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# Regime-switching analysis of ADR home market pass-through

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ABSTRACT

We model and estimate ADRs' home market pass-through and pricing-to-market using a regime-switching approach, which nests the two regimes in a conditional capital asset pricing model and treats any changes in these two regimes probabilistically. Our results from the 1998 to 2006 data show that the pricing-to-market regime dominates ADRs from China and Japan, whereas the home market pass-through regime dominates ADRs from Argentina and Germany when their respective home markets are volatile.

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## 1. Introduction

Foreign firms typically list their stocks on US stock exchanges in the form of American Depository Receipts (ADRs), which are issued by a US depository bank and signify ownership of shares in a non-US corporation. Investors holding ADRs receive dividends, and indirectly pay fees to the depository bank. While extensive research has been done in the past two decades rationalizing why foreign firms list their stocks on US stock exchanges in the form of ADRs, we still lack adequate knowledge of the pricing behavior of these cross-listed shares.[1] This research addresses this issue, particularly the following questions: What determines the price movements of exchange-listed ADRs? Do they move with their respective home markets, or with the US market?

When a home country's market fundamentals move an ADR's pricing, we term this "home market systematic risk pass-through." Anecdotal evidence has shown that ADRs can also move with the US market, though this is theoretically incomprehensible. When this happens, we call it pricing to the US market's systematic risks, or simply, "pricing-to-market." The existence of the pricing-to-market phenomenon may be due to US investors' demands and non-overlapping trading hours across countries (Kim et al., 2000; Fang and Loo, 2002). This pricing-to-market effect may also vary over time, depending on the performance of the US economy and its covariance with ADR returns.

Early research on ADRs has examined their underlying assets in search of evidence for the law of one price (e.g., Officer and Hoffmeister, 1987; Kato et al., 1991). The common theme from these papers is that, in the absence of direct or indirect trading barriers, ADRs and their underlying shares should be perfect substitutes, offering no arbitrage opportunities. In other words, ADRs are the "pass-throughs" of home shares and should price the same as their home market shares, barring the effects of the appropriate exchange rates. Later studies find ADRs from emerging markets bring diversification benefits to US investors and can serve as a proxy for the home markets (Bekaert and Urias, 1999; Errunza et al., 1999). More recent studies report contradictory results showing ADRs' performances can differ from the underlying shares (Foerster and Karolyi, 2000; Alagnar and Bhar, 2001). It is now generally agreed that although ADRs reflect their underlying share values to a certain extent, their own risk characteristics come into play in pricing considerations.

How does the US market affect ADR returns? What factors cause ADR prices to deviate from home prices? Kadiyala and Subrahmanyam (2004) find short-run price differences between ADRs and their underlying shares stem from US investors' excess demand. If US investors are overly-optimistic or overly-pessimistic toward one ADR, it can affect the share price (Arquette et al., 2008). Furthermore, there is evidence that liquidity affects the differences between ADRs and their underlying assets (Chan

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[1] See surveys by Karolyi (1998, 2006) for a comprehensive review of this literature.

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et al., 2008; Silva and Chavez, 2008). Here we use the term "pricing-to-market" to summarize the effects of the US market on ADR pricing, which includes both macroeconomic development and the time-varying market sentiment in the US market.

The purpose of this paper is to explore how "home market pass-through" and "pricing-to-market" affect ADRs over time. In this research, instead of searching for a "yes or no" answer to the question of pricing-to-market vs. home market pass-through for the ADR price movements, we recognize the uncertainties about the nature and timing of these two regimes. That is, the two different market effects may vary or switch over time. We believe their co-existence and time variations happen only when the global financial market is not fully integrated. If it were, there would be no separation between the home and US markets, and an ADR would no longer be needed. When markets are not fully integrated, external shocks or changes in either market can affect ADR returns; therefore, one regime may appear to dominate ADR returns in one period or another. We treat the changes of these two regimes probabilistically to characterize this uncertainty. This is what motivates us to apply the regime-switching framework to ADR pricing.

We adopt the regime-switching model by Hamilton (1989) to nest the ADRs' home and US markets. In the home market pass-through regime, ADRs are priced to the home market using the domestic Capital Asset Pricing Model (CAPM). In the pricing-to-market regime, ADRs are treated as US domestic assets and priced by their exposures to the US market risk. This regime-switching framework extends the domestic CAPM but is not as idealized as the International CAPM (ICAPM), which assumes full integration of the world market. The regime probabilities capture the time-varying degree of home market pass-through. This has not previously been done in ADR pricing.

We apply the regime-switching model to ADR index returns from Argentina, China, Germany, and Japan, and develop a weekly proxy for the home market pass-through effect for each country from 1998 to 2006. Our proxy shows that that the pricing-to-market regime dominates ADRs from China and Japan, whereas the home market pass-through regime dominates ADRs from Argentina and Germany when their respective home markets are volatile. We also compare the regime-switching CAPM with single-regime conditional CAPMs. The out-of-sample forecast generated by our regime-switching CAPM explains more about ADR pricing for ADRs of China, Germany, and Japan than does its single-regime counterpart.

In Section 2 of this paper, we discuss the regime-switching framework in further detail, and in Section 3 we briefly describe the empirical methodology. We report data sources in Section 4, and present empirical results and country-by-country findings in Section 5. We compare the regime-switching CAPM with single-regime models and discuss the advantages of the regime-switching framework in Section 6. In Section 7, we follow up with a discussion of an alternative regime-switching framework wherein we replace the "pricing-to-US-market" regime with the "pricing-to-world-market" regime. The final section summarizes the paper and points out further extensions of this research.

## 2. The regime-switching framework

Our base model for ADR pricing starts with a conditional CAPM in a completely integrated market with the absence of exchange rate risk, similar to Bekaert and Harvey (1995)[2]:

$$E_{t-1}\left[R^{adr}_{n,t}\right] = \lambda^{m}_{t-1}\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R^{m}_{t}\right]. \quad (1)$$

Here $n = 1, 2, \ldots, N$ countries, $\lambda^{m}_{t-1}$, is the market price of covariance risk at time $t-1$, and $\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R^{m}_{t}\right]$ is the expected conditional covariance of ADR returns from country $n$ with market returns for time $t$ at time $t-1$.

One problem with this CAPM is that, in the absence of a completely integrated world market, one cannot determine which market returns to use for ADRs from a particular country. Do ADRs reflect their home market risks or US market risks? To incorporate this uncertainty into the model, we set an unobserved state variable $S_t$. This variable takes on the value of 1 when ADRs are priced to the US market and a value of 2 when ADRs reflect complete pass-through of home market variations. At each point in time, the model infers the probability of the state variable $S_t$ being 1 or 2.

In the first regime, where ADRs are priced to the US market, ADR returns are determined by the price of the US market risk times exposure of ADR returns to changes in US market returns. Eq. (1) is then modified as:

$$E_{t-1}\left[R^{adr}_{n,t}\right] = \lambda^{US}_{t-1}\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R_{US,t}\right]. \quad (2)$$

In this equation, $\lambda^{US}_{t-1}$ represents the US price of covariance risk at time $t-1$, and $\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R_{US,t}\right]$ is the expected conditional covariance of ADR returns from country $n$ with US market returns for time $t$ at time $t-1$. In other words, we have substituted the US market portfolio for the market portfolio in Eq. (1).

On the other hand, if there is a complete home market pass-though in the ADRs, which we call Regime 2, the ADR returns are determined by the home market price of risk times the ADRs' exposure to changes in the home market returns. The expected return equation is:

$$E_{t-1}\left[R^{adr}_{n,t}\right] = \lambda^{n}_{t-1}\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R^{\$}_{n,t}\right]. \quad (3)$$

This expected return formula has $\lambda^{n}_{t-1}$ as the home market price of covariance risk for country n at time $t-1$, and $\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R^{\$}_{n,t}\right]$ is the expected conditional covariance of ADR returns with home market returns (in US dollars) for time $t$ at time $t-1$.[3]

Given the information set $Z_{n,t-1}$ for country $n$ at time $t-1$, we use $\phi_{n,t-1}$ to denote the likelihood of ADRs pricing to the US market (Regime 1). The parameter $\phi_{n,t-1}$ falls in the interval $[0,1]$ and changes across time. It is expressed as:

$$\phi_{n,t-1} = prob[S_t = 1 | Z_{n,t-1}]. \quad (4)$$

In this case, the expected conditional mean return of ADRs for time $t$ at time $t-1$ equals the weighted average of the expected value of each regime, with probabilities as the weights:

$$E_{t-1}\left[R^{adr}_{n,t}\right] = \phi_{n,t-1}\lambda^{US}_{t-1}\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R_{US,t}\right] + (1-\phi_{n,t-1})\lambda^{n}_{t-1}\mathrm{cov}_{t-1}\left[R^{adr}_{n,t}, R^{\$}_{n,t}\right]. \quad (5)$$

One benefit of using regime-switching models, is that they allow us to infer the time path of regime probabilities, $\phi_{n,t}$ (ADRs' pricing-to-market), or $1-\phi_{n,t}$ (ADRs' home market pass-through).

Recent empirical studies suggest US market risk, home market risk, and exchange rate risk impact ADR returns (e.g., Kim et al., 2000; Fang and Loo, 2002). However, there are two drawbacks in these factor pricing models. First, they do not capture the time var-

[2] We choose conditional models over unconditional models because conditional models help capture the time variation in betas and risk premiums. Since this approach is fully parametric, one can recover any quantity that is a function of the first two conditional moments (De Santis and Gerard, 1998). All CAPMs used in this paper are conditional models.

[3] Following Bekaert and Harvey (1995), we measure home market returns in US dollars. Thus the home market returns capture exchange rate risks as well as home market risks. Home market factors used in the ensuing sections are measured in the same way.

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