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Koichi Iwai

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Financial Research Center (FSA Institute)
Financial Services Agency
Government of Japan
3-2-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-8967, Japan

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Koichi IWAI[†]

Abstract

This paper investigates possible obstacles to the Law of One Price in Japanese ETF markets. Our findings suggest that there are at least two major reasons why the Law fails in the markets. First, the difference in the speed of price discovery between the primary and secondary markets causes mispricing. Unique institutions in Japanese ETF markets could be potential sources of this phenomenon. Second, idiosyncratic noise trader risks seem to prevent arbitrageurs from engaging in long-short arbitrage trading. Unlike previous studies, systematic investor sentiment is not found to be a major obstruction in Japanese ETF markets.

Key Words: Exchange-traded funds, the Law of One Price, investor sentiment, market microstructure

[†] Research Fellow, FSA Institute, Financial Services Agency. This paper represents the personal views of the author and is not the official view of the Financial Services Agency or FSA Institute. Any possible errors in the paper are entirely the responsibility of the author.

1. Introduction

In traditional finance theory, the Law of One Price is taken for granted. That is, since the market price of a financial asset ought to coincide with the present value of cash flows generated by the asset—namely, its fundamental value—, if multiple assets have the same cash flow, they will have the same market price. According to this line of thinking, any fluctuations in a market price are caused by changes in the fundamental value itself.

However, a variety of phenomena contrary to this basic principle have been observed in actual financial markets; for example, financial assets which are supposed to have the same fundamental value have different market prices, and significant asset price fluctuations occur which cannot be explained in terms of variation of fundamental values. With regard to the reasons why the Law of One Price fails, many theoretical models have been proposed—some of which incorporate the effects of short-selling constraints, noise trader risk, and investor sentiment—and a number of empirical studies have also been reported. Nevertheless, researchers have not yet reached a shared consensus on the obstacles to the Law.

This paper explores the reasons why the Law of One Price fails. By focusing our eyes on ETF markets, it saves us from explicitly formulating the fundamental value of an ETF, and so we can look closely at mechanisms whereby the Law fails. Furthermore, this paper presents the results of analyses on Japanese ETF markets and complements the discussions of existing literature while almost all previous studies paid attention to the U.S. and European markets.

The remainder of this paper is organized as follows. In the next section, we provide an overview of previous literature, and state the research interests in this paper. In section 3, we summarize the institutional characteristics of Japanese ETF markets, and present an asset pricing model and estimation formula which capture those characteristics. Section 4 reports two empirical analyses: we evaluate the extent to which an ETF’s return can be explained using its fundamental value, then, we examine the factors that cause mispricing in ETF markets.[1] We empirically verify whether or not market microstructures, investor sentiment and arbitrage risk hinder the Law. Finally, section 5 concludes this paper.

2. Related literature

Numerous phenomena that contradict the Law of One Price have been reported (see, Roll 1988, Cutler *et al*. 1989, Lamont and Thaler 2003). Why does the Law fail in financial markets? The first thing that probably comes to mind is short-selling constraints. In the case of goods markets, even supposing that real assets with the same value were traded at different prices, a lack of a lending market and related institutions would prevent possible arbitrage trading using short selling. Consequently, mispricing sometimes remains. On the other hand, in the case of financial markets, short-selling can generally be conducted with relative ease because lending tools and accompanying institutions are available. Notwithstanding, the Law has been found to fail for a number of financial products even in situations

[1] In this paper, a price (or pricing) that is likely to contradict the Law of One Price is termed “mispricing.”

where the securities can be sold short without any constraints. Therefore, it is difficult to regard short-selling restrictions as a principal factor of mispricing.

As for causes aside from short-selling constraints, attention has been drawn to such factors as arbitrage risk (noise trader risk), investor sentiment and investor heterogeneity, and theoretical investigation along these lines has been active recently. De Long *et al*. (1990) and Shleifer and Vishny (1997) show that arbitrage could be obstructed by noise trader risk. Liu and Longstaff (2004) build a theoretical model taking collateral requirements into account, and they point out that the optimal arbitrage position for a risk-averse investor could be affected by fluctuations in the expected return on the arbitrage position. The larger the fluctuation of the arbitrage return, the more the arbitrage is constrained. Barberis *et al*. (2005) separate the mechanisms whereby multiple asset prices co-move into two branches of theory: (i) the traditional finance viewpoint that information about fundamentals is correlated, and (ii) the non-traditional view that investor sentiment has an impact on the price formation. Other scholars, such as Baker and Stein (2004), emphasize that asset prices will settle at a level that reflects the opinions of optimistic investors in the presence of short-selling constraints. Thus, despite a number of convincing hypotheses on obstacles to the Law, researchers are yet to reach a consensus on what exactly are the decisive factors.

The reason why previous literature fails to reach an agreement seems to be related to the fact that conducting rigorous empirical analysis of these issues is difficult. When verifying the Law of One Price, we inevitably come up against the problem that we cannot directly observe the fundamental value of a financial asset. In many cases, researchers assume a specific asset pricing model in order to address this problem, and end up regarding the theoretical price as the fundamental value. However, this method relies on two assumptions, namely, that the supposed asset pricing model is the true model, and that investors behave according to the asset pricing model. Consequently, even when we observe deviation of market price from its theoretical price which is now assumed to be the fundamental value, we cannot distinguish the two possible hypotheses: one that the assumed pricing model is not the true model, and the other that investors are not rational. In other words, it is difficult for researchers to determine a dominant obstacle to the Law with certainty.

If there were special circumstances where fundamental values could be observed directly, the Law of One Price could be verified with relative ease without assuming a specific asset pricing model. While not perfect, fundamental values can be observed to some extent with closed-end funds (CEF), twin shares, depository receipts, and exchange-traded funds (ETF) because multiple securities that generate the same cash flow are traded separately in these markets. Therefore, it is possible to regard the value of one security as the fundamental value of the other security. By utilizing this characteristic, we can examine the Law rigorously.

As for CEFs, it has been regarded as an anomaly that a price differential arises between the market price of a CEF and the market value of the assets held by that CEF. Lee *et al*. (1991), Bodurtha *et al*. (1995), Pontiff (1996, 1997), Gemmill and Thomas (2002), and Cherkes *et al*. (2009) suggest taxation factors, liquidity (redeemability), agency costs and investor sentiment as possible obstacles to the Law. However, it is still hard to examine precisely the causes of mispricing in CEF markets, because fund managers have discretion over the management of funds and information on fund holdings is not necessarily disclosed frequently.

In contrast, the problems raised with regard to CEFs have no bearing on twin shares or depository receipts. Some researchers focus on these two markets and assess the validity of the Law of One Price. Froot and Dabora (1999), Scruggs (2007), Mei *et al*. (2009), and Gagnon and Karolyi (2010) point out that the Law fails in these markets, and report a significant relationship between the return on an individual security and the market return on which the security is listed. This relationship is supposed to substantiate the claim that investors' sentiment and their heterogeneity could affect asset prices. As seen in these studies, attention is being drawn to the possibility that investor sentiment hinders the Law.

It must be noted that these arguments contain many unresolved issues; for instance, how should investor sentiment be measured, and what variables will serve as better proxy variables. In particular, existing studies handle the issues about an appropriate proxy variable in different ways. Baker and Wurgler (2007) and Chen *et al*. (2010) list several different variables observed in financial markets as potential proxy indicators of investor sentiment.[2] Barberis *et al*. (2005) and Scruggs (2007) regard the overall index return of the market on which a security is listed as the proxy of investor sentiment. In contrast, Ofek and Richardson (2003), Baker and Stein (2004), and Hong and Stein (2007) take a stance that measures of liquidity, such as trading volume turnover, are indicative of investor sentiment. Karpoff (1986), and Harris and Raviv (1993) discuss the relationship between the heterogeneity of investors and trading volume. Meanwhile, Brown and Cliff (2005) use data from investor surveys. As this shows, various methods have been explored for developing appropriate indicators of investor sentiment, but a commonly agreed method is yet to be established.

The difference between the market price of an ETF and the market value of the assets held by the ETF (net asset value, NAV hereafter) is also analyzed recently. Market price and NAV are expected to converge smoothly since the number of issued shares (number of ETF shares) changes through in-kind transactions.[3] Since it is common to focus on cross-listed shares when analyzing twin shares and depositary receipts, existing empirical findings on these markets are affected by differences in trading hours and foreign exchange risks. In contrast, ETFs linked to a domestic share price index avoid these problems. Thus, it is arguable that ETF markets are sufficiently endowed with properties desirable for examining the Law of One Price.

There are two viewpoints as to why an ETF's market price and NAV diverge: the view that institutions and transaction costs are the cause, and the opinion that looks for the cause in investor sentiment and investor behavior. For example, DeFusco *et al*. (2007) regard the process for in-kind transactions and the number of stocks held by the ETF as possible causes for the mispricing. Jares and Lavin (2004) suggest the possibility that, with an ETF linked to an overseas share price index, differences in trading hours could be

[2] There have also been trials to create a single index (composite index) based on individual proxy variables.
[3] "In-kind transaction" refers to a transaction whereby beneficiary certificates (ETF shares) of an ETF are exchanged with a package of underlying assets held by the ETF. Such transactions form the basis of arbitrage in ETF markets. Refer to Iwai (2009) for further details.

causing a divergence between the market price and NAV. On the other hand, Delcoure and Zhong (2007) point out that explaining mispricing in ETFs from the rational investors' perspective is difficult, and they suggest the possibility of irrational effects, such as the overconfidence of investors. Gleason *et al.* (2004) observe that the behavior of investors in U.S. ETF markets differs depending on whether the markets are in up or down trends. In addition, Engle and Sarkar (2006) comment that price formation is less efficient for ETFs linked to overseas equity indexes than ETFs indexed to domestic indexes, and regard investors' expectations as a possible causal factor. Simon and Sternberg (2005) analyze ETFs listed in the U.S. that are linked to European equity indexes. They show that an ETF's market price in the U.S. market can predict the NAV return in the European market, and at the same time suggest that the market price in the U.S. market possibly overreacts to movements in the U.S. stock markets.

As for the Japanese ETF markets, there are few empirical research. Iwai (2009, 2010, 2011) suggest that both low liquidity and a lack of several institutions — market makers with affirmative liquidity obligations, the indicative NAV and the Portfolio Composition File (PCF) — seem to contribute to the inefficient price formation, but they do not consider any effect of investors sentiment.

As described above, when examining the Law of One Price, analysis on ETF markets would be useful because it does not require fundamental values to be explicitly modeled. However, even if explicit formularization of fundamental values can be avoided, there is still the issue of how to measure investor sentiment. This paper addresses the latter problem by using several proxy variables. This paper aims to make contributions in two ways. First, Japanese ETF markets have been outside the spotlight of previous studies, and so my analysis of Japanese markets provides new findings on the Law of One Price. Second, we will elicit suggestions on preferable institutional designs for ETF markets by explicitly incorporating into the analyses the various institutions and business practices unique to Japanese ETF markets.

3. Model

3.1. Market microstructure of ETF markets

Although the legal definition of ETFs varies from country to country, we can identify major characteristics common to U.S. and European ETF markets: ETFs is a collective investment scheme consisting of a primary market and a secondary market; the number of shares can change through in-kind transactions in the primary market, and; trades can be made at any time in the secondary market. In cases where the NAV, which is the "price" in the primary market, deviates from the market price, which is the "price" in the secondary market, arbitrage trading such as through in-kind transactions is expected to occur. Various institutions are devised in U.S. and European ETF markets so that arbitrage occurs swiftly and efficient price formation is achieved. Specifically: (i) publication/disclosure of indicative NAVs, (ii) publication of PCFs that include information on assets held, (iii) use of in-kind transactions, (iv) market makers with affirmative liquidity obligations, and (v) ETF derivative markets.

In contrast, market microstructure in Japanese ETF markets is different from that in the U.S. and European ETF markets: in Japanese ETF markets, (i) indicative NAVs are not used, (ii) the published information of PCFs is limited, (iii) there are many days on which in-kind transactions cannot be conducted,

(iv) there are no market makers with affirmative obligations, and (v) there are no ETF derivative markets.[4] Without indicative NAVs being used and with PCFs being imperfect, there is a chance that an information gap will arise between some institutional investors, such as authorized participants, and retail investors. In particular, even supposing that information about fundamentals is widely known among participants in the primary markets, since published information is insufficient, it is expected that the information will be communicated late to investors in the secondary markets. Moreover, the information about fundamentals will be slowly reflected in the secondary market price since arbitrage over secondary and primary markets becomes restricted on days on which in-kind transactions cannot be conducted.

3.2. Pricing model

Bearing in mind the peculiar market microstructure in Japan, we will derive a pricing model for ETF markets. We assume that both returns on primary and secondary markets can be determined using four mutually independent factors as proposed by Scruggs (2007). That is, we postulate that returns can be determined by:

$$r_{t,i}^{S} = u_{t,i}^{S} + \omega_{t,i}^{S} + \eta_{t,i}^{S} + \varepsilon_{t,i}^{S} \quad \cdot\cdot (1)$$

$$r_{t,i}^{P} = u_{t,i}^{P} + \omega_{t,i}^{P} + \eta_{t,i}^{P} + \varepsilon_{t,i}^{P} \quad \cdot\cdot (2)$$

The superscript letter S and P indicates secondary market and primary market respectively, while the subscript letter *t* refers to time and *i* specifies the identity of the securities. $r_{t,i}^{S}$ and $r_{t,i}^{P}$ indicate the market price return and the NAV return respectively. $u_{t,i}$ represents the change in fundamental value brought about by fundamental shocks to the economy as a whole, while $\omega_{t,i}$ is the change in fundamental value arising due to a firm-specific fundamental shock. $u_{t,i}, \omega_{t,i}$ are both independent in terms of time. $\eta_{t,i}$ is the systematic noise shock arising due to the change in noise trader sentiment. This shock can be correlated in cross sections. In contrast, $\varepsilon_{i,t}$ is the shock attributable to changes in noise trader sentiment that is specific to the security.

As described earlier, indicative NAVs and PCFs are used imperfectly in Japanese ETF markets. As a result, the speed at which new information on fundamentals is reflected in prices —called "*price discovery speed*" hereafter— might be different between the primary and secondary markets. It is also possible that *price discovery speed* in secondary markets will become even slower on days on which in-kind transactions are not allowed. In order to model these features, we define $\upsilon_{t,i}^{S} \equiv u_{t,i}^{S} + \omega_{t,i}^{S}$, $\upsilon_{t,i}^{P} \equiv u_{t,i}^{P} + \omega_{t,i}^{P}$, and postulate the following equations:

$$\upsilon_{t,i}^{S} = \alpha \upsilon_{t,i}^{P} + (1-\alpha)\upsilon_{t-1,i}^{P}, \quad t \in \text{days when in kind transactions are allowed} \quad \cdot\cdot (3)$$

$$\upsilon_{t,i}^{S} = \beta \upsilon_{t,i}^{P} + (1-\beta)\upsilon_{t-1,i}^{P}, \quad t \in \text{days when in kind transactions are not allowed} \quad \cdot\cdot (4)$$

Here, α, β are constants that satisfy $0 < \alpha, \beta < 1$. Equation (3) and (4) demonstrate that information on fundamentals that arises at time *t* is fully reflected in the primary market whereas only some information,

[4] It is only recently that indicative NAVs and PCFs have begun to be used. Specifically, the Tokyo Stock Exchange has just commenced calculating and publishing indicative NAVs for some ETFs in April 2011, and the Osaka Securities Exchange has indicated a policy of publishing PCFs. However, indicative NAVs were not being used and information on PCFs was imperfect during the sample period of this paper. Refer to Iwai (2009, 2010, 2011) for more on this point and on the difference in market microstructure between domestic and international ETF markets.

which is captured thorough parameters α and β, is incorporated in the secondary market at the same time, while the remainder of the information will be reflected at time t+1. Supposing that *price discovery speed* in the secondary market was to become even slower on a non-trading day, it follows that,

$$0 < \beta < \alpha < 1 \tag{5}$$

Thus, on days when in-kind transactions are allowed, the return difference between the primary market and secondary market ($r_{t,i}^{S-P}$) can be expressed as:

$$\underbrace{r_{t,i}^{S-P}}_{\text{Return difference}} = \underbrace{(\alpha-1)\upsilon_t^P - (\alpha-1)\upsilon_{t-1}^P}_{\text{Fundamentals shock}} + \underbrace{(\eta_t^S - \eta_t^P)}_{\text{Systemic noise shock}} + \underbrace{(\varepsilon_t^S - \varepsilon_t^P)}_{\text{Firm-specific noise shock}} \tag{6}$$

and on days when in-kind transactions are not allowed, it can be expressed as:

$$r_{t,i}^{S-P} = (\beta-1)\upsilon_t^P - (\beta-1)\upsilon_{t-1}^P + (\eta_t^S - \eta_t^P) + (\varepsilon_t^S - \varepsilon_t^P) \tag{7}$$

Return difference, $r_{t,i}^{S-P}$, on the left side of the equation is comprised of fundamentals shock, systematic noise shock, and firm-specific noise shock. It could also be construed that this return difference represents the return on the long-short position extending over the primary and secondary markets.[5] Now, if we posit some assumptions[6] between the factors of equation (1) and equation (2), we get:

$$Cov\left(r_{t,i}^{S-P}, r_{t-1,i}^{S-P}\right) = -(\alpha-1)^2 Var\left(\upsilon_{t-1,i}^P\right), t \in \text{days when in kind transactions are allowed} \tag{8}$$

$$Cov\left(r_{t,i}^{S-P}, r_{t-1,i}^{S-P}\right) = -(\beta-1)^2 Var\left(\upsilon_{t-1,i}^P\right), t \in \text{days when in kind transactions are not allowed} \tag{9}$$

This demonstrates that, under certain conditions, the return difference exhibits negative first-order serial correlation. If equation (5) holds true, then it follows that $0 > -(\alpha-1)^2 Var\left(\upsilon_{t-1,i}^P\right) > -(\beta-1)^2 Var\left(\upsilon_{t-1,i}^P\right)$, and the negative serial correlation becomes more pronounced on days when in-kind transactions are restricted.

3.3. Estimation model

Based on the similar pricing model in the previous section, Scruggs (2007) proposes a GARCH model in which the return difference is an dependent variable while its first-order lag and investor sentiment index are the explanatory variables (equations (10)-(12)).[7] However, the estimation model adopted by Scruggs (2007) does not include fundamental shock at time t as an explanatory variable which appears in equation (6). In this paper, we first estimate the same model as that found in Scruggs (2007). In addition, we report

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[5] $r_{t,i}^{S-P}$ is the return difference at the same point in time. Therefore, the term "long-short position" as used here refers to a trading strategy reconstructing positions at each point in time. The definition adopted in this paper would be inappropriate if we were composing a long-short position extending over a secondary market and primary market at a certain point in time and then examining what kind of returns were being generated by this position over time. In this paper, since we are focused on the reasons why return differences arise between the secondary and primary markets, our analysis has been conducted using return difference at the same point in time.

[6] In this paper, due to space constraints, we have not stipulated all the preconditions required for developing the model. Most of the omitted preconditions relate to the covariance between the factors contained in equation (1) and equation (2), and are not very restrictive.

[7] Froot and Dabora (1999) do not assume any GARCH terms in the error term, but estimate a similar model.

the results of another GARCH model which uses equation (10') instead of equation (10) and takes into account the fundamental variable at time *t*. The specific estimation formulae are:

$$r_{t,i}^{S-P} = c + \phi r_{t-1,i}^{S-P} + \delta I_{t,i} r_{t-1,i}^{S-P} + \lambda\left(Sentiment_{t,i}^{S} - Sentiment_{t,i}^{P}\right) + e_{t,i} \quad \cdot\ \cdot (10)$$

$$e_{t,i} \sim N\left(0, h_{t,i}\right) \quad \cdot\ \cdot (11)$$

$$h_{t,i} = c' + a h_{t-1,i} + b e_{t-1,i}^{2} \quad \cdot\ \cdot (12)$$

$$r_{t,i}^{S-P} = c + \phi r_{t-1,i}^{S-P} + \delta I_{t,i} r_{t-1,i}^{S-P} + \lambda\left(Sentiment_{t,i}^{S} - Sentiment_{t,i}^{P}\right) + \xi r_{t,i}^{P} + e_{t,i} \quad \cdot\ \cdot (10')$$

In these equations, $I_{t,i}$ is a dummy variable where 1 indicates days on which in-kind transactions are allowed, and $Sentiment_{t,i}^{S}$ and $Sentiment_{t,i}^{P}$ are variables that capture investor sentiment at time *t* for the secondary market and primary market respectively. $c(c'), \phi, \delta, \lambda, \xi, a$ and b are coefficient parameters. $e_{t,i}$ is the error term, and is thought to include firm-specific noise shocks.

As described earlier, indicative NAVs and PCFs have not been fully utilized in Japan, and there is a possibility that *price discovery speed* in the secondary market is slower than in the primary market. Assuming this is true, then ϕ will be negative. Similarly, if not being able to conduct in-kind transactions makes *price discovery speed* in the secondary market even slower, then δ should be positive. Furthermore, as indicated in Scruggs (2007), and Froot and Dabora (1999), if systematic investor sentiment affects price, it is expected that λ will be positive.

4. Empirical results

4.1. Data

The sample is 53 ETFs, each of which is linked to a domestic share price index, for which all the necessary data are available (Table 1). Data source is QUICK Corp's Astra Manager. The sample period varies for each ETF according to data availability. The longest period is from August 2008 until August 2010, and all data are daily basis.

The variables are defined as follows. $r_{t,i}^{S-P}$ is the difference between the daily market return ($r_{t,i}^{S}$) and daily NAV return ($r_{t,i}^{P}$). $r_{t,i}^{S}$ is closing price basis while $r_{t,i}^{P}$ is calculated based on NAVs published by each ETF sponsor.[8]

Although it is preferable to identify the dates on which in-kind transactions are allowed when defining the $I_{t,i}$ series, there is no detailed public information about each ETF's in-kind transaction that can be accessed retroactively for our sample period. Therefore we regard the dates on which the number of ETF shares actually changes as dates when in-kind transactions are allowed. We create dummy variables which takes 1 if the number of ETF shares changes. In view of the practice of in-kind transactions in reality, we use the three dummy variables:[9]

[8] In order to make ex-dividend adjustments, we use adjusted NAV series in which dividends per share are subtracted from the NAV for the period between three business days and one business day prior to the ETF settlement date.

[9] For example, as far as "creation" is concerned, if the number of ETF shares increases in the timely-disclosure on day *t*, then the applications for the creation transaction are supposed to have already occurred during the period from *t* – 3 to *t* – 1. Accordingly, it is expected that investors, who make applications for "creation", conduct a series of arbitrage transactions during the period from *t* – 3 to *t* – 1.

$$I_{t,i} = \begin{cases} 1 \text{ if Changes in the number of ETF shares is confirmed on the x days later timely disclosure} \\ 0 \quad \text{otherwise} \end{cases}, \mathrm{x} = 1,2,3 \qquad \cdot \cdot (13)$$

On the basis of the arguments in previous studies, we use the following three proxies for $Sentiment_{t,i}^{S} - Sentiment_{t,i}^{P}$:

$$Sentiment_{t,i}^{S} - Sentiment_{t,i}^{P} =$$

$$\begin{cases} TOPIX\ return - ETF\ liked\ index\ return \\ Trading\ turnover\ on\ TSE\ 1st\ section - Trading\ \ turnover\ on\ ETF \\ dlog(Trading\ turnover\ on\ TSE\ 1st\ section) - dlog(Trading\ turnover\ on\ ETF) \end{cases} \qquad \cdot \cdot (14)$$

The two trading turnover variables in equation (14) are calculated as daily trading volume divided by total market value. We presume that investors' sentiment in the secondary market and that in primary market can be captured in the Tokyo Stock Exchange (TSE) First Section and in the relevant ETF market respectively.[10] Our reasoning for this assumption is as follows. Most of investors participating in the primary market are authorized participants and other institutional investors, and these investors are supposed to constantly monitor the detailed trends of ETF markets, collecting information on intraday prices and order flows of ETFs. Consequently, it seems to be reasonable to assume that the sentiment of these investors will be affected by movements in ETF markets. In contrast, a relatively large number of retail investors participate in the secondary market. Under the unique conditions that indicative NAVs and PCFs are imperfect, these investors in the secondary market will lag behind the investors in the primary market in acquiring the information on intraday movements in ETF markets, so they are likely to be influenced more by the general movements in stock markets rather than movements of an ETF.

4.2. Fundamentals

As a preliminary analysis, we decompose an ETF's market return into the component attributable to changes in fundamentals and that are not. Since any changes in fundamental value of an ETF are expected to be reflected in the NAV return, we will examine the linear model as shown in equation (15), in which market return is the dependent variable and NAV return is the explanatory variable.

$$r_{i,t}^{S} = c + \alpha_{-1} r_{i,t-1}^{P} + \alpha_0 r_{i,t}^{P} + \alpha_{+1} r_{i,t+1}^{P} + \varepsilon_{i,t} \qquad \cdot \cdot (15)$$

c, α_{-1}, α_0 and α_{+1} are coefficient parameters. Table 2 shows the summary of OLS estimation of equation (15) for each ETF.[11] For all ETFs, α_0 is significantly different from zero.[12] Furthermore, α_{-1} is significantly different from zero for about half of ETFs, whereas significant results could not be obtained for about 90% of the sample for α_{+1}. These findings show that the secondary market is affected by price changes in the primary market that occur on the same day and on the previous day. In particular, we could

[10] Since data from the TSE First Section is being used in $\mathrm{Sentiment}_{t,i}^{S}$, TOPIX-linked ETFs are excluded from analysis in this paper.

[11] Unit root tests (ADF test, 5% level) are conducted on $r_{i,t}^{S}$ and $r_{i,t}^{P}$, and they are confirmed to be stationary for almost all ETFs.

[12] In this paper, unless otherwise noted, statistical assessments are made with a significance level of 5%.

say that price discovery in the secondary market tends to lag at least one day behind the primary market for ETFs with α_{-1} being significantly different from zero. Furthermore, looking at R^2 to assess the fitness of the model, we notice that both the mean and median of R^2 is about 0.8, which implies approximately 20 percent of price changes in the secondary market would be brought about by factors other than fundamentals.[13]

4.3. Other factors

How then are the 20 percent of ETF price fluctuations not attributable to fundamentals occurring? We will examine this point by estimating the GARCH model introduced in section 3.2 for each ETF. Tables 3 and Table 4 are the results.[14] The GARCH model that includes equation (10) corresponds to Table 3 while the GARCH model based on equation (10') are reported in Table 4. We can confirm the following points. First, the estimates of ϕ are negative and significant for all ETFs. This indicates that *price discovery speed* in the secondary market is slower than in the primary market, and supports the view that the market microstructure in Japan, in which indicative NAVs and PCFs are imperfect, causes this phenomenon.

Second, the estimates of δ are positive and significant for many ETFs. Positive δ means that the secondary market incorporates fundamentals-related information relatively quickly on the day when in-kind transactions occur than on the day when they do not. In other words, this result suggests that arbitrage through in-kind transactions functions effectively. However, contrary to our expectation, we observe negative δs for a considerable number of ETFs. Hence, it is conceivable that the efficacy of in-kind transactions facilitating arbitrage does not necessarily appear for all ETFs.

Third, the estimates of λ are not significant except for the formularization set forth in Panel A of Table 3. Considering this result, there seems to be little chance that systematic investor sentiment causes mispricing in ETF markets.

Fourth, the result that R^2 is less than 0.6 for most ETFs suggests that firm-specific noise shocks would have a considerable effect on mispricing.

4.4. Robustness

The results of the previous section show that not only the differences in *price discovery speed* but also the firm-specific noise shocks could be an obstacle to the Law of One Price. In this section, we explicitly deal with the effects of firm-specific noise shocks on mispricing. Specifically, we estimate the following linear regression model with one of explanatory variables being the GARCH term ($\hat{h}_{i,t}$) of equation (10) and equation (10'). The dependent variable is the absolute value of the return difference, and $c, \beta_1, \beta_2, \beta_3, \beta_4$ and β_5 are coefficient parameters.

$$\left|r_{i,t}^{S-P}\right| = c + \beta_1\left|r_{i,t-1}^{S-P}\right| + \beta_2 I_{i,t}\left|r_{i,t-1}^{S-P}\right| + \beta_3\left|Sentiment_{i,t}^{S} - Sentiment_{i,t}^{P}\right| + \beta_4\hat{h}_{i,t} + \nu_{i,t} \quad \cdots (16)$$

[13] Almost the same conclusions are confirmed by estimating $r_{i,t}^{S} = c + \alpha_0 r_{i,t}^{P} + \varepsilon_{i,t}$ or $r_{i,t}^{S} = c + \alpha_{-1} r_{i,t-1}^{P} + \alpha_0 r_{i,t}^{P} + \varepsilon_{i,t}$, instead of equation (15).

[14] We conduct unit root tests (ADF test, 5% level) on each of the variables in equation (10) and equation (10'), and confirm that almost all variables are thought to be stationary.

$$\left|r_{i,t}^{S-P}\right| = c + \beta_1\left|r_{i,t-1}^{S-P}\right| + \beta_2 I_{i,t}\left|r_{i,t-1}^{S-P}\right| + \beta_3\left|Sentiment_{i,t}^{S} - Sentiment_{i,t}^{P}\right| + \beta_4\hat{h}_{i,t} + \beta_5\left|r_{i,t}^{P}\right| + \nu_{i,t} \quad \cdots (16')$$

Looking at the OLS results (Table 5, 6), we can confirm the following points. First, the estimates of β_1 are positive and significant for the majority of ETFs. This demonstrates that mispricing tends to continue, which is consistent with the fact that ϕs are negative and significant for all ETFs in equations (10) and (10').

Second, the estimates of β_2 are negative and significant for most ETFs. This shows that the degree of mispricing lessens in the situation where the number of ETF shares changes by way of in-kind transactions, which is consistent with the findings set forth in the previous section.

Third, the results for the estimates of β_3 are unstable. Significant results can occasionally be seen in cases where trading turnover is used as a proxy variable for investor sentiment (Panel B of Tables 5 and 6). This result is different from the finding of the previous section. In Tables 3 and 4, significant results are being obtained in cases where the return variable is used for investor sentiment. Taking an overall view of the results from Tables 3 to 6, it should be seen that the estimation results are greatly affected depending on which variable is used as the proxy for investor sentiment. In any case, the results of Tables 5 and 6 again show that the effects of systematic investor sentiment on price formation in ETF markets are not clear.

Fourth, the estimates of β_4 are positive and significant in the majority of cases. This finding supports the theoretical hypothesis of Liu and Longstaff (2004) that the greater the fluctuation of the returns on long-short positions, the more likely arbitrage will be obstructed, and consequently, mispricing will occur.

Lastly, the R^2 are at a higher level compared to Tables 3 and 4, but even still, the mean remains at about 0.3. Therefore, there seems to be other mechanisms impacting on the failure of the Law of One Price in ETF markets, in addition to the market microstructure factors, investor sentiment, and arbitrage risk examined in this paper.

5. Conclusion

In this paper, we examine price formation in Japanese ETF markets, and investigate the reasons why the Law of One Price fails. By analyzing ETF markets, we are able to avoid having to assume a specific asset pricing model. Furthermore, the market microstructure adopted in Japanese ETF markets is different from that in U.S. and European markets. Keeping these institutional differences in mind, we conduct empirical examinations.

The findings of our analysis show that prices in the secondary market are affected by various factors other than fundamentals, and that this impedes the Law of One Price. Among the specific factors that obstruct the Law, the most obvious factor is the difference in the speed of information reflection between the secondary and the primary markets. The time needed for information on fundamentals to be incorporated in market prices is longer than the time for it to be reflected in NAVs. It seems to be probable that the unique market microstructure in Japanese ETF markets — that is, indicative NAVs and PCFs are imperfectly used — would bring about this phenomenon. There is another possibility that mispricing might be produced by in-kind transactions being restricted. These findings are consistent with the results reported in Iwai (2010, 2011), who estimated the degree of inefficiency in the Japanese ETF markets.

Second, we also confirm the possibility that arbitrage is constrained by firm-specific noise trader risk. Since taking arbitrage positions could be risky investment under the presence of noise traders, arbitrages will not occur sufficiently and hence the Law of One Price is being obstructed.

On the other hand, almost no effects of systematic investor sentiment on price formation are observed. This finding suggests that there is not a great deal of difference between the sentiments of investors participating in domestic stock markets and in ETF markets. Consequently, the habitat view and the category view presented by such researchers as Barberis *et al*. (2005) do not seem to apply to investor behavior in the Japanese market.

However, it is difficult to explain why the Law of One Price fails using institutional factors and noise trader risk alone. It is possible that some other kind of mechanism is at work which is not analyzed in this paper. This will be the subject of future study. Although some institutional changes in market microstructure—for example, the introduction of indicative NAV and fully disclosed PCF—have been observed recently, the need for further institutional reform will also need to be examined.

Table 1 Sample ETFs

Security ID	Exchange	Index
1320	OSE	Nikkei 225
1321	OSE	Nikkei 225
1329	TSE	Nikkei 225
1330	TSE	Nikkei 225
1346	OSE	Nikkei 225
1343	TSE	TSE REIT
1345	TSE	TSE REIT
1310	TSE	TOPIX Core 30
1311	TSE	TOPIX Core 30
1344	TSE	TOPIX Core 30
1316	TSE	TOPIX100
1317	TSE	TOPIX Mid 400
1318	TSE	TOPIX Small
1617	TSE	TOPIX17-Food
1634	TSE	TOPIX17-Food
1618	TSE	TOPIX17-Energyl Resource
1635	TSE	TOPIX17-Energyl Resource
1619	TSE	TOPIX17-Construction&Material
1636	TSE	TOPIX17-Construction&Material
1620	TSE	TOPIX17-Raw Materials&Chemicals
1637	TSE	TOPIX17-Raw Materials&Chemicals
1621	TSE	TOPIX17-Pharmaceutical
1638	TSE	TOPIX17-Pharmaceutical
1622	TSE	TOPIX17-Automobiles&Transportation Equipment
1639	TSE	TOPIX17-Automobiles&Transportation Equipment
1623	TSE	TOPIX17-Steel&Nonferrous Metals
1640	TSE	TOPIX17-Steel&Nonferrous Metals
1624	TSE	TOPIX17-Machinery
1641	TSE	TOPIX17-Machinery
1625	TSE	TOPIX17-Electric Appliances&Precision Instruments
1642	TSE	TOPIX17-Electric Appliances&Precision Instruments
1626	TSE	TOPIX17-IT&Services, Others
1643	TSE	TOPIX17-IT&Services, Others
1627	TSE	TOPIX17-Electric Power&Has
1644	TSE	TOPIX17-Electric Power&Has
1628	TSE	TOPIX17-Transportation&Logistics
1645	TSE	TOPIX17-Transportation&Logistics
1629	TSE	TOPIX17-Commercial&Wholesale Trade
1646	TSE	TOPIX17-Commercial&Wholesale Trade
1630	TSE	TOPIX17-Retail Trade
1647	TSE	TOPIX17-Retail Trade
1631	TSE	TOPIX17-Banks
1648	TSE	TOPIX17-Banks
1632	TSE	TOPIX17-Financials (ex Banks)
1649	TSE	TOPIX17-Financials (ex Banks)
1633	TSE	TOPIX17-Real Estate
1650	TSE	TOPIX17-Real Estate
1610	TSE	TSE Electric Appliances
1613	TSE	TSE Electric Appliances
1612	TSE	TSE Banks
1615	TSE	TSE Banks
1314	TSE	S&P Nippon Shinkou-kabu 100
1312	OSE	Russel-Nomura Small Cap Core

TSE and OSE refer to Tokyo Stock Exchange and Osaka Securities Exchange, respectively.

Table 2 Explained variation in daily return by fundamental factors

$$r_{i,t}^{S} = c + \alpha_{-1} r_{i,t-1}^{P} + \alpha_0 r_{i,t}^{P} + \alpha_{+1} r_{i,t+1}^{P} + \varepsilon_{i,t}$$

Figures in parentheses are p-value. Robust standard errors corrected for heteroskedasticity (Newey &West's method) is used.
# of rejection is the number of ETFs in which p-value is less than 0.05.

	c		α_{-1}		α_0		α_{+1}		$\chi^2(\alpha_{-1}+\alpha_0+\alpha_{+1}=1)$		adj R^2	DW-stat
mean	0.000	(0.846)	0.082	(0.227)	0.875	(0.000)	0.017	(0.423)	1.372	(0.428)	0.789	2.843
median	0.000	(0.860)	0.067	(0.042)	0.903	(0.000)	0.013	(0.434)	0.790	(0.374)	0.818	2.876
max	0.000	(0.996)	0.259	(0.999)	0.991	(0.000)	0.174	(0.982)	7.641	(0.945)	0.987	3.240
min	0.000	(0.448)	-0.015	(0.000)	0.646	(0.000)	-0.183	(0.012)	0.005	(0.006)	0.414	2.144
# of rejection (a)	0		27		53		6		5			
# of all sample (b)	53		53		53		53		53			
a/b	0.0%		50.9%		100.0%		11.3%		9.4%			

Table 3 Determinants of return difference [Base model]

$$\begin{cases} r_{t,i}^{S-P} = c + \phi r_{t-1,i}^{S-P} + \delta I_{t,i} r_{t-1,i}^{S-P} + \lambda\left(Sentiment_{t,i}^{S} - Sentiment_{t,i}^{P}\right) + e_{t,i} \\ e_{t,i} \sim N\left(0, h_{t,i}\right) \\ h_{t,i} = c' + a h_{t-1,i} + b e_{t-1,i}^{2} \end{cases}$$

Figures in table show the number of ETFs with the coefficient being statistically different from 0 at 5% significant level. For example, ϕ <0 (0< ϕ means that estimates of ϕ is smaller (larger) than 0 at 5% significant level. × is calculated as (# of all ETFs) − (# of ϕ <0)−(# of 0< ϕ).

	ϕ			δ			λ			a			b			adj R^2		
	ϕ <0	×	0< ϕ	δ<0	×	0<δ	λ<0	×	0<λ	a<0	×	0<a	b<0	×	0<b	min	mean	max
Panel A : Sentiment^S-Sentiment^P=TOPIX return−ETF linked index return																		
I_t=1day	53	0	0	10	30	13	1	31	21	1	5	47	2	11	40	-0.08	0.21	0.45
I_t=2day	53	0	0	4	43	6	2	30	21	1	5	47	2	12	39	-0.08	0.21	0.46
I_t=3day	53	0	0	3	43	7	2	30	21	0	6	47	2	13	38	-0.08	0.20	0.46
Panel B : Sentiment^S-Sentiment^P=Trading turnover on TSE 1st section−Trading turnover on ETF																		
I_t=1day	53	0	0	9	35	9	3	49	1	0	6	47	2	15	36	-0.11	0.19	0.44
I_t=2day	53	0	0	4	43	6	3	49	1	0	7	46	2	15	36	-0.11	0.19	0.44
I_t=3day	53	0	0	1	47	5	3	50	0	0	6	47	2	15	36	-0.12	0.18	0.44
Panel C : Sentiment^S-Sentiment^P=dlog(Trading turnover on TSE 1st section)−dlog(Trading turnover on ETF)																		
I_t=1day	53	0	0	10	31	12	3	45	5	0	6	47	2	17	34	-0.10	0.19	0.49
I_t=2day	53	0	0	4	43	6	6	42	5	0	6	47	2	17	34	-0.10	0.19	0.49
I_t=3day	53	0	0	2	47	4	3	45	5	0	7	46	2	16	35	-0.10	0.18	0.49

Table 4 Determinants of return difference [Extended model]

$$\begin{cases} r_{t,i}^{S-P} = c + \phi r_{t-1,i}^{S-P} + \delta I_{t,i} r_{t-1,i}^{S-P} + \lambda\left(Sentiment_{t,i}^{S} - Sentiment_{t,i}^{P}\right) + \xi r_{t,i}^{P} + e_{t,i} \\ e_{t,i} \sim N\left(0, h_{t,i}\right) \\ h_{t,i} = c' + a h_{t-1,i} + b e_{t-1,i}^{2} \end{cases}$$

Figures in table show the number of ETFs with the coefficient being statistically different from 0 at 5% significant level. For example, $\phi<0$ ($0<\phi$) means that estimates of ϕ is smaller (larger) than 0 at 5% significant level. × is calculated as (# of all ETFs) − (# of ϕ <0)−(# of 0< ϕ).

	φ			δ			λ			ξ			a			b			adj R2		
	φ<0	×	0<φ	δ<0	×	0<δ	λ<0	×	0<λ	ξ<0	×	0<ξ	a<0	×	0<a	b<0	×	0<b	min	mean	max
Panel A : Sentiment^S-Sentiment^P=TOPIX return − ETF linked index return																					
I_t=1day	53	0	0	11	31	11	4	44	5	35	18	0	1	8	44	1	14	38	0.04	0.24	0.53
I_t=2day	53	0	0	4	46	3	3	45	5	35	18	0	1	8	44	1	14	38	0.04	0.24	0.53
I_t=3day	53	0	0	6	38	9	3	46	4	35	18	0	0	10	43	1	17	35	0.04	0.24	0.54
Panel B : Sentiment^S-Sentiment^P=Trading turnover on TSE 1st section − Trading turnover on ETF																					
I_t=1day	53	0	0	11	31	11	5	45	3	38	15	0	1	8	44	1	14	38	0.04	0.24	0.53
I_t=2day	53	0	0	3	45	5	5	46	2	37	16	0	0	9	44	1	13	39	0.04	0.24	0.53
I_t=3day	53	0	0	6	39	8	5	47	1	39	14	0	1	10	42	1	15	37	0.04	0.24	0.54
Panel C : Sentiment^S-Sentiment^P=dlog(Trading turnover on TSE 1st section) − dlog(Trading turnover on ETF)																					
I_t=1day	53	0	0	9	34	10	7	43	3	39	14	0	1	9	43	2	13	38	0.05	0.24	0.56
I_t=2day	53	0	0	3	46	4	6	44	3	40	13	0	1	8	44	2	12	39	0.05	0.24	0.56
I_t=3day	53	0	0	5	40	8	6	43	4	40	13	0	0	11	42	2	13	38	0.05	0.24	0.57

Table 5 Determinants of absolute return difference [Base model]

$$\left|r_{i,t}^{S-P}\right| = c + \beta_1\left|r_{i,t-1}^{S-P}\right| + \beta_2 I_{i,t}\left|r_{i,t-1}^{S-P}\right| + \beta_3\left|Sentiment_{i,t}^{S} - Sentiment_{i,t}^{P}\right| + \beta_4 \hat{h}_{i,t} + \nu_{i,t}$$

Figures in table show the number of ETFs with the coefficient being statistically different from 0 at 5% significant level. For example, $\beta_1<0$ ($0<\beta_1$) means that estimates of β_1 is smaller (larger) than 0 at 5% significant level. × is calculated as (# of all ETFs) − (# of β_1<0)−(# of 0<β_1).
Robust standard errors corrected for heteroskedasticity (Newey &West's method) is used.

	β1			β2			β3			β4			adj R2		
	β_1<0	×	0<β_1	β_2<0	×	0<β_2	β_3<0	×	0<β_3	β_4<0	×	0<β_4	min	mean	max
Panel A : Sentiment^S-Sentiment^P=TOPIX return − ETF linked index return															
I_t=1day	0	17	36	17	30	6	0	47	6	0	22	31	-0.04	0.27	0.65
I_t=2day	0	17	36	20	26	7	0	46	7	0	22	31	-0.03	0.27	0.66
I_t=3day	0	18	35	13	34	6	0	46	7	0	22	31	-0.03	0.27	0.66
Panel B : Sentiment^S-Sentiment^P=Trading turnover on TSE 1st section − Trading turnover on ETF															
I_t=1day	0	17	36	17	28	8	0	34	19	0	21	32	-0.03	0.27	0.67
I_t=2day	0	20	33	15	30	8	0	34	19	0	22	31	-0.03	0.28	0.67
I_t=3day	0	22	31	14	31	8	0	34	19	0	20	33	-0.03	0.28	0.67
Panel C : Sentiment^S-Sentiment^P=dlog(Trading turnover on TSE 1st section) − dlog(Trading turnover on ETF)															
I_t=1day	0	17	36	16	32	5	0	53	0	0	20	33	-0.03	0.26	0.67
I_t=2day	0	19	34	18	29	6	0	53	0	0	21	32	-0.02	0.26	0.67
I_t=3day	0	21	32	16	31	6	0	52	1	0	18	35	-0.02	0.26	0.67

Table 6 Determinants of absolute return difference [Extended model]

$$|r^{S-P}_{i,t}| = c + \beta_1|r^{S-P}_{i,t-1}| + \beta_2 I_{i,t}|r^{S-P}_{i,t-1}| + \beta_3|Sentiment^{S}_{i,t} - Sentiment^{P}_{i,t}| + \beta_4 \hat{h}_{i,t} + \beta_5|r^{P}_{i,t}| + \nu_{i,t}$$

Figures in table show the number of ETFs with the coefficient being statistically different from 0 at 5% significant level. For example, β_1<0 (0<β_1) means that estimates of β_1 is smaller (larger) than 0 at 5% significant level. × is calculated as (# of all ETFs) − (# of β_1<0)−(# of 0<β_1). Robust standard errors corrected for heteroskedasticity (Newey &West's method) is used.

	β_1			β_2			β_3			β_4			β_5			adj R2		
	β_1<0	×	0<β_1	β_2<0	×	0<β_2	β_3<0	×	0<β_3	β_4<0	×	0<β_4	β_5<0	×	0<β_5	min	mean	max
Panel A : Sentiment^S-Sentiment^P=TOPIX return−ETF linked index return																		
I_t=1day	0	14	39	16	30	7	1	50	2	0	26	27	0	40	13	-0.05	0.28	0.68
I_t=2day	0	14	39	19	27	7	1	50	2	0	27	26	0	40	13	-0.04	0.28	0.68
I_t=3day	0	13	40	15	31	7	0	51	2	0	26	27	0	40	13	-0.05	0.28	0.68
Panel B : Sentiment^S-Sentiment^P=Trading turnover on TSE 1st section−Trading turnover on ETF																		
I_t=1day	0	17	36	16	29	8	0	43	10	0	28	25	0	38	15	-0.05	0.29	0.69
I_t=2day	0	17	36	16	30	7	0	41	12	0	30	23	0	38	15	-0.04	0.29	0.69
I_t=3day	0	16	37	11	34	8	0	41	12	0	26	27	0	38	15	-0.05	0.29	0.69
Panel C : Sentiment^S-Sentiment^P=dlog(Trading turnover on TSE 1st section)−dlog(Trading turnover on ETF)																		
I_t=1day	0	17	36	16	31	6	0	53	0	0	25	28	0	36	17	-0.04	0.28	0.69
I_t=2day	0	19	34	17	29	7	0	53	0	0	28	25	0	36	17	-0.03	0.28	0.69
I_t=3day	0	16	37	14	32	7	0	53	0	0	26	27	0	37	16	-0.04	0.28	0.69

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Financial Research Center（FSA Institute）
Financial Services Agency
Government of Japan

3-2-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-8967, Japan

TEL：03-3506-6000（ext 3293）
FAX：03-3506-6716
URL：http://www.fsa.go.jp/frtc/english/index.html