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Using the CCAPM with Stochastic Taxation and Money Supply to Examine US REITs Pricing Bubbles

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Abstract

This paper examines three issues relating to US REITs pricing. First, using a modified Capital Consumption Asset Pricing Model (CCAPM) with stochastic taxation and money supply, we compute the fundamental values for United States Real Estate Investment Trusts (REITs) for our sample time horizon, 1972-2013. Our empirical analysis for US REIT pricing is statistically consistent with the CCAPM with stochastic taxation and monetary policy. Second, for our purposes, for publicly traded equity REITs, we define a bubble at a point in time to be the difference between the actual stock market price and the fundamental value derived from our theoretical model. United States REITs have, among other corporate structural features, special rules governing dividend distributions and corporate taxation treatment that make them an especially attractive and preferred vehicle for testing for the presence of pricing bubbles. Our study suggests that during the sample time horizon, United States REITs experienced many price bubbles, some of which were quite large. Third, our empirical results imply that monetary policy, in the short run, plays a role in the formation of these pricing bubbles.

Keywords: Bubbles, Equity Premium, REITs, Risk Aversion, Stochastic Tax, Monetary Policy

I. Introduction

Economists and others have toiled and lucubrated for literally hundreds of years attempting to identify, analyze, and explain asset market bubbles, booms and busts. From these efforts have emerged numerous studies and substantial and substantive academic and practitioner debates. This paper uses the infinite horizon Capital Consumption Asset Pricing Model (CCAPM) with stochastic taxation and money supply derived in Magin (2016) and the relatively idiosyncratic corporate structural features of the US Equity REIT market to identify and statistically analyze bubbles for US Equity REITs between 1972 and 2013. As employed in this study, an economic bubble occurs when significant trading occurs at prices that appear to be inconsistent with intrinsic fundamental value.

Our statistical results suggest that during the sample time horizon, 1972-2013, United States Equity REITs experienced many price bubbles (i.e., observed REIT prices differed from theoretical fundamental values), some of which were quite large. We discuss plausible explanations for these bubbles. In particular, our empirical results indicate that changes in the real money supply play a statistically significant role for accentuating US Equity REIT pricing bubbles.

Of course, statistical analyses of pricing bubbles are joint tests of the theoretical Fundamental Value metric and deviations of the observed market prices from this metric. So in order to examine bubbles it is important to create a trustworthy measure of Fundamental Value. Our statistical strategy to perform the joint test, therefore, is to divide the analyses into two sequential parts. First, we test the statistical reliability of the Fundamental Value, which serves as the precursor to the second test. Then we statistically analyze deviations of the observed market prices from Fundamental Values, i.e., pricing bubbles. We employ two separate but related models for deriving fundamental, intrinsic REIT values based upon two variants of the CCAPM. The first value model is the CCAPM with stochastic taxation; and the second value model is the CCAPM with stochastic taxation and money supply.[1] As explained below, we believe these two theoretical models provide reasonable estimates for Fundamental Value.

How and why is this pricing-bubble study different from the multitude of predecessors. First, while it should almost go without saying, corporate managing, organizing, and planning as well as shareholder-investor decision-making tend to be tax sensitive. Any analysis of stock prices that does not take into account the impacts and effects of corporate and investor taxation is likely to be ignoring an important explanatory element for market behavior. Our analysis in this paper attempts to take into account that taxation is both stochastic and important; our analysis integrates stochastic taxation into an asset-pricing model employing the CCAPM theoretical framework.

Second, publicly traded Equity REITs vis-à-vis publicly traded C–corporations provide a natural laboratory for analyzing asset pricing and evaluating bubbles for the following reasons: a) REITs, if they follow regulatory requirements, effectively do not pay taxation on net income at the corporate level; b) REITs are required to pay at least 90% of net income in the form of dividends. In essence, REITs distribute a substantial amount of cash flow in the form of dividends, and do not pay dividends from after-tax earnings, unlike "normal" profitable C-corporations. While corporations and shareholders-investors are typically carefully planning and monitoring taxation, in the case of REITs, corporate taxes de facto are inconsequential. These factors obviate our need to develop a pricing model for both corporate and investor taxation. Instead our models will be able to focus on taxation at the shareholder-investor level only.

Third, in order to identify and evaluate asset price bubbles, one needs to have a reliable fundamental theory of value (price) in order to compare with the observed market value (price). It is the difference between the observed contemporaneous market value and the theoretical, fundamental value that is the measure for the magnitude of the asset price bubble. Many asset bubble pricing studies either do not provide an explicit theory of price (value) and/or simply compare market prices to data related to general economic fundamentals. For example, several studies of housing price bubbles simply compare the rates of change of observed housing sales prices to changes in household incomes and so forth. In contrast, we calibrate fundamental theoretical value for US REITs by employing modified existing CCAPM with stochastic taxation. These models have been able to explain a substantial portion of the Equity Premium Puzzle in real estate. The obverse side for explaining the "Puzzle" is related to estimating reliable fundamental value pricing.

Fourth, many well-respected analyses of the booms and busts (and bubbles) claim that debt (often associated with the growth in the money supply) frequently plays a paramount role in the generation of these asset boom, bust, bubble cycles. To address possible effects of monetary policy on the real asset prices, we use a new modified infinite horizon CCAPM with stochastic taxation and real money supply derived in Magin (2016). Thus, by incorporating the real money supply into our theoretical price model, we provide a benchmark for the theoretical asset price, taking into account the real money supply.

Fifth, why do we use the modified CCAPM versus the simpler CAPM (Capital Asset Pricing Model) to perform our statistical analysis? The CAPM is a one time period analysis that identifies the risk of any security as the covariance between the securities rate of return and the rate of return of the market portfolio. According to the simple CAPM, the uncertainty associated with the market portfolio is the sole source of risk in the economy, but this model does not provide a theoretical intertemporal structure that allows one to identify the causes of the market portfolio to be risky. In contrast, macroeconomics does provide a theoretical structure that enables us to identify various sources of aggregate uncertainty over time, as well as understand the mechanisms by which these macroeconomic variables affect security returns and prices. The intertemporal asset pricing model that is embedded in stochastic models of macroeconomics is the CCAPM. The name derives from the fact that the equations that describe the behavior of asset prices and returns in the CCAPM devolve from the intertemporal consumption/savings and asset choice decisions of households. Hence, the

CCAPM provides a preferred macroeconomic intertemporal stochastic asset pricing framework. As indicated, we use the modified CCAPM explicitly incorporating stochastic taxation and money supply.

The remainder of the paper is organized as follows. Section II provides a selective, targeted review of the voluminous booms, busts, bubbles and debt literature as well as that for stochastic taxation and the Equity Premium Puzzle, and how these subject areas relate to this paper. Section III, first, reviews the theoretical foundations of this paper – the CCAPM with stochastic taxation and real money supply. Then, in the same section, employing a set of reasonable parametric values for key variables, we quantify and statistically test the theoretical pricing equations derived in Magin (2016). Section IV uses the theoretical values (prices) for REITs implied by the CCAPM with stochastic taxation and the real money supply to identify and statistically analyze possible asset pricing bubbles. Section V contains a brief conclusion and summary.

II. A Targeted Selected Literature Review

This research paper spans, interfaces, and extends several well-developed, extensive and expansive financial economic research subject areas. Our paper is influenced by several interesting and important analyses pertaining to real estate market booms and busts. Our research is, also, intertwined with asset pricing models with concomitant issues, such as the Equity Premium Puzzle, the coefficient of relative risk aversion for investors, and the impacts of stochastic taxation on investment decision-making. We will now provide a very brief selective review of pertinent prior research.

1. Booms, Busts Bubbles and Debt

As a starting point for understanding bubbles, one should acknowledge the contribution made by Charles Kindleberger in his book, *Manias, Panics and Crashes.* Kindleberger traces and analyzes various bubbles episodes across history in which economic outcomes are speculative, and in no way reflective of the underlying fundamental economic values. His analyses of the northern European tulipmania in 1636-1637, and the English South Seas bubble in the early 1700s are captivating, and reminiscent of alleged bubbles through history to the modern day. During the peak of Tulipmania in March 1637, tulip bulbs were transacting for values that were about 10 times the annual income of a skilled craftsman. Suddenly, in 1637 the tulip bulb values started to decline precipitously to levels of 2 to 5% of their peak. The South Sea Company, a British stock company founded in 1711, was a public-private partnership that was granted a monopoly for British trade with South America. However, England was at war with Spain, and Spain controlled South America. Hence, there was little real prospects that trade would take place for the company in South America. However, the company stock skyrocketed as it expanded its transactions in British government debt. The company's value peaked in 1720, before collapsing to approximately the original flotation price; hence, the so-called South Sea Bubble. Because of the public outcry, Britain in 1720 passed the Bubble Act which forbade the creation of such stock companies without royal chartering.

Milton Friedman and Anna Schwartz in their study of the great depression, *The Great Contraction: 1929–1933*, demonstrate that the inept mismanagement of monetary policy exacerbated an economic downturn, creating a downward spiral bubble for the monetary system as well as the real economy. They claim that "a moderately informed understanding of them (the monetary economics of the banking panic) would have cut short the liquidity crisis before it had gone very far, and perhaps before the end of 1930 (page 112)." They also aver that bubbles – collapses can sometime be readily avoided, but once underway are difficult to control and rectify: "... Economic collapse often has the character of a cumulative process. Let it go beyond a certain point, and it will tend to for a time to gain strength from its own development as its effects spread and return to intensify the process of collapse. Because no great strength would be required to hold back the rock that starts a landslide, it does not follow that the landslide will not be of major proportions (page 123)."

Later, however, in his 1968 AER paper *The Role of Monetary Policy,* Milton Friedman concludes that monetary policy cannot affect real variables in the long run. He writes "...It cannot use its control over nominal quantities to peg a real quantity-the real rate of interest, the rate of unemployment, the level of real national income, the real quantity of money, the rate of growth of real national income, or the rate of growth of the real quantity of money."

More recently, in a speech (2012) Federal Reserve Chairman, Ben Bernanke, citing research by Krishnamurthy and Vissig-Jorgensen (2011), Wright (2012), Fuster and Willen (2010), and Hancock and Passmore (2011) claims "early skeptics of balance sheet (monetary) policies worried that any effects on treasury yields would not be transmitted to other interest rates and asset prices. The evidence reported in these papers refutes this concern. . . " In the same speech, he recognizes that stimulative monetary policy may have potential for creating "risks to financial stability." In his 2015 working paper, Swanson indicates that monetary policy, and especially large-scale asset purchases, during 2009-2015 has had large effects on corporate yields (raising corporate bond prices) and stock market asset prices. Swanson suggests that these monetary policy impacts may not be persistent (i.e., generate short-run asset price effects). In sum, more recent research suggests that monetary policy has the potential to play a substantive part in the genesis of bubbles, booms and busts.

Reinhardt and Rogoff (2009), in their book *This Time Is Different: Eight Centuries of Financial Folly* explore the interrelationship between speculative bubbles, inflation, debt, and monetary crises over the last 800 years. As in the Kindleberger book, they examine several historical episodes of speculative bubbles, and attribute many the bubbles to unrealistic expectations, speculative behavior, and over leverage. They conclude that public and private sector mishandling of debt is frequently the cause for these speculative bubbles. The most recent work by Mian and Sufi (2014) examines how the Great Recession of 2008 and the housing market were intertwined with the financial sector, especially because of overzealous mortgage debt issuance.

Robert Shiller (2005) in the second edition of his book, *Irrational Exuberance*, a phrase coined by a now infamous quote from then Federal Reserve chieftain Alan Greenspan, develops several arguments demonstrating how the stock market was “overvalued.” In this book, he also suggests that the U.S. real estate market at the time (2005) was likely to be a bubble, a bubble that was punctured three or four years after the book!

It is often thought that ”bubbles” are relatively short-term phenomena, and quickly come down to earth. The U.S. residential real estate bubble commenced in 2001, and did not reach its peak until 2006. This real estate bubble was replicated in many parts of the world, coming to a crashing halt in 2007 (see Bardhan, Edelstein, and Kroll (2012)). In fact, bubbles can last decades as documented by Ambrose, et al (2012). In their study of 300+ years of housing price behavior in Holland, they find that bubbles can have elongated lives, lasting 70 or 80 years where housing prices systematically do not reflect the underlying economic rental fundamentals.

While there are many explanations, ranging from overleverage – loose monetary policy, crowd herding, animal spirits, and heterogeneous expectations, the upshot is that observed asset prices can differ significantly, sometimes for prolonged periods, from intrinsic underlying fundamental economic value. This said, it is sometimes difficult to determine what is the underlying intrinsic fundamental economic value, irrespective of the mechanism causing the speculative bubble.

2. Macro Policy and Stock Market Prices – Returns

Many earlier studies trace the interrelationships between and among various aspects of macro policy, especially monetary policy, and their impacts on stock market prices and returns. Fama and French (1989), Schwert (1990) and Chen (1991), among others, indicate that the term structure, affected by monetary policy, can explain variations in expected stock returns. The findings in Fama and French (1989) imply that monetary policy strongly influences the equity market required rate of return. Jensen and Johnson (1995) claim that there is a direct link between Federal Reserve discount rate changes and stock market returns. Patelis (1997) suggests that monetary policy variables can be used to forecast stock market returns. Thorbecke (1997) provides empirical evidence that the various forms of monetary policy, measured by federal fund rates and so forth, impact stock market returns. Jensen, Mercer, and Johnson (1996) find that the impacts of monetary policy over the business cycle affect expected security returns asymmetrically. In their 2006 study, Jensen and Mercer find that turning points and monetary policy are important predictors of future security market behavior.

More recent studies, such as Bjournland and Leitemo (2009) and Ozdagli and Yu (2012), among others, suggest that monetary policy changes do not affect stock market returns uniformly. The effects of monetary policy on the expected returns and pricing of individual stocks appear to depend upon both the economic cycle and the micro circumstances of individual firms. Several studies (e.g.,Chen, Peng, Shyu, and Zeng (2011); Darius and Glasscock (1989); and Mueller and Pauley (1995)), also, indicate that the rates of return for real estate investments and REITs are sensitive to changes in monetary policy. In summary, the empirical evidence strongly suggests that monetary policy is intertwined in the economic process for determining stock market expected rates of returns.

3. Fundamental Asset Prices, Stochastic Taxation and the Equity Premium Puzzle

Paradoxically, almost no research has been done about the effects of stochastic taxes on asset prices and allocations. The research that has been done was primarily motivated by the Equity Premium Puzzle. The Equity Premium Puzzle was originally identified by Mehra and Prescott (1985), using historical data for the stock market portfolio $\beta = 1$. The traditional CCAPM, with an isoelastic Constant Relative Risk Aversion (CRRA) utility function and an expected equity risk premium of 6% for the S&P 500, using average historical stock returns, produces a coefficient of relative risk aversion of roughly 47.6. This unbelievably high coefficient of relative risk aversion constitutes the so-called "Equity Premium Puzzle." There have been many attempts to resolve the Equity Premium Puzzle. See DeLong and Magin (2009), for example, for a review and analysis of various attempts to resolve the Equity Premium Puzzle. The introduction of taxation into the standard macroeconomic models seemed to pave one of the most promising ways to approach the puzzle. McGrattan and Prescott (2005), Sialm (2006) and (2011) were among the first to introduce taxation into the General Equilibrium models. However, their work does not resolve or directly address the puzzle.

Magin (2016) derives the infinite horizon CCAPM with stochastic dividend taxation and monetary policy. He finds that under reasonable assumptions on assets' dividends and probability distributions of the future dividend taxes and consumption, the model implies the constant price/after-tax dividend ratios. He also obtains that the higher current and expected dividend tax rates imply lower current asset prices. Finally, he derives that, contrary to popular belief, monetary policy is neutral, in the long run, with respect to the real equilibrium asset prices.

Magin (2015a) proves the existence of equilibria in the infinite horizon general equilibrium with incomplete markets (GEI) model with insecure property rights. Insecure property rights come in the form of the stochastic taxes imposed on agents' endowments and assets' dividends. He finds that under reasonable assumptions, Financial Markets (FM) equilibria exist for most of the stochastic tax rates. Moreover, sufficiently small changes in stochastic taxation preserve the existence and completeness of FM equilibria.

Magin (2015b), recognizing that taxation uncertainty plays a major role for investors, introduced a modified CCAPM with a stochastic tax rate τ_t imposed on the income and capital wealth of stock holders. Using this modified model, he finds that for a typical investor, who realizes after-tax dividend income as well as short-term and long-term gains in accordance with historical patterns, the coefficient of relative risk aversion is 3.76. Since earlier studies by Mehra (2003) and Mehra and Prescott (2003) suggest that a coefficient of relative risk aversion, a, between 2 and 4 would seem reasonable, the Magin estimate for $a = 3.76$ is believable.

The risk premium puzzle for asset classes other than $\beta = 1$ stock market portfolios has been largely unexplored. The known exceptions for real estate assets are Shilling (2003) and Edelstein and Magin (2013, 2014). In his study, Shilling (2003) deploys the CCAPM and two different real estate value data sets; but he does not take into account the possible impacts of taxation. He confirms the existence of the Equity Premium Puzzle for real estate assets, and concludes that the "puzzle" is even more pronounced for real estate than for the general stock market.

In contrast, employing a novel modeling twist by applying the CCAPM with stochastic taxation derived in Magin (2015b) to NAREIT data, Edelstein and Magin (2013) demonstrate that, for a range of reasonable stochastic tax burdens, the coefficient of relative risk aversion for US Equity REITs shareholders is likely to fall within the interval of 4.32 to 6.29, values significantly lower than those reported in most prior studies for real estate and other asset markets. These results imply that the CCAPM with stochastic taxation will generate reasonable fundamentally determined REIT asset prices.

III. Developing and Testing CCAPM for REITs Pricing

In this section, we delineate two related theoretical models for computing the fundamental value for REITs. We then examine statistically for each of our REIT fundamental values how well the theory fits actual, observed REIT market prices. In this way, by presenting an explicit theory for asset pricing first and subsequently testing it empirically, we are following the time honored recommended practices advocated by economists, such as Lucas (1976) and Koopmans (1947). Since the CCAPM with stochastic taxation generates a reasonable coefficient of risk aversion, a first natural application is to use this model to create theoretical REITs asset prices. We dub this first theoretical price to be the "Fundamental REIT Value, without money." The money supply, as discussed above, is believed by many to have a special impact on asset prices. Hence, we use here a second extension of the CCAPM with stochastic taxation and money supply to derive a second measure for REIT fundamental value. We dub this second theoretical price to be the "Fundamental REIT Value, with money."

1. CCAPM with Stochastic Dividend Taxation and without Monetary Policy

According to Magin (2016), CCAPM with stochastic dividend taxation and without monetary policy implies

$$p_{kt} = \left[\frac{e^{\mu_c + \frac{1}{2}\sigma_c^2}}{1 - e^{\mu_c + \frac{1}{2}\sigma_c^2}} \right] \cdot (1 - \tau_t) \cdot d_{kt} \; \forall k \in \{1, ..., n\}, \tag{1}$$

where p_{kt} is the price per share of an asset k at period t,

d_{kt} is the dividend per share paid by an asset k at period t,

τ_t is the dividend tax at period t,

$\mu_c = E\left[\ln b(\frac{c_{t+l+1}}{c_{t+l}})^{(1-a)}\right]$,

$\sigma_c^2 = VAR\left[\ln b(\frac{c_{t+l+1}}{c_{t+l}})^{(1-a)}\right]$.

Taking logarithms of both sides, we obtain

$$\ln\left[p_{kt}\right] = \ln\left[\frac{e^{\mu_c+\frac{1}{2}\sigma_c^2}}{1-e^{\mu_c+\frac{1}{2}\sigma_c^2}}\right] + \ln\left[(1-\tau_t)\cdot d_{kt}\right] \ \forall k \in \{1, ..., n\}. \qquad (2)$$

Let us quantify now this theoretical model.

Historically, Mehra (2003) and Mehra and Prescott (2003) finds that

$$E\left[\ln(\frac{c_{t+l+1}}{c_{t+l}})\right] = 0.02,$$
$$VAR\left[\ln(\frac{c_{t+l+1}}{c_{t+l}})\right] = 0.00125.$$

Set

$$b = \frac{1}{R_f} = \frac{1}{1.01} = 0.99.$$

Therefore, we estimate

$$\mu_c = \ln(0.99) + (1-a)\cdot 0.02,$$

$$\sigma_c^2 = (1-a)^2 \cdot 0.00125.$$

Thus,

$$\mu_c + \tfrac{1}{2}\sigma_c^2 = \ln(0.99) + (1-a)\cdot 0.02 + \tfrac{1}{2}\cdot(1-a)^2\cdot 0.00125.$$

Hence,

$$e^{\mu_c + \frac{1}{2}\sigma_c^2} = e^{\ln(0.99)+(1-a)\cdot 0.02+\frac{1}{2}\cdot(1-a)^2\cdot 0.00125}.$$

Edelstein and Magin (2013) estimated that for Equity REITs holders

$$4.32 < a < 6.29.$$

Therefore, it is reasonable for the purposes of our analyses to set

$$a = 5.$$

So

$$\left[\frac{e^{\mu_c+\frac{1}{2}\sigma_c^2}}{1-e^{\mu_c+\frac{1}{2}\sigma_c^2}}\right] = \left[\frac{e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}{1-e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}\right] = 13.8$$

and

$$\ln\left[\frac{e^{\mu_c+\frac{1}{2}\sigma_c^2}}{1-e^{\mu_c+\frac{1}{2}\sigma_c^2}}\right] = \ln\left[\frac{e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}{1-e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}\right] = 2.6247.$$

As in Edelstein and Magin (2013, 2014), we are assuming that the typical investor in REITs, who has below average ordinary income tax rates, pays an overall effective dividend tax rate $\tau^d_{re\ kt}$ of half of that of an investor in general stocks.[2] Therefore, using equation (2), we obtain the following expression for calculating theoretical prices of Equity REITs

$$\boxed{\ln\left[p_{kt}\right] = \mathbf{2.63} + \mathbf{1.00}\cdot \ln\left[(1-\tau^{d}_{re\ kt})\cdot d_{kt}\right]\ \ \forall k \in \{1, ..., n\}\,.} \tag{3}$$

Thus, equation (3) represents the resultant of applying the CCAPM with stochastic taxation, with our parametric assumptions, to REITs.

In order to test statistically the empirical validity of our theory, we regress, using OLS, the logarithm of the annual NAREIT real price index $\ln\left[\overline{p}_{kt}\right]$ for equity REITs against the logarithm of the annual after-tax real REIT dividend payout $\ln\left[(1-\tau^{d}_{re\ kt})\cdot d_{kt}\right]$ for the 1972-2013 time period.[3] We obtain the following OLS regression for 1972-2013:

$$\boxed{\ln\left[\overline{p}_{kt}\right] = \underset{(0.29)}{\mathbf{3.34}} + \underset{(0.13)}{\mathbf{0.89}}\cdot \ln\left[(1-\tau_{t})\cdot d_{kt}\right].} \tag{4}$$

$$Adjusted\ R^2 = 0.55,\ F - statistic = 49.98,\ DW - statistic = 0.98$$

Equation (4) is the regression output, analogous to the theoretical REIT pricing model equation (3). The empirical results are partially consistent with the theoretical model. In particular, the coefficient for after-tax REIT dividend payouts is statistically different from zero, but not statistically different from unity (both at the 1% confidence levels). On the other hand, the estimated value of the intercept term is statistically different from zero (at the 1% significance level) and statistically different (at the 5% level) from the theoretical model intercept value. The adjusted R^2 is 0.55. Hence, the empirical model explain a little more than half of the of the REIT price variation, during an era with several significant perceived bubbles in real estate markets.

Unfortunately, the Durbin Watson statistic associated with the OLS estimation for equation (4) indicates that there is significant autocorrelation.[4] Thus, the estimated coefficients are likely to be biased. In order to address this problem, we adopt a modified Error Correction Model (ECM). This statistical method will create indirectly unbiased coefficient estimators for the long-run equilibrium relationship between the price (value) of REITs and the after-tax dividends. See Appendix for the derivation of the modified Error Correction Model (ECM).

The form of the ECM will be:

$\Delta \ln [\overline{p}_{kt}] = \delta_0 + \delta_1 \cdot \Delta \ln [(1-\tau_t) \cdot d_{kt}] + \delta_2 \cdot \ln [\overline{p}_{kt-1}] + \delta_3 \cdot \ln [(1-\tau_{t-1}) \cdot d_{kt-1}] +$ $\phi_1 (DPRE\ 1989) + \phi_2 (D\ 2008) + \phi_3 (D\ 2009)$, where

$$DPRE\ 1989 = \begin{cases} 1\ if\ t \leqslant 1989 \\ 0\ otherwise \end{cases},$$

$$D\ 2008 = \begin{cases} 1\ if\ t = 2008 \\ 0\ otherwise \end{cases},$$

$$D\ 2009 = \begin{cases} 1\ if\ t = 2009 \\ 0\ otherwise \end{cases}.$$

Equation (4’) below represents the statistical estimation of the ECM, with the addition of fixed time effects for pre-1989, 2008, and 2009:

$$\Delta \ln\left[\overline{p}_{kt}\right] = \underset{(0.30)}{\mathbf{-0.98}} - \underset{(0.11)}{\mathbf{0.81}} \cdot \Delta \ln\left[(1-\tau_t)\cdot d_{kt}\right] + \underset{(0.07)}{\mathbf{0.37}} \cdot \ln\left[\overline{p}_{kt-1}\right] - \underset{(0.07)}{\mathbf{0.41}} \cdot \ln\left[(1-\tau_{t-1})\right.$$

$$\underset{(0.05)}{\mathbf{0.04}} \cdot (DPRE\ 1989) - \underset{(0.11)}{\mathbf{0.36}} \cdot (D\ 2008) - \underset{(0.15)}{\mathbf{0.55}} \cdot (D\ 2009). \qquad (4’)$$

$$Adjusted\ R^2 = 0.69$$

In turn, equation {4’) can be employed to generate the unbiased coefficient estimates for the long-term relationship for our theoretical model:

$$\ln\left[\overline{p}_{kt}\right] = \overset{\wedge}{\alpha} + \overset{\wedge}{\gamma} \cdot \ln\left[(1-\tau_t)\cdot d_{kt}\right]\ \forall k \in \{1, ..., n\},$$

$$\overset{\wedge}{\alpha} = \frac{-\delta_0}{\delta_2} = 2.64 \; (s.e. = 0.69),$$

$$\overset{\wedge}{\gamma} = \frac{-\delta_3}{\delta_2} = 1.11 \; (s.e. = 0.44).$$

The derived statistical results for $\overset{\wedge}{\alpha}$ and $\overset{\wedge}{\gamma}$ imply that each of these coefficients are statistically different from zero and statistically consistent with the economic theory personified in equation (3). Put somewhat differently, the statistical results suggest that the relationship described by equation (3) is an appropriate measure of fundamental long-run equilibrium value for REITs at each point in time.

It is claimed that monetary policy may have had a significant influence on the pricing of real estate assets at various times during the data sample time horizon, 1972-2013. In order to examine the influence of the real money supply on REIT prices, we will apply the CCAPM to include both stochastic taxation and real money supply.

2. CCAPM with Stochastic Dividend Taxation and with Monetary Policy

According to Magin (2016), CCAPM with stochastic dividend taxation and monetary policy implies

$$p_{kt} = e^{\mu_\tau + \frac{1}{2}\sigma_\tau^2} \cdot \left[\frac{e^{\mu_c + \frac{1}{2}\sigma_c^2}}{1 - e^{\mu_c + \frac{1}{2}\sigma_c^2}} \right] \cdot d_{kt} \; \forall k \in \{1, ..., n\}. \tag{5}$$

Taking logarithms of both sides, we obtain

$$\ln [p_{kt}] = \ln \left[e^{\mu_\tau + \frac{1}{2}\sigma_\tau^2} \cdot \frac{e^{\mu_c + \frac{1}{2}\sigma_c^2}}{1 - e^{\mu_c + \frac{1}{2}\sigma_c^2}} \right] + \ln [d_{kt}] \;\; \forall k \in \{1, ..., n\}, \tag{6}$$

where $\mu_\tau = E[\ln[1 - \tau_t]]$,

$\sigma_\tau^2 = VAR[\ln[1 - \tau_t]]$.

We also know that

$$\mu_\tau = -0.3560,$$

$$\sigma_\tau^2 = 0.0090.$$

So

$$\left[e^{\mu_\tau+\frac{1}{2}\sigma_\tau^2}\cdot\frac{e^{\mu_c+\frac{1}{2}\sigma_c^2}}{1-e^{\mu_c+\frac{1}{2}\sigma_c^2}}\right]=\left[e^{-0.3560+\frac{1}{2}\cdot 0.0090}\cdot\frac{e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}{1-e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}\right]=$$

$$e^{-0.3560+\frac{1}{2}\cdot 0.0090}\cdot 13.8$$

and

$$\ln\left[e^{\mu_\tau+\frac{1}{2}\sigma_\tau^2}\cdot\frac{e^{\mu_c+\frac{1}{2}\sigma_c^2}}{1-e^{\mu_c+\frac{1}{2}\sigma_c^2}}\right]=$$

$$\ln\left[e^{-0.3560+\frac{1}{2}\cdot 0.0090}\cdot\frac{e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}{1-e^{\ln(0.99)+(1-5)\cdot 0.02+\frac{1}{2}\cdot(1-5)^2\cdot 0.00125}}\right]=$$

$$-0.3560+\tfrac{1}{2}\cdot 0.0090+2.6247=2.2732.$$

Using equation (6), we obtain the following expression for calculating theoretical prices of Equity REITs

$$\boxed{\ln\left[p_{kt}\right]=\mathbf{2.72}+\mathbf{1.00}\cdot\ln\left[d_{kt}\right]\ \ \forall k\in\{1,...,n\}\,.}\tag{7}$$

Thus, Equation (7) represents the resultant of applying the CCAPM with both stochastic taxation and monetary policy, with our parametric assumptions, to Real Estate Investment Trusts.

In order to test statistically the empirical validity of our theory represented by Equation (7), we regress, using OLS, the logarithm of the annual NAREIT real price index $\ln\left[\overline{p}_{kt}\right]$ for equity REITs against the logarithm of the annual real REIT dividend payout $\ln\left[(d_{kt}\right]$ for the 1972-2013 time period. We obtain the following OLS regression for 1972-2013:

$$\boxed{\ln\left[\overline{p}_{kt}\right] = \underset{(0.43)}{\mathbf{2.81}} + \underset{(0.16)}{\mathbf{0.97}} \cdot \ln\left[d_{kt}\right].} \tag{8}$$

$$\textit{Adjusted } R^2 = 0.47,\ F - \textit{statistic} = 36.81,\ DW - \textit{statistic} = 0.95$$

Analogous to Equation (4), Equation (8) is the OLS regression for empirically testing the validity of the theoretical REIT pricing model, inclusive of the real money supply, Equation (7). In Equation (8), the values of the regression intercept and the coefficient for the REIT real annual dividend payouts are statistically different from zero (at the 1% level), but not statistically different from the theoretical numerical values computed in Equation (7). That is, the statistical results are consistent with the theoretical REIT pricing model, with the inclusion of the real money supply. The overall fit for the OLS regression is 0.47.

However, the Durbin Watson statistic associated with the OLS estimation for equation (8) suggests that there is a significant autocorrelation problem. In such circumstances, the estimated coefficients for equation (8) are likely to be biased. In order to address this issue, as we have done similarly above for equation (4) for the stochastic taxation theoretical model, we employ a modified Error Correction Model (ECM) for the stochastic taxation - money supply theoretical model. The ECM will permit us to derive unbiased coefficient estimators for the long-run equilibrium relationship between the price (value) of REITs and the dividends (for the stochastic taxation/money supply theoretical model). The form of the ECM will be:

$$\Delta \ln\left[\overline{p}_{kt}\right] = \delta_0 + \delta_1 \cdot \Delta \ln\left[d_{kt}\right] + \delta_2 \cdot \ln\left[\overline{p}_{kt-1}\right] + \delta_3 \cdot \ln\left[d_{kt-1}\right] + \\ \phi_1 \cdot (DPRE\ 1989) + \phi_2 \cdot (D\ 2008) + \phi_3 \cdot (D\ 2009).$$

Equation (8') represents the statistical estimation of the ECM, with the addition of fixed time effects for pre–1989, 2008,and 2009:

$$\Delta \ln\left[\overline{p}_{kt}\right] = -\underset{(0.24)}{\mathbf{0.59}} - \underset{(0.09)}{\mathbf{0.87}} \cdot \Delta \ln\left[d_{kt}\right] + \underset{(0.06)}{\mathbf{0.36}} \cdot \ln\left[\overline{p}_{kt-1}\right] - \underset{(0.07)}{\mathbf{0.49}} \cdot \ln\left[d_{kt-1}\right] \\ + \underset{(0.05)}{\mathbf{0.04}} \cdot (DPRE\ 1989) - \underset{(0.10)}{\mathbf{0.33}} \cdot (D\ 2008) - \underset{(0.13)}{\mathbf{0.56}} \cdot (D\ 2009). \tag{8'}$$

$$Adjusted\ R^2 = 0.76$$

Equation (8') can be utilized to create the unbiased coefficient estimates for the long-term relationship for our theoretical model:

$$\ln\left[\overline{p}_{kt}\right] = \overset{\wedge}{\alpha} + \overset{\wedge}{\gamma} \cdot \ln\left[d_{kt}\right] \; \forall k \in \{1, ..., n\},$$

$$\overset{\wedge}{\alpha} = \tfrac{-\delta_0}{\delta_2} = 1.61 \; (s.e. = 0.55),$$

$$\overset{\wedge}{\gamma} = \tfrac{-\delta_3}{\delta_2} = 1.36 \; (s.e. = 0.50).$$

The derived statistical results for $\overset{\wedge}{\alpha}$ and $\overset{\wedge}{\gamma}$ imply that each of these coefficients are statistically different from zero and statistically consistent with the theoretically determined coefficients in equation (7), the theoretically derived pricing model with stochastic taxation and money supply. Put somewhat differently, the statistical results suggest that the relationship described in Equation (7) is an appropriate measure of fundamental long-run equilibrium value for REITs at each point in time.

These overall statistical results (derived by using the ECM's to estimate equations (4') and (8')) imply that the long- run theoretical equilibrium price/dividend relationships from equations (3) and (7) provide reasonable measures for REIT fundamental values over time.

IV. Analyzing REITs Bubbles

Let us turn now to the analysis of REITs bubbles. Conventionally, the asset-pricing bubble for an asset k at time t is defined as the difference $\overline{p}_{kt} - p_{kt}$ between the actual market price $\overline{p}_{kt}$ of an asset and its fundamental p_{kt}.

To provide a visual sense for REIT bubbles during the 1972-2013 time period, Figures 1 and 2 track actual market prices $\overline{p}_{kt}$ versus theoretical prices p_{kt}. The actual (market) REIT price index in Figure 1 and Figure 2 is set to be 100 for 1972. Figure 1 charts theoretical REITs prices p_{kt} generated by the CCAPM with stochastic taxation τ_t and without the real money supply $\frac{M_t}{P_t}$, i.e., equation (1), and actual market prices $\overline{p}_{kt}$ for Equity REITs for the period of 1972–2013.

Similarly, Figure 2 below charts theoretical REITs prices p_{kt} generated by the CCAPM with stochastic taxation τ_t and with real money supply $\frac{M_t}{P_t}$, i.e., equation (5), and actual market prices $\overline{p}_{kt}$ for Equity REITs for the period of 1972–2013.

Figures 1 and 2 provide a pictorial vision of REITs booms, busts, bubbles between 1972 and 2013. A careful examination of these Figures indicates that positive and negative bubbles suggested by our models are consistent with regulatory changes and economic events. For example, the negative bubble (i.e., the market undervaluation for REITs vis-à-vis our theoretical fundamental valuations) during the 1973 and 1974 reflects the fact that real estate markets, in general, and REITs, in particular, were in substantial decline caused, at least in part, by the recessionary economy. The change in the Tax Law in 1986 made REITs more attractive to real estate investors versus public and private syndication vehicles. These tax changes created a boom/positive bubble for REITs between 1986 and 1989, especially reflected Figure 1, and to a lesser extent, in Figure 2. Figures 1 and 2 identify significant negative REITs bubbles during the general decline in real estate markets and a concomitant elongated recession during 1989-1991. For most of the subsequent 1990's there was a robust market for REITs, and an emergence of many REIT IPOs and secondary offerings. During this time period, there was a pronounced REIT market ebullience. Figure 1 and especially Figure 2 suggest a prolonged REIT market positive bubble. The REIT positive bubbles declined as the DotCom boom peaked around 2000. The DotCom boom was precipitously followed by the DotCom bust. In this DotCom bust environment, investors preferences changed, and were seeking cash flowing investments. Thus, REITs became a market favorite for investing during the early 2000's. This set of circumstances is reflected by a series of positive bubbles for REITs between 2000 and 2007 in Figures 1 and 2. The REIT industry struggled beginning in 2007 as the Global Financial Crisis affected most asset markets. REIT values plunged during the Great Financial Crisis, and, as many believe, REIT prices declined to levels that were substantially below their fundamental value. Figures 1 and 2 are consistent with these notions about the great financial crisis, with a negative bubble for REITs pricing occurring in 2008. Because of the Great Financial Crisis many Listed Equity REITs responded by deleveraging and increasing their equity positions. As equity REITs became solvent and interest rates declined, investors were attracted back to REITs. The REIT market has experienced a boom during 2010-2013; in fact, according to our models for fundamental value, many stock analysts, and as reflected in Figure 1 and 2, REITs have been in a period of positive bubbles. Hence, overall, we believe, our models provide reasonable methods for detecting asset pricing bubbles in the REIT market.

FIGURE 1: THEORETICAL AND MARKET PRICES FOR EQUITY REITs FOR 1972-2013

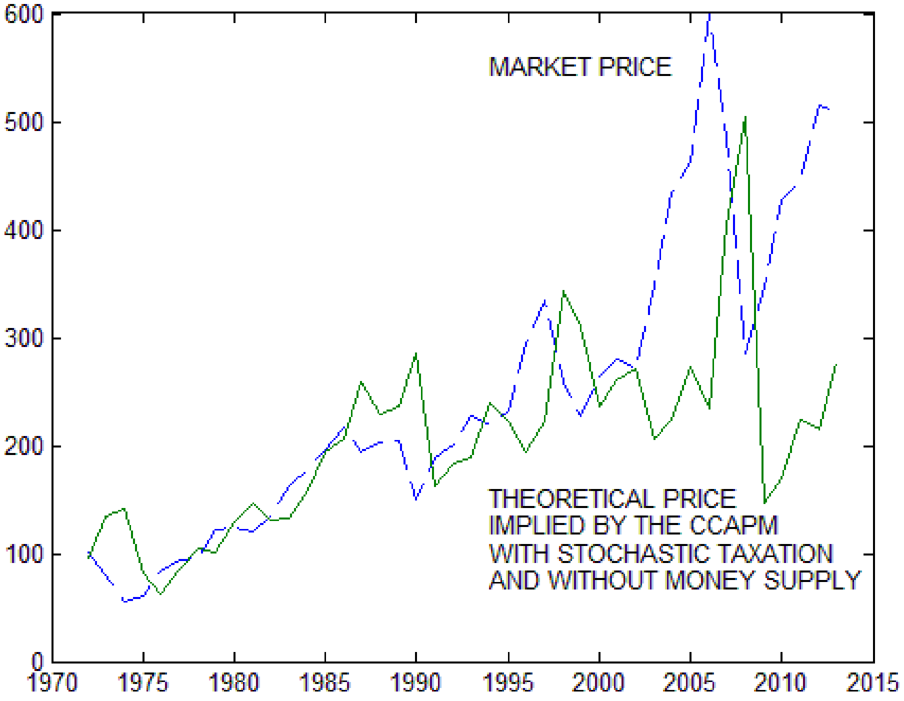
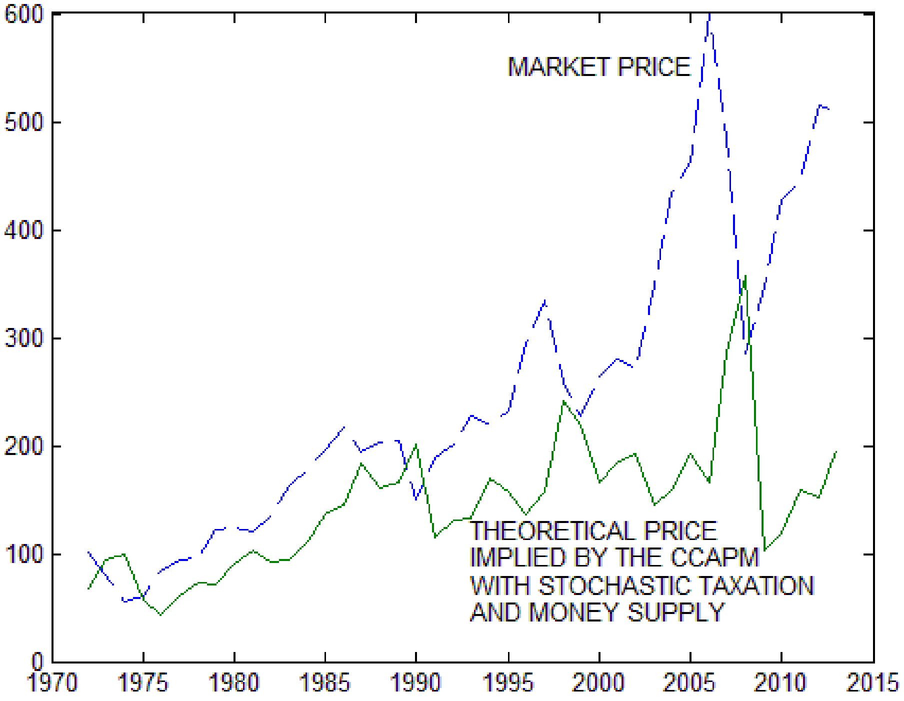


FIGURE 2: THEORETICAL AND MARKET PRICES FOR EQUITY REITs FOR 1972-2013



As discussed above, a large prevalent quantum of earlier research indicates that, in the short run, a driving force for the generation of asset price bubbles is the unanticipated rapid growth in debt instruments, in general, and the money supply, in particular. Given the log-linear nature of the CCAPM, as is evident by Equations (3) and (7), it is natural then to create a simple statistical test to examine the empirical impact of the log of the money supply, $\ln\left[\frac{M_t}{P_t}\right]$, upon the differential $\ln\left[\overline{p}_{kt}\right]-\ln\left[p_{kt}\right]$. Therefore, for the purposes of this analysis, it makes sense to define the asset-pricing bubble as $\ln\left[\overline{p}_{kt}\right]-\ln\left[p_{kt}\right]$. Equations (9) and (10) below represent partial statistical tests for the effect of changes in the log of the US real money supply, $\ln\left[\frac{M_t}{P_t}\right]$, upon US REITs bubbles $\ln\left[\overline{p}_{kt}\right]-\ln\left[p_{kt}\right]$ during the 1972-2013 time horizon

$$\ln\left[\overline{p}_{kt}\right]-\ln\left[p_{kt}\right]=-\underset{(0.66)}{\mathbf{2.50}}+\underset{(0.20)}{\mathbf{0.86}}\cdot\ln\left[\frac{M_t}{P_t}\right]. \tag{9}$$

$$\mathit{Adjusted}\ R^2=0.30,\ F-\mathit{statistic}=18.17$$

In Equation (9), using OLS, the dependent variable is $\ln\left[\overline{p}_{kt}\right]-\ln\left[p_{kt}\right]$, where $\ln\left[p_{kt}\right]$ is given by Equation (3), i.e., it is derived from the CCAPM with stochastic taxation but without money supply. The independent variable is $\ln\left[\frac{M_t}{P_t}\right]$. This regression suggests that increases in the real money supply statistically explain, in part, the US REIT price bubbles; the coefficient for the money supply is statistically significant at the 1% level. The positive coefficient for the money supply implies that the difference between the observed actual REIT market price and the theoretical REIT price increases as the money supply grows. Put somewhat differently, ceteris paribus, increases in the real money supply explain a portion of the variation in $\ln[\overline{p}_{kt}] - \ln[p_{kt}]$. The adjusted R^2 implies that, in the short run, the money supply explains 30% of the variation in $\ln[\overline{p}_{kt}] - \ln[p_{kt}]$.

Similar to Equation (9), in Equation (10), using OLS, the dependent variable is $\ln[\overline{p}_{kt}] - \ln[p_{kt}]$, where $\ln[p_{kt}]$ is now given by Equation (7), i.e., it is derived from the CCAPM with both stochastic taxation and money supply. Again, the independent variable is $\ln\left[\frac{M_t}{P_t}\right]$

$$\ln[\overline{p}_{kt}] - \ln[p_{kt}] = \underset{(0.65)}{-\mathbf{2.89}} + \underset{(0.20)}{\mathbf{0.98}} \cdot \ln\left[\frac{M_t}{P_t}\right]. \tag{10}$$

$$\textit{Adjusted } R^2 = 0.36,\ F - \textit{statistic} = 24.31$$

The statistical results from Equation (10) are similar to those found for Equation (9). The coefficient for the log money supply is statistically significantly positive at the 1% level. The overall fit for Equation (10) explains 36% of the variation between the REIT market price and the theoretical model REIT price.

Taken together, the statistical results from Equations (9) and (10) are consistent with the notion that, in the short run, the money supply (monetary policy) can have a significant impact upon the magnitude of US REIT pricing bubbles. While the statistical findings are for a particular market, the US REIT market during a relatively short time horizon, they do provide new confirming evidence for earlier research that claims that the money supply is an important determinant of the magnitude of asset pricing bubbles.

V. Conclusion

This paper identifies United States REITs price bubbles using the NAREIT database, 1972-2013. For this analysis, a bubble is defined for publicly traded REITs to be the difference between the log of the actual, observed stock price and the log of the intrinsic, fundamental value at a point in time. We employ two similar models for estimating fundamental value. The first fundamental, intrinsic value is calculated by utilizing the CCAPM with stochastic taxation and with reasonable parametric assumptions. Since the money supply (and other debt instruments) are believed by many to play a crucial role in the generation of asset bubbles, we extend our earlier analysis to calculate a second measure of fundamental value by utilizing the CCAPM with both stochastic taxation and money supply. For analytical purposes, REITs provide a preferred natural laboratory experiment for bubble testing because of the rules governing net income taxation and dividend distributions; in essence, REITs basically are pass-through vehicles without taxation at the entity level, permitting our theoretical modeling to focus upon the inclusion of shareholder-investor taxation, without the additional complications of investment vehicle taxation. Taken together, the two modified CCAPM fundamental value measures we are using and the special structure of REITs create a setting for streamlined statistical analyses for testing for the presence of asset price bubbles.

Our analysis and findings suggest that REITs price bubbles are omnipresent and statistically significant during our sample time horizon. Moreover, changes in the money supply appear to play a role in generating REIT bubbles. While we provide plausible macroeconomic rationales for the various sequences of bubbles, our research should be characterized as identifying but not necessarily explaining the root causes, the intensities and/or the persistency of these bubbles. We leave the determining of causal explanations and the intensity-persistency relationships between REITs bubbles and other variables as a task for future research.

VI. Appendix

The error correction model (ECM) is designed to create statistically unbiased coefficient estimators in the presence of autocorrelation. The error correction model is described by equation (A1):

$$\ln\left[\overline{p}_{kt}\right] = \mathbf{B_0} + \mathbf{B_1}\cdot \ln\left[X_t\right] + \mathbf{B_2}\cdot \ln\left[X_{t-1}\right] + \mathbf{B_3}\cdot \ln\left[\overline{p}_{kt-1}\right] \;\; \forall k \in \{1,...,n\}\,, \tag{A1}$$

where

$$X_t = (1-\tau_t)\cdot d_{kt} \;\forall k \in \{1,...,n\}\,.$$

The underlying long-term relationship from the theoretical model for REIT pricing can be described as equation (A2):

$$\ln\left[\overline{p}_{kt}\right] = \boldsymbol{\alpha} + \boldsymbol{\gamma}\cdot \ln\left[X_t\right] \;\; \forall k \in \{1,...,n\}\,, \tag{A2}$$

In long-run equilibrium, it is assumed that

$$\ln\left[\overline{p}_{kt}\right] = \ln\left[\overline{p}_{kt-1}\right] \;\; \forall k \in \{1,...,n\} \;\text{ and }\; \ln\left[X_t\right] = \ln\left[X_{t-1}\right], \tag{A3}$$

Therefore,

$$\boldsymbol{\alpha} = \frac{\mathbf{B_0}}{1-\mathbf{B_3}} \text{ and } \boldsymbol{\gamma} = \frac{\mathbf{B_1}+\mathbf{B_2}}{1-\mathbf{B_3}}.$$

Subtracting $\ln\left[\overline{\mathbf{p}}_{\mathbf{kt-1}}\right]$ from both sides of equation (A1) and adding and subtracting $\mathbf{B_1}\cdot\ln\left[X_{t-1}\right]$ from the right-hand side of equation (A1) produces

$$\Delta\ln\left[\overline{p}_{kt}\right] = -\left(\mathbf{B_3}-1\right)\cdot\boldsymbol{\alpha}+\mathbf{B_1}\cdot\Delta\ln\left[X_t\right]+\left(\mathbf{B_3}-1\right)\cdot\ln\left[\overline{\mathbf{p}}_{\mathbf{kt-1}}\right]+\left(1-\mathbf{B_3}\right)\cdot\boldsymbol{\gamma}\cdot\ln\left[X_{t-1}\right]\ \ \forall k\in\{1,...,n\} \tag{A4}$$

Equation (A4) can be rewritten for convenience as:

$$\Delta\ln\left[\overline{p}_{kt}\right] = \boldsymbol{\delta_0}+\boldsymbol{\delta_1}\cdot\Delta\ln\left[X_t\right]+\boldsymbol{\delta_2}\cdot\ln\left[\overline{\mathbf{p}}_{\mathbf{kt-1}}\right]+\boldsymbol{\delta_3}\cdot\ln\left[X_{t-1}\right]\ \ \forall k\in\{1,...,n\}, \tag{A4'}$$

such that

$$\delta_{\mathbf{0}} = (1-B_3)\cdot\alpha,$$

$$\delta_1 = B_1,$$

$$\delta_2 = B_3-1,$$

$$\delta_3 = (1-B_3)\cdot\gamma.$$

Equation (A4') becomes the statistical relationship to be estimated in order to correct for the coefficient estimation biases created by autocorrelation. Equation (A4'), with fixed time effects added, is the relationship estimated above as equation (4').

Using a similar approach for the ECM, equation (8') can be derived to generate coefficient estimates for $\overset{\wedge}{\alpha}$ and $\overset{\wedge}{\gamma}$ for the fundamental REITs pricing model with both stochastic taxation and money supply.

Notes

[1] See Magin (2015b) for the original derivation of the CCAPM with stochastic taxation. See Magin (2016) for the derivation of the infinite horizon CCAPM with stochastic taxation and money supply. See Edelstein and Magin (2013) for our prior analysis of REITs.

[2] Effective dividend tax rates for investors in general stocks can be found at

http://users.nber.org/~taxsim/marginal-tax-rates/af.html

[3] Calculations are based on monthly NAREIT ALL EQUITY REITs INDEX data for Equity REITs prices and dividends.

[4] It is not surprising that there exists autocorrelation for the NAREIT rate of return (log price) data series. This empirical issue of autocorrelation in REIT stock data has been identified by several researchers. It is the other side of the coin for research that finds "momentum" in stock market returns. See for examples, Goebel, Harrison, Mercer, and Whitby (2013) and Hung and Glasscock (2010).

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