	3.822	4.936	2.036	1.787	0.428	0.348	0.080	0.051	0.131	0.378	0.218
	Median	3.759	4.725	2.019	2.008	0.515	0.327	-0.192	0.121	0.137	0.376	0.212
	Max	5.178	9.159	3.535	2.727	5.307	4.744	-2.145	4.968	4.469	0.416	0.275
	Min	2.026	2.838	1.220	-1.351	-4.393	-8.691	8.581	-4.777	-8.881	0.329	0.171
	Stdev	0.783	1.167	0.405	0.786	1.408	2.069	1.516	1.407	2.065	0.020	0.025

Notes: Y_T: Nominal Yield on the U.S. Treasury Index; Y_I: Nominal Yield on the U.S. TIPs Index; RY_I: Real Yield on the U.S. Treasury TIPs Index; R_T: Total Return on the U.S. Treasury Index; R_I: Total Return on the U.S. Treasury TIPs Index; PRR_T: Price Return on the U.S. Treasury Index; PRR_I: Price Return on the U.S. Treasury TIPs Index; CUR_T: Coupon Return on the U.S. Treasury Index; CUR_I: Coupon Return on the U.S. Treasury TIPs Index. The summary statistics are based on monthly data on the Barclays Capital U.S. Treasury Index (_T) and U.S. Treasury TIPs Index (_I) from March 1997 to November 2008.

Table 3 presents the return, risk and correlation of TIPs with other major bond and stock asset classes. In addition to the returns on TIPs index (R_I) and Nominal Treasury index (R_T), I also include the returns on investment-grade corporate bond index (R_CI), high-yield corporate bond index (R_CH), agency mortgage-backed securities index (R_MBS), Home-Equity Asset-backed Securities index (R_AHE), Credit-Card Asset-backed Securities index (R_ACR), AAA rated Commercial Mortgage-backed Securities index (R_CMA), Baa rated Commercial Mortgage-backed Securities index (R_CMB), S&P 500 stock index (R_SP), and Russell 3000 stock index (R_RU). During the period from March 1997 to November 2008, the Nominal Treasury and TIPs (R_T and R_I) have the first and second highest mean returns and Sharpe ratios among all the fixed income and stock asset classes. These results, however, should be interpreted with caution given the short history of TIPs (less than 12 years) and the occurrence of two major severe equity market corrections (one in 2000-2003 and another in 2007-2008) during the period. The standard deviation of R_I was lower than those of the R_T and R_CI during the first half, but higher during the second half. The higher risk of the TIPs market during the second half is mainly affected by the global financial crisis and the resulted liquidity crunch and inflation/deflation uncertainty.

As expected, the correlation between TIPs and stocks is very low, ranging from -0.29 in the first half and 0.22 in the second half. The correlation between Nominal Treasuries and stocks is -0.28 and -0.26 in the first half and second half, showing a more stable correlation pattern. During the first half, the R_I's correlations with R_CI, R_AHE, R_ACR, R_SP and R_RU are all lower than the R_T's correlations with these asset classes, but the pattern is completely reversed during the second half. Since R_CMA and R_CMB data are not available for the first half, I only show the correlation with these two CMBS indices during the second half. Similar to other asset classes during the second half, the R_CMA and R_CMB show a stronger correlation with the R_I than with the R_T. The recent credit crisis and liquidity crunch have been influential in driving these results as investors flee to quality and liquidity in Nominal Treasuries. Overall, these results show that the expected diversification benefits by investing in TIPs may have been overstated, especially in a stressed market environment.

Table 3

Return, Risk and Correlation for the TIPs and other Major Asset Classes

Period	Stat	R_T	R_I	R_CI	R_CH	R_MBS	R_AHE	R_ACR	R_CMA	R_CMB	R_SP	R_RU
Whole Period (Mar. 1997 -Nov. 2008)	Mean	0.549	0.489	0.407	0.218	0.515	0.088	0.392			0.337	0.353
	Median	0.560	0.542	0.616	0.680	0.575	0.432	0.472			0.971	1.052
	Std. Dev.	1.343	1.667	1.596	2.713	0.825	1.800	1.142			4.630	4.706
	Sharpe ratio	0.189	0.117	0.071	-0.028	0.267	-0.115	0.085			0.009	0.013
	Corr with R_T	1.000	0.675	0.690	-0.139	0.849	-0.026	0.636			-0.260	-0.271
	Corr with R_I	0.675	1.000	0.739	0.262	0.599	0.206	0.759			0.000	0.007
First Half (Mar. 1997 -Dec. 2002)	Mean	0.671	0.631	0.632	0.191	0.625	0.650	0.652			0.418	0.411
	Median	0.626	0.564	0.684	0.427	0.668	0.669	0.743			0.663	0.865
	Std. Dev.	1.273	1.121	1.264	2.446	0.739	0.588	0.799			5.406	5.408
	Sharpe ratio	0.245	0.243	0.216	-0.069	0.360	0.496	0.367			0.011	0.010
	Corr with R_T	1.000	0.715	0.772	-0.117	0.813	0.695	0.903			-0.281	-0.290
	Corr with R_I	0.715	1.000	0.609	0.003	0.559	0.444	0.643			-0.291	-0.294
Second Half (Jan. 2003 -Nov. 2008)	Mean	0.428	0.348	0.184	0.244	0.406	-0.467	0.135	-0.194	0.054	0.257	0.295
	Median	0.515	0.327	0.588	0.979	0.418	0.118	0.197	0.214	0.372	1.118	1.198
	Std. Dev.	1.408	2.069	1.850	2.969	0.895	2.348	1.358	2.781	2.671	3.749	3.931
	Sharpe ratio	0.141	0.057	-0.025	0.005	0.196	-0.297	-0.070	-0.153	-0.066	0.007	0.017
	Corr with R_T	1.000	0.680	0.646	-0.154	0.875	-0.234	0.514	-0.006	-0.079	-0.255	-0.266
	Corr with R_I	0.680	1.000	0.789	0.386	0.628	0.162	0.801	0.481	0.336	0.222	0.228

Notes: R_T: Total Return on the Treasury Index; R_I: Total Return on the Treasury TIPs Index; R_CI: Total Return on the Investment Grade Corporate Bond Index; R_CH: Total Return on the High Yield Corporate Bond Index; R_MBS: Total Return on the Fixed-Rate Mortgage-Backed Securities Index; R_AHE: Total Return on the Home Equity Asset-Backed Securities Index; R_ACR: Total Return on the Credit Card Asset-Backed Securities Index; R_CMA: Total Return on the Aaa Commercial Mortgage-Backed Securities Index; R_CMB: Total Return on the Baa Commercial Mortgage-Backed Securities Index; R_SP: Total Return on the S&P 500 Index; R_RU: Total Return on the Russell 3000 Index. Total returns on the fixed income indices are provided by Barclays Capital, and the total returns on the two stock indices are obtained from Bloomberg. The statistics are based on monthly data from March 1997 to November 2008.

Table 4

Summary Statistics on the Financial and Economic Variables Used in the VAR Model

Period	Stat	RFS	RFL	TS	INF	UER	IPG	AAA	BAA	CS
Whole Period (Mar. 1997 -Nov. 2008)	Mean	3.529	4.876	1.347	2.692	4.960	2.295	6.272	7.205	0.934
	Median	3.990	4.720	1.070	2.600	4.800	2.400	6.170	7.160	0.870
	Max	6.360	6.890	3.680	5.600	6.700	8.800	7.990	9.220	3.070
	Min	0.190	3.330	-0.700	1.100	3.800	-6.200	4.960	5.820	0.550
	Stdev	1.750	0.819	1.241	0.968	0.675	3.202	0.819	0.798	0.335
First Half (Mar. 1997 -Dec. 2002)	Mean	4.307	5.456	1.149	2.289	4.676	2.934	6.995	7.840	0.845
	Median	4.940	5.480	0.920	2.200	4.500	4.000	7.010	7.905	0.790
	Max	6.360	6.890	3.460	3.800	6.000	8.800	7.990	8.900	1.410
	Min	1.210	3.870	-0.700	1.100	3.800	-5.700	6.150	7.090	0.550
	Stdev	1.533	0.711	1.117	0.773	0.637	4.033	0.477	0.416	0.252
Second Half (Jan. 2003 -Nov. 2008)	Mean	2.763	4.304	1.541	3.090	5.241	1.665	5.558	6.580	1.021
	Median	2.580	4.270	1.590	3.000	5.100	2.000	5.520	6.460	0.920
	Max	5.160	5.110	3.680	5.600	6.700	4.500	6.280	9.220	3.070
	Min	0.190	3.330	-0.520	1.100	4.400	-6.200	4.960	5.820	0.620
	Stdev	1.615	0.420	1.331	0.980	0.592	1.912	0.278	0.551	0.382

Notes: RFS: Short-term Risk Free Rate (Constant Maturity Yield on 3-month Treasury Bills); RFL: Long-term Risk Free Rate (Constant Maturity Yield on 10-year Treasury Bills); TS: Team Structure Spread=RFL-RFS; INF: Inflation as computed by the 12-month % change in CPI-U; UEM: Unemployment Rate in %; IPG: 12-month % Growth in Industrial Production; Aaa: Moody's Aaa Corporate Bond Yield; Baa: Moody's Baa Corporate Bond Yield; QS: Quality Spread=Baa-Aaa. The summary statistics are based on monthly data from March 1997 to November 2008.

4. Performance Drivers of TIPs and Nominal Treasuries

I use a structural vector autoregressive (VAR) model to determine the variables that drive the TIPs return and how each variable does so. The total return on TIPs is analyzed in the context of six other financial and economic endogenous variables. In addition to R_I (TIPs return), the other endogenous variables are RFSD (change in short-term risk-free rate), TSD (change in term structure spread), QSD (change in quality spread), INF (inflation rate), IPG (growth in industrial production), and UERD (change in unemployment rate). Table 4 reports the descriptive statistics of these financial and economic variables that are potential drivers of the TIPs return dynamics.

In a reduced form of the VAR, each endogenous variable in the system is modeled as a function of the lag values of all the endogenous variables in the system, and the error terms may be correlated with one another. In this structural form of the VAR, restrictions are placed on the contemporaneous relations among the endogenous variables to allow for identification of uncorrelated/independent structural shocks. Sims [1980] first introduced the impulse response analysis into VAR modeling as a descriptive device intended to represent the reaction of each variable to a shock (or innovation) in each equation of the VAR system over time. A meaningful impulse response analysis requires that shocks be uncorrelated. This orthogonal condition is fulfilled in this structural VAR framework.

Based on the structural VAR model, Table 5 reports the impulse response and variance decomposition of TIPs return (R_I) to shocks in four financial variables (change in the short-term risk-free rate, change in the term structure spread, change in the quality spread, and the inflation rate) and two real economic variables (growth in industrial production and change in the unemployment rate). Table 6 reports a structural VAR analysis on the Treasury return (R_T), using the same set of financial and economic variables as endogenous variables.

The impulse response analysis shows that the change in the short-term risk-free rate (RFSD) has a negative and highly significant effect on both R_I and R_T, confirming the negative discount rate effect. The change in the term structure spread (TSD) also has a negative and highly significant effect on R_I and R_T, since both TIPs and Treasuries are long-term securities that would be associated with a lower return when the maturity yield spread goes up. In addition, there is a significantly

positive but much smaller lag-two TSD effect on both the R_I and R_T.

Table 5

A Structural VAR Model for the U.S. TIPs Return

Panel A. Impulse Response of U.S. Treasury TIPs Return to One S.D. of Innovation in Variables

Period	UERD	IPG	INF	QSD	TSD	RFSD	R_I
0	-0.078	-0.003	0.137	**-0.508**	**-0.623**	**-0.689**	**1.243**
	(-0.57)	(-0.02)	(0.99)	**(-3.78)**	**(-4.96)**	**(-6.11)**	**(16.73)**
1	-0.124	0.056	0.062	-0.036	0.147	0.204	0.210
	(-0.90)	(1.10)	(0.74)	(-0.27)	(1.10)	(1.56)	(1.57)
2	-0.010	0.019	-0.006	-0.043	***0.115***	0.065	-0.131
	(-0.17)	(0.49)	(-0.08)	(-0.61)	***(1.73)***	(1.07)	(-1.90)
3	0.012	0.023	-0.027	-0.022	-0.011	-0.015	-0.011
	(0.50)	(0.73)	(-0.44)	(-0.48)	(-0.42)	(-0.46)	(-0.36)
4	-0.016	0.025	-0.030	0.010	-0.009	0.000	0.007
	(-1.21)	(0.85)	(-0.58)	(0.27)	(-0.77)	(0.00)	(0.40)
5	-0.011	0.024	-0.031	0.018	-0.004	0.003	-0.007
	(-0.94)	(0.80)	(-0.74)	(0.53)	(-0.43)	(0.17)	(-0.80)
6	-0.010	0.021	-0.031	0.019	-0.005	-0.001	-0.008
	(-0.82)	(0.74)	(-0.89)	(0.67)	(-0.70)	(-0.07)	(-1.08)
7	-0.009	0.019	-0.029	0.019	-0.006	-0.002	-0.006
	(-0.75)	(0.70)	(-1.01)	(0.80)	(-0.86)	(-0.17)	(-0.92)
8	-0.008	0.017	-0.027	0.018	-0.006	-0.002	-0.005
	(-0.72)	(0.65)	(-1.09)	(0.93)	(-0.82)	(-0.20)	(-0.93)
9	-0.007	0.015	-0.025	0.017	-0.005	-0.002	-0.005
	(-0.66)	(0.61)	(-1.09)	(1.01)	(-0.79)	(-0.25)	(-0.91)
10	-0.006	0.014	-0.022	0.016	-0.005	-0.002	-0.004
	(-0.62)	(0.57)	(-1.04)	(1.04)	(-0.76)	(-0.30)	(-0.85)

Panel B. Variance Decomposition of US Treasury TIPs Return

Period	UERD	IPG	INF	QSD	TSD	RFSD	R_I
0	0.23	0.00	0.70	9.60	14.44	17.63	57.41
1	0.76	0.11	0.80	9.20	14.53	18.30	56.30
2	0.76	0.12	0.79	9.14	14.80	18.21	56.18
3	0.76	0.14	0.81	9.15	14.80	18.20	56.14
4	0.77	0.16	0.84	9.15	14.79	18.19	56.10
5	0.77	0.18	0.88	9.15	14.78	18.17	56.06
6	0.78	0.20	0.91	9.16	14.77	18.16	56.02
7	0.78	0.21	0.94	9.17	14.76	18.15	55.99
8	0.78	0.22	0.96	9.17	14.76	18.14	55.96
9	0.78	0.23	0.98	9.18	14.75	18.13	55.94
10	0.78	0.24	1.00	9.19	14.75	18.13	55.92

Notes: R_I: Total Return on the U.S. Treasury TIPs Index; RFSD: Change in the Short-term Risk Free Rate; TSD: Change in the Team Structure Spread; QSD: Change in Quality Spread between BAA and AAA Corporate Bonds; INF: Inflation as computed by the 12-month % change in CPI-U; IPG: 12-month % Growth in Industrial Production; UEMD: Change in Unemployment Rate. The estimates are based on monthly data from March 1997 to November 2008.

t-ratios are in parentheses. **Bold** -- Significant at 5%; ***Bold and Italic*** -- Significant at 10%

Table 6
A Structural VAR Model for the U.S. Nominal Treasury Return

Panel A. Impulse Response of U.S. Treasury Return to One S.D. of Innovation in Variables

Period	UERD	IPG	INF	QSD	TSD	RFSD	R_T
0	0.067	-0.016	**-0.265**	0.114	**-0.512**	**-0.825**	**0.813**
	(0.61)	(-0.14)	**(-2.44)**	(1.06)	**(-5.00)**	**(-9.76)**	**(16.73)**
1	0.013	0.072	0.012	**0.262**	0.066	0.103	0.143
	(0.12)	(1.40)	(0.17)	**(2.47)**	(0.63)	(1.04)	(1.48)
2	-0.026	0.018	**0.130**	0.029	***0.094***	0.061	**-0.170**
	(-0.46)	(0.44)	**(2.12)**	(0.50)	***(1.74)***	(1.04)	**(-2.47)**
3	0.028	0.007	0.062	-0.050	-0.033	-0.055	0.037
	(1.19)	(0.22)	(1.40)	(-1.39)	(-1.11)	(-1.52)	(1.03)
4	0.008	0.024	0.056	-0.025	0.003	0.015	0.021
	(0.45)	(0.76)	(1.50)	(-0.93)	(0.20)	(0.75)	(0.79)
5	0.000	0.028	***0.053***	-0.030	0.014	***0.026***	-0.022
	(-0.02)	(0.95)	***(1.70)***	(-1.35)	(1.14)	***(1.78)***	(-1.69)
6	-0.002	0.031	0.033	-0.031	-0.001	0.010	-0.006
	(-0.17)	(1.11)	(1.21)	(-1.50)	(-0.05)	(0.85)	(-0.74)
7	-0.007	0.035	0.017	-0.020	-0.002	0.012	-0.003
	(-0.51)	(1.34)	(0.69)	(-1.16)	(-0.25)	(1.25)	(-0.42)
8	-0.011	0.036	0.006	-0.012	-0.002	0.013	-0.006
	(-0.86)	(1.51)	(0.25)	(-0.80)	(-0.30)	(1.61)	(-1.51)
9	-0.013	0.036	-0.005	-0.006	-0.005	0.009	-0.005
	(-1.06)	(1.63)	(-0.19)	(-0.42)	(-0.69)	(1.38)	(-1.27)
10	-0.014	***0.034***	-0.013	0.000	-0.006	0.007	-0.003
	(-1.23)	***(1.74)***	(-0.56)	(0.01)	(-0.92)	(1.23)	(-0.95)

Panel B. Variance Decomposition of U.S. Treasury Return

Period	UERD	IPG	INF	QSD	TSD	RFSD	R_T
0	0.28	0.01	3.98	0.64	15.96	40.09	39.04
1	0.29	0.32	3.72	4.67	15.20	38.12	37.68
2	0.30	0.36	4.30	4.63	15.27	37.09	38.05
3	0.31	0.36	4.45	4.70	15.24	37.05	37.89
4	0.31	0.38	4.58	4.71	15.21	36.97	37.83
5	0.31	0.42	4.72	4.74	15.17	36.90	37.73
6	0.31	0.45	4.79	4.79	15.14	36.84	37.67
7	0.31	0.50	4.81	4.82	15.13	36.81	37.62
8	0.32	0.55	4.82	4.83	15.11	36.78	37.59
9	0.33	0.60	4.81	4.83	15.10	36.76	37.56
10	0.33	0.65	4.81	4.83	15.09	36.74	37.54

Notes: R_T: Total Return on the U.S. Treasury Index; RFSD: Change in the Short-term Risk Free Rate; TSD: Change in the Team Structure Spread; QSD: Change in Credit Spread between BAA and AAA Corporate Bonds; INF: Inflation as computed by the 12-month % change in CPI-U NSA; IPG: 12-month % Growth in Industrial Production; UEMD: Change in Unemployment Rate. The estimates are based on monthly data from March 1997 to November 2008.

t-ratios are in parentheses. Bold -- Significant at 5%; Bold and Italic -- Significant at 10%

The change in quality spread (QSD) has a significantly negative effect on the R_I. However, the contemporaneous and lag-one effects on the R_T are both positive,

with the lag-one positive effect being highly significant. During periods of credit crunch, investors tend to flee to Treasuries due to concerns with credit and liquidity risks, leading to a positive relationship between QSD and R_T. Although both TIPs and Treasuries are free of credit risk, TIPs are associated with much lower liquidity (i.e., higher liquidity risk). In addition, the widening of the quality spread is often associated with weaker economic conditions and lower inflation expectations, leading to a negative relationship between QSD and R_I.

The inflation rate (INF) has neither a contemporaneous nor a lag effect on the R_I. This is intuitive since cash flows from TIPs (both coupon payments and principal) are adjusted for inflation. In contrast, INF has a significantly negative contemporaneous effect on the R_T, which is expected since the realized return on Nominal Treasuries would be lower during a high inflationary environment. Finally, the two real economy variables, growth in Industrial Production (IPG) and change in unemployment rate (UERD), both appear to have no additional impact beyond those already contained in the financial variables (RFSD, TSD, QSD, and INF).

While the impulse response analysis above is performed to illustrate how variables in the VAR system react over time to innovations or shocks in other variables, a variance decomposition technique allows us to compare the role that different variables play in causing such responses. Panel B of Table 5 reports results showing variance decomposition of TIPs return, while Panel B of Table 6 reports those of Treasury return.

Several results are worth noting. First, shocks to the TIPs return explain about 57% of the variation in its own movement, while the Treasury return explains about 39% of the variation in its own movement. Second, the changes in the short-rate and term structure spread explain 18% and 14% of the variation in the TIPs return, respectively, and 40% and 16% of the variation in Treasury return, respectively. Third, the change in the quality spread consistently accounts for 9% of the variation in the TIPs return, but only 4% of the lag variation in the Treasury return. Fourth, the inflation rate accounts for less than 1% in the TIPs return variation, but 4% in the Treasury return variation. Finally, growth in industrial production and change in unemployment account for less than 1% of the time-series variation in TIPs or Treasuries. The financial market variables, such as the short rate, term structure spread, and quality spread, explain the return variation of TIPs and Treasuries much more than the real economy variables of industrial production and unemployment. This is perhaps due to the fact that financial variables have incorporated the

information content of the real economy variables.

Table 7

A Structural VAR Model for the U.S. Treasury TIPs Return Spread

Panel A. Impulse Response of U.S. Treasury TIPs Return Spread to One S.D. of Innovation in Variables

Period	UERD	IPG	INF	QSD	TSD	RFSD	RS_I
0	0.133	-0.057	**-0.330**	**0.564**	0.058	-0.075	**0.921**
	(1.38)	(-0.59)	**(-3.52)**	**(6.62)**	(0.74)	(-0.96)	**(16.73)**
1	0.137	-0.029	-0.050	**0.274**	-0.052	-0.088	**0.324**
	(1.38)	(-0.60)	(-0.80)	**(2.89)**	(-0.54)	(-0.89)	**(3.41)**
2	0.044	-0.030	0.071	0.104	-0.022	-0.041	**0.135**
	(1.25)	(-0.81)	(1.14)	(1.48)	(-0.36)	(-0.63)	**(2.28)**
3	0.044	-0.021	**0.126**	0.001	-0.009	-0.003	0.032
	(1.70)	(-0.57)	**(2.03)**	(0.02)	(-0.30)	(-0.08)	(0.83)
4	0.023	-0.013	**0.142**	-0.050	0.005	0.017	-0.017
	(1.03)	(-0.37)	**(2.44)**	(-1.29)	(0.29)	(0.63)	(-0.58)
5	0.017	-0.005	**0.139**	**-0.072**	0.009	0.026	-0.042
	(0.75)	(-0.15)	**(2.66)**	**(-1.96)**	(0.57)	(1.10)	(-1.52)
6	0.008	0.001	**0.126**	**-0.078**	0.012	0.029	***-0.051***
	(0.37)	(0.04)	**(2.76)**	**(-2.11)**	(0.63)	(1.22)	***(-1.83)***
7	0.003	0.007	**0.108**	**-0.074**	0.011	0.029	***-0.051***
	(0.16)	(0.24)	**(2.70)**	**(-2.09)**	(0.61)	(1.24)	***(-1.92)***
8	-0.001	0.012	**0.088**	**-0.065**	0.010	0.027	***-0.047***
	(-0.05)	(0.42)	**(2.44)**	**(-2.02)**	(0.58)	(1.26)	***(-1.93)***
9	-0.004	0.016	**0.070**	***-0.055***	0.008	0.024	***-0.041***
	(-0.22)	(0.59)	**(2.03)**	***(-1.89)***	(0.53)	(1.27)	***(-1.89)***
10	-0.006	0.019	0.053	***-0.044***	0.006	0.021	***-0.034***
	(-0.39)	(0.75)	(1.57)	***(-1.71)***	(0.48)	(1.30)	***(-1.79)***

Panel B. Variance Decomposition of U.S. Treasury TIPs Return Spread

Period	UERD	IPG	INF	QSD	TSD	RFSD	RS_I
0	1.35	0.25	8.36	24.35	0.26	0.43	65.00
1	2.40	0.27	7.35	25.87	0.40	0.89	62.82
2	2.46	0.32	7.50	25.91	0.42	0.97	62.42
3	2.56	0.34	8.41	25.60	0.42	0.96	61.72
4	2.55	0.35	9.55	25.37	0.42	0.96	60.81
5	2.53	0.35	10.58	25.26	0.41	0.99	59.89
6	2.49	0.34	11.37	25.23	0.42	1.03	59.12
7	2.46	0.34	11.92	25.25	0.42	1.06	58.55
8	2.44	0.34	12.28	25.27	0.42	1.10	58.15
9	2.42	0.36	12.49	25.29	0.42	1.12	57.89
10	2.42	0.38	12.61	25.30	0.42	1.15	57.73

Notes: RS_I: Return Spread for U.S. Treasury TIPs = Total Return on the U.S. Nominal Treasury Index minus Total Return on the U.S. Treasury TIPs Index; RFSD: Change in the Short-term Risk Free Rate; TSD: Change in the Team Structure Spread; QSD: Change in Quality Spread between BAA and AAA Corporate Bonds; INF: Inflation as computed by the 12-month % change in CPI-U; IPG: 12-month % Growth in Industrial Production; UEMD: Monthly change in Unemployment Rate. The estimates are based on monthly data from March 1997 to November 2008.

t-ratios are in parentheses. Bold -- Significant at 5%; Bold and Italic -- Significant at 10%

Table 7 presents additional structural VAR analysis on the return difference between Nominal Treasuries and TIPs (also called Treasury TIPs return spread, RS_I). The duration difference between the Nominal Treasuries and TIPs is used as an exogenous variable to control for the return difference due to difference in the maturity of cash flows. The results from Table 7 largely confirm the findings from Table 5 (on TIPs return) and Table 6 (on Nominal Treasury return). The most important confirmation from Table 7 is that the change in the quality spread has positive contemporaneous and lag-one effects on the RS_I, but the inflation rate has a negative contemporaneous effect on the RS_I. This suggests that Treasuries outperform TIPs during periods with increasing concern for credit and liquidity risks, but TIPs outperform Treasuries during high inflationary environment. This has important implications for the investors and portfolio managers' asset allocation decision since the differential performance between TIPs and Nominal Treasuries is clearly driven by the inflation rate and the change in quality spread.

5. Conclusion

Using monthly data on the Barclays Capital U.S. TIPs Index and Treasury Index from March 1997 to November 2008, I first examine the comparative performances of Treasury Inflation-Protected Securities and Nominal Treasuries as two asset classes. During the sample period, the TIPs nominal yield is statistically higher than the Treasury nominal yield. The monthly coupon return and total return on TIPs are 0.19% and 0.06% lower than those on the Nominal Treasuries, while the price return on the TIPs is about 0.13% higher than that on the Nominal Treasuries. The difference in coupon return on TIPs and Nominal Treasuries is statistically significant, but insignificant for the differences in price return or total return between the two groups. The return correlation between TIPs and stocks is very low, ranging from -0.29 in the first half and 0.22 in the second half. The correlation between Nominal Treasuries and stocks is -0.28 and -0.26 in the first half and second half, showing a more stable correlation pattern. During the first half, the TIPs' return correlations with corporate bonds, asset-backed securities, and stocks are all lower than the Treasuries' return correlations with these asset classes, but the pattern is completely reversed during the second half of the sample period. The recent credit crisis and liquidity crunch have been influential in driving these results as investors flee to quality and liquidity in Nominal Treasuries. Overall, these results show that the expected diversification benefits by investing in TIPs may have been overstated, especially in a stressed market environment.

In the second part of this study, I use a structural VAR model to examine the drivers of the return performance on TIPs. The total return on TIPs is analyzed in the context of six other financial and economic endogenous variables, including four financial variables (change in the short-term risk-free rate, change in the term structure spread, change in the quality spread, and inflation rate), and two macroeconomic variables (growth in industrial production and change in unemployment rate). A similar analysis is also performed for the return on Nominal Treasuries to allow for comparison of the return drivers on these two asset classes.

While the returns on TIPs and Treasuries are both negatively driven by the changes in the level and term structure spread of interest rates, their responses to the change in the quality spread, as measured by the BAA and AAA corporate bond yield spread, and the inflation rate are completely different. During periods with increasing credit and liquidity concerns, investors flee to Treasuries and drive up Treasury returns, leading to a positive effect of the change in the quality spread on the Treasury return. Although credit risk is not a concern for TIPs, widening of the quality spread is often associated with increasing liquidity premium, weaker economic conditions and lower inflationary expectation, leading to a negative effect of the change in the quality spread on the TIPs return. As for the inflation rate, it does not drive the return on TIPs due to its inflation-adjusted cash flows, but its effect on the Treasury return is significantly negative. This suggests that Treasuries outperform TIPs during periods with increasing concern for credit and liquidity risks, but TIPs outperform Treasuries during a high inflationary environment.

The variance decomposition from the structural VAR analysis reveals that shocks to the TIPs return explain about 57% of the variation in its own movement, and changes in the short rate, term structure spread, and quality spread, respectively, explain 18%, 14% and 9% of the variation in the return on TIPs. The inflation rate, growth in industrial production, and change in unemployment all account for less than 1% in the variation in the return on TIPs.

This is the first empirical study that uses comprehensive TIPs and Nominal Treasury index data to provide a clear characterization of their comparative performances. It is also the first to empirically examine the performance drivers of these two asset classes in a dynamic structural VAR framework. The empirical results from this paper can provide guidance to investors and portfolio managers who are confronted with asset allocation decisions between Nominal Treasuries and TIPs. Finally, given the improved availability of data, empirical research examining

whether the performance drivers are different across different government ILB markets around the world would be of great interest to investors and policy makers.

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