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EXCHANGE RATE EXPECTATIONS, CURRENCY CRISES, AND THE PRICING OF AMERICAN DEPOSITARY RECEIPTS

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To Mareike

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Chapter I

Introduction

I.1 Motivation

Exchange rates are a key issue in international economics and politics.[1] While the determinants of exchange rates have been extensively studied in previous works, this dissertation contributes to the literature by deriving exchange rate *expectations* from stock market (ADR) data and analyzing their determinants. This exercise is done for three cases where one has to resort to exchange rate expectations since the national exchange rate is either manipulated by the central bank (the first paper in Chapter II), fixed in pegged exchange rate regimes (the second paper in Chapter III), or not existent as the considered country is part of a currency union and therefore has no national currency (the third paper in Chapter IV).[2]

The first paper presented in Chapter II analyzes exchange rate expectations for the case of China in the period 1998-2009 in order to test standard exchange rate theories.[3] American officials repeatedly accused China of systematically undervaluing its currency against the U.S. dollar[4], which produces political tensions between both countries. A recent climax in this dispute was reached on September 28, 2010, when the House of

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[1] Throughout this dissertation the term exchange rate is used to describe the nominal exchange rate, which is defined as the amount of national currency units one must pay for one U.S. dollar.

[2] The papers included in this dissertation have been modified compared to the published versions. The numbering of pages, tables, figures, formulas, and appendices has been modified in order to improve the readability of the dissertation. The text has also been slightly modified in some passages.

[3] This paper is based on Eichler (2011a).

[4] For example, in its semiannual report to the Congress, the U.S. Department of the Treasury called the yuan "substantially undervalued" (U.S. Department of the Treasury, 2011, p. 16). In his Congressional Testimony Fred Bergsten, director of the Peterson Institute for International Economics, called for a 25% appreciation of the yuan against the U.S. dollar (Bergsten, 2010).

Representatives passed the Currency Reform for Fair Trade Act, which would allow the imposition of import duties for countries with undervalued currencies, namely China. Although this bill did not pass the Senate, Chinese officials clearly opposed the bill arguing against significant undervaluation of the yuan and in favor of political opportunism of U.S. officials.[5] As the assessments of a fair exchange rate significantly differ among officials of both countries, the Chinese-American exchange rate dispute continues. Measuring the development of market determined exchange rate expectations may help to find a compromise in this international political dispute and knowing the determinants of these expectations may help to identify macroeconomic policies necessary to influence future exchange rates.

The second paper presented in Chapter III investigates the development of exchange rate expectations and their determinants for the currency crisis episodes in Argentina (2001-2002), Malaysia (1998-1999), and Venezuela (1994-1996 and 2003-2007).[6] Large devaluations of Southeast Asian and Latin American currencies were to be observed during the currency crises in the 1990's and at the beginning of the last decade. Due to an appreciation of foreign currency denominated debt, capital withdrawals, and bank runs, for example, currency crises typically lead to significant output losses in the affected economies (Hutchison and Noy, 2002). Avoiding currency crisis outbreaks has therefore become one of the major policy goals in many developing countries, which may explain the rapid accumulation of foreign exchange reserves aimed to fend off speculative attacks in these countries. The costs of this currency crisis prevention policy are however often overseen. Since foreign exchange reserves are typically invested in U.S. Treasuries, they yield a

[5] Chinese Foreign Ministry spokesman Jiang Yu, for example, argued that U.S. policymakers would use the "exchange rate issue as an excuse to engage in trade protectionism against China" (Buckley, 2010). Moreover, depending on the methodology used, some exchange rate models suggest that the yuan may also have become overvalued against the U.S. dollar recently (Cheung et al., 2010).

[6] This paper is based on Eichler et al. (2009). This paper was co-authored by Professor Alexander Karmann and Professor Dominik Maltritz. Professor Alexander Karmann wrote the introductory chapter (Chapter III.1), which provides the motivation and relates the paper to existing works in the literature. Professor Dominik Maltritz wrote the conclusion section (Chapter III.6), which provides policy conclusions and an outlook for future research. Throughout the writing of this paper I benefited from valuable discussions with Professor Alexander Karmann and Professor Dominik Maltritz.

relatively low return compared to the high cost of domestic capital in these countries. Moreover, foreign exchange reserves may lose in value as the domestic currency appreciates against the U.S. dollar (Rodrik, 2006). An alternative way to avoid the outbreak of currency crises may be to regularly adjust the official exchange rate (typically managed by the domestic central bank) to levels in line with market expectations. Knowing market-based exchange rate expectations and their determinants may therefore be a cheaper way to avoid currency crises than holding excess amounts of foreign exchange reserves.

The third paper presented in Chapter IV uses daily ADR data to analyze the determinants of the risk of withdrawals from the Economic and Monetary Union (EMU) for the five vulnerable member countries Greece, Ireland, Italy, Portugal, and Spain for the period 2007-2009. [7] The subprime lending crisis has triggered significant financial turmoil in the EMU. Banking systems were destabilized and the governments of Greece, Ireland, and Portugal had to be bailed out. Reasserting national authority over monetary policy may help domestic policymakers to address the problems caused by banking and sovereign debt crises or an overvalued euro at national discretion. While the abandonment of fixed exchange rate regimes has so far been analyzed for countries with national currencies, the financial vulnerabilities in the EMU offer a new case to study the possibility of withdrawals from a monetary union. Although a country's membership in the EMU is typically considered irreversible, many authors agree that sovereign states can choose to leave the EMU (Cohen, 1993; Scott, 1998; Buiter, 1999; Eichengreen, 2007). The new Treaty of Lisbon now includes a provision outlining voluntary withdrawal from the Union, which may cause the members to re-think the pros and cons of remaining in the EMU.[8] Although the European Central Bank (ECB) has implemented measures meant to support the banking sectors and governments in the EMU, autonomous national central banks would probably pursue more expansionary

[7] This paper is based on Eichler (2011b).
[8] See Art. 50 of the Treaty of Lisbon.

monetary policies.[9] By analyzing the determinants of exchange rate expectations in the monetary union one may therefore analyze the drivers of the risk of withdrawal from the EMU.

I.2 Deriving exchange rate expectations from prices of American Depositary Receipts

Measuring movements in exchange rate expectations is a relatively easy task for currencies in which a liquid and free forward exchange market exists. For the cases considered in this dissertation, however, the forward exchange market either produces bad forecasts or does not even exist. For the case of China, the yuan/U.S. dollar forward exchange rate is most likely managed by the Chinese central bank in the course of its foreign exchange market intervention policies, which hampers its ability to provide good signals for the future spot market exchange rate (see, for example, Wang, 2010).[10] For the considered member countries of the EMU, no national currencies exist and consequently forward exchange rates cannot be used. For the case of the currency crisis episodes studied in this dissertation, one could use regression-based forecasting models that employ data on macroeconomic variables in order to produce currency crisis signals (see, among others, Eichengreen et al., 1995; Frankel and Rose, 1996; Kaminsky et al., 1998; Kaminsky and Reinhart, 1999; Karmann et al., 2002). The drawback of these approaches is the nature of macroeconomic data used, which enables one to create only monthly or quarterly crisis signals based on backward-looking data.[11]

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[9] The ECB has, for example, implemented the "Enhanced Credit Support" program and the "Securities Markets Programme" meant to support the banking systems and vulnerable governments within the EMU. Sinn and Wollmershäuser (2011) point to a yet overlooked support measure within the eurosystem. They show that the Deutsche Bundesbank (in particular) grants TARGET II credits particularly to the national central banks of the vulnerable EMU member states Greece, Ireland, Portugal and Spain. These TARGET II credits are generated in order to finance the current account deficits of the vulnerable countries and may diminish in value in the case of a sovereign default of one of the debtor countries.

[10] Moreover, a comparison in forecast accuracy outlined in Section II.4 in Chapter II reveals that yuan/U.S. dollar forward exchange rates provide less accurate signals for future spot exchange rate changes than the stock market measure used in this dissertation.

[11] As market data obviously exhibit some advantages over macroeconomic data, such as high frequency and a forward-looking nature, a literature emerged that uses market-based approaches to forecast banking and sovereign debt crises. While some papers forecast the occurrence of banking crises using macroeconomic data (see, e.g., Demirgüc-Kunt and Detragiache, 1998), recent papers use market information to predict banking

In this dissertation I use stock market data to derive exchange rate expectations, which has several advantages compared to existing approaches. First of all, the prices of the considered stocks are most probably not manipulated by central bank interventions since these stocks are traded in the United States, which enables the derivation of exchange rate expectations formed under free market conditions (also for China). The used stock market data is available for the considered EMU member countries, which facilitates the analysis of the risk of withdrawals from the EMU. Moreover, stock market data is forward-looking and available on a daily basis, which enables the derivation of more accurate and up-to-date currency crisis signals for the considered crisis episodes.

In order to derive exchange rate expectations I use data on a particular type of stock called American Depositary Receipt (ADR). An ADR is a financial instrument for foreign companies to list their shares at stock exchanges in the Unites States. An ADR represents the ownership of a specific number of underlying shares of a company in the home market on which the ADR is written. While the underlying stock is denominated in the currency and traded at the stock exchange of the home market, the ADR is denominated in U.S. dollars and traded at a U.S. stock exchange. Since both types of stocks of the same company generate identical cash flows and incorporate equivalent rights and dividend claims, cross-border arbitrage implies that the ADR and its underlying stock have the same price when adjusted for the current exchange rate. When capital controls or ownership restrictions are implemented, cross-border arbitrage is not possible and the law of one price is not binding. In such an environment, information efficiency suggests that the relative prices of ADRs and their underlying stocks – which only differ with respect to the currency they are denominated in –

distress (see, e.g., Gropp et al., 2006; Moshirian and Wu, 2009; Eichler et al., 2011). To forecast sovereign debt crises, some papers use economic fundamentals (see, e.g., Detragiache and Spilimbergo, 2004) while others apply market data to estimate country default risk (see, e.g., Claessens and Pennacchi, 1996; Karmann, 2000; Karmann and Maltritz, 2004, 2010; Huschens et al. 2007).

will signal exchange rate expectations of stock market investors.[12] Using data on relative prices (or returns) of ADRs and their underlying stocks and the current exchange rate I can calculate measures for exchange rate expectations of stock market investors.

Although the papers presented in this dissertation differ with respect to the considered companies, countries, and time periods, each paper uses the same kind of data and a similar methodology to derive exchange rate expectations – relative prices or returns of ADRs[13] and their corresponding underlying stocks. In each paper I use a panel regression framework in order to analyze the determinants of exchange rate expectations. Each of the included papers focuses on a distinct facet of exchange rate expectations. The first paper focuses on standard exchange rate theories such as the relative purchasing power parity or the uncovered interest rate parity in order to analyze the factors that drive exchange rate expectations in general. The second paper studies the determinants of currency crisis expectations. The third paper analyzes the determinants of the risk of withdrawals from the EMU as expected by ADR market investors.

I.3 Contribution to the literature

This dissertation adds to two strands of the literature. First, it contributes to a literature that studies the determinants of exchange rates, currency crisis outbreaks, and risk of withdrawal from the EMU. The first paper (Chapter II) contributes to a vast literature on the determinants of exchange rates. An incomplete list of exchange rate determinants analyzed in the literature includes: labor productivity (Chinn, 2000; Cheung et al., 2007); inflation rates (Lothian and Taylor, 1996; Taylor et al., 2001); interest rates (Froot and Thaler, 1990; Chinn, 2006);

[12] For the case of the considered EMU member countries in Chapter IV, no capital controls or ownership restrictions are in place and thus relative stock prices cannot be used. Instead, I use ADR returns to study changes in exchange rate expectations.

[13] In the first paper presented in Chapter II I additionally use data on another type of cross-listed stock called H-share. An H-share represents the ownership of one original stock of a Chinese company (called A-share). The A-share is denominated in yuan and traded at a Chinese stock exchange. The H-share is traded in Hong Kong and denominated in Hong Kong dollars. Similar to ADRs the price relation between H-shares and A-shares can signal expectations of the future yuan/U.S. dollar exchange rate.

overvaluation of the domestic currency (Glick and Rose, 1999; Corsetti et al., 2000); or export growth (Williamson, 1994; Isard, 2007). I study the impact of these macroeconomic fundamentals on ADR investors' exchange rate expectations for China. China makes a good case to study standard exchange rate theories since the Chinese central bank manages the official yuan/U.S. dollar exchange rate, which therefore reacts much less to changes in macroeconomic fundamentals than is suggested by theory. Using ADR market data, I can test exchange rate theories for the Chinese peg/managed float regime under free market conditions. The second paper (Chapter III) contributes to a literature, which analyzes the determinants of currency crisis outbreaks (Eichengreen et al., 1995; Kaminsky and Reinhart, 1999; Karmann et al., 2002). Existing papers employ low-frequent and backward-looking macroeconomic data to forecast currency crises. This dissertation uses ADR market data to derive more accurate and up-to-date currency crisis signals on a daily basis. Moreover, the determinants of currency crisis expectations, such as banking or sovereign debt crisis risk, can be studied using daily market-based risk proxies. The third paper (Chapter IV) contributes to a literature on the sustainability of the EMU. Several papers discuss the possibility of withdrawal from the EMU (Cohen, 1993; Scott, 1998; Buiter, 1999; Eichengreen, 2007). I present empirical evidence that daily ADR market data reflects the risk that vulnerable member countries may leave the EMU and analyzes which determinants drive this withdrawal risk perceived by ADR investors.

Second, this dissertation contributes to the literature on the pricing of ADRs. A common finding in the literature is that the outbreak of a currency crisis negatively affects the returns of U.S. dollar-denominated ADRs as the devaluation of the local currency depresses the dollar value of the underlying stock (see, for example, Bailey et al., 2000; Kim et al., 2000; Bin et al., 2004). Several papers find that the introduction of capital controls (typically meant to prevent a currency crisis outbreak) can lead to a permanent violation of the law of one price between ADRs and their underlying stocks since cross-border arbitrage cannot take place (Melvin, 2003; Levy Yeyati et al., 2004, 2009; Auguste et al., 2006). Arquette et al. (2008) and Burdekin and Redfern (2009) find that the price spreads of Chinese cross-listed stocks are significantly driven by market-traded forward exchange rates. This dissertation builds on these findings and uses the relative prices (or returns) of ADRs and their underlying stocks to derive exchange rate expectations. I present empirical evidence that ADR investors' exchange rate expectations are driven by theory-based determinants of exchange rates, currency crisis outbreaks, or the risk of withdrawal from the EMU. This analysis therefore provides new insights into the price (return) determinants of ADRs.

I.4 Main findings and policy implications

The findings of this dissertation may broaden the understanding of exchanger rate expectations. The results of the first paper (Chapter II) suggest that stock market investors form their exchange rate expectations in accordance with standard exchange rate theories. Based on a monthly panel data set comprised of 22 ADR/underlying stock pairs and 52 H-share/underlying stock pairs from December 1998 to February 2009 I find that stock market investors expect more yuan appreciation against the U.S. dollar: if the yuan's overvaluation decreases (the incentive of competitive devaluation); if the inflation differential vis-à-vis the United States falls (relative purchasing power parity); if the productivity growth in China accelerates relative to the United States (the Harrod-Balassa-Samuelson effect); if the Chinese interest rate differential vis-à-vis the United States decreases (uncovered interest rate parity); when Chinese domestic credit relative to GDP decreases (lower risk of a twin banking and currency crisis); or, if Chinese sovereign bond yields fall (lower risk of a twin sovereign debt and currency crisis), ceteris paribus. These findings suggest that the theoretical links between macroeconomic variables and exchange rates in most cases also apply to exchange rate *expectations*. In this way, the results support the validity of many exchange rate theories and substantiate the rationality of stock market investors' expectations. This approach (based on stock prices formed under free market conditions) provides an opportunity to test exchange rate theories in managed floating regimes, where the official exchange rate is manipulated by the central bank and does therefore not necessarily respond to changes in macroeconomic fundamentals. Moreover, I use a rolling regressions forecasting framework in order to evaluate the quality of exchange rate expectations. I find that exchange rate expectations drawn from the ADR and H-share market have a better ability to predict changes in the yuan/U.S. dollar exchange rate than the random walk or forward exchange rates, at least at forecast horizons longer than one year. The People's Bank of China may take advantage of ADR and H-share based exchange rate expectations in order to determine possible misalignments of the yuan/U.S. dollar exchange rate. In this way, the Chinese central bank may improve the timing and intensity of foreign exchange market interventions meant to manipulate the yuan/U.S. dollar exchange rate.

The second paper (Chapter III) focuses on the derivation and determination of currency crisis signals formed by ADR market investors. Using daily data on 17 ADR/underlying stock pairs for the capital control episodes in Argentina (2001-2002), Malaysia (1998-1999), and Venezuela (1994-1996 and 2003-2007) we find that ADR investors anticipate currency crises or realignments well before they actually occur. Policymakers could use ADR investors' up-to-date assessment of the peg's sustainability in order to identify currency crisis risk earlier and to take the necessary steps to realign an (unsustainable) peg rate before a crisis breaks out. In this way, they could prevent the outbreaks of damaging currency crises without holding excess amounts of costly foreign exchange reserves. Using panel regressions we find that ADR investors anticipate a higher currency crisis risk when export commodity prices fall, the currencies of trading partners depreciate, sovereign bonds yield spreads rise, and interest rate spreads increase. These findings suggest that ADR investors' currency crisis expectations are based on currency crisis theories even on a daily basis underlining the validity of these theories.

The third paper (Chapter IV) studies a particular form of currency crisis risk: the risk that vulnerable member countries could leave the EMU. I use a multifactor pricing model to test whether the financial vulnerability measures assumed to reflect the incentives of national governments to withdraw from the EMU (banking crisis risk, sovereign debt crisis risk, and overvaluation of the euro) are priced in ADR returns. Using daily data on 22 ADR/underlying stock pairs of Greece, Ireland, Italy, Portugal, and Spain in the period January 2007 to March 2009 I find that ADR investors perceive a higher risk of withdrawal (priced in ADR returns) when the risk of banking and sovereign debt crisis and the overvaluation of the euro increase. Policymakers could use ADR market data in order to assess the stability of the EMU. Higher correlations between ADR returns and currency crisis risk factors would suggest a higher risk of withdrawals from the EMU. In such a case, financial vulnerabilities may be addressed within the EMU in order to preserve the integrity of the eurozone. However, time will show how long the policymakers in the EMU will continue with the implementation of even more anti-crisis measures. Growing controversies on the ECB's sovereign bond purchases and the bailouts for Greece, Ireland and Portugal cast doubt on the sustainability of the EMU in its current form.

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Chapter II

Exchange rate expectations and the pricing of Chinese cross-listed stocks[14]

Abstract

I show that the relative prices of Chinese cross-listed stocks (American Depositary Receipts (ADRs) and H-shares) and their underlying A-shares can be used as an indicator of yuan/U.S. dollar exchange rate expectations. The forecasting models reveal that ADR and H-share discounts predict exchange rate changes more accurately than the random walk and forward exchange rates, particularly at forecast horizons longer than one year. Using panel estimations, I find that ADR and H-share investors form their exchange rate expectations according to standard exchange rate theories such as the Harrod-Balassa-Samuelson effect, the risk of competitive devaluations, relative purchasing power parity, uncovered interest rate parity, the risk of twin banking and currency crisis, and the risk of twin debt and currency crisis.

[14] This paper is based on: Eichler, S., 2011. Exchange rate expectations and the pricing of Chinese cross-listed stocks. Journal of Banking & Finance 35, 443-55. Used with permission from Elsevier.

II.1 Introduction

For two decades, Chinese companies have been allowed to issue regular domestic shares (called A-shares) at domestic stock exchanges and to list their shares at international stock exchanges in the form of H-shares in Hong Kong or American Depositary Receipts (ADRs) in the United States.[15] As A-shares and cross-listed stocks of the same Chinese company generate identical streams of cash flows and incorporate equivalent rights and dividend claims, both types of stocks should exhibit the same price in exchange rate-adjusted terms. In perfect capital markets, deviations from this "law of one price" should be arbitraged away. However, numerous papers find that the simple fact that both types of stocks are traded at different stock exchanges can lead to market segmentation. Several of these papers show that cross-listed stocks are more correlated with the stock market on which they are traded than the one on which their cash flows are generated (Froot and Dabora, 1999; Chan et al., 2003; Chan et al., 2008).[16]

Capital controls or ownership restrictions can lead to a permanent violation of the law of one price between domestic and cross-listed stocks since cross-border arbitrage can not take place (Melvin, 2003; Levy Yeyati et al., 2004, 2009; Auguste et al., 2006). Chinese ownership restrictions, for example, prevent domestic investors from buying cross-listed stocks and international investors from buying domestic stocks. Arquette et al. (2008) observe ADR and H-share discounts of up to 95% relative to domestic A-shares in the period 1998 to 2006. Given the large and persistent deviations from the law of one price, a literature has emerged that examines the determinants of price discounts on Chinese cross-listed stocks. ADR or H-share discounts relative to A-shares are found to be driven by: investor sentiments

[15] At the microeconomic level, companies may benefit from cross-listing abroad by increasing the valuation of their stocks relative to domestic rival firms (Melvin and Valero, 2009), by reducing the share of voting rights held by controlling shareholders (Ayyagari and Doidge, 2010), by becoming more immune to the effects of currency crises (Chandar et al., 2009), or by improving investor protection and corporate disclosure (Roosenboom and Dijk, 2009). At the macroeconomic level, cross-listing may lead to a more integrated domestic capital market with positive effects, such as lower equity costs, even for non-cross-listed companies (Fernandes, 2009).

[16] For price discovery, however, trading in local stocks is frequently found to be more informative than trading in cross-listed stocks (Eun and Sabherwal, 2003; Agarwal et al., 2007; Frijns et al., 2010).

(Wang and Jiang, 2004; Grossman et al., 2007; Arquette et al., 2008; Burdekin and Redfern, 2009); trading liquidity (Wang and Jiang, 2004; Chan et al., 2008); and systematic risk premiums (Li et al., 2006; Burdekin and Redfern, 2009).[17]

Arquette et al. (2008) and Burdekin and Redfern (2009) find that a significant part of ADR and H-share discounts can be explained by changes in the non-deliverable yuan/U.S. dollar forward exchange rate. Their finding suggests that ADR and H-share investors take the risk of future exchange rate changes into account when pricing cross-listed stocks. This finding relates to papers that examine how exchange rates affect ADR returns. Since ADRs are denominated in U.S. dollars and their underlying stocks in the domestic currency, these papers find that a depreciation of the domestic currency against the U.S. dollar leads to falling ADR returns (Kim et al., 2000; Bailey et al., 2000; Bin et al., 2004; Grammig et al., 2005).

I contribute to the literature in two ways. Firstly, I show that the relative prices of cross-listed ADRs or H-shares and their underlying A-shares can be used as an indicator for exchange rate expectations. Since China has imposed capital controls and transnational ownership restrictions, cross-border arbitrage cannot take place and the law of one price between A-shares and cross-listed stocks is thus not binding. I argue that ADR and H-share investors will align the relative prices of yuan-denominated A-shares and U.S. dollar-denominated ADRs or Hong Kong dollar-denominated H-shares[18] with their expectation about the future yuan/U.S. dollar exchange rate rather than with the current official exchange rate. Using a rolling regressions forecasting framework I find that ADR and H-share discounts

[17] Chinese companies can also issue U.S. dollar-denominated B-shares in Shanghai or Hong Kong dollar-denominated B-shares in Shenzhen. I do not include B-shares in my analysis because the ownership restrictions on B-shares were alleviated in February 2001 (Wang and Jiang, 2004; Arquette et al., 2008). As this regime change would complicate the analysis for B-share discounts, I focus on ADR and H-share discounts. B-share discounts relative to A-shares are found to be driven by: the risk aversion of Chinese investors (Ma, 1996); the liquidity of B-shares relative to A-shares (Chen et al., 2001); information asymmetries (Chakravarty et al., 1998; Chui and Kwok, 1998); and, the availability of other types of cross-listed stocks (Sun and Tong, 2000).

[18] The Hong Kong dollar/U.S. dollar exchange rate shows only minimal fluctuations as Hong Kong has implemented a currency board with the U.S. dollar as the anchor currency since 1983. H-share discounts may therefore signal yuan/U.S. dollar exchange rate expectations.

have a better ability to predict changes in the yuan/U.S. dollar exchange rate than the random walk or forward exchange rates, at least at forecast horizons longer than one year.

Secondly, I investigate the determinants of ADR and H-share investors' exchange rate expectations. China makes a good case to study the validity of exchange rate theories since the yuan was pegged to the U.S. dollar from 1994 to July 20, 2005 and heavily managed afterwards. This implies that the official exchange rate does not react (in the peg regime), or reacts much less (in the managed floating regime), to changes in macroeconomic fundamentals than suggested by theory. I study the validity of exchange rate theories by testing the impact of macroeconomic fundamentals on the exchange rate expectations ADR and H-share investors form under free market conditions. Using panel data on 22 ADR/A-share stock pairs and 52 H-share/A-share stock pairs from December 1998 to February 2009 I find that ADR and H-share investors expect more yuan appreciation against the U.S. dollar: if the yuan's overvaluation decreases (the incentive of competitive devaluation); if the inflation differential vis-à-vis the United States falls (relative purchasing power parity); if the productivity growth in China accelerates relative to the United States (the Harrod-Balassa-Samuelson effect); if the Chinese interest rate differential vis-à-vis the United States decreases (uncovered interest rate parity); when Chinese domestic credit relative to GDP decreases (lower risk of a twin banking and currency crisis); or, if Chinese sovereign bond yields fall (lower risk of a twin debt and currency crisis), ceteris paribus. The results suggest that ADR and H-share investors form their exchange rate expectations in accordance with standard exchange rate theories.

The remainder of the paper is organized as follows. Section II.2 rationalizes the argument that the relative prices of cross-listed stocks and their underlying stocks contain information about exchange rate expectations. Section II.3 discusses the development of the ADR and H-share discounts in the period 1998-2009. Section II.4 presents a forecasting framework testing the ability of ADR and H-share discounts to signal exchange rate changes.

Section II.5 analyzes the determinants of ADR and H-share investors' exchange rate expectations. Section II.6 concludes.

II.2 Exchange rate expectations and the Chinese ADR and H-share discounts

II.2.1 The ADR discount

An ADR represents ownership of a specific number of underlying shares in the home market – in this case, China – on which the ADR is written.[19] While the ADR is traded at a U.S. stock exchange and is denominated in U.S. dollars, the underlying Chinese A-share is denominated in yuan and traded at a Chinese stock exchange (Shanghai or Shenzhen). The starting point of the discussion is ADR conversion. ADR conversion means that one ADR, traded in the United States and quoted in U.S. dollars at price p_{it}^{ADR}, can be converted into γ_i A-shares, traded in China and quoted in yuan at price p_{it}^{CN}. The variable γ_i is called the conversion ratio and is specific to each Chinese company, i. ADR conversion implies that the ADR and its underlying A-share are perfect substitutes. As both types of stocks of the same company generate identical streams of cash flows and incorporate equivalent rights and dividend claims, ADRs and their underlying A-shares should exhibit the same price after applying the current official exchange rate, S_t, defined as the amount of yuan per U.S. dollar. In a perfect capital market (with no ownership restrictions or capital controls), arbitrage forces ensure the validity of the law of one price:

$$p_{it}^{ADR} = \frac{p_{it}^{CN}\gamma_i}{S_t}. \tag{II.1}$$

China is not a perfect capital market in this sense. Ownership restrictions and capital controls in China prohibit foreign investors from buying A-shares and domestic investors from buying cross-listed ADRs making cross-border arbitrage between domestic A-shares and cross-listed

[19] See Karolyi (1998) for an excellent survey on the ADR market.

ADRs impossible. The absence of arbitrage forces allows for a permanent violation of the law of one price, i.e. that price discrepancies between A-shares and ADRs can occur and persist over time suggesting that Eq. (II.1) is not binding. That is, the relative share prices do not necessarily reflect the current official exchange rate (which is managed by the Chinese central bank) but can indicate ADR investors' expected exchange rate. If ADR investors anticipate that the expected future exchange rate, $S_{it}^{\exp}$, deviates from the current official exchange rate, S_t, the price relation between ADRs and A-shares should incorporate this expectation as outlined in Eq. (II.2):

$$p_{it}^{ADR} = \frac{p_{it}^{CN}\gamma_i}{S_{it}^{exp}} . \tag{II.2}$$

If ADR investors expect the yuan to depreciate against the U.S. dollar, the relative prices of the ADR and the underlying A-share will reflect an expected exchange rate that is higher than the current official exchange rate, i.e. $S_{it}^{exp} > S_t$. In this case, the ADR seems to be undervalued since its price (Eq., II.2) is lower than the right-hand side of Eq. (II.1) indicates. Expectations of a depreciation of the yuan against the U.S. dollar thus lead to an ADR discount as the actual market-traded ADR price $p_{it}^{ADR} = p_{it}^{CN}\gamma_i / S_{it}^{exp}$ trades at a discount to the ADR price implied by the current official exchange rate, $p_{it}^{ADR} < p_{it}^{CN}\gamma_i / S_t$. If investors expect the yuan to appreciate against the U.S. dollar, $S_{it}^{\exp} < S_t$, the actual market-traded ADR price, $p_{it}^{ADR} = p_{it}^{CN}\gamma_i / S_{it}^{exp}$, trades at a premium to the ADR price implied by the current official exchange rate, $p_{it}^{ADR} > p_{it}^{CN}\gamma_i / S_t$.

In the literature the ADR discount is typically used to measure price discrepancies between an ADR and its underlying stock, as outlined in Eq. (II.3):

$$ADR\ discount_{it} = \frac{p_{it}^{ADR} - \frac{p_{it}^{CN}\gamma_i}{S_t}}{\frac{p_{it}^{CN}\gamma_i}{S_t}}, \tag{II.3}$$

where p_{it}^{ADR} is the actual market-traded ADR price (that contains the expected exchange rate, $S_{it}^{\exp}$) and $p_{it}^{CN}\gamma_i / S_t$ is the hypothetical ADR price implied by the current official exchange rate, S_t. Assuming that the relative price of the ADR and its underlying A-share reflects the expected exchange rate as shown in Eq. (II.2), it is straightforward to show that the ADR discount indicates ADR investors' expected exchange rate:

$$ADR\ discount_{it} = \frac{S_t}{S_{it}^{exp}} - 1. \tag{II.4}$$

Assuming information efficiency, the ADR discount is an indicator of exchange rate expectations ADR investors form on the basis of publicly available information. As soon as the market receives new information about the yuan's fair future value against the U.S. dollar, the ADR discount will adjust. If ADR investors expect a relatively weaker yuan (i.e. more yuan depreciation or less yuan appreciation against the U.S. dollar), they will attach lower prices to ADRs and the ADR discount will fall, ceteris paribus. If ADR investors expect a relatively stronger yuan (i.e. less yuan depreciation or more yuan appreciation against the U.S. dollar), they will attach higher prices to ADRs and the ADR discount will increase, ceteris paribus.[20]

[20] The considerations so far build on the assumption of perfect capital markets. In reality, however, some aspects of the ADR market, such as transaction costs, bid-ask spreads or infrequent trading, contradict this assumption. These frictions can lead to company- or market-specific no-arbitrage bands within which arbitrage strategies, aimed at exploiting price spreads between ADRs and their underlying stocks, do not pay off. These market frictions should have only a minor impact on the results. First, this analysis relies on exploiting the variation in the ADR discount over time. As market frictions should not change much over time, they should be captured by the constant in the regressions. Second, Levy Yeyati et al. (2009) find for a large set of emerging economies that no-arbitrage bands are generally narrow and that price spreads outside these bands are arbitraged away very quickly. It therefore seems reasonable to assume that market frictions play only a minor role in determining the

II.2.2 The H-share discount

An H-share is another type of cross-listed stock. It represents the ownership of one Chinese A-share of company i.[21] The H-share is traded in Hong Kong and denominated in Hong Kong dollars. Translating the H-share price into U.S. dollars using the (nearly constant) Hong Kong dollar/U.S. dollar exchange rate, I denote the H-share price as p_{it}^{HK} (measured in U.S. dollars).[22] Analogous to the case of ADRs, the price relation between H-shares and A-shares can signal expectations of the future yuan/U.S. dollar exchange rate since cross-border arbitrage between H-shares and A-shares cannot take place due to ownership restrictions and capital controls in China.

The literature typically uses the H-share discount to measure price discrepancies between H-shares and A-shares, which is defined as:

$$H\text{-}share\ discount_{it} = \frac{p_{it}^{HK} - \dfrac{p_{it}^{CN}}{S_t}}{\dfrac{p_{it}^{CN}}{S_t}}, \tag{II.5}$$

where the H-share price contains the future yuan/U.S. dollar exchange rate expected by H-share investors, i.e. $p_{it}^{HK} = p_{it}^{CN} / S_{it}^{exp}$. Similar to the case of ADRs, the H-share discount can be used as an indicator of H-share investors' exchange rate expectations as outlined in Eq. (II.6):

$$H\text{-}share\,discount = \frac{S_t}{S_{it}^{exp}} - 1. \tag{II.6}$$

ADR discount during capital controls as well. Accordingly, the majority of the variation in the ADR discount can be attributed to changes in exchange rate expectations.

[21] Contrary to the case of ADRs, the conversion ratio of H-shares is one by definition.

[22] Hong Kong has implemented a currency board system with the U.S. dollar as the anchor currency since 1983. The Hong Kong dollar/U.S. dollar exchange rate therefore shows only minimal fluctuations.

Lower H-share discounts indicate that H-share investors anticipate a relatively less valuable yuan, i.e. more yuan depreciation or less yuan appreciation against the U.S. dollar, ceteris paribus. Higher H-share discounts indicate expectations of a relatively more valuable yuan, i.e. less yuan depreciation or more yuan appreciation against the U.S. dollar, ceteris paribus.

II.3 ADR and H-share discounts in China 1998-2009

The empirical analysis uses data on 22 ADR/A-share pairs and 52 H-share/A-share pairs from December 1998 to February 2009. The included companies are listed in Table II.A1 in Appendix II. Using data on prices of A-shares and ADRs or H-shares, conversion ratios, and the official yuan/U.S. dollar exchange rate, I calculate the ADR discount for each ADR/A-share pair according to Eq. (II.3) and the H-share discount for each H-share/A-share pair according to Eq. (II.5) over time. All data is taken from Datastream. Each stock pair has an individual ADR or H-share discount suggesting that investors' assessments of the future yuan/U.S. dollar exchange rate (can) vary by company, for example due to investor sentiments or liquidity conditions[23] Figure II.1 depicts the arithmetic average of ADR and H-share discounts.[24]

At the beginning of the sample period (December 1998), the average ADR and H-share discounts were near their lowest points, at around -79% and -86%.[25] These low discounts may indicate that investors expected the yuan to devaluate along with most of the Southeast Asian

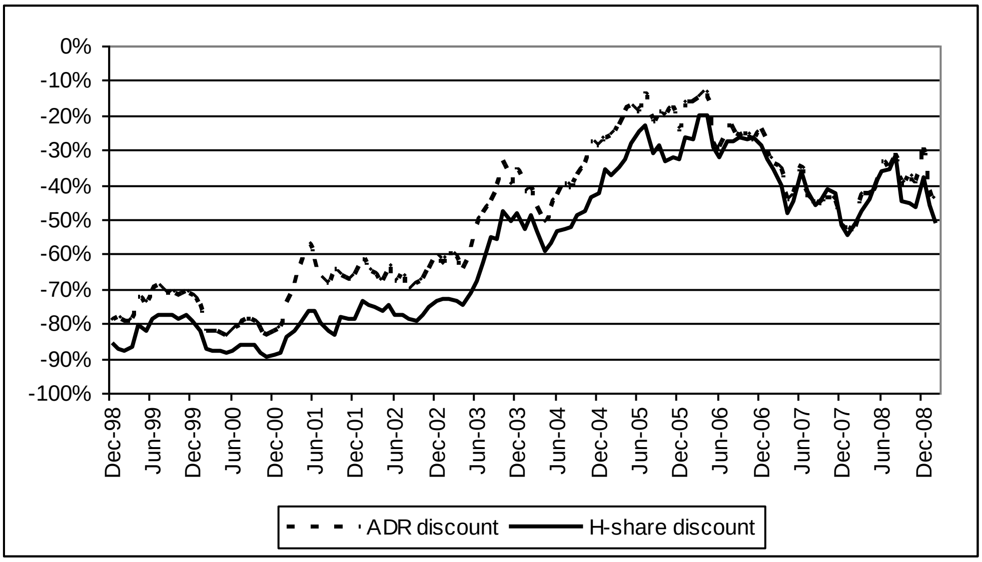
[23] In the empirical analyses in Sections II.4 and II.5 I use company-specific discounts. In the regression analysis in Section II.5, I control for company-specific determinants of the ADR and H-share discounts by including control variables, for example, company-specific investor sentiments or liquidity conditions.

[24] This descriptive explanation of the development of ADR and H-share discounts does not consider the exact value of ADR and H-share discounts but rather focuses on the development of the discounts in time. That is because the exact value of the discounts is, for example, driven by company-specific determinants (such as investor sentiments, liquidity, or market capitalization), which are not in the scope of the dissertation. I focus on the time variation of ADR and H-share discounts, which is presumably driven by changes in exchange rate expectations of stock market investors (see Chapter II.2).

[25] In the period December 1998 to mid 2006 the averaged ADR discounts are systematically higher than the averaged H-share discounts. This observation may be explained by the fact that the averaged ADR discount is based on much less individual stocks than the averaged H-share discount, which is due to the better availability of data on H-shares (see Table II.A1 in the Appendix). Since the discounts of individual ADRs or H-shares may systematically differ due to company-specific factors (such as investor sentiments, liquidity, or market capitalization), the averaged values of ADRs and H-share discounts may also be different.

currencies, which had sharply depreciated against the U.S. dollar during the Asian financial crisis. After the Asian crisis was over and China's "economic miracle", characterized by fast export and productivity growth and low inflation, started, the discounts increased between 2000 and 2005, which reflected investors' expectations of a more valuable

Figure II.1: Average ADR and H-share discounts of Chinese cross-listed companies



Note: This figure shows the averaged ADR and H-share discounts for the sample companies in the period December 1998 to February 2009 (see Table II.A1 in Appendix II for the list of included companies). The ADR and H-share discounts are computed using Eqs. II.3 and II.5.

yuan relative to the U.S. dollar. The highest values for ADR and H-share discounts were -13% in July 2005 and -20% in April 2006, respectively. These peaks occurred following the Chinese government's decision to move from a peg to the U.S. dollar to a managed float in July 2005. On July 21, 2005, the yuan was revaluated by 2% from 8.27 to 8.11 yuan/U.S. dollar. Subsequent revaluations fed expectations of a lower yuan/U.S. dollar exchange rate resulting in near record high values of ADR and H-share discounts to between -35% and -13% in 2005 and 2006.

The outbreak of the subprime lending crisis in 2007 was associated with lower ADR and H-share discounts ranging from -55% to -30% between 2007 and 2009. The lower discounts may partly reflect a fundamental change in exchange rate expectations. In an effort to shield the domestic export industry from unfavorable world market conditions, Chinese authorities stopped revaluating the yuan against the U.S. dollar from July 2008 to June 2010, thereby disrupting expectations of future yuan appreciations (in the observation period of this paper). The subprime lending crisis may also have had a negative impact on investors' assessments of the yuan's fair fundamental value against the U.S. dollar. China's growth in exports and labor productivity slowed in 2008 and 2009, which negatively affects the yuan's fair value. The Chinese banking system is suffering from bad loans, feeding expectations of large-scale bank re-capitalizations that could lead to inflationary pressure and, in turn, to a less valuable yuan.

II.4 Forecasting performance of ADR and H-share investors' exchange rate expectations

In order to test the ability of ADR and H-share discounts to forecast changes in the yuan/U.S. dollar exchange rate, I apply a "rolling regressions" framework. That is, I estimate a regression model that explains the actual exchange rate change using ADR or H-share discounts in sample, produce an out-of-sample forecast, move the sample one observation forward, and repeat the procedure until the sample observations are exhausted. The in-sample forecasting regression models for ADR and H-share discounts are outlined in Eqs. (II.7) and (II.8):

$$\frac{S_{t+k}-S_t}{S_t}-\frac{S_{t-1+k}-S_{t-1}}{S_{t-1}}=\alpha_{ik}+\beta_{ik}\left(ADR\,discount_{it}-ADR\,discount_{it\text{-}1}\right)+u_{ikt}\,, \qquad \text{(II.7)}$$

$$\frac{S_{t+k}-S_t}{S_t}-\frac{S_{t-1+k}-S_{t-1}}{S_{t-1}}=\alpha_{ik}+\beta_{ik}\left(H\text{ - }share\,discount_{it}-H\text{ - }share\,discount_{it\text{-}1}\right)+u_{ikt}\,, \qquad \text{(II.8)}$$

where the first difference in the k periods ahead percentage change of the yuan/U.S. dollar exchange rate is regressed on the first difference in the ADR or H-share discount. I estimate the model in first differences for two reasons. Firstly, ADR and H-share discounts of many included companies contain unit roots in levels. Using stationary time series in first differences avoids the problem of spurious regressions caused by unit root processes (see Chapter V). Secondly, the first difference of ADR/H-share discounts can easily be interpreted in terms of the change in exchange rate expectations as explained in the following. Assume that the expected exchange rate incorporated in the ADR discount (see Eq., II.4) measures ADR investors' *k* periods ahead forecast of the exchange rate, i.e. ADR investors expect the exchange rate to change from S_t today to $S_{ikt}^{\exp}$ in $t+k$, which equals an expected exchange rate change of $g_{ikt} = \left(S_t - S_{ikt}^{\exp}\right) / S_{ikt}^{\exp}$ percent. Using Eq. (II.4) one can show that the first difference in ADR discounts measures the change in depreciation expectations, i.e. $ADR\,discount_{it} - ADR\,discount_{it\text{-}1} = g_{ikt} - g_{ikt-1}$.[26] Thus, the forecasting model tests whether the today's change in ADR or H-share investors' depreciation expectations helps to forecast the change in the realized depreciation in the next *k* periods.

I apply the forecasting model to exchange rate changes in the managed float period from July 21, 2005 to the end of February 2009 (the end of the observation period of this paper).[27] Since the forecasting period is relatively short, I use weekly data to produce and evaluate a reasonable number of exchange rate forecasts. To evaluate the quality of the forecasts, I use six different forecast horizons *k*: one month, two months, six months, one year, two years, and five years. The forecasting models (Eqs. II.7 and II.8) are estimated using 52 consecutive weekly observations. For each forecast horizon/ADR or H-share pair I estimate 137 in-sample regressions.[28] I use six ADR and 20 H-share pairs.[29] For each in-sample estimation, I use the

[26] This holds analogously for H-shares.
[27] Exchange rate changes in the peg regime before July 21, 2005 cannot be considered since the yuan/U.S. dollar exchange rate was fixed and thus every forecasting model would fail to provide reasonable predictions.
[28] The considered floating rate period (July 21, 2005 to end of February 2009) spans 189 weeks. Since the first 52 weeks are needed to produce in-sample estimates I can produce 137 forecasts.
[29] The ADRs and H-shares used in the forecasting models represent only a sub-sample of the shares used in the panel regression analysis in Section II.5. For the forecasting exercises in this section, I exclude some companies because their shares started trading after the beginning of the five year forecasting horizon in July 2000.

model parameters (α_{ik} and β_{ik}) and the next period change in the ADR or H-share discounts to produce an out-of-sample forecast. This out-of-sample forecast is then compared with the realized percentage change in the yuan/U.S. dollar exchange rate within the forecast horizon of *k* weeks. In total, this analysis relies on more than 21,000 exchange rate forecasts.

To evaluate the forecasting quality of each model, I use the direction of change statistic and the mean squared error (MSE) ratio. The direction of change statistic is calculated as the number of forecasts with correct predictions of the direction of exchange rate change over the total number of predictions (137). Values above (below) 50% indicate better (worse) forecasting ability than a random walk. To assess whether the direction of change statistic is significantly different from 0.5, Diebold and Mariano (1995) propose the test statistic $\left(\bar{d}_{ik} - 0.5\right) / \sqrt{0.25/T}$, where $\bar{d}_{ik}$ denotes the direction of change statistic and T is the number of forecasts. Under the null of $\bar{d}_{ik} = 0.5$ this test statistic is distributed as standard normal.

As a second evaluation criterion I use the ratio between the MSE[30] of the ADR/H-share-based forecast and the MSE of the forward exchange rate-based forecast.[31] MSE ratios above (below) one indicate that ADR/H-share discounts have worse (better) forecasting ability than forward exchange rates. To test the significance of the MSE ratio, I use the Diebold and Mariano (1995) statistic (DM-statistic), which tests the null that the difference between the ADR/H-share-based MSE and the forward exchange rate-based MSE, $L_{ikt} = MSE_{ikt}^{ADR/H-share} - MSE_{kt}^{Forward}$, is zero. Using the mean of L_{ikt} , $\bar{L}_{ik}$, and the variance, $var\left(\bar{L}_{ik}\right)$, the DM-statistic is calculated as $\bar{L}_{ik} \big/ \sqrt{var\left(\bar{L}_{ik}\right)}$ and distributed standard normal. A significantly negative (positive) DM-statistic indicates that ADR/H-shares produce better (worse) forecasts than forward exchange rates. The results of the evaluation of the

[30] The MSE equals the average of the squared differences between the forecasted exchange rate and the realized exchange rate.
[31] I calculate the out-of-sample forecasts of forward rates using the week-over-week change in the forward premium (i.e. the percentage deviation of the forward exchange rate over the spot exchange rate) in a forecasting equation similar to Eqs. (II.7) and (II.8). For each forecast horizon *k* I use the forward rates with the same maturity *k*.

forecast models are presented in Tables II.1 and II.2. Table II.1 reports the direction of change statistics of the ADR and H-share forecast models for each forecast horizon together with the associated t-values. A direction of change statistic significantly greater than (lower than) 0.5 indicates better (worse) forecasting ability than a random walk. For short forecast horizons (one month to one year) I find that the direction of change statistic is not significantly different from 0.5 for almost all stock pairs indicating that ADR and H-share discounts do not predict changes in the yuan/U.S. dollar exchange rate significantly better than the random walk. For long forecast horizons (two years and five years) I find that the direction of change statistic is significantly greater than 0.5 for almost all ADR and H-share pairs indicating that ADR and H-share discounts tend to predict the correct direction of exchange rate change in the long run. This result resembles the conclusion of the literature, that the random walk beats exchange rate forecast models in the short run while some models perform well in the long run.

Table II.2 reports the MSE ratio between ADR/H-share-based and forward rate-based forecasts together with the DM-statistic. MSE ratios below (above) one and a significantly negative (positive) DM-statistic indicate that ADR/H-shares have better (worse) forecasting ability than forward exchange rates. The results indicate that for all forecast horizons ADR and H-share discounts are significantly more accurate in forecasting yuan/U.S. dollar exchange rate changes than forward exchange rates. A possible explanation for the poor forecasting performance of forward rates may be that the People's Bank of China (PBoC) intervenes in the forward exchange market in order to influence investors' exchange rate expectations, thereby facilitating the conduct of its exchange rate policy. In the recent managed floating period beginning in July 2005 the PBoC may have been interested in systematically increasing the yuan/U.S. dollar forward exchange rate, thereby cushioning expectations toward more yuan appreciation against the U.S. dollar in order to reject U.S. calls to more yuan appreciation.

Table II.1: Direction of change statistics of out-of-sample forecasts

	Forecast horizon					
	1 month	2 months	6 months	1 year	2 years	5 years
ADRs						
China Eastern Airlines ADR	0.445	0.489	0.540	0.504	0.620	0.664
	(-1.282)	(-0.256)	(0.940)	(0.085)	(2.819) ***	(3.845) ***
Shanghai Chlor Chemical ADR	0.460	0.489	0.526	0.518	0.606	0.664
	(-0.940)	(-0.256)	(0.598)	(0.427)	(2.478) **	(3.845) ***
Shanghai Erfangji ADR	0.518	0.445	0.504	0.547	0.620	0.650
	(0.427)	(-1.282)	(0.085)	(1.111)	(2.819) ***	(3.503) ***
Sinopec Shanghai ADR	0.496	0.467	0.540	0.518	0.628	0.657
	(-0.085)	(-0.769)	(0.940)	(0.427)	(2.990) ***	(3.674) ***
Tsingtao Brewery ADR	0.482	0.482	0.533	0.504	0.628	0.657
	(-0.427)	(-0.427)	(0.769)	(0.085)	(2.990) ***	(3.674) ***
Yanzhou Coal Mining ADR	0.467	0.445	0.533	0.511	0.628	0.672
	(-0.769)	(-1.282)	(0.769)	(0.256)	(2.990) ***	(4.015) ***
H-shares						
Angang Steel H-share	0.467	0.511	0.547	0.496	0.584	0.664
	(-0.769)	(0.256)	(1.111)	(-0.085)	(1.965) **	(3.845) ***
Beiren Printing Machines H-share	0.474	0.460	0.518	0.540	0.620	0.672
	(-0.598)	(-0.940)	(0.427)	(0.940)	(2.819) ***	(4.015) ***
China Eastern Airlines H-share	0.423	0.401	0.518	0.526	0.613	0.664
	(-1.794) *	(-2.307) **	(0.427)	(0.598)	(2.649) ***	(3.845) ***
Dofang Electric H-share	0.467	0.445	0.511	0.504	0.555	0.679
	(-0.769)	(-1.282)	(0.256)	(0.085)	(1.282)	(4.186) ***

Guangzhou Pharmaceutical H-share	0.504	0.526	0.453	0.555	0.613	0.664
	(0.085)	(0.598)	(-1.111)	(1.282)	(2.649) ***	(3.845) ***
Guangzhou Shipyard H-share	0.445	0.518	0.504	0.511	0.591	0.664
	(-1.282)	(0.427)	(0.085)	(0.256)	(2.136) **	(3.845) ***
Hisense Kelon Electrical H-share	0.467	0.496	0.533	0.540	0.620	0.672
	(-0.769)	(-0.085)	(0.769)	(0.940)	(2.819) ***	(4.015) ***
Jiangsu Expressway H-share	0.467	0.482	0.533	0.540	0.591	0.679
	(-0.769)	(-0.427)	(0.769)	(0.940)	(2.136) **	(4.186) ***
Jingwei Textile Machines H-share	0.489	0.533	0.540	0.555	0.606	0.672
	(-0.256)	(0.769)	(0.940)	(1.282)	(2.478) **	(4.015) ***
Luoyang Glass H-share	0.467	0.504	0.518	0.526	0.620	0.664
	(-0.769)	(0.085)	(0.427)	(0.598)	(2.819) ***	(3.845) ***
Maanshan Iron & Steel H-share	0.474	0.526	0.540	0.511	0.606	0.657
	(-0.598)	(0.598)	(0.940)	(0.256)	(2.478) **	(3.674) ***
Nanjing Panda Electronic H-share	0.474	0.496	0.518	0.555	0.577	0.664
	(-0.598)	(-0.085)	(0.427)	(1.282)	(1.794) *	(3.845) ***
Northeast Electric H-share	0.496	0.555	0.518	0.496	0.606	0.664
	(-0.085)	(1.282)	(0.427)	(-0.085)	(2.478) **	(3.845) ***
Shandong Xinhua Pharma H-share	0.511	0.555	0.482	0.511	0.620	0.664
	(0.256)	(1.282)	(-0.427)	(0.256)	(2.819) ***	(3.845) ***
Shenji Group Kumato H-share	0.489	0.474	0.496	0.518	0.620	0.657
	(-0.256)	(-0.598)	(-0.085)	(0.427)	(2.819) ***	(3.674) ***
Sinopec Shanghai Petrochemicals H-share	0.496	0.489	0.540	0.482	0.635	0.650
	(-0.085)	(-0.256)	(0.940)	(-0.427)	(3.161) ***	(3.503) ***
Sinopec Yizheng Chemcial H-share	0.467	0.489	0.504	0.504	0.577	0.657
	(-0.769)	(-0.256)	(0.085)	(0.085)	(1.794) *	(3.674) ***

Tianjin Capital H-share	0.482	0.453	0.518	0.504	0.591	0.672
	(-0.427)	(-1.111)	(0.427)	(0.085)	(2.136) **	(4.015) ***
Tsingtao Brewery H-share	0.511	0.460	0.533	0.504	0.635	0.664
	(0.256)	(-0.940)	(0.769)	(0.085)	(3.161) ***	(3.845) ***
Yanzhou Coal Mining H-share	0.504	0.496	0.562	0.496	0.606	0.672
	(0.085)	(-0.085)	(1.452)	(-0.085)	(2.478) **	(4.015) ***

Note: This table presents the direction of change statistics of the out-of-sample forecasts for the period July 21, 2005 to February 23, 2009. The first entry in each cell is the direction of change statistic defined as the number of ADR/H-share-based forecasts with correct predictions of the direction of exchange rate change over the total number of predictions. The second entry in each cell is the t-value (in parentheses) testing the null that the direction of change statistic is 0.5. *, **, and *** denotes significance at the 10%, 5%, and 1% level.

Table II.2: MSE ratios and Diebold-Mariano statistics of out-of-sample forecasts

	Forecast horizon					
	1 month	2 months	6 months	1 year	2 years	5 years
ADRs						
China Eastern Airlines ADR	0.582	0.470	0.340	0.526	0.237	0.010
	(-1.864) *	(-1.734) *	(-2.168) **	(-1.739) *	(-4.702) ***	(-5.396) ***
Shanghai Chlor Chemical ADR	0.582	0.472	0.340	0.518	0.241	0.010
	(-1.841) *	(-1.772) *	(-2.177) **	(-1.830) *	(-4.721) ***	(-5.398) ***
Shanghai Erfangji ADR	0.581	0.482	0.332	0.511	0.237	0.010
	(-1.888) *	(-1.756) *	(-2.206) **	(-1.851) *	(-4.780) ***	(-5.399) ***
Sinopec Shanghai ADR	0.588	0.467	0.338	0.521	0.241	0.010
	(-1.941) *	(-1.764) *	(-2.168) **	(-1.785) *	(-4.637) ***	(-5.397) ***
Tsingtao Brewery ADR	0.566	0.448	0.329	0.517	0.238	0.010
	(-1.851) *	(-1.751) *	(-2.173) **	(-1.795) *	(-4.658) ***	(-5.397) ***
Yanzhou Coal Mining ADR	0.576	0.469	0.336	0.523	0.236	0.010
	(-1.869) *	(-1.765) *	(-2.183) **	(-1.777) *	(-4.694) ***	(-5.399) ***
H-shares						
Angang Steel H-share	0.585	0.464	0.337	0.525	0.235	0.010
	(-1.813) *	(-1.732) *	(-2.172) **	(-1.778) *	(-4.693) ***	(-5.394) ***
Beiren Printing Machines H-share	0.575	0.466	0.338	0.527	0.231	0.009
	(-1.858) *	(-1.774) *	(-2.173) **	(-1.756) *	(-4.834) ***	(-5.398) ***
China Eastern Airlines H-share	0.588	0.485	0.340	0.540	0.238	0.010
	(-1.846) *	(-1.691) *	(-2.165) **	(-1.775) *	(-4.682) ***	(-5.397) ***
Dofang Electric H-share	0.577	0.475	0.346	0.535	0.240	0.010
	(-1.809) *	(-1.731) *	(-2.137) **	(-1.708) *	(-4.654) ***	(-5.397) ***

Guangzhou Pharmaceutical H-share	0.577	0.472	0.336	0.520	0.244	0.010
	(-1.886) *	(-1.726) *	(-2.177) **	(-1.788) *	(-4.605) ***	(-5.397) ***
Guangzhou Shipyard H-share	0.582	0.455	0.352	0.537	0.255	0.009
	(-1.829) *	(-1.789) *	(-2.083) **	(-1.680) *	(-4.461) ***	(-5.395) ***
Hisense Kelon Electrical H-share	0.583	0.473	0.342	0.510	0.235	0.009
	(-1.896) *	(-1.774) *	(-2.178) **	(-1.810) *	(-4.716) ***	(-5.399) ***
Jiangsu Expressway H-share	0.582	0.468	0.332	0.517	0.239	0.010
	(-1.780) *	(-1.772) *	(-2.185) **	(-1.824) *	(-4.646) ***	(-5.398) ***
Jingwei Textile Machines H-share	0.569	0.469	0.338	0.531	0.240	0.010
	(-1.846) *	(-1.759) *	(-2.157) **	(-1.718) *	(-4.617) ***	(-5.396) ***
Luoyang Glass H-share	0.566	0.472	0.344	0.520	0.238	0.010
	(-1.846) *	(-1.763) *	(-2.185) **	(-1.836) *	(-4.685) ***	(-5.398) ***
Maanshan Iron & Steel H-share	0.570	0.453	0.339	0.522	0.235	0.009
	(-1.890) *	(-1.800) *	(-2.119) **	(-1.805) *	(-4.661) ***	(-5.397) ***
Nanjing Panda Electronic H-share	0.581	0.463	0.345	0.525	0.242	0.010
	(-1.896) *	(-1.757) *	(-2.141) **	(-1.790) *	(-4.535) ***	(-5.397) ***
Northeast Electric H-share	0.589	0.466	0.373	0.543	0.239	0.010
	(-1.949) *	(-1.737) *	(-1.978) **	(-1.676) *	(-4.693) ***	(-5.396) ***
Shandong Xinhua Pharma H-share	0.580	0.448	0.336	0.518	0.236	0.010
	(-1.815) *	(-1.776) *	(-2.181) **	(-1.814) *	(-4.712) ***	(-5.400) ***
Shenji Group Kumato H-share	0.574	0.469	0.335	0.525	0.239	0.009
	(-1.858) *	(-1.725) *	(-2.169) **	(-1.763) *	(-4.612) ***	(-5.399) ***
Sinopec Shanghai Petrochemicals H-share	0.588	0.463	0.334	0.518	0.240	0.010
	(-1.950) *	(-1.781) *	(-2.175) **	(-1.800) *	(-4.635) ***	(-5.396) ***
Sinopec Yizheng Chemcial H-share	0.582	0.465	0.343	0.541	0.244	0.009
	(-1.943) *	(-1.765) *	(-2.145) **	(-1.662) *	(-4.484) ***	(-5.400) ***

Tianjin Capital H-share	0.579	0.474	0.339	0.529	0.240	0.009
	(-1.880) *	(-1.719) *	(-2.161) **	(-1.735) *	(-4.704) ***	(-5.399) ***
Tsingtao Brewery H-share	0.576	0.456	0.332	0.522	0.237	0.010
	(-1.835) *	(-1.760) *	(-2.168) **	(-1.778) *	(-4.621) ***	(-5.397) ***
Yanzhou Coal Mining H-share	0.579	0.465	0.336	0.526	0.236	0.010
	(-1.889) *	(-1.789) *	(-2.163) **	(-1.761) *	(-4.666) ***	(-5.399) ***

Note: This table presents the MSE ratios and the Diebold-Mariano statistics of the out-of-sample forecasts for the period July 21, 2005 to February 23, 2009. The first entry in each cell is the MSE ratio defined as the ratio between the MSE of the ADR/H-share-based forecast and the MSE of forward rate-based forecast. The second entry in each cell reports the Diebold and Mariano (1995) statistic (in parentheses) testing the null that the difference between the MSE of the ADR/H-share-based forecast and the MSE of forward rate-based forecast is zero. *, **, and *** denotes significance at the 10%, 5%, and 1% level.

I conclude that the exchange rate expectations incorporated in ADR and H-share discounts are informative about the long-run direction of change of the yuan/U.S. dollar exchange rate and that ADR and H-share discounts have better forecasting ability than forward exchange rates at all forecast horizons tested.

II.5 Determinants of ADR and H-share investors' exchange rate expectations

In this section I study how ADR and H-share investors form their exchange rate expectations. In Section II.5.1 I present eight variables that, according to theory, determine exchange rates. I hypothesize that these variables also determine ADR and H-share investors' exchange rate *expectations*. In Section II.5.2 I use panel regressions to test these hypotheses.

II.5.1 Hypotheses

II.5.1.1 The incentive to devaluate competitively

Several papers show the importance of competitive devaluations to explain the development of exchange rates (for example, Fernald et al., 1999; Glick and Rose, 1999; Corsetti et al., 2000). If ADR and H-share investors anticipate the temptation for the Chinese government to devaluate the yuan competitively in order to promote export growth, I expect that a higher degree of yuan overvaluation will lead to expectations towards more yuan depreciation. To measure real overvaluation of the yuan, I use data on JP Morgan's real effective trade-weighted exchange rate index, which weights changes in the yuan's bilateral real exchange rates with bilateral trade.[32] To measure relative overvaluation of the yuan, I compute the percentage deviation of the exchange rate index from its linear time trend. Higher values indicate higher yuan overvaluation.

[32] All data is taken from Datastream.

Hypothesis 1: A more overvalued yuan increases the incentive to devaluate the yuan competitively, which increases the yuan's depreciation expectations and lowers ADR and H-share discounts.

II.5.1.2 Relative purchasing power parity (PPP)

The relative PPP assumes that the bilateral real exchange rate is constant over time. According to relative PPP, the yuan depreciates (appreciates) against the U.S. dollar when Chinese inflation exceeds (trails) U.S. inflation. Several studies find evidence in favor of the relative PPP (for example, Lothian, 1990; Lothian and Taylor, 1996; Lothian and Simaan, 1998; Taylor et al., 2001; Sarno and Valente, 2006).[33] If ADR and H-share investors believe in the validity of relative PPP, they will expect a relatively weaker yuan when Chinese inflation increases relative to U.S. inflation. To test the validity of relative PPP, I use the difference between Chinese and U.S. inflation taken from the International Monetary Fund (IMF)'s International Financial Statistics.

Hypothesis 2: In accordance with relative purchasing power parity (PPP), a larger inflation differential between China and the United States increases the yuan's depreciation expectations and, thus, lowers ADR and H-share discounts.

II.5.1.3 Harrod-Balassa-Samuelson (HBS) effect

According to the HBS hypothesis higher labor productivity growth in China, relative to the United States, leads to real appreciation of the yuan against the U.S. dollar.[34] While Chinn (2000), Bergin et al. (2006), and Thomas and King (2008) find empirical support for the HBS

[33] See Rogoff (1996) and Taylor and Taylor (2004) for excellent surveys on PPP.

[34] See Harrod (1933), Balassa (1964), and Samuelson (1964). Increasing labor productivity in the tradable goods sector leads to nominal wage increases in this sector. Perfect labor mobility implies that nominal wages in the non-tradable goods sector, where labor productivity is assumed to be constant, increase by the same amount, thereby increasing the prices of non-tradable goods. Thus, higher labor productivity leads to higher inflation, which, in turn, causes the domestic currency to appreciate in real terms.

effect, Cheung et al. (2007) and Lothian and Taylor (2008) find weak evidence. I quantify the HBS effect by measuring the labor productivity of China relative to the United States. To do so, I first divide real GDP per capita in China (provided by the National Bureau of Statistics of China) by real GDP per capita in the United States (provided by the Bureau of Labor Statistics). I then compute the percentage deviation of relative GDP per capita from its linear time trend.

Hypothesis 3: In accordance with the Harrod-Balassa-Samuelson (HBS) effect, a larger productivity differential between China and the United States increases the yuan's appreciation expectations and, thus, raises ADR and H-share discounts.

II.5.1.4 Uncovered interest rate parity (UIP)

UIP asserts that the returns on Chinese and U.S. risk-less assets are equal in exchange rate-adjusted terms. Higher interest rates in China relative to the United States should therefore indicate expected depreciation of the yuan against the U.S. dollar. Most studies that use short forecast horizons find evidence against the validity of UIP (Froot and Thaler, 1990; Flood and Rose, 2002). Some studies that use long-term interest rates confirm UIP (Lothian and Simaan, 1998) while others find mixed results (Meredith and Chinn, 1998; Chinn, 2006). In order to test the validity of the UIP, I use the difference between the three-month interbank interest rates of China (taken from the PBoC) and those of the United States (taken from the British Bankers Association).

Hypothesis 4: In accordance with the uncovered interest rate parity (UIP), a larger interest rate differential between China and the United States increases the yuan's depreciation expectations, which, in turn, lowers ADR and H-share discounts.

II.5.1.5 Foreign exchange reserves growth

The PBoC manages the yuan/U.S. dollar exchange rate by systematically buying U.S. dollars against yuan at the foreign exchange market. An increase in China's foreign exchange reserves may affect ADR and H-share investors' exchange rate expectations in two ways. First, higher reserve growth may indicate more undervaluation of the yuan. The more undervalued the yuan, the more foreign exchange reserves the PBoC must buy to maintain the (intentionally undervalued) yuan/U.S. dollar exchange rate. That is, faster foreign exchange reserves growth may increase the yuan's appreciation expectations. On the contrary, faster foreign exchange reserves growth may also increase the yuan's depreciation expectations. This is because unsterilized reserve accumulation increases money supply in China and may eventually lead to inflation and yuan depreciation. I use data on the monthly percentage change in foreign exchange reserves plus gold provided by the PBoC.

Hypothesis 5: The impact of foreign exchange reserve growth on the ADR and H-share discounts is not clear a priori. Faster foreign exchange reserve growth may increase or decrease the yuan's appreciation expectations.

II.5.1.6 Export growth

The fundamental equilibrium exchange rate (FEER) approach relates the equilibrium level of exchange rates to a current account target an economy reaches in the long run (Williamson, 1994; Isard, 2007). The FEER approach asserts that large current account surpluses produced by high export growth in China will fall in the long run as the yuan appreciates against the U.S. dollar. Higher export growth (provided by the General Administration of Customs China) thus increases expectations of yuan appreciation against the U.S. dollar.

Hypothesis 6: In accordance with the fundamental equilibrium exchange rate (FEER) approach, faster export growth in China increases the yuan's appreciation expectations and, thus, raises ADR and H-share discounts.

II.5.1.7 Risk of twin banking and currency crisis

Currency and banking crises often occur together (Kaminsky and Reinhart, 1999). A banking crisis may force the central bank – acting as a lender of last resort – to bail out troubled banks by printing money which, in turn, produces inflationary pressure that can lead to a currency crisis (Diaz-Alejandro, 1985; Velasco, 1987; Calvo, 1998; Miller, 2000). The connection between banking and currency crises suggests using a banking crisis indicator in the analysis. To measure banking crisis risk, I divide domestic credit (obtained from the PBoC) by GDP (provided by the National Bureau of Statistics of China). A higher ratio of domestic credit to GDP is presumably associated with a higher share of bad loans in domestic banks' loan portfolios and thus indicates higher banking crisis risk (Kaminsky, 2006).

Hypothesis 7: If ADR and H-share investors anticipate the risk of a twin banking and currency crisis, higher ratios of domestic credit to GDP, which indicate greater banking crisis risk, increase the yuan's depreciation expectations and lower ADR and H-share discounts.

II.5.1.8 Risk of twin sovereign debt and currency crisis

Several studies confirm the frequent incidence of twin sovereign debt and currency crises (Reinhart, 2002; Dreher et al., 2006; Herz and Tong, 2008). To capture the dependency between both types of crises, many approaches apply a second-generation currency crisis framework (Bauer et al., 2003; Benigno and Missale, 2004). A general finding is that a twin debt and currency crisis is more probable if a country's government is highly-indebted. As both types of crises are interrelated, sovereign debt crisis indicators may be useful indicators for exchange rate expectations as well. In order to measure the risk of sovereign debt crisis, I use data on the redemption yield of China's sovereign bonds taken from JP Morgan's Emerging Markets Bond Index (EMBI) Global. The EMBI includes the most liquid Brady and Eurobond issues of the respective country and is widely used in the literature on sovereign debt crises. Higher EMBI sovereign yields indicate a higher sovereign default risk, ceteris paribus.

Hypothesis 8: If ADR and H-share investors anticipate the risk of a twin sovereign debt and currency crisis, higher EMBI sovereign yields, which indicate greater risk of a sovereign debt crisis, will increase the yuan's depreciation expectations and, thus, lower ADR and H-share discounts.

II.5.2 Panel regression analysis

In addition to the exchange rate determinants discussed in Section II.5.1, I include ten control variables in the regressions. In accordance with Arquette et al. (2008) and Burdekin and Redfern (2009) I include the non-deliverable yuan/U.S. dollar forward premium in order to control for the impact of the forward exchange rate rate on ADR and H-share discounts.[35] Liquidity conditions are also found to affect price spreads of cross-listed stocks (Sun and Tong, 2000; Chen et al., 2001; Wang and Jiang, 2004; Chan et al., 2008). To measure liquidity conditions I use the relative turnover ratio defined as the monthly trading volume of the ADR or H-share over the monthly trading volume of the A-share. I expect that better liquidity conditions of the ADR or H-share relative to the A-share lead to falling relative A-share returns and, in turn, to higher ADR or H-share discounts. To control for company size, I include the company's market capitalization measured in trillions of yuan. I expect that larger firms have lower trading costs and that price discovery after news is released is quicker,

[35] The forward premium is calculated as the percentage deviation of the one-year non-deliverable yuan/U.S. dollar forward exchange rate over the yuan/U.S. dollar spot exchange rate.

thereby reducing the scope of news-driven changes in the discounts. Several authors find that ADR and H-share discounts react to differences in market-specific risks (Froot and Dabora, 1999; Kim et al., 2000; Wang and Jiang, 2004). I include the return differential between the Chinese A-share market (as measured by the Shanghai SE A-share Index) and the U.S. market (as measured by the S&P 500 Index) or the Hong Kong market (as measured by the Hang Seng Index). I expect that a higher risk of the Chinese stock market relative to the U.S. or Hong Kong stock market leads to higher relative A-share returns and thus to lower ADR and H-share discounts.

Several papers find that investor sentiments influence the relative prices of cross-listed stocks and their underlyings (for example, Kim et al., 2000; Arquette et al., 2008; Burdekin and Redfern, 2009). In accordance to Arquette et al. (2008) I measure investor sentiment towards the Chinese stock market relative to the U.S. or Hong Kong stock market using the relative market price-earnings (P/E) ratio, the relative market price-cash flow (P/CF) ratio, and the relative market price-book (P/B) ratio. I calculate the relative market P/E, P/CF, and P/B ratios by dividing the P/E, P/CF, and P/B ratio of the Chinese stock market by the P/E, P/CF, and P/B ratio of the U.S. stock market (for ADRs) or the Hong Kong stock market (for H-shares).[36] I measure investor sentiments towards individual companies using the relative company P/E, P/CF, and P/B ratios, which are calculated by dividing the P/E, P/CF, and P/B ratio of the A-share by the P/E, P/CF, and P/B ratio of the Chinese stock market as a whole.[37] I expect higher relative market and company P/E, P/CF, and P/B ratios to be associated with lower ADR and H-share discounts because more positive investor sentiments towards the Chinese stock market or individual stocks increase the relative price investors are willing to pay for the Chinese A-shares compared to ADRs or H-shares. All data is taken from Datastream.

[36] The P/E, P/CF, and P/B ratios of the stock markets are taken from the broad Datastream Global Equity Index for each stock market available from Datastream.
[37] As proposed by Arquette et al. (2008), I use the relative company P/E, P/CF, and P/B ratios in natural logs (to reduce the impact of outliers on the results) and one period lagged.

To test the hypotheses, I use panel regressions for ADR and H-share discounts as outlined in Eqs. (II.9) and (II.10):

$$ADR\,discount_{it} = \alpha + \sum_k \beta_k x_{kt} + \sum_j \beta_j x_{jit} + \gamma_i + \varepsilon_{it}\,, \tag{II.9}$$

$$H\text{-}share\,discount_{it} = \alpha + \sum_k \beta_k x_{kt} + \sum_j \beta_j x_{jit} + \gamma_i + \varepsilon_{it}\,. \tag{II.10}$$

The ADR (H-share) discount of company i in month t is regressed on a constant α, on k variables which do not vary across companies, x_{kt}, i.e., the eight macroeconomic variables outlined in Section II.5.1 plus the forward premium, the market return differential, and the relative market P/E, P/CF, and P/B ratios, and on j company-specific variables, x_{jit}, i.e., the relative trading volume, the market capitalization, and the relative company P/E, P/CF, and P/B ratios. β_k and β_j are the coefficients; γ_i is the company-specific fixed effects; ε_{it} is the error.

The ADR and H-share discounts are calculated as outlined in Eqs. (II.3) and (II.5). The ADR and H-share panels consist of 22 ADR/A-share pairs and 52 H-share/A-share pairs in the period December 1998 to February 2009. The companies included are listed in Table II.A1 in Appendix II. Table II.A2 in Appendix II shows the summary statistics of the variables. The analysis is restricted to monthly data, which is the highest frequency at which macroeconomic data is available. I test for unit roots using the panel unit root tests of Im et al. (2003) and Maddala and Wu (1999).[38] Under the null of each test, the variable contains a unit root. Table II.A3 in Appendix II reports the results of the panel unit root tests. Variables with a unit root in levels are used in first differences as indicated by a Δ in the results tables. I consequently use the yuan's overvaluation, the productivity differential,

[38] Chapter V provides a short overview of (panel) unit root tests.

the interest rate differential (in the ADR panel), and domestic credit to GDP in first differences in the estimations. The estimation results for the ADR and H-share panels are reported in Tables II.3 and II.4.

For each panel, I estimate eight specifications. The first specification only includes the eight macroeconomic determinants. In each of the following specifications I include an additional control variable: the yuan/U.S. dollar forward premium (II); the relative trading volume (III); the market capitalization (IV); and the return differential (V). Specifications (VI), (VII), and (VIII) additionally include investor sentiment variables based on the P/E, P/CF, and P/B ratio. Each regression includes company fixed effects.[39] The t-values are computed using robust standard errors clustered by company in order to control for heteroskedasticity and serial correlation. A positive coefficient indicates that a higher value of the exogenous variable increases the ADR or H-share discount reflecting expectations of a relatively more valuable yuan, i.e. more yuan appreciation, or, equivalently, less yuan depreciation against the U.S. dollar. Accordingly, a negative coefficient indicates that a higher value of the exogenous variable lowers the ADR or H-share discount reflecting expectations of a relatively less valuable yuan, i.e. more yuan depreciation, or, equivalently, less yuan appreciation against the U.S. dollar.

The estimation results for both panels confirm many of the hypotheses outlined in Section II.5.1. For 15 of the 16 specifications I find a negative and significant coefficient for the overvaluation of the yuan, which provides evidence for the competitive devaluations hypothesis (Hypothesis 1). This result suggests that ADR and H-share investors appear to anticipate that a more overvalued yuan may be an incentive for the Chinese government to devaluate the yuan in order to restore the competitiveness of the Chinese export industry.

[39] I also tested whether a random effects model would be more appropriate than the applied fixed effects model using the Hausman (1978) specification test, which tests the null that the random and fixed effects coefficients are equal. The results of the Hausman test indicate significantly different coefficient values suggesting that the fixed effects model is more appropriate.

Table II.3: Panel estimation results: ADR discounts

	I	II	III	IV	V	VI	VII	VIII
Real overvaluation of yuan (Δ)	-12.155	-74.752 **	-77.125 **	-75.296 ***	-70.053 **	-69.917 ***	-49.894 **	-45.706 *
	(-0.40)	(-2.68)	(-2.77)	(-2.88)	(-2.67)	(-3.00)	(-2.57)	(-1.89)
Inflation differential China vs. U.S.	-2.308 ***	-3.443 ***	-3.487 ***	-3.049 ***	-3.014 ***	-0.264	0.374	0.171
	(-4.06)	(-6.09)	(-6.27)	(-5.24)	(-5.13)	(-0.52)	(0.78)	(0.36)
Productivity differential China vs. U.S. (Δ)	8.924 ***	4.955 ***	4.925 ***	5.411 ***	5.310 ***	5.315 ***	4.550 ***	6.220 ***
	(4.99)	(3.73)	(3.89)	(4.41)	(4.43)	(4.37)	(3.99)	(5.87)
Interest rate differential China vs. U.S. (Δ)	-6.212 ***	-7.249 ***	-7.231 ***	-6.794 ***	-7.201 ***	-4.004 ***	-3.058 ***	-4.973 ***
	(-3.97)	(-4.58)	(-4.59)	(-4.44)	(-4.89)	(-6.26)	(-3.56)	(-6.39)
Foreign exchange reserves growth	-0.172	-1.583 ***	-1.582 ***	-1.640 ***	-1.569 ***	-1.049 **	-2.346 ***	-2.173 ***
	(-0.41)	(-3.65)	(-3.63)	(-3.75)	(-3.66)	(-2.67)	(-4.95)	(-5.07)
Export growth	0.050	-0.013	-0.011	-0.024	-0.023	-0.107 ***	-0.123 ***	-0.147 ***
	(1.15)	(-0.28)	(-0.26)	(-0.60)	(-0.58)	(-3.06)	(-3.84)	(-4.29)
Domestic credit to GDP (Δ)	-0.493 ***	-0.482 **	-0.478 **	-0.402 **	-0.447 **	0.062	0.116	-0.030
	(-2.94)	(-2.79)	(-2.75)	(-2.23)	(-2.58)	(0.52)	(0.98)	(-0.24)
EMBI sovereign bond yield	-8.081 ***	-5.724 ***	-5.705 ***	-4.659 **	-4.799 ***	-0.620	0.632	-3.132 **
	(-4.35)	(-3.33)	(-3.33)	(-2.79)	(-2.86)	(-0.49)	(0.49)	(-2.26)
Yuan/USD forward premium		-2.348 ***	-2.375 ***	-2.623 ***	-2.606 ***	-2.574 ***	-2.180 ***	-2.726 ***
		(-4.27)	(-3.97)	(-4.79)	(-4.79)	(-5.68)	(-6.75)	(-6.31)
Relative trading volume A-share vs.			0.193	0.227	0.294	-0.235	-0.111	0.057
ADR			(0.28)	(0.38)	(0.49)	(-0.55)	(-0.31)	(0.12)
Market capitalization				-0.306 ***	-0.305 ***	-0.124 **	-0.079	-0.098
				(-3.24)	(-3.23)	(-2.18)	(-1.25)	(-1.48)
Return differential China vs. U.S.					0.118 **	0.301 ***	0.139 ***	0.260 ***

					(2.60)	(6.84)	(3.31)	(6.74)
Relative company P/E ratio (in logs)						-0.003 ***		
						(-0.14)		
Relative market P/E ratio						-0.229 ***		
						(-7.67)		
Relative company P/CF ratio (in logs)							-0.044 ***	
							(-0.98)	
Relative market P/CF ratio							-0.312 ***	
							(-10.99)	
Relative company P/B ratio (in logs)								-0.025 ***
								(-0.30)
Relative market P/B ratio								-0.308 ***
								(-8.14)
Constant	-0.054	-0.177 *	-0.181 *	-0.205 **	-0.200 ***	-0.114 ***	-0.074 ***	0.027 ***
	(-0.60)	(-1.99)	(-2.01)	(-2.28)	(-2.22)	(-1.54)	(-0.92)	(0.37)
F-statistic	23.1 ***	31.31 ***	27.47 ***	25.53 ***	23.19 ***	49.02 ***	35.99 ***	27.59 ***
Within R-squared	0.207	0.285	0.285	0.32	0.323	0.521	0.594	0.498
No. of observations	909	909	909	909	909	909	909	909

Note: This table presents the results of the panel regressions for the ADR sample (see Eq., II.9) in the period December 1998 to February 2009. All estimations include company fixed effects. The t-statistics in parentheses are computed based on robust standard errors clustered by company. *, **, and *** denotes significance at the 10%, 5%, and 1% level.

Table II.4: Panel estimation results: H-share discounts

	I	II	III	IV	V	VI	VII	VIII
Real overvaluation of yuan (Δ)	-35.542 **	-68.201 ***	-68.248 ***	-68.802 ***	-68.570 ***	-77.840 ***	-64.197 ***	-66.555 ***
	(-2.51)	(-4.73)	(-4.71)	(-4.81)	(-4.83)	(-6.22)	(-5.04)	(-4.65)
Inflation differential China vs. U.S.	-0.476	-1.348 ***	-1.368 ***	-1.171 ***	-1.162 ***	0.419	0.573	-1.052 ***
	(-1.32)	(-3.50)	(-3.62)	(-3.15)	(-3.13)	(1.33)	(1.64)	(-2.98)
Productivity differential China vs. U.S.	7.614 ***	5.957 ***	5.917 ***	5.886 ***	5.763 ***	5.496 ***	6.797 ***	5.873 ***
(Δ)	(8.99)	(6.51)	(6.47)	(6.54)	(6.24)	(6.92)	(8.28)	(6.62)
Interest rate differential China vs. U.S.	-6.830 ***	-5.548 ***	-5.474 ***	-5.340 ***	-5.462 ***	-5.071 ***	-4.015 ***	-5.696 ***
	(-9.86)	(-8.63)	(-8.88)	(-8.54)	(-8.85)	(-8.23)	(-6.89)	(-9.28)
Foreign exchange reserves growth	-0.888 ***	-1.622 ***	-1.609 ***	-1.521 ***	-1.560 ***	-1.066 ***	-1.735 ***	-1.598 ***
	(-3.26)	(-6.28)	(-6.28)	(-5.85)	(-6.06)	(-4.46)	(-6.53)	(-6.26)
Export growth	0.071 ***	0.017	0.016	0.013	0.012	0.004	-0.018	0.006
	(4.14)	(1.18)	(1.09)	(0.90)	(0.83)	(0.27)	(-1.39)	(0.41)
Domestic credit to GDP (Δ)	-0.644 ***	-0.546 ***	-0.542 ***	-0.501 ***	-0.505 ***	-0.044	-0.297 ***	-0.492 ***
	(-7.24)	(-6.76)	(-6.78)	(-6.51)	(-6.61)	(-0.64)	(-4.33)	(-6.71)
EMBI sovereign bond yield	-13.222 ***	-10.439 ***	-10.349 ***	-9.271 ***	-9.359 ***	-7.107 ***	-5.380 ***	-9.354 ***
	(-8.20)	(-6.97)	(-6.93)	(-6.35)	(-6.42)	(-4.91)	(-4.06)	(-6.94)
Yuan/USD forward premium		-1.465 ***	-1.472 ***	-1.844 ***	-1.829 ***	-1.236 ***	-1.292 ***	-1.717 ***
		(-6.06)	(-6.09)	(-8.69)	(-8.78)	(-7.18)	(-9.53)	(-8.52)
Relative trading volume A-share vs.			-8.8E-04	-8.6E-04	-1.0E-03	7.1E-04	-1.1E-03	-1.4E-03
H-share			(-0.63)	(-0.63)	(-0.74)	(0.61)	(-0.91)	(-1.06)
Market capitalization				-0.608 ***	-0.613 ***	-0.338 ***	-0.507 ***	-0.619 ***
				(-4.13)	(-4.17)	(-3.71)	(-4.10)	(-4.07)
Return differential China vs. HK					-0.071 **	0.111 ***	0.010	-0.075 *

					(-2.12)	(5.39)	(0.38)	(-2.21)
Relative company P/E ratio (in logs)						-0.056 ***		
						(-3.53)		
Relative market P/E ratio						-0.155 ***		
						(-8.90)		
Relative company P/CF ratio (in logs)							-0.048 **	
							(-2.19)	
Relative market P/CF ratio							-0.216 ***	
							(-8.59)	
Relative company P/B ratio (in logs)								0.041
								(1.22)
Relative market P/B ratio								-0.022 ***
								(-1.68)
Constant	0.076	-0.060	-0.061	-0.084	-0.078 ***	0.099 ***	0.008 ***	-0.076 ***
	(1.00)	-(0.84)	-(0.85)	-(1.20)	-(1.11)	(1.24)	(0.11)	-(1.15)
F-statistic	24.740 ***	22.600 ***	20.340 ***	25.230 ***	24.410 ***	30.390 ***	28.150 ***	24.870 ***
Within R-squared	0.337	0.360	0.360	0.397	0.398	0.562	0.518	0.401
No. of observations	2600	2600	2600	2600	2600	2600	2600	2600

Note: This table presents the results of the panel regressions for the H-share sample (see Eq., II.10) in the period December 1998 to February 2009. All estimations include company fixed effects. The t-statistics in parentheses are computed based on robust standard errors clustered by company. *, **, and *** denotes significance at the 10%, 5%, and 1% level.

The coefficient of the inflation differential is significantly negative in ten of 16 specifications ranging from -2.3 to -3.5 in the ADR panel and from -1.1 to -1.4 in the H-share panel. That is, a 1% increase in inflation in China relative to the United States reduces ADR discounts by 2.3% to 3.5% and H-share discounts by 1.1% to 1.4%. ADR and H-share investors appear to anticipate that higher inflation in China relative to the United States will contribute to a weakening of the yuan against the U.S. dollar. The results thus support the relative PPP (Hypothesis 2).

I also find evidence for the Harrod-Balassa-Samuelson effect (Hypothesis 3). A higher productivity differential between China and the United States significantly increases ADR and H-share discounts in all specifications. ADR and H-share investors appear to anticipate that higher productivity growth in China relative to the United States will lead to a yuan appreciation in the long run, thereby driving up the discounts of cross-listed stocks. I also find robust evidence in favor of the uncovered interest rate parity hypothesis (Hypothesis 4). The coefficient for the interest rate differential is negative and significant in all specifications. This means that a 1% increase in the Chinese interest rate relative to the U.S. interest rate translates to a 3.1% to 7.2% decrease in ADR discounts and a 4% to 6.8% decrease in H-share discounts. Investors thus anticipate that the higher-interest rate currency will depreciate against the lower-interest rate currency. The coefficient of the foreign exchange reserve growth is negative and significant in most of the specifications. That is, ADR and H-share investors increase their depreciation expectations of the yuan when the pace of the reserve accumulation of the PBoC increases. This result suggests that ADR and H-share investors fear that unsterilized reserve accumulation may subsequently lead to monetary expansion and inflationary pressure in China which may weaken the yuan. The coefficient of export growth is insignificant in most of the specifications. Thus, I find no evidence for the validity of the FEER approach (Hypothesis 6).

The results provide evidence that ADR and H-share investors anticipate the risk of a twin banking and currency crisis in China (Hypothesis 7). A higher ratio of domestic credit to GDP, which indicates higher banking crisis risk, significantly reduces ADR and H-share discounts for 12 of 16 specifications. This result suggests that the easy lending of Chinese banks increases the share of bad loans, which may lead to solvency-driven bank defaults (Setser, 2006). If the PBoC acts as a lender of last resort in the event of a banking crisis, the recapitalization of banks may lead to excessive money creation and inflation, which could lead to a devaluation of the yuan. The results also indicate that ADR and H-share investors anticipate the risk of a twin debt and currency crisis (Hypothesis 8). For 14 of 16 specifications, I find that higher EMBI sovereign bond yields significantly lower ADR and H-share discounts. A rise in sovereign debt crisis risk in China thus translates into expectations of yuan depreciation against the U.S. dollar.

The results also confirm some of the hypotheses for the control variables. The coefficient of the forward premium is negative and significant in all specifications confirming the findings of Arquette et al. (2008) and Burdekin and Redfern (2009). This result suggests that higher depreciation expectations of the yuan against the U.S. dollar formed on the forward market spill over to the ADR and H-share market. The coefficient of relative trading volume is insignificant in all specifications, suggesting that liquidity conditions do not play an important role in my sample. The coefficient for the market capitalization is negative and significant for eight of ten specifications. This result suggests that larger companies have lower ADR or H-share discounts since they have lower trading costs and price discovery is quicker. For the return differential I find that ADRs are more correlated with the Chinese stock market than with the U.S. stock market, while the coefficients for H-shares have different signs. For five of six specifications, I find that better investor sentiment towards the individual A-share or the Chinese stock market significantly decreases ADR and H-share discounts confirming the findings of Arquette et al. (2008) and Burdekin and Redfern (2009).

II.6 Conclusions

I show that the price discounts of ADRs and H-shares to their underlying A-shares can be used as an indicator of ADR and H-share investors' expectations of the future yuan/U.S. dollar exchange rate. Using a rolling regressions forecasting framework I find that during the recent managed float period (July 2005 to February 2009) ADR and H-share discounts are more accurate in predicting changes in the yuan/U.S. dollar exchange rate than the random walk or forward exchange rates, at least at forecast horizons longer than one year. Using a panel framework, I find that many macroeconomic variables which – theory has shown – determine exchange rates also have a significant impact on ADR and H-share investors' exchange rate *expectations*. I find that ADR and H-share investors form their exchange rate expectations according to the Harrod-Balassa-Samuelson effect, the risk of competitive devaluations, relative purchasing power parity, uncovered interest rate parity, the risk of a twin banking and currency crisis, and the risk of a twin debt and currency crisis.

The results have implications for academics and practitioners. The forecasting exercises show that ADR and H-share discounts are helpful to predict changes in the yuan/U.S. dollar exchange rate, at least at long horizons. The PBoC might use the changes in ADR and H-share discounts to measure the market-determined exchange rate expectations and to determine possible misalignments of the exchange rate. The upward trend in ADR and H-share discounts prior to the float of the yuan in July 2005, for example, indicated that ADR and H-share investors expected a relatively stronger yuan. The PBoC may take advantage of ADR and H-share discounts to manage the timing and intensity of foreign exchange market interventions and realignments. Investors may use ADR and H-share discounts in order to speculate on exchange rate movements (particularly in the long run). The forecasting models indicate that ADR and H-share discounts are more accurate than forward rates in forecasting exchange rate changes. If, for example, ADR and H-share discounts indicate more (less) yuan appreciation against the U.S. dollar than suggested by the forward exchange rate, a potentially profitable trading strategy may be to buy (sell) yuan against U.S. dollars at the forward market and make the reverse transaction at the spot market at maturity.

The panel regressions show that the theoretical links between macroeconomic variables and exchange rates in most cases also apply to exchange rate *expectations*. This supports the validity of many exchange rate theories and substantiates the rationality of stock market investors' expectations. What is more, my approach provides an opportunity to study exchange rates in managed floating regimes. The official yuan/U.S. dollar exchange rate is heavily managed by the PBoC, which implies that it is not the ideal measure to test exchange rate theories. ADR and H-share discounts, on the contrary, enable one to study the impact of macroeconomic events using exchange rate expectations formed under free market conditions.

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II. Appendix

Table II.A1: Stock pairs included in the sample

ADR panel
Air China; Aluminium Corporation of China; Angang Steel; China Eastern Airlines; China Life Insurance; China Petroleum & Chemical; China Shipping Development; China Southern Airlines; Datang International Power Generation Company; Guangsheng Railway; Huaneng Power International; Jiangsu Expressway; Jiangxi Copper; Jilin Chemical Industry; Petrochina; Ping An Insurance; Shanghai Chlor Chemical; Shanghai Erfangji; Sinopec Shanghai Petrochemicals; Tianjin Capital Environmental Protection Group; Tsingtao Brewery; Yanzhou Coal Mining.
H-share panel
Air China; Aluminium Corporation of China; Angang Steel; Anhui Conch Cement; Anhui Expressway; Bank of China; Bank of Communications; Beijing North Star; Beiren Printing Machines; China Citic Bank; China Coal Energy; China Construction Bank; China Cosco Holdings; China Eastern Airlines; China Life Insurance; China Merchants Bank; China Railway Construction; China Shenhua Energy Company; China Shipping Development; China Southern Airlines; Datang International Power Generation Company; Dofang Electric; Guangsheng Railway; Guangzhou Pharmaceutical; Guangzhou Shipyard International; Hisense Kelon Electrical Holdings; Huadian Power International; Huaneng Power International; Industrial and Commercial Bank of China; Jiangsu Expressway; Jiangxi Copper; Jilin Chemical Industry; Jingwei Textile Machines; Luoyang Glass; Maanshan Iron & Steel; Nanjing Panda Electronic; Northeast Electric Development; Petrochina; Ping An Insurance; Shandong Chenming Paper Holdings; Shandong Xinhua Pharmaceutical; Shanghai Jin Jiang International Hotel Group; Shenji Group Kumato; Shenzhen Expressway; Sinopec Shanghai Petrochemicals; Sinopec Yizheng Chemcial Fibre; Tianjin Capital Environmental Protection Group; Tsingtao Brewery; Weichai Power; Xinjiang Tianye Water Saving Irrigation System; Yanzhou Coal Mining; ZTE.

Note: Information on ADRs is taken from the internet databases of JP Morgan (www.adr.com) and Bank of America (www.adrbny.com). Information on H-shares is taken from Datastream.

Table II.A2: Summary statistics for the variables of the ADR and H-share samples

	Mean	Std. Dev.	Minimum	Maximum
Real overvaluation of yuan (Δ)	0.001	0.019	-0.071	0.052
Inflation differential China vs. U.S.	-0.010	0.022	-0.045	0.046
Productivity differential China vs. U.S. (Δ)	0.004	0.007	-0.017	0.022
Interest rate differential China vs. U.S.	-0.014	0.018	-0.046	0.016
Foreign exchange reserves growth	0.021	0.016	-0.041	0.063
Export growth	0.014	0.119	-0.420	0.362
Domestic credit to GDP (Δ)	0.002	0.032	-0.079	0.132
EMBI sovereign bond yield	0.054	0.012	0.033	0.079
Yuan/USD forward premium	-0.011	0.042	-0.098	0.113
ADR panel				
ADR discount	-0.408	0.261	-0.937	0.326
Relative trading volume	0.014	0.030	0.001	0.355
Market capitalization	122.851	307.168	0.887	2925.930
Return differential China vs. U.S.	0.009	0.094	-0.279	0.259
Relative company P/E ratio (in logs)	0.318	0.898	-1.246	4.477
Relative market P/E ratio	1.381	0.443	0.688	2.775
Relative company P/CF ratio (in logs)	0.163	0.598	-1.338	3.171
Relative market P/CF ratio	1.240	0.430	0.573	2.170
Relative company P/B ratio (in logs)	0.004	0.319	-0.959	0.985
Relative market P/B ratio	0.966	0.337	0.549	2.216
H-share panel				
H-share discount	-0.479	0.280	-0.954	0.386
Relative trading volume	0.029	0.047	0.001	0.789
Market capitalization	67.350	235.185	0.661	2925.930
Return differential China vs. HK	0.008	0.088	-0.250	0.274
Relative company P/E ratio (in logs)	0.344	0.798	-1.543	4.477
Relative market P/E ratio	1.890	0.600	0.891	3.366
Relative company P/CF ratio (in logs)	0.413	0.717	-1.338	3.584
Relative market P/CF ratio	1.163	0.393	0.570	2.222
Relative company P/B ratio (in logs)	-0.015	0.437	-1.411	2.012
Relative market P/B ratio	1.774	0.428	0.942	2.536

Table II.A3: Results of the panel unit root tests

	ADR panel				H-share panel			
	IPS t-statistic		MW-Chi2		IPS t-statistic		MW-Chi2	
ADR discount/H-share discount	-2.449	***	56.448	**	-3.493	***	149.602	***
Real overvaluation of yuan	1.819		31.345		-0.154		94.824	
	(-14.494)	***	(321.096)	***	(-23.571)	***	(834.555)	***
Inflation differential China vs. U.S.	-3.339	***	118.410	***	-8.656	***	400.317	***
Productivity differential China vs. U.S.	3.675		33.814		6.859		67.485	
	(-1.424)	*	(56.768)	*	(-2.255)	**	(63.873)	**
Interest rate differential China vs. U.S.	-0.839		53.017		-4.151	***	162.411	***
	(-9.632)	***	(204.297)	***				
Foreign exchange reserves growth	-6.461	***	170.923	***	-15.284	***	619.933	***
Export growth	-11.101	***	247.946	***	-10.994	***	425.348	***
Domestic credit to GDP	-1.253		58.240	*	96.895		53.918	
	(-11.826)	***	(245.045)	***	(-13.497)	***	(438.722)	***
EMBI sovereign bond yield	-2.251	**	62.766	**	-5.424	***	211.045	***

Yuan/USD forward premium	-2.833	***	88.899	***	-5.934	***	260.233	***
Relative trading volume A-share vs. ADR/H-share	-14.771	***	252.691	***	-15.290	***	594.103	***
Return differential China vs. U.S./HK	-15.251	***	327.303	***	-17.653	***	666.317	***
Market capitalization	-3.383	***	89.223	***	-4.339	***	179.816	***
Relative company P/CF ratio	-1.741	**	55.780		-3.685	***	168.976	***
Relative market P/CF ratio	-2.299	**	62.958	**	-3.369	***	179.510	***
Relative company P/B ratio	-2.999	***	81.933	***	-3.551	***	172.461	***
Relative market P/B ratio	-4.061	***	94.211	***	-2.390	***	153.473	***
Relative company P/E ratio	-2.177	**	67.579	**	-2.794	***	167.151	***
Relative market P/E ratio	-2.112	**	61.016	**	-2.368	***	113.538	**

Note: This table presents the panel unit root test statistics of Im et al. (2003) (the IPS average t-statistic) and of Maddala and Wu (1999) (the MW Chi2 distributed average p-value) for the respective variable in levels and in first differences (in parentheses). Under the null hypothesis of each test the variable contains a unit root in levels. *, **, and *** denotes that the null hypothesis of a unit root is rejected in favor of stationarity at the 10%, 5%, and 1% significance level. The optimal lag length is determined using the Akaike information criterion.

Chapter III

The ADR shadow exchange rate as an early warning indicator for currency crises[40]

Abstract

We develop an indicator for currency crisis risk using price spreads between American Depositary Receipts (ADRs) and their underlying stocks. This measure signals the mean exchange rate ADR investors expect after a potential currency crisis or realignment. It makes crisis prediction possible on a daily basis as depreciation expectations are reflected in ADR market prices. Using daily data for the capital control episodes in Argentina (2001-2002), Malaysia (1998-1999), and Venezuela (1994-1996 and 2003-2007), we analyze the impact of several risk drivers related to currency crisis theories on depreciation expectations. We find that ADR investors perceive higher currency crisis risk when export commodity prices fall, trading partners' currencies depreciate, sovereign yield spreads increase, or interest rate spreads widen.

40 This paper is based on Eichler, S., Karmann, A., Maltritz, D., 2009. The ADR shadow exchange rate as an early warning indicator for currency crises. Journal of Banking & Finance 33, 1983-1995. Used with permission from Elsevier. This paper was co-authored by Professor Alexander Karmann and Professor Dominik Maltritz. Professor Alexander Karmann wrote the introductory chapter (Chapter III.1), which provides the motivation and relates the paper to existing works in the literature. Professor Dominik Maltritz wrote the conclusion section (Chapter III.6), which provides policy conclusions and an outlook for future research. Throughout the writing of this paper I benefited from valuable discussions with Professor Alexander Karmann and Professor Dominik Maltritz.

III.1 Introduction

This paper uses American Depositary Receipt (ADR) market data to measure and explain currency crisis expectations on a daily basis. After the introduction of capital controls, price spreads can develop between U.S. dollar-denominated ADRs and their local currency-denominated underlying stocks in the emerging market. These price spreads are considered as a high-frequency indicator of currency crisis risk. We use these market price data to calculate the ADR shadow exchange rate, i.e. the mean exchange rate ADR investors expect after a potential currency crisis or realignment. Using daily data we study the capital control episodes in Argentina (2001-2002), Malaysia (1998-1999), and Venezuela (1994-1996 and 2003-2007). We find that the ADR shadow exchange rate exceeds the pegged rate well before a currency crisis or realignment actually occurs, indicating that ADR investors correctly anticipate these events.

In order to explain the magnitude of depreciation expectations, we use the ADR spread, which measures the percentage premium of the ADR shadow exchange rate over the official exchange rate. Within panel regressions, we analyze which currency crisis risk drivers ADR investors use to make their pricing decisions, which then determine the level of the ADR spread. In the literature, low-frequency data are often used to verify theoretical hypotheses concerning the occurrence of currency crises. As we focus on a highly frequent currency crisis measure based on stock market quotes, we are able to identify the observable variables that drive currency crisis risk on a daily basis as measured by the ADR spread. This enables us to analyze the impact of five risk drivers that are closely related to theories regarding the occurrence of currency crises using daily data: the link between commodity prices and currency crisis risk, the temptation of competitive devaluations, the risk of twin debt and currency crises, the risk of twin banking and currency crises, and the accuracy of uncovered interest rate parity to signal a devaluation. We find that falling export commodity prices, depreciating export partners' currencies, rising sovereign yield spreads, and rising interest rate spreads increase the risk of a currency crisis – as indicated by rising ADR spreads. This provides evidence that ADR investors take information about the sustainability of a peg as signaled by other segments of the financial market into account when modifying their depreciation expectations.

Having identified the risk drivers that determine the magnitude of devaluation ADR investors expect, we study whether there are regime switches in the process of determination of currency crisis expectations by applying the regime switching methodology of Bai et al. (1998).[41] For the capital control episodes in Malaysia (1998-1999) and Venezuela (2003-2007), we find a switch from a relatively tranquil peg regime to a vulnerable peg regime as the correlation between the ADR spread and the risk drivers increased significantly. For Argentina, we find that shortly after the breakdown of the peg, devaluation expectations became much less responsive to the risk drivers of other markets. For Venezuela (1994-1996) we find no significant regime switch.

The most important branches of literature dealing with the prediction of currency crises are based either on logit/probit models (see, for example, Eichengreen et al., 1995; Frankel and Rose, 1996; Karmann et al., 2002) or on the signals approach (see, for example, Kaminsky et al., 1998; Kaminsky and Reinhart, 1999).[42] Recently, some authors have applied Markov switching methodology to develop early warning systems for currency crises (see, for example, Kittelmann et al., 2006; Alvarez-Plata and Schrooten, 2006). These prediction models use macroeconomic variables and show that a deterioration of macroeconomic fundamentals can lead to currency crises. This literature not only provides useful insight into the nature and causes of currency crises but also shows that crisis prediction is possible at all.

[41] Kallberg et al. (2005) and Pasquariello (2008), for example, use this methodology to determine regime breaks in stock pricing induced by financial crises.
[42] Edison (2003), Berg et al. (2005), and Beckmann et al. (2006) review the forecasting performance of different types of early warning systems.

As market data obviously exhibits some advantages over macroeconomic data, such as high frequency and a forward-looking nature, we contribute to the literature by using ADR market data as an early warning indicator for currency crises. This adds to the literature that uses market-based approaches to forecast other types of financial crises such as banking and sovereign debt crises. While some papers forecast the occurrence of banking crises using macroeconomic data (see, for example, Demirgüc-Kunt and Detragiache, 1998), recent papers use market information to predict banking distress (see, for example, Gropp et al., 2006; Moshirian and Wu, 2009; Eichler et al., 2010, 2011). To forecast sovereign debt crises, some papers use economic fundamentals (see, for example, Detragiache and Spilimbergo, 2004) while others apply market data to estimate country default risk (see, for example, Claessens and Pennacchi, 1996; Karmann, 2000; Karmann and Maltritz, 2004, 2010; Huschens et al. 2007).

Our paper contributes to a literature that studies the impact of financial crises on ADR pricing. A common finding is that the returns on U.S. dollar-denominated ADRs are negatively affected by currency crises as the devaluation of the local currency depresses the dollar value of the underlying stock (see, for example, Bailey et al., 2000; Kim et al., 2000; Bin et al., 2004). Pasquariello (2008) finds that the outbreak of a financial crisis typically leads to a disintegration of the local capital market measured by a persistent violation of the law of one price between an ADR and its underlying stock.[43] Another branch of the literature studies how the introduction of capital controls in the home market affects ADR pricing. In general, the ADR and its corresponding underlying stock have the same exchange rate adjusted price since both types of stocks generate identical streams of cash flows and incorporate equivalent rights and dividend claims. Several authors find, however, that the introduction of capital controls can lead to a permanent violation of the law of one price

[43] Chandar et al. (2009) find that stocks of cross-listed companies exhibit higher average returns than stocks of non-cross-listed companies, particularly after the outbreak of financial crises.

between ADRs and their underlying stocks since cross-border arbitrage cannot take place (Melvin, 2003; Levy Yeyati et al., 2004; Auguste et al., 2006).[44] Arquette et al. (2008) analyze the price spreads between Chinese underlying stocks and their corresponding ADRs (or Hong Kong H-shares). They find that exchange rate expectations – extracted from forward exchange rates – explain 40% of the variation in the ADR price spread. The literature thus far has concluded that capital controls can lead to a violation of the law of one price, that financial crises influence the relative pricing of ADRs and their underlying stocks, and that the price spread is correlated with market-traded forward exchange rates.

We contribute to this literature in several ways. First, we quantify ADR shadow exchange rates, which can be used as early warning indicators for currency crises on a daily basis. Second, we explain ADR investors' devaluation expectations, as reflected in the ADR spreads, within a panel regression framework using market-based risk drivers that are related to theories that explain the occurrence of currency crises. Third, we date regime switches in the process of determination of currency crisis expectations, thereby deriving evidence for an endogenous change in ADR investors' assessment of the sustainability of the currency peg.

The remainder of this paper is organized as follows. Section III.2 describes how depreciation expectations are derived from ADR market data. Section III.3 applies this approach to four capital control episodes. Section III.4 discusses the risk drivers used to explain ADR investors' currency crisis expectations. Section III.5 tests the hypotheses of Section III.4 and searches for regime breaks in the process of determination of currency crisis expectations. Section III.6 concludes.

[44] Levy Yeyati et al. (2009) confirm this view finding that controls on capital outflows (inflows) lead to persistent price premiums (discounts) of the underlying stock over the ADR.

III.2 Measuring currency crisis expectations using ADR market data

The following presents a formal representation of the price relation between ADRs and their underlying stocks in the emerging market and how this information can signal a currency crisis. An ADR represents the ownership of a specific number of underlying shares in the home market on which the ADR is written.[45] While the ADR is traded at a U.S. stock exchange and is denominated in U.S. dollars, the underlying stock is denominated in the local currency and traded at the stock exchange of the home (emerging) market. The starting point of our discussion is ADR conversion. ADR conversion means that one ADR, traded in the United States and quoted in U.S. dollars at price p_{it}^{ADR}, can be converted into γ_i shares of the underlying stock, traded in the emerging market and quoted in the emerging market's currency at price p_{it}^{EM}. The variable γ_i is called the conversion ratio and is specific to the ADR of each company, i.[46]

Since ADR conversion can be conducted at any point in time and both types of stocks of the same firm generate identical streams of cash flows and incorporate equivalent rights and dividend claims, the ADR and its corresponding underlying stock are perfect substitutes. Thus, assuming perfect capital markets, both types of stocks should exhibit the same price after applying the current official exchange rate, S_t[47]. In the absence of capital controls, arbitrage forces ensure the validity of the following price parity:

$$p_{it}^{EM} = \frac{p_{it}^{ADR} S_t}{\gamma_i} . \tag{III.1}$$

As long as the government of the emerging market fixes its exchange rate to the U.S. dollar at the peg rate S^*, the arbitrage consistent ADR pricing Eq. (III.1) can be rewritten as:

---

[45] See Karolyi (1998) for an excellent survey on the ADR market.
[46] Conversely, one emerging market stock can be converted into $1/\gamma_i$ ADRs.
[47] The exchange rate is defined as the amount of domestic currency units per U.S. dollar.

$$p_{it}^{EM} = \frac{p_{it}^{ADR} S^*}{\gamma_i}. \qquad \text{(III.2)}$$

Since arbitrage forces guarantee that both types of stocks are worth the same, an investor is indifferent as to where to allocate his capital. Eqs. (III.1) and (III.2) are, however, only binding as long as ADR arbitrage is possible and cross-border capital flows are not being restricted.

The imposition of capital controls can result in a permanent violation of the arbitrage consistent pricing Eqs. (III.1) and (III.2). Because financial proceeds cannot be transferred across borders and, thus, ADR arbitrage is no longer possible, discrepancies between the price of the ADR and the price of its underlying stock can occur and persist over time. If ADR investors anticipate a devaluation of the emerging market currency against the U.S. dollar, the price relation between the ADR and its underlying stock should incorporate an expected exchange rate, $S_{it}^{\exp}$, that is higher than the current peg rate, S^*; that is, $S_{it}^{\exp} > S^*$.[48] Information efficiency suggests the following speculation-consistent pricing equation:

$$p_{it}^{EM} = \frac{p_{it}^{ADR} S_{it}^{\exp}}{\gamma_i}. \qquad \text{(III.3)}$$

In times of capital controls and in the presence of currency crisis expectations, the price of the emerging market stock seems to be overvalued since it is higher than the right-hand side of the arbitrage condition (III.2) suggests, $\left(p_{it}^{ADR} S_{it}^{exp}\right)/\gamma_i > \left(p_{it}^{ADR} S^*\right)/\gamma_i$.[49] This speculation-consistent pricing Eq. (III.3) is reasonable in the context of information efficiency as all public information concerning the sustainability of the peg is reflected in the ADR shadow

[48] In principle, investors could also expect an appreciation of the domestic currency, i.e. $S_{it}^{exp} < S^*$. However, in our dataset comprised of currency crisis episodes, the case of appreciation expectations is irrelevant.
[49] In the case of the Argentine crisis (2001-2002), Melvin (2003), Levy Yeyati et al. (2004) and Auguste et al. (2006) observe exploding premiums of Argentine underlying stocks over their ADRs of 40-45% prior to the devaluation of the Argentine peso on January 11, 2002.

exchange rate, $S_{it}^{\exp}$. The shadow exchange rate will change as soon as the market receives new information about the peg's credibility.[50] Rearranging Eq. (III.3), we can figure out the ADR investors' expected shadow exchange rate, $S_{it}^{\exp}$:

$$S_{it}^{\exp} = \frac{p_{it}^{EM} \gamma_i}{p_{it}^{ADR}}. \tag{III.4}$$

This ADR shadow exchange rate represents the mean exchange rate expected by ADR market participants. Rising (falling) values of $S_{it}^{\exp}$ point to an increasing (decreasing) risk of a currency crisis. ADR investors reveal their "true" assessment of a reasonable exchange rate because as soon as capital controls are lifted, ADR arbitrage will resume, the price relation between the ADR and the emerging market stock will be determined by Eq. (III.1) again, and the official exchange rate will apply. Thus, "false" expectations (incorporated in the price relation between ADRs and underlying stocks) would penalize either shareholders of the ADR or of the underlying stock and should therefore be speculated away.

Although the shadow exchange rate is an intuitive instrument to measure devaluation expectations, we use the ADR spread as the dependent variable in the empirical analysis in Section III.5. The ADR spread, Y_{it}, is calculated as the percentage premium of the ADR shadow exchange rate over the official exchange rate as outlined in Eq. (III.5):

$$Y_{it} = \frac{S_{it}^{\exp} - S^*}{S^*}. \tag{III.5}$$

The ADR spread measures the expected amount of domestic currency devaluation against the U.S dollar. The ADR spread has the advantage that it accounts for possible realignments. If the government realigns the official peg rate by a certain percentage, expectations of a further

[50] Again, note that the price deviation shown in Eq. (III.3) and its corresponding implications only hold true if capital controls are installed and, thus, cross-border arbitrage cannot take place.

devaluation – as measured by the ADR spread – should fall by the same amount. To capture this effect of realignments, we use the ADR spread in Section 5 to explain devaluation expectations within a regression framework.[51]

The reflection of currency crisis expectations through ADR data can be summarized as follows: following the introduction of capital controls (typically meant to avoid the outbreak of a currency crisis), the price of the emerging market stock typically exceeds the exchange rate-adjusted price of the ADR, indicating that ADR investors anticipate a devaluation of the emerging market currency against the U.S. dollar. We calculate the ADR shadow exchange rate and the ADR spread from the price ratio of both types of stocks. Both measures reflect the ADR investors' assessment of the peg's sustainability. While rising values of the ADR shadow exchange rate and the ADR spread point to a higher currency crisis risk, falling values signal a lower risk of a currency crisis.

III.3 ADR spread and shadow exchange rate in times of currency crisis

In this section we discuss the development of the ADR shadow exchange rate and ADR spread during the following four capital control regimes: Argentina (December 3, 2001 to November 29, 2002), Malaysia (September 1, 1998 to August 31, 1999), Venezuela (June 28, 1994 to April 19, 1996), and Venezuela (February 7, 2003 to May 11, 2007). These capital control regimes effectively prevented cross-border capital flows, which enables us to study

[51] Our considerations build on the assumption of perfect capital markets. In reality, however, some aspects of the ADR market such as transaction costs, bid-ask spreads or infrequent trading contradict this assumption. These frictions can lead to market-specific no-arbitrage bands within which arbitrage strategies, aimed at exploiting price spreads between ADRs and their underlying stocks, do not pay off. These market frictions should have only a minor impact on our results. First, our analysis relies on exploiting the variation in the ADR spread over time and across companies within a country. As market frictions should not change much over time, they should, thus, be captured by the constant in the regressions. Second, our data reveals that the departure from the law of one price is very small during periods of free capital movements. Moreover, for a large set of emerging economies, Levy Yeyati et al. (2009) find that these no-arbitrage bands are generally narrow and that price spreads outside these bands are arbitraged away very quickly. It therefore seems reasonable to assume that market frictions only play a minor role in determining the ADR spreads during capital controls as well. Accordingly, the majority of the variation in the ADR spread and the ADR shadow exchange rate can be attributed to changes in depreciation expectations.

price deviations between ADRs and their underlying stocks.[52] For each capital control episode, we calculate the ADR shadow exchange rate according to Eq. (III.4), whereby in this section we report the average ADR shadow exchange rate over all companies included in a capital control episode.[53]

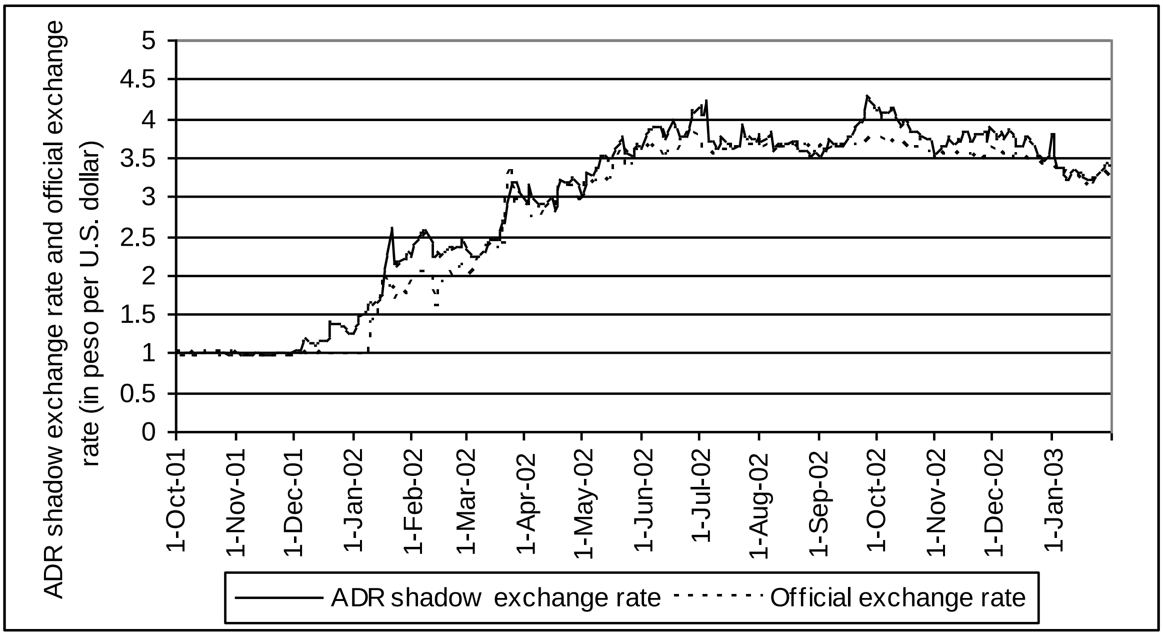
Our empirical analysis is based on data for 17 ADR/underlying stock pairs. A list of included stocks is included in Table III.A1 in Appendix III.[54] Figures III.1 to III.4 illustrate the ADR shadow exchange rate and the official exchange rate during the considered capital control periods. We also depict these values during two months before the introduction and following the lifting of capital controls in order to show the ADR pricing mechanism under free capital movements. The spreads between the ADR shadow exchange rate and the official exchange rate during periods without capital controls are quite small in each country, suggesting that market frictions play a minor role in our context.

Figure III.1 displays the ADR shadow exchange rate and the official exchange rate during the period of capital controls in Argentina. The Argentine capital controls, *corralito*, were in place from December 3, 2001 to November 29, 2002 and were meant to rescue the currency board, which guaranteed a fixed exchange rate of 1 Argentine peso (ARS)/U.S. dollar (USD).[55] The currency board collapsed on January 11, 2002, but capital controls were not lifted until December 2, 2002. The abandoning of the currency board and a depreciation of the peso to 1.4 ARS/USD on January 11, 2002 was fairly expected by ADR investors who set the ADR shadow exchange rate at around 1.5 ARS/USD in the week preceding the devaluation. Thus, the ADR spread of 50% fairly accurately anticipated the actual

[52] Of course, there may have occurred illegal cross-border capital flows during these capital control episodes such as through trade misinvoicing or other types of illegal cross-border transactions. However, arbitrage in the ADR market is typically done by stock market investors which are presumably less likely to engage in outright illegal economic transactions.
[53] In the panel regression analysis in Section III.5 we use company-specific ADR spreads.
[54] Information on ADRs is taken from the internet databases of JP Morgan (www.adr.com) and Bank of America (www.adrbny.com). Data on stock prices are taken from Datastream.
[55] See Stiglitz (2002) and de la Torre et al. (2003) for the timeline and causes of the Argentine crisis.

devaluation of 40%. Until the lifting of capital controls, the ADR shadow exchange rate remained mostly above the official exchange rate, resulting in positive ADR spreads and indicating that ADR investors expected the peso to depreciate even further.

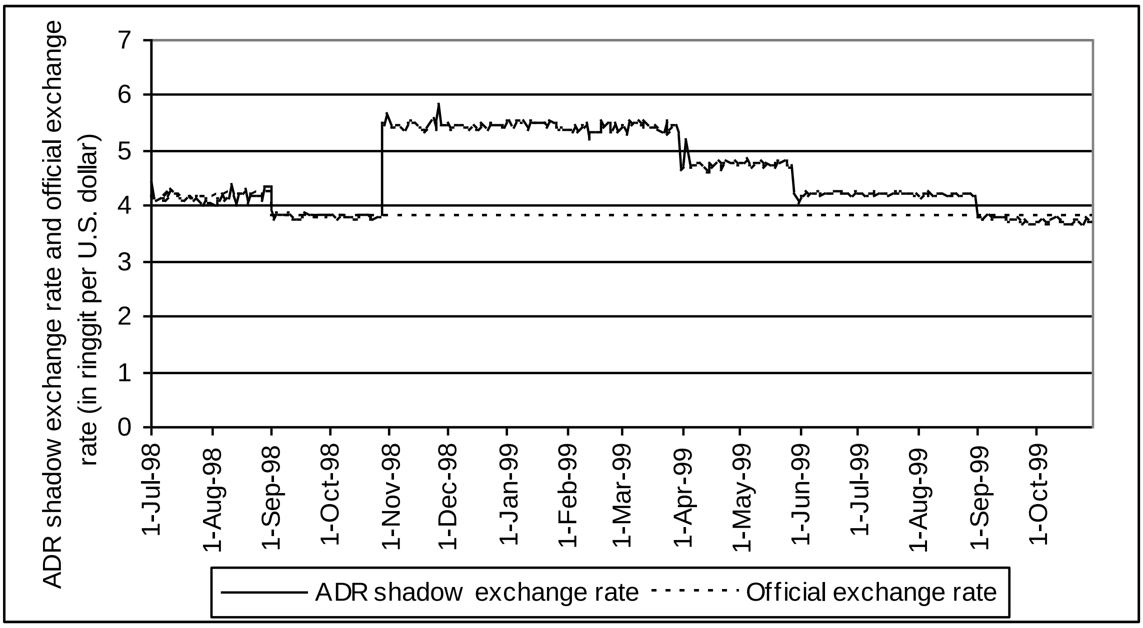
Figure III.1: ADR shadow exchange rate and official exchange rate Argentina (2001-2002)



Note: This figure shows the ADR shadow exchange rate and the official exchange rate for Argentina during the capital control period from December 3, 2001 thru November 29, 2002. On January 11, 2002 the Argentine currency board collapsed. The ADR shadow exchange rate is calculated according to Eq. (III.4).

In contrast to Argentina, where the *corralito*'s purpose was to save the existing peso currency board, Malaysian capital controls (implemented from September 1, 1998 to August 31, 1999) were introduced at the same time as the flexible exchange rate regime was abandoned and a fixed exchange rate of 3.8 ringgit (MYR)/USD was adopted (see Ariyoshi et al., 2000, for details). The Malaysian ADR shadow exchange rate and the official exchange rate are displayed in Figure III.2. At the peak of the Southeast Asian crisis, the Malaysian government decided on September 1, 1998 to stop the steady depreciation of the ringgit by introducing capital controls and pegging the ringgit vis-à-vis the U.S. dollar. Shortly after the introduction of capital controls, strong devaluation expectations arose, leading to an increase in the ADR shadow exchange rate from 3.8 MYR/USD to 5.5 MYR/USD, equal to an ADR spread of about 45%. Apparently, ADR market participants considered the new peg unsustainable in a situation where the prices of Malaysia's main export commodities (such as palm and crude oil) fell, the Asian financial crisis had not yet been resolved, and Russia experienced the outbreak of a currency crisis. After macroeconomic conditions improved and the currencies of Malaysia's trading partners appreciated against the U.S. dollar, the new peg regime became more stable and the ADR shadow exchange rate steadily converged to the peg rate in 1999.

Figure III.2: ADR shadow exchange rate and official exchange rate Malaysia (1998-1999)

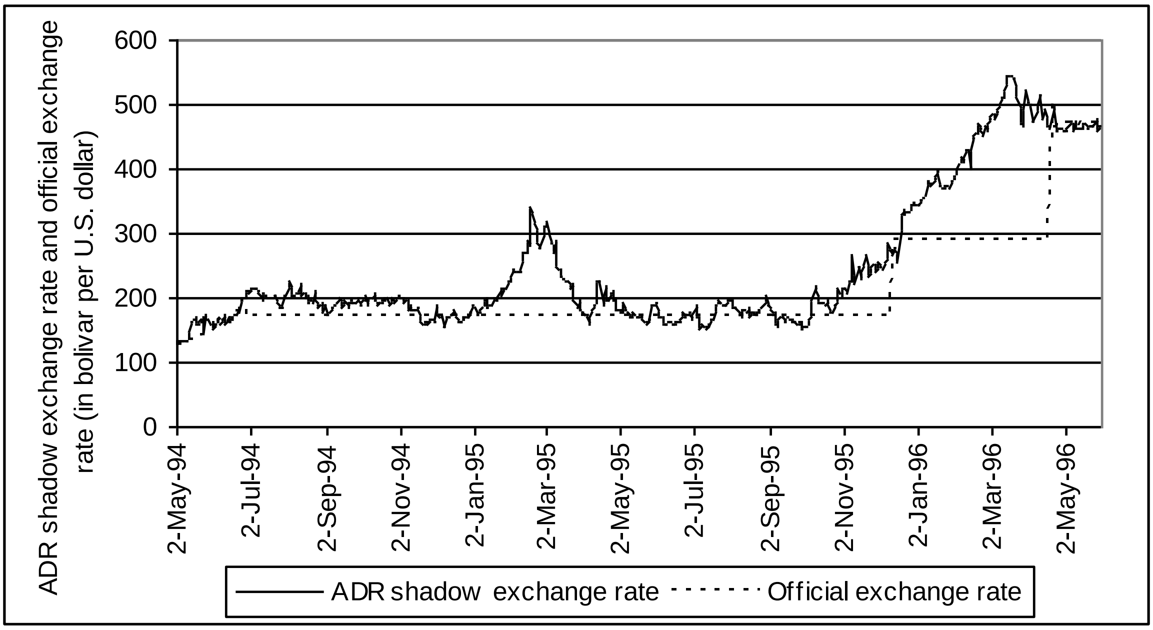


Note: This figure shows the ADR shadow exchange rate and the official exchange rate for Malaysia during the capital control period from September 1, 1998 thru August 31, 1999. The ADR shadow exchange rate is calculated according to Eq. (III.4).

Venezuela introduced capital controls on June 28, 1994 and abandoned its crawling peg, replacing it with a fixed exchange rate of 170 bolivar (VEB)/USD (for details, see Ariyoshi et al., 2000). The ADR shadow exchange rate and the official exchange rate for Venezuela

(1994-1996) are displayed in Figure III.3. In an effort to cope with a banking crisis, the Venezuelan central bank recapitalized troubled banks, thereby increasing both the money supply and inflationary pressure. This led to rising devaluation expectations reflected by an increasing ADR shadow exchange rate. ADR investors anticipated the realignment of the fixed exchange rate from 170 VEB/USD to 290 VEB/USD on December 12, 1995 as the ADR shadow exchange rate reached values of approximately 250 VEB/USD one week before the realignment. On April 22, 1996, the capital controls were lifted. The bolivar was allowed to float, and it depreciated to around 500 VEB/USD. This currency crisis – associated with a 72% devaluation – was also expected by ADR investors who set the ADR shadow exchange rate at 494 VEB/USD one week before, equal to an ADR spread of about 70%.

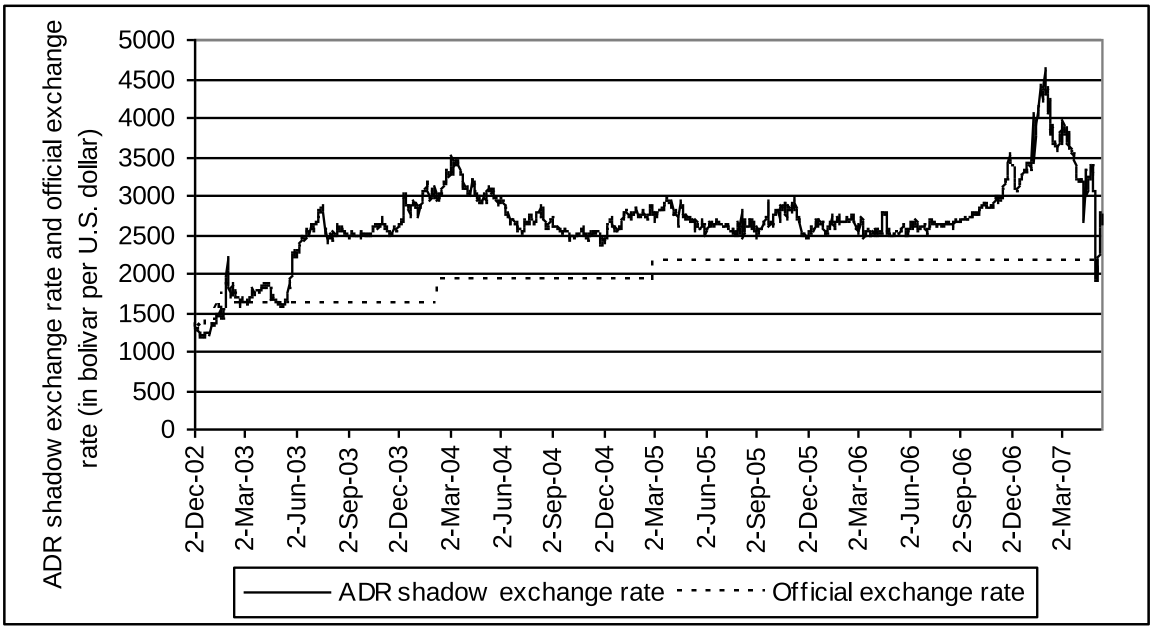
Figure III.3: ADR shadow exchange rate and official exchange rate Venezuela (1994-1996)



Note: This figure shows the ADR shadow exchange rate and the official exchange rate for Venezuela during the capital control period from June 28, 1994 thru April 19, 1996. On December 12, 1995 the exchange rate was realigned from 170 bolivar/dollar to 290 bolivar/dollar. On April 22, 1996, the peg collapsed. The ADR shadow exchange rate is calculated according to Eq. (III.4).

After a period of floating exchange rates and absent capital controls, the Venezuelan government reintroduced capital controls on February 7, 2003 and pegged the exchange rate at 1,600 VEB/USD. The ADR shadow exchange rate and the official exchange rate for the more recent Venezuelan capital controls are displayed in Figure III.4.[56] Interruptions in oil production due to strikes stalled exports and diminished currency reserves thereby raising devaluation expectations, indicated by rising ADR shadow exchange rates. Two realignments took place to soften the real appreciation of the bolivar induced by high inflation in Venezuela: on February 9, 2004 to 1,920 VEB/USD and on March 1, 2005 to 2,150 VEB/USD. Both realignments were fairly anticipated by a rising ADR shadow exchange rate although the exchange rate forecasts are far less accurate than in the cases of Argentina and Venezuela (1994-1996).

Figure III.4: ADR shadow exchange rate and official exchange rate Venezuela (2003-2007)



Note: This figure shows the ADR shadow exchange rate and the official exchange rate for Venezuela during the capital control period from February 7, 2003 thru May 11, 2007. On February 9, 2004 the exchange rate was

[56] The sample is truncated to May 11, 2007, the day the only recently trading Venezuelan ADR (Compañía Anónima Nacional de Teléfonos de Venezuela) was de-listed from the New York Stock Exchange.

realigned to 1,920 bolivar/dollar. On March 1, 2005 it was realigned to 2,150 bolivar/dollar. The ADR shadow exchange rate is calculated according to Eq. (III.4).

III.4 Currency crisis-related variables that drive the ADR spread

In this section we identify five variables that supposedly drive currency crisis expectations of ADR investors. Based on currency crisis theory, we first examine potential determinants of currency crisis risk. We then explain how these determinants can be measured empirically. Each of these five determinants can be measured on a daily basis and reflects – according to the theories described below – a separate issue concerning the peg's sustainability.

III.4.1 Discussion of hypotheses

First, we focus on the relation between commodity prices and exchange rates. For each of the considered countries, commodities exports account for a considerable share of total exports.[57] Cashin et al. (2004) and Zalduendo (2006), for example, find evidence that increasing prices of a country's export commodities are associated with an appreciation of the domestic currency. Rising prices of exported commodities lead, ceteris paribus, to increasing export revenues and rising inflows of foreign exchange, thereby increasing central bank reserves and, thus, decreasing the risk of a currency crisis. We therefore expect the prices of exported commodities to be negatively correlated with the ADR spread.

The incentive for competitive devaluations may serve as another source of currency crisis risk. Glick and Rose (1999) show that, due to beggar-thy-neighbour exchange rate policies, currency crises tend to spread regionally. If the home currency is pegged to the U.S. dollar, a depreciation of the export destination countries' currencies against the U.S. dollar will lead to an appreciation of the home currency against the export destination countries' currencies. An appreciation of the home currency deteriorates the competitiveness of

[57] See Table III.A2 in Appendix III.

domestic exporters, resulting in lower export revenues and thereby negatively affecting the central bank's foreign exchange reserves and increasing the risk of a currency crisis. Thus, we expect a depreciation of the export destination countries' currencies against the U.S. dollar to be positively correlated with the ADR spread.

Currency and sovereign debt crises often occur together. Several empirical studies confirm the incidence of this twin crisis (Dreher et al., 2006; Herz and Tong, 2008). To capture the dependency of both types of crises, many theoretical approaches apply a second-generation currency crisis framework where the government weights the benefits/costs of devaluating the currency and defaulting on sovereign debt (Bauer et al., 2003; Benigno and Missale, 2004). A general result of these models is that a twin sovereign debt and currency crisis is more probable for countries with overindebted governments. As both types of crises are interrelated, we expect sovereign debt crisis indicators, such as sovereign yield spreads, to be indicators for currency crises as well. We expect that higher sovereign yield spreads (which reflect a higher risk of a sovereign debt crisis) will lead to higher ADR spreads (because sovereign debt and currency crises often go hand in hand).

Interest rate spreads for bank deposits or interbank funds represent another indicator for currency crisis risk. Let us suppose Argentine[58] banks offer an interest rate of i_{ARG}^{Peso} for peso deposits and i_{ARG}^{USD} for U.S. dollar deposits. Uncovered interest rate parity requires that the interest rate spread compensates investors for the expected peso depreciation against the U.S. dollar, i.e. $i_{ARG}^{Peso} - i_{ARG}^{USD} = \left(S^{exp} - S^{*}\right)/S^{*}$.[59] A higher currency crisis risk in Argentina should lead to a larger interest rate spread, $i_{ARG}^{Peso} - i_{ARG}^{USD}$. We therefore expect a positive correlation between this currency crisis-related interest rate spread and the ADR spread.

[58] This argument analogously applies to the cases of Malaysia and Venezuela.

[59] S^{exp} denotes the exchange rate expected by money market investors. S^{*} denotes the current official exchange rate. As both interest rates are offered by the same bank or banking system, the risk of a banking crisis or bank default does not affect this interest rate spread.

The joint occurrence of currency and banking crises is intensively discussed in the literature. Kaminsky and Reinhart (1999) present empirical evidence for the incidence of this twin crisis. A banking crisis may force the central bank – acting as a lender of last resort – to bail out troubled banks by printing money which, in turn, produces inflationary pressure that can lead to a currency crisis (Diaz-Alejandro, 1985; Velasco, 1987; Calvo, 1998; Miller, 2000). Thus, the connection between the risk of a banking crisis and the risk of a currency crisis justifies the inclusion of a banking crisis indicator in our analysis. To measure the risk of a banking crisis, we use the spreads between interest rates on proceeds denominated in the same currency but offered by banks of different countries. For example, the spread between the interest rate on U.S. dollar deposits offered by Argentine banks, i_{ARG}^{USD}, and the interest rate on U.S. dollar deposits offered by U.S. banks, $i_{U.S.}^{USD}$, signals the relative risk that Argentine banks will default. The higher the risk of a banking crisis in Argentina, the higher the interest rate spread $i_{ARG}^{USD} - i_{U.S.}^{USD}$.[60] According to these considerations, the risk measure of a currency crisis (the ADR spread) should increase whenever the risk measure of a banking crisis (the interest rate spread $i_{ARG}^{USD} - i_{U.S.}^{USD}$) increases.

III.4.2 Empirical identification of the currency crisis risk drivers

To study the impact of price changes of the export commodities on the ADR spread, we construct country-specific value-weighted commodity price indices. We calculate the commodity price index as a chain-linked index for each capital control episode i on day t, CP_t^i:

$$CP_t^i = \left(1 + I_{t-T}^i\right) \times \left(1 + I_{t-T+1}^i\right) \times \ldots \times \left(1 + I_{t-1}^i\right) \times \left(1 + I_t^i\right), \tag{III.6}$$

[60] Exchange rate risk does not affect this interest rate spread, as both interest rates relate to the same currency.

where the percentage change of the commodity price index from day $t-1$ to day t is given by I_t^i, which is a weighted arithmetic mean as shown in Eq. (III.7):

$$I_t^i = \sum_j \left(w_j^i \frac{p_{j,t} - p_{j,t-1}}{p_{j,t-1}} \right), \tag{III.7}$$

where $p_{j,t}$ is the U.S. dollar price of commodity j and w_j^i represents the export share of commodity j in i's total (considered) commodity exports. The country-specific commodity export weights are compiled from various IMF Staff Country Reports and domestic statistical sources and are reported in Table III.A2 in Appendix III. Data on commodity prices are largely drawn from the Dow Jones-AIG Commodity Sub-Indices.[61] A higher commodity price index indicates higher prices of a country's exported commodities.

The effect of an appreciation of the domestic currency relative to the currencies of the export destination countries on the ADR spread is also analyzed by using country-specific indices. Similar to the case of the commodity price index, the export destination exchange rate index for each capital control episode i on day t, EER_t^i, is a chain-linked index

$$EER_t^i = \left(1 + I_{t-T}^i\right) \times \left(1 + I_{t-T+1}^i\right) \times \ldots \times \left(1 + I_{t-1}^i\right) \times \left(1 + I_t^i\right), \tag{III.8}$$

where the percentage change of i's EER index from day $t-1$ to day t is given by I_t^i. I_t^i is calculated as a weighted arithmetic mean as shown in Eq. (III.9):

$$I_t^i = \sum_{j=1} \left(w_j^i \frac{e_{j,t} - e_{j,t-1}}{e_{j,t-1}} \right), \tag{III.9}$$

where $e_{j,t}$ is the bilateral dollar exchange rate of the 20 largest export trading partners j – measured as the amount of currency units of i's export trading partner j per U.S. dollar –

[61] For the Malaysian export commodities palm oil and rubber, we use prices from the Kuala Lumpur Commodity Exchange because no Dow Jones Sub-Index is available for these commodities.

and w_j^i represents the share of i's exports to j relative to i's total exports to the 20 trading partners. The country-specific export shares reported in Table III.A3 in Appendix III are computed using the International Monetary Fund's Direction of Trade Statistics.[62] A rising exchange rate index indicates and appreciation of a country's currency against the currencies of the export destination countries. The commodity price and exchange rate indices are used in natural logs.

In order to measure sovereign default risk we use sovereign bond yield spreads for each country taken from the JP Morgan's Emerging Markets Bond Index (EMBI) Global. The spread is calculated as the difference between the redemption yield on domestic U.S. dollar denominated sovereign bonds and the redemption yield of U.S. sovereign bonds. The EMBI spreads are averaged spreads of the most liquid Brady and Eurobond issues of the respective country and are widely used in the literature on sovereign debt crises. Higher EMBI sovereign yield spreads indicate a higher sovereign default risk.

Interest rate spreads that signal the risk of a currency crisis or a banking crisis separately are only available for Argentina (2001-2002) and Malaysia (1998-1999).[63] In order to measure currency crisis expectations formed on the money market, we use deposit interest rates for Argentina and the Kuala Lumpur Interbank Offered Rate for Malaysia. For both countries, the domestic banking system offers interest rates for funds in domestic currency (pesos or ringgits), i_{ARG}^{Peso}, and in U.S. dollars, i_{ARG}^{USD}, enabling us to calculate the currency crisis proxy $i_{ARG}^{Peso} - i_{ARG}^{USD}$.[64] According to uncovered interest rate parity, a rising interest rate

[62] Exports to the U.S. are not included in the index which shows relative changes in the U.S. dollar exchange rates of a country's trading partners.
[63] Data on interest rates on U.S. dollar-denominated funds offered by Venezuelan banks are not available.
[64] Both interest rates differ only with respect to the currency denomination of the funds the interest is paid on. Both interest rates are offered by domestic banks. Thus, the interest rate spread does not respond to banking crisis risk but signals solely currency crisis expectations.

spread $i_{ARG}^{Peso} - i_{ARG}^{USD}$ indicates higher depreciation expectations of the peso (or ringgit) against the U.S. dollar.

To compute the banking crisis risk proxy $i_{ARG}^{USD} - i_{U.S.}^{USD}$, we use the interest rate for certificates of deposit offered by U.S. banks for dollar funds in order to identify $i_{U.S.}^{USD}$.[65] A rising interest rate spread $i_{ARG}^{USD} - i_{U.S.}^{USD}$ indicates higher banking crisis risk for Argentina (or Malaysia).

For the Venezuelan capital control episodes, no data on interest rates on U.S. dollar denominated funds offered by Venezuelan banks are available. We therefore include the "raw" spread between the Venezuelan interest rate for bolivar deposits and the U.S. certificates of deposit rate to compute a crude measure that accounts for both the currency crisis and the banking crisis risk. Data is taken from Datastream. To eliminate term structure effects, we only use interest rates with a maturity of one month.

III.5 Empirical analysis

In order to test the hypotheses explained in Section III.4, we regress the ADR spread – assumed to be an indicator for currency crisis expectations – on the five market-based risk drivers. We use two types of models. The first model employs a panel framework to explain the determination of the currency crisis expectations contained in the ADR spread for a set of ADR stock pairs over time. The second model applies the time series framework proposed by Bai et al. (1998) in order to test whether there are regime switches in ADR investors' currency crisis expectation-making process during episodes of capital controls.

Each model is estimated using daily data. We favor daily data as the episodes of capital controls studied were rather short. In addition, we want to test whether ADR

[65] The U.S. dollar interest rates offered by Argentine and Malaysian banks are the same rates as employed for the currency crisis proxy, i.e. deposit rates for the case of Argentina and Kuala Lumpur Interbank Offered Rates for Malaysia.

investors' currency crisis expectations react to new information reflected in the risk drivers even on such a high data frequency.[66] In addition to the five currency crisis risk drivers discussed in Section III.4, we use six control variables.[67] First, we include four variables to control for investor sentiments. Several papers find that changes in investor sentiments are significant drivers of the price spread between ADRs and their underlying stocks (Kim et al., 2000; Wang and Jiang, 2004; Arquette et al., 2008; Burdekin and Redfern, 2009). To control for investor sentiments, we use the variables proposed by Arquette et al. (2008). Investor sentiment towards the local stock market versus the U.S. stock market is measured by the relative market price-earnings (P/E) ratio, which is calculated by dividing the P/E ratio of the local stock market by the P/E ratio of the U.S. stock market. Investor sentiment towards an individual company is measured by the relative company P/E ratio, which is calculated by dividing the local stock's P/E ratio by the P/E ratio of the local stock market as a whole. As alternative measures of investor sentiments, we include the relative market dividend yield (DY) ratio and the relative company DY ratio to check the robustness of our results. Both variables have a similar interpretation as the sentiment variables based on the P/E ratio explained above. The relative market DY ratio is calculated by dividing the DY of the local stock market by the DY of the U.S. stock market.[68] The relative company DY ratio is computed by dividing the company's DY by the DY of the local stock market. We expect higher relative market and company P/E and DY ratios to be associated with higher ADR spreads, ceteris paribus, as more positive investor sentiments increase the relative price investors are willing to pay for the local stock.

[66] There are, of course, some shortcomings of daily data, such as short term noise and high volatility (see, for example, Kallberg et al., 2005; Arquette et al., 2008). As a robustness check, we have estimated each model using weekly data to address these problems but found only minor changes in the results.
[67] The data on control variables are also taken from Datastream.
[68] The P/E and DY ratios of the stock markets are taken from the country-specific Datastream Global Equity Index.

To control for company size, we include the firm's market capitalization. In order to account for a possible tax bias, we include the annual dividend per share as different tax structures in the home country and the United States may have an impact on ADR pricing (see Arquette et al., 2008, p. 1924 for a detailed discussion).

III.5.1 Panel analysis of the determinants of currency crisis expectations

Within the panel regressions, we aim to explain the variation of the firm-specific ADR spreads across companies and over time by using data on currency crisis risk drivers and control variables. For each episode of capital controls for Argentina, Malaysia, and Venezuela (1994-1996)[69] we estimate the fixed effects panel model[70] outlined in Eq. (III.10):

$$Y_{it} = \alpha + \sum_k \beta_k x_{kt} + \sum_j \beta_j x_{jit} + \gamma_i + \varepsilon_{it} \,. \tag{III.10}$$

Y_{it} denotes the ADR spread of company i on day t; α is a constant; x_{kt} denotes the k exogenous variables that do not vary across companies, i.e. the five potential risk drivers outlined in Section III.4 plus the relative market P/E ratio and the relative market DY ratio; x_{jit} represents the j company-specific exogenous variables, i.e. the relative company P/E ratio, the relative company DY ratio, the market capitalization, and the dividend per share; β_k and β_j are the associated coefficients; γ_i is company-specific fixed effects; and ε_{it} is the error.

The ADR spread is calculated as outlined in Eq. (III.5). The companies included for each episode of capital controls are listed in Table III.A1 in Appendix III. The levels of the

[69] The capital control episode for Venezuela (2003-2007) cannot be studied in a panel framework as data for only one company and its corresponding ADR is available for this case.
[70] We use the Hausman (1978) specification test in order to determine whether or not a random effects model would be more appropriate than the applied fixed effects model. Under the null of the test the random and fixed effects coefficients are equal. The results of the Hausman test indicate that the random and fixed effects coefficients are significantly different, suggesting that the fixed effects model is more appropriate.

commodity price index, the export destination exchange rate index, and the market capitalization are used in logs. Before estimating the panel models, we check for unit roots in the variables using the panel unit root tests of Im et al. (2003) and Maddala and Wu (1999).[71] Under the null of each test, the variable contains a unit root. Table III.A4 in Appendix III reports the results of the panel unit root tests. In the panel regressions, we include a variable in levels only if the null of a unit root is rejected at least at the 10% significance level by both tests. The Δ symbol in the results tables indicates that the variable is used in first differences.

The panel estimation results for Argentina, Malaysia, and Venezuela (1994-1996) are displayed in Tables III.1, III.2, and III.3, respectively. For each capital control episode, we estimate four different specifications. Each specification includes the five risk drivers, the market capitalization, and the dividend per share. In specifications I and III, we use the relative company and market P/E ratios whereas for II and IV, we include the relative company and market DY ratios in order to control for investor sentiments. Specifications I and II report pooled estimations while specifications III and IV allow for company-specific fixed effects. In all panel estimations, the t-values are computed using robust standard errors clustered by company to control for possible heteroskedasticity and serial correlation in the residuals for a company across time.

Overall, the results of the panel estimations confirm the theoretical hypotheses. The coefficient of the commodity price index is significantly negative for all specifications of the Argentina and Malaysia regressions while for Venezuela (1994-1996) it is insignificant. In the case of Argentina, for example, a 1% fall in the commodity price index significantly increases depreciation expectations (measured by the ADR spread) by approximately 0.3% to 0.5%, ceteris paribus. We thus find evidence that falling export commodity prices increase the risk of currency crisis outbreaks as expected by ADR investors.

[71] Chapter V provides a short overview of (panel) unit root tests.

Table III.1: Panel estimation results for Argentina

Dependent variable: *ADR spread*	I	II	III	IV
Commodity price index (in logs) (Δ)	-0.466^{**}	-0.298^{*}	-0.526^{**}	-0.295^{*}
	(-2.31)	(-1.93)	(-2.69)	(-2.10)
Exchange rate index (in logs) (Δ)	0.841^{***}	0.683^{***}	0.474^{**}	0.718^{***}
	(5.19)	(4.11)	(3.31)	(4.34)
EMBI sovereign yield spread	-0.024	0.215	-0.143	0.336^{*}
(sovereign debt crisis risk)	(-0.52)	(1.73)	(-1.23)	(2.24)
Interest rate spread (Δ)	0.011	0.004	0.012	0.005
(currency crisis risk)	(1.57)	(0.55)	(1.55)	(0.71)
Interest rate spread	0.882^{***}	-0.108	0.958^{**}	0.118
(banking crisis risk)	(3.59)	(-1.15)	(3.18)	(0.72)
Relative company P/E ratio (Δ)	$6.0E-04^{***}$	--	$5.8E-04^{**}$	--
	(4.49)		(2.41)	
Relative market P/E ratio (Δ)	0.026^{***}	--	0.036	--
	(5.13)		(1.15)	
Relative company DY ratio (Δ)	--	-0.015	--	-0.013
		(-0.99)		(-0.71)
Relative market DY ratio	--	0.051^{***}	--	0.048^{***}
		(3.69)		(3.69)
Market capitalization (in logs)	8.0E-04	0.007	0.053	0.067^{*}
	(0.06)	(0.50)	(1.36)	(2.07)
Dividend per share	0.104	0.052	0.412^{***}	0.232^{*}
	(1.18)	(0.62)	(3.50)	(2.08)
Constant	0.174^{*}	-0.207	-0.585	-0.978^{**}
	(1.99)	(-1.34)	(-1.33)	(-2.53)
Company-specific fixed effects	no	no	yes	yes
R-squared	0.150	0.181	0.202	0.258
p-value F-statistic	0.000	0.000	0.000	0.000
No. of observations	2340	2340	2340	2340

Note: This table reports the results of the panel regressions (see Eq., III.10) for Argentina during the capital control episode from December 3, 2001 thru November 29, 2002. The t-statistics in parentheses are computed based on robust standard errors clustered by company. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table III.2: Panel estimation results for Malaysia

Dependent variable: Δ *ADR spread*	I	II	III	IV
Commodity price index (in logs) (Δ)	-0.953*	-0.970*	-0.915*	-0.947*
	(-3.69)	(-3.80)	(-3.59)	(-3.57)
Exchange rate index (in logs) (Δ)	9.680***	9.750***	9.560***	9.613***
	(15.76)	(16.36)	(15.34)	(16.45)
EMBI sovereign yield spread (Δ)	-8.070	-7.312	-7.602	-6.940
(sovereign debt crisis risk)	(-2.43)	(-2.35)	(-2.28)	(-2.08)
Interest rate spread (Δ)	4.406**	4.390**	4.481**	4.443**
(currency crisis risk)	(5.57)	(5.53)	(5.46)	(5.17)
Interest rate spread (Δ)	-0.215	-1.038	-0.090	-0.918
(banking crisis risk)	(-0.14)	(-0.61)	(-0.06)	(-0.52)
Relative company P/E ratio (Δ)	4.5E-04***	--	6.5E-04**	--
	(18.31)		(4.60)	
Relative market P/E ratio (Δ)	-0.055	--	-0.073	--
	(-0.59)		(-0.74)	
Relative company DY ratio (Δ)	--	-0.064	--	-0.082
		(-0.84)		(-0.88)
Relative market DY ratio	--	0.082**	--	0.080**
		(4.51)		(4.80)
Market capitalization (in logs) (Δ)	-0.142	-0.073	-0.130	-0.070
	(-1.75)	(-1.48)	(-1.57)	(-1.22)
Dividend per share	-0.677**	0.154	-0.748**	0.340
	(-7.64)	(0.15)	(-8.78)	(0.28)
Constant	0.306***	0.311***	0.332***	0.341***
	(17.49)	(28.34)	(65.16)	(42.73)
Company-specific fixed effects	no	no	yes	yes
R-squared	0.277	0.280	0.287	0.29
p-value F-statistic	0.000	0.000	0.000	0.000
No. of observations	783	783	783	783

Note: This table reports the results of the panel regressions (see Eq., III.10) for Malaysia during the capital control episode from September 1, 1998 thru August 31, 1999. The t-statistics in parentheses are computed based on robust standard errors clustered by company. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table III.3: Panel estimation results for Venezuela (1994-1996)

Dependent variable: Δ *ADR spread*	I	II	III	IV
Commodity price index (in logs) (Δ)	-0.140	-0.110	-0.138	-0.108
	(-1.00)	(-0.74)	(-0.96)	(-0.72)
Exchange rate index (in logs) (Δ)	0.239	0.221	0.237	0.219
	(1.35)	(1.40)	(1.34)	(1.39)
EMBI sovereign yield spread (Δ)	2.006***	2.000***	2.001***	1.997***
(sovereign debt crisis risk)	(6.28)	(6.38)	(6.22)	(6.30)
Raw interest rate spread (Δ)	0.393***	0.404***	0.394***	0.405***
(currency plus banking crisis risk)	(8.98)	(8.72)	(8.82)	(8.62)
Relative company P/E ratio (Δ)	0.002	--	0.002	--
	(1.61)		(1.59)	
Relative market P/E ratio (Δ)	0.156	--	0.157	--
	(0.66)		(1.59)	
Relative company DY ratio (Δ)	--	5.4E-04	--	9.82E-04
		(0.06)		(0.11)
Relative market DY ratio (Δ)	--	0.592**	--	0.600**
		(3.24)		(3.35)
Market capitalization (in logs) (Δ)	0.645**	0.731***	0.648**	0.734***
	(4.47)	(7.30)	(4.43)	(7.15)
Dividend per share	0.003	0.004	-4.4E-04	5.7E-05
	(0.64)	(0.81)	(-0.61)	(0.06)
Constant	6.3E-05	3.9E-04	-9.2E-04	-4.1E04
	(0.06)	(0.41)	(-0.65)	(-0.34)
Company-specific fixed effects	no	no	yes	yes
R-squared	0.153	0.152	0.154	0.153
p-value F-statistic	0.000	0.000	0.000	0.000
No. of observations	654	654	654	654

Note: This table reports the results of the panel regressions (see Eq., III.10) for Venezuela during the capital control episode from June 28, 1994 thru April 19, 1996. The t-statistics in parentheses are computed based on robust standard errors clustered by company. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.

The exchange rate index is significantly positive in all specifications for Argentina and Malaysia. ADR investors' devaluation expectations increase when the domestic currency appreciates relative to the currencies of the country's export trading partners. Competitive devaluations thus seem to be a relevant factor when explaining the perceived risk of a currency crisis. The strong incidence of this argument in Malaysia confirms the existence of the widely discussed beggar-thy-neighbor exchange rate policy in Southeast Asia.[72]

For Venezuela (1994-1996), we find a significantly positive correlation between the EMBI sovereign yield spread and the ADR spread. A 1% increase in the sovereign yield spread – indicating a higher sovereign debt crisis risk – leads to a 2% increase in depreciation expectations for Venezuela. Thus, for Venezuela (1994-1996) we find empirical support for the hypothesis that sovereign debt and currency crises are interdependent. Apparently, ADR investors anticipate the risk that a sovereign default can lead to a currency crisis in Venezuela. For Argentina and Malaysia we find, however, no significant effect.

The interest rate spread measuring currency crisis risk is significantly positive for all specifications for Malaysia while for Argentina, it is insignificant.[73] That is, for the case of Malaysia rising depreciation expectations in the money market carry over to the ADR market. This finding supports the validity of uncovered interest rate parity during currency crises. Investors in vulnerable currencies receive higher domestic interest rates to compensate for the risk of devaluation.

The interest rate spread measuring the risk of a banking crisis is insignificant for the Malaysia regressions but significant for specifications I and III for Argentina. Thus, we find weak evidence for the hypothesis that ADR investors take the risk of a joint currency and banking crisis into account when modifying their depreciation expectations.

[72] For a discussion of competitive devaluations in Southeast Asia see, among others, Corsetti et al. (2000) and Chinn (2006).
[73] For Venezuela (1994-1996) we can only interpret the coefficient of the "raw" interest rate spread measuring the combined risk of a currency crisis and a banking crisis as discussed above.

For Venezuela (1994-1996), we find a significantly positive coefficient for the “raw” interest rate spread measuring the combined currency and banking crisis expectations. A 1% increase in the raw interest rate spread yields a 0.4% increase in the ADR spread. Thus, we find robust evidence that a higher crisis risk assessment in the Venezuelan money market spills over to ADR investors’ perceptions of currency crisis risk.

The variables controlling for investor sentiment largely confirm the findings of Arquette et al. (2008). The relative company P/E ratio is significantly positive in the regressions for Argentina and Malaysia. Moreover, we find significant evidence of a positive correlation between the relative market DY ratio and the ADR spread. Apparently, there is a kind of pro-cyclical behavior among ADR investors where better investor sentiment towards local stocks lead to higher local stock prices and thus to higher ADR spreads. The market capitalization is largely insignificant, except for Venezuela (1994-1996) where we find a positive and significant coefficient. For the dividend per share we largely find insignificant results indicating that differences in tax regimes only play a minor role in our dataset.

III.5.2 Regime switches in the determination of currency crisis expectations

The estimation results of the panel models provide evidence that ADR investors’ depreciation expectations are determined by daily observable currency crisis risk drivers, which measure the sustainability of a peg regime. In this section, we determine whether there are regime switches in ADR investors’ currency crisis expectations-making process. If the peg is relatively safe, for example, because capital controls effectively shield the domestic currency from speculative pressure, depreciation expectations will be low and the ADR spread will respond to variation in the risk drivers only moderately. If the peg regime becomes vulnerable and ADR investor do not believe that the fixed rate regime will survive, depreciation expectations – as measured by the ADR spread – will be significantly driven by crisis variables that inform the ADR investors about the sustainability of the peg.

We apply the regime switching methodology of Bai et al. (1998), which allows us to determine the most significant date of the regime change, i.e., the day when the most significant change in the correlation between the ADR spread and the crisis risk drivers occurs, as well as the confidence interval at this break date. The methodology of Bai et al. (1998) has been applied, for example, by Kallberg et al. (2005) and Pasquariello (2008).[74]

The following presentation of the regime switching model is based on Kallberg et al. (2005). We estimate the following linear time series equation for each capital control episode, where the ADR spreads and the company-specific control variables are averaged:

$$Y_t = \mu + \sum_p B_p x_{pt} + d_t(k)\left[\Delta\mu + \sum_p \Delta B_p x_{pt}\right] + \varepsilon_t \,. \qquad \text{(III.11)}$$

The first part of Eq. (III.11) shows the determination of the average ADR spread, Y_t, in the first regime, where Y_t, is regressed on a constant, μ, and a set of p exogenous variables, x_{pt}, including the risk drivers, the (averaged) control variables, and the lagged average ADR spread, with the corresponding coefficients of the first regime, B_p. The second part of the equation shows the change in the coefficients in the second regime, where $d_t(k)$ is a dummy variable equal to one if t is greater than or equal to the potential break date k and otherwise equal to zero, $\Delta\mu$ and ΔB_p denote the change in the value of the constant and the coefficients in the second regime, respectively, and ε_t is the error term. In matrix form, Eq. (III.11) reads:

[74] Kallberg et al. (2005) study whether the Asian crisis 1997/98 induced a regime switch in the dependency of the currency and equity returns (or return volatilities). Pasquariello (2008) examines whether financial crises lead to structural breaks in the efficiency of ADR pricing.

$$Y_t = V_t'\theta + d_t(k)V_t'S'S\delta + \varepsilon_t, \tag{III.12}$$

where $V_t' = [1, x_{1t}, ..., x_{pt}]$, $\theta = [\mu, B_1, ..., B_p]'$, $\delta = [\Delta\mu, \Delta B_1, ..., \Delta B_p]'$, and S is a selection matrix with ones on the diagonal for parameters of the variables in V_t' that are allowed to change, and zeros otherwise. Rewriting Eq. (III.12) yields:

$$Y_t = Z_t'(k)\beta + \varepsilon_t, \tag{III.13}$$

with $Z_t'(k) = [V_t', d_t(k)V_t'S']$ and $\beta = [\theta, S\delta]$. In order to find the optimal date of the regime change, k, Eq. (III.13) is estimated for each possible value of k, i.e., for a time sample of $t = 1,..,T$, this implies $k = 2,..,T-1$. As Bai et al. (1998, p. 398) we consider the maximum of the Wald *F*-statistic outlined in Eq. (III.14), which tests the null that the second-regime coefficient changes of the variables allowed to break are jointly equal to zero, i.e. $S\delta = 0$:

$$\hat{F}(k) = T\{R\hat{\beta}(k)\}'\left\{R\left(T^{-1}\sum_{t=1}^{T} Z_t\hat{\Sigma}_k^{-1}Z_t'\right)^{-1}R'\right\}^{-1}\{R\hat{\beta}(k)\}, \tag{III.14}$$

where T is the length of the time sample, $R = [0, I]$ is such that $R\beta = S\delta$, and $\hat{\beta}(k)$ and $\hat{\Sigma}_k$ are the estimators for β and the error variance, σ_ε^2, respectively, for a given value of $\hat{k}$. The critical values for the test statistic $\hat{F}(k)$ can be found in Bekaert et al. (2002, pp. 244-245). If the maximum of the *F*-statistic for a chosen $\hat{k}$ is significant at least at the 10% level, we conclude that a regime switch occurred on this day. The asymptotic confidence interval at this break date that covers at least $100(1-\pi)\%$ is given by Bai et al. (1998, p. 402):

$$\hat{k} \pm c_{(1/2\pi)}\left[\left(S\hat{\delta}\right)'S\left(\hat{\Sigma}_k^{-1}T^{-1}\sum_{t=1}^{T} V_tV_t'\right)S'\left(S\hat{\delta}\right)\right]^{-1}, \tag{III.15}$$

where $c_{(1/2\pi)}$ is the $100(1-\pi)th$ quantile of the Picard (1985) distribution.

We apply the Bai et al. (1998) methodology to search for the most significant regime switch in the determination of ADR investors' currency crisis expectations. We estimate Eq. (III.13) for each possible break date, k, during a capital control episode.[75] We allow the coefficients of the five[76] potential crisis risk drivers – the commodity price index, the exchange rate index, the EMBI sovereign yield spread, and the interest rate spreads measuring currency and banking crisis risk, respectively – to change.[77] The binary selection matrix, S, thus has five ones on the diagonal, which correspond to the matrix position of the five currency crisis risk drivers, and zeros otherwise. For each k, the estimators for the regression coefficients and the error variance are used to compute the Wald *F*-statistic as outlined in Eq. (III.14).

Table III.4 shows the results for the *dates* of regime switches for the four episodes of capital controls. We report the median date of the regime switch, the maximum value of the Wald *F*-statistic, and the corresponding 5% confidence interval computed using Eq. (III.15). Table III.5 reports the estimation results of the regime switching regressions, on which the regime break dates reported are based (see Eq., III.13).

As reported in Table III.4, we find significant regime switches for the capital control episodes of Argentina, Malaysia, and Venezuela (2003-2007). This means that the estimated changes in risk driver coefficients in the second regime are jointly different from zero at least at the 10% significance level. Thus, during these episodes of capital controls, ADR investors significantly altered the modus of determination of their currency crisis expectations. For Venezuela (1994-1996), we find no significant regime change.

[75] We only include stationary variables in the regressions. The results of the Augmented Dickey Fuller (Dickey and Fuller, 1979) tests are reported in Table III.A5 in Appendix III.
[76] Note that in the case of Venezuela (1994-1996) and Venezuela (2003-2007), the coefficients of only four crisis drivers are allowed to change as only data on a "raw" interest rate spread is available.
[77] The coefficients of the control variables are not allowed to change as these variables should play no vital role in assessing the risk of currency crisis.

Table III.4: Regime switches in currency crisis expectations

Episode	2.5th percentile	Median	97.5th percentile	Maximum Wald *F*-statistic
Argentina	January 13, 2002	January 14, 2002	January 15, 2002	71.524***
Malaysia	March 19, 1999	April 5, 1999	April 20, 1999	16.641*
Venezuela (1994-1996)	October 28, 1994	January 12, 1995	March 29, 1995	10.755
Venezuela (2003-2007)	January 4, 2007	January 5, 2007	January 6, 2007	49.367***

Note: This table reports the median structural break date $\hat{k}$ determined using the maximum Wald *F*-statistic (see Eq., III.14), which tests the null that the second-regime coefficient changes of the variables allowed to break are jointly equal to zero. The optimal break dates are determined using the coefficients of the regime switching regressions reported in Table III.5. We conclude that a break date is significant if the maximum of the *F*-statistic rejects the null at least at the 10% level. The critical values for the Wald *F*-statistic are taken from Bekaert et al. (2002, pp. 244-245): 14.030, 15.656, and 19.384 correspond to the 10%, 5%, and 1% significance level for Venezuela (1994-1996) and Venezuela (2003-2007) where four coefficients are allowed to break; 16.564, 18.441, and 23.057 correspond to the 10%, 5%, and 1% significance level for Argentina and Malaysia where five coefficients are allowed to break. *, **, *** denotes 10%, 5%, and 1% level of significance, respectively. The 2.5th and the 97.5the percentiles around the break date are computed using Eq. (III.15).

In the case of Argentina, we find evidence for a significant regime change on January 14, 2002, shortly after the breakdown of the peg on January 11, 2002. Inspecting the pre-break coefficients and the post-break coefficient changes, we find that currency crisis expectations were driven by the EMBI sovereign yield spread and the interest rate spread measuring banking crisis risk before the regime switch. After the regime switch on January 14, 2002, ADR investors' depreciation expectations no longer reacted to changes in these risk drivers as the sum of the pre-break coefficients and the post-break change in these coefficients virtually equals zero.

Table III.5: Results of the regime switching regressions

Dependent variable: Δ *Average ADR spread*	Argentina	Malaysia	Venezuela (1994-1996)	Venezuela (2003-2007)
Regime 1 coefficients				
Pre-break commodity price index (in logs) (Δ)	0.898	-0.386	0.227	-0.051
	(0.51)	(-1.44)	(0.74)	(-1.63)
Pre-break exchange rate index (in logs) (Δ)	-5.457	0.968	0.465^{**}	0.128
	(-1.26)	(1.48)	(2.44)	(0.17)
Pre-break EMBI sovereign yield spread (Δ) (debt crisis risk)	1.088^{**}	1.752	0.275	3.141^{***}
	(2.10)	(1.55)	(0.51)	(4.03)
Pre-break interest rate spread (Δ) (currency crisis risk)	-1.482	-0.427	Δ Raw interest rate spread	Δ Raw interest rate spread
	(-0.70)	(-0.33)		
Pre-break interest rate spread (Δ) (banking crisis risk)	16.165^{**}	1.656^{*}	0.358^{**}	0.058
	(2.01)	(1.66)	(2.09)	(0.69)
Regime 2 coefficient changes				
Post-break commodity price index (in logs) (Δ)	-1.278	0.309	-0.405	-0.449
	(-0.71)	(1.06)	(-0.97)	(-1.27)
Post-break exchange rate index (in logs) (Δ)	5.845	-1.154	-0.172	6.134
	(1.35)	(-0.80)	(-0.27)	(0.67)
Post-break EMBI sovereign yield spread (Δ) (debt crisis risk)	-1.072^{*}	-2.196	2.917^{***}	30.186^{**}
	(-1.80)	(-1.02)	(3.09)	(2.40)
Post-break interest rate spread (Δ) (currency crisis risk)	1.491	6.572^{**}	Δ Raw interest rate spread	Δ Raw interest rate spread
	(0.70)	(2.56)		
Post-break interest rate spread (Δ) (banking crisis risk)	-16.240^{**}	10.255^{**}	-0.017	-13.756
	(-2.02)	(2.42)	(-0.06)	(-0.64)
R-squared	0.337	0.564	0.111	0.409
p-value F-statistic	0.000	0.000	0.000	0.000
Durbin-Watson Statistic	2.028	2.465	2.002	2.036
No. of observations	260	261	474	1111

Note: This table reports the results of the regime switching regression as outlined in Eq. (III.13). The coefficients of the vulnerability measures are allowed to break. The table reports the pre-break (regime 1) coefficients and the post-break (regime 2) coefficients. The variables are used in first differences (indicated by a Δ) in order to avoid the problem of unit roots. The regressions also include the averaged control variables, i.e. the Δ average relative company P/E ratio, the Δ average relative market P/E ratio, the Δ average relative company DY ratio, the Δ average relative market DY ratio, the Δ average log market capitalization, the average dividend per share, and the Δ average ADR spread lagged one day. The coefficients of the control variables are not reported but available upon request. The t-values in parentheses are computed using the heteroskedasticity and autocorrelation consistent Newey and West (1987) covariance matrix. *, **, *** denotes 10%, 5%, and 1% level of significance, respectively.

To explain this, one could argue that the Argentine exchange rate regime switched from a crisis mode with depreciation expectations exceeding 50% before the breakdown of the peg (see Section III.3) to a state of relative tranquility with steady depreciation but with much less volatility. For Malaysia, we find a significant regime switch on April 5, 1999 with a confidence interval of two weeks around the break. Analyzing the estimated coefficients, we find that depreciation expectations were driven mainly by the interest rate spread measuring banking crisis risk before the break. After the regime switch, the impact of the banking crisis-related interest rate spread on ADR investors' currency crisis expectations increased whereby the currency crisis-related interest rate spread also appear to be a significant driver of the ADR spread. This result suggests that ADR investors' currency crisis expectations became increasingly dependent on market-based currency crisis risk drivers in the second regime.

For Venezuela (2003-2007), we detect a significant regime switch on January 5, 2007. This regime switch was induced by a significantly higher correlation between the ADR spread and the EMBI sovereign yield spread after the regime switch. A possible explanation for this result may be that ADR investors were increasingly aware of the risk of a twin sovereign debt and currency crisis in Venezuela.

III.6 Conclusion

The ADR spread and the ADR shadow exchange rate seem to be promising early warning indicators of currency crises. If capital controls are introduced, the prices of ADRs and their underlying stocks can diverge. These ADR spreads reflect the ADR investors' expectations of a devaluation. The price spread can be used to calculate the ADR shadow exchange rate, which represents the mean exchange rate ADR investors expect following a currency crisis or a realignment. As stock market data is used, currency crisis signals are generated on a daily basis and reflect ADR investors' up-to-date assessment of the peg's sustainability. This approach enables policymakers to identify currency crisis risk earlier and to take the necessary steps to realign an (unsustainable) peg rate before a crisis breaks out. In the capital control episodes analyzed, the ADR spread and the ADR shadow exchange rate fairly accurately identified the risk of a currency crisis and the need for realignment well before each crisis actually occurred, substantiating the rational expectations of ADR investors.

Using panel regressions, we identify the risk drivers observable in daily frequency that feed ADR investors' currency crisis expectations. We find that the ADR spread is driven by falling export commodity prices, depreciating currencies of trading partners, rising sovereign yield spreads, and rising interest rate spreads. Our high-frequency framework thus provides evidence that ADR investors use the academic knowledge about the occurrence of currency crises in their assessment of the peg's sustainability. We also test for regime changes in the process of determining currency crisis expectations. We find evidence of a regime switch during the capital control episodes in Argentina (2001-2002), Malaysia (1998-1999), and Venezuela (2003-2007). Thus, the impact of market-based crisis risk drivers on ADR investors' expectations of a currency crisis depends on the state of the exchange rate regime.

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III. Appendix

Table III.A1: List of included ADR/underlying stock pairs

Country	Included ADR/underlying stock pairs
Argentina (2001-2002)	BBVA Banco Frances, Cresud S.A.C.I.F., Grupo Financiero Galicia, Metrogas, Petrobras Energia Participacoes, Telecom Argentina, Telefonica de Argentina, Transportadora de Gas del Sur, YPF
Malaysia (1998-1999)	Bandar Raya Developments, Silverstone Corporation, Sime Darby
Venezuela (1994-1996)	Corimon C.A. S.A.[a], Mantex Common Shares[b], Sivensa Common Shares[b], Sudamtex de Venezuela 'B'[b]
Venezuela (2003-2007)	Compañía Anónima Nacional de Teléfonos de Venezuela (CANTV)

Information on ADRs is taken from the internet databases of JP Morgan (www.adr.com) and Bank of America (www.adrbny.com); [a]Included from June 28, 1994 to December 18, 1995. [b]Included from December 18, 1995 to April 19, 1996.

Table III.A2: Index weights for the commodity price indices

Country	Index weights for the country-specific commodity price indices
Argentina (2001-2002)[a]	Cereals (19.6%), Soya oil (19.6%), Crude oil (18.9%), Industrial metals (11.6%), Gas/fuel (11.4%), Soya beans/seeds (11.2%), Natural gas (4.9%), Copper (2.8%)
Malaysia (1998-1999)[b]	Palm oil (52.1%), Crude oil (22.0%), Natural gas (17.6%), Rubber (8.3%)
Venezuela (1994-1996)[c]	Crude oil (85.4%), Industrial metals (6.7%), Aluminium (5.6%), Gold (2.0%)
Venezuela (2003-2007)[d]	Crude oil (67.0%), Gas/fuel (27.8%), Industrial metals (2.9%), Aluminium (2.3%)

Note: [a]The total value of exported commodities in 2001 was 12,497 million U.S. dollars which equals 47.1% of total exports; Source: INDEC (National Institute of Statistics and Census), Argentine Ministry of Economy; [b]The total value of exported commodities in 1998 was 8,699 million U.S. dollars which equals 12.1% of total exports; Source: IMF Staff Country Report No. 99/85; [c]The total value of exported commodities in 1994 was 13,432million U.S. dollars which equals 83.5% of total exports; Source: IMF Staff Country Report No. 98/117; [d]The total value of exported commodities in 2004 was 28,917 million U.S. dollars which equals 86% of total exports; Source: ECLAC (Economic Commision for Latin America and the Caribbean) Statistical Yearbook of Latin America and the Caribbean, 2006.

Table III.A3: Index weights for the export destinations' exchange rate indices

Country	Index weights for the country-specific export destinations' exchange rate indices
Argentina (2001-2002)[a]	Brazil (31.8%), Eurozone (20.5%), Chile (14.7%), China (5.8%), Paraguay (2.6%), Mexico (2.5%), India (2.2%), Iran (2.1%), Peru (2.0%), Korea (2.0%), Japan (1.8%), Egypt (1.8%), South Africa (1.6%), Thailand (1.5%), Malaysia (1.5%), Bolivia (1.4%), Denmark (1.2%), Canada (1.2%), Colombia (1.0%), Algeria (0.8%)
Malaysia (1998-1999)[b]	Singapore (25.8%), Japan (16.0%), Netherlands (7.1%), Hong Kong (7.1%), United Kingdom (5.5%), Thailand (4.8%), Germany (4.6%), China (4.1%), India (3.9%), Australia (3.5%), Korea (3.5%), Philippines (2.4%), Indonesia (2.1%), Belgium (1.8%), France (1.6%), Pakistan (1.6%), UAE (1.3%), Canada (1.1%), Italy (1.1%), Ireland (0.9%)
Venezuela (1994-1996)[c]	Colombia (23.7%), Suriname (14.7%), Brazil (9.5%), United Kingdom (7.2%), Germany (5.6%), Dominican Republic (5.3%), Japan (4.8%), Mexico (4.5%), Netherlands (4.1%), Canada (3.5%), Ecuador (2.6%), Italy (2.2%), Guatemala (2.0%), Chile (1.8%), Peru (1.7%), Spain (1.7%), Cuba (1.5%) Costa Rica (1.5%), Sweden (1.3%), France (0.8%)
Venezuela (2003-2007)[d]	Netherlands Antilles (47.4%), Eurozone (8.8%), Colombia (7.1%), Mexico (4.2%), Peru (3.8%), Dominican Republic (3.6%), United Kingdom (3.5%), Singapore (3.4%), Canada (2.7%), Nicaragua (2.6%), Ecuador (2.6%), Costa Rica (2.1%), China (1.9%), Japan (1.4%), El Salvador (1.1%), Brazil (1.1%), Trinidad and Tobago (0.9%), Chile (0.7%), Guatemala (0.6%), Jamaica (0.6%)

Note: Source: IMF Directions of Trade Statistics (DOTS); [a]The total value of exports to the 20 largest trading partners in 2001 was 19,451 million U.S. dollars which equals 87.3% of total exports; [b]The total value of exports to the 20 largest trading partners in 1998 was 48,164 million U.S. dollars which equals 65.6% of total exports; [a]The total value of exports to the 20 largest trading partners in 1994 was 6,032 million U.S. dollars which equals 35.3% of total exports [a]The total value of exports to the 20 largest trading partners in 2004 was 14,746 million U.S. dollars which equals 37.2% of total exports.

Table III.A4: Results of the panel unit root tests

	Argentina		Malaysia		Venezuela (1994-1996)	
	MW-Chi2	IPS t-statistic	MW-Chi2	IPS t-statistic	MW-Chi2	IPS t-statistic
ADR spread	69.579***	-5.115***	4.358	-0.182	12.832	-1.205
			(283.440)***	(-22.745) ***	(121.859)***	(-13.775) ***
Commodity price index (in logs)	3.468	2.269	0.254	3.132	0.277	3.791
	(321.097)***	(-16.934)***	(378.239)***	(-29.558)***	(660.899)***	(-42.994)***
Exchange rate index (in logs)	0.501	5.941	12.095*	-1.837**	3.116	0.782
	(955.873)***	(-40.705)***	(217.098)***	(-16.737)***	(663.661)***	(-48.289)***
EMBI sovereign yield spread	49.110***	-4.303***	1.255	1.438	10.618	-1.315*
(sovereign debt crisis risk)			(357.175)***	(-27.028)***	(100.793)***	(-8.807)***
Interest rate spread	10.981	-0.001	0.425	2.351	Raw interest	Raw interest
(currency crisis risk)	(611.469)***	(-27.141)***	(100.553)***	(-9.372)***	rate spread:	rate spread:
Interest rate spread	44.660***	-3.975***	11.482	-1.743	10.348	-1.267
(banking crisis risk)			(248.837)***	(-18.541)***	(144.479)***	(-11.314)***
Relative company price/earnings	15.845	0.356	3.971	0.410	4.607	0.353
ratio	(960.620)***	(-43.849)***	(376.450)***	(-29.310)***	(663.982)***	(-47.942)***
Relative market price/earnings ratio	21.297	-1.4842*	2.906	0.408	1.538	1.631
	(1133.35)***	(-51.200)***	(396.689)***	(-33.513)***	(208.254)***	(-14.523)***
Relative company dividend yield	13.903	0.698	32.221***	-4.346***	4.087	0.529
ratio	(1109.36)***	(-49.562)***			(616.533)***	(-44.858)***

Relative market dividend yield ratio	51.641***	-4.486***	0.512	2.311	0.576	3.015
			(326.965)***	(-23.838)***	(666.596)***	(-46.315)***
Market capitalization (in logs)	36.214***	-1.873**	2.845	0.889	0.110	5.662
			(207.456)***	(-16.032)***	(496.901)***	(-32.082)***
Dividend per share	31.572**	-2.651***	20.972***	-3.475***	31.047***	-3.866***

Note: This table presents the panel unit root test statistics of Im et al. (2003) (the IPS average t-statistic) and of Maddala and Wu (1999) (the MW Chi2 distributed average p-value) for the respective variable in levels and in first differences (in parentheses). Under the null hypothesis of each test the variable contains a unit root in levels. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively. For the order of the autoregressive correction, we use the Akaike Information Criterion (AIC).

Table III.A5: Results of the time series unit root tests

	Argentina	Malaysia	Venezuela 1994-1996	Venezuela 2003-2007
Average ADR spread	-1.659	-1.639	-1.710	-2.483
	(-17.15***)	(-18.5***)	(-15.8***)	(-36.9***)
Commodity price index (in logs)	-0.689	0.137	0.892	-0.359
	(-15.5***)	(-16.1***)	(-20.0***)	(-35.0***)
Exchange rate index (in logs)	0.147	-2.306	-2.215	-1.181
	(-13.1***)	(-15.6***)	(-21.7***)	(-33.9***)
EMBI sovereign yield spread	-2.457	-0.817	-1.485	-3.067**
(sovereign debt crisis risk)	(-17.2***)	(-9.38***)	(-18.2***)	(-30.4***)
Interest rate spread	-1.726	-2.638*	Raw interest rate:	
(currency crisis risk)	(-19.7***)	(-17.3***)		
Interest rate spread	-2.504	-3.350**	-3.200**	-5.644***
(banking crisis risk)	(-25.5***)	(-19.6***)	(-4.16***)	(-182***)
Avg. relative company P/E ratio	-1.928	-0.551	-0.704	-2.516
	(-4.237***)	(-3.84***)	(-4.52***)	(-13.4***)
Avg. relative market P/E ratio	-1.956	-1.330	-0.773	-2.387
	(-9.114***)	(-9.12***)	(-7.87***)	(-8.93***)
Avg. relative company DY ratio	-1.133	-4.052***	-3.036**	-1.717
	(-5.223***)	(-3.83***)		(-33.0***)
Avg. relative market DY ratio	-2.820*	-3.732***	-0.240	-1.606
	(-3.475***)	(-4.52***)	(-4.54***)	(-5.79***)
Avg. log market capitalization	-1.785	-2.830*	-0.574	-3.089**
	(-3.445**)	(-9.61***)	(-4.22***)	(-6.05***)
Avg. dividend per share	-5.390***	-3.547***	-3.25**	-3.051**

Note: The Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1979) tests the null that the variable contains a unit root in levels. Test statistics for variables in levels and first differences (in parenthesis) are reported; *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively. The critical values for the ADF test statistic are taken from McKinnon (1996). For the order of the autoregressive correction for the ADF test, we use the modified Akaike Information Criterion (AIC).

Chapter IV

What can currency crisis models tell us about the risk of withdrawal from the EMU? Evidence from ADR data[78]

Abstract

I study whether American Depositary Receipt (ADR) investors perceive the risk that vulnerable member countries such as Greece, Ireland, Italy, Portugal, or Spain, could leave the eurozone in order to address financial problems associated with the subprime crisis using national monetary policy. Employing daily data, I analyze the impact of vulnerability measures related to currency crisis theories on ADR returns. I find that ADR returns fall when: sovereign bond yield spreads or sovereign credit default swap (CDS) spreads rise (i.e., sovereign debt crisis risk increases); domestic banks' CDS premiums rise or stock returns fall (i.e., banking crisis risk increases); or, the euro's overvaluation increases (i.e., the risk of competitive devaluation increases).

[78] This paper is based on: Eichler, S., 2011. What can currency crisis models tell us about the risk of withdrawal from the EMU? Evidence from ADR data. Journal of Common Market Studies 49, 719-40. Used with permission from Wiley.

IV.1 Introduction

Twelve years after its inception, the Economic and Monetary Union (EMU) is facing its most difficult challenge. The subprime lending crisis, triggered by significant reductions in leverage and prices in the U.S. housing market (Geanakoplos, 2010) and intensified by global macroeconomic imbalances and lacking policy coordination (Pauly, 2009), insufficient banking regulation (Karmann, 2008), fast credit expansion driven by lax monetary policy (Carmassi et al., 2009), and bad investment policies particularly of state-owned banks (Hau and Thum, 2009), has brought many banks in the EMU to the verge of bankruptcy. High public debt levels (produced by chronic overspending, severe recessions, and national bank bailout plans) feed speculations about possible sovereign debt defaults in the most vulnerable EMU member countries – Greece, Ireland, Italy, Portugal, and Spain. What is more, the export industry in several member countries is suffering under the strong euro whose exchange rate still stands near a record high against the U.S. dollar and many other major currencies.

If the central banks of the EMU member countries above were not subordinate to the European Central Bank (ECB), they could ease their monetary policies at national discretion. In that case, a national central bank would have several options: to increase the liquidity supply in order to prevent bank failures; to purchase national sovereign bonds to reduce the lending costs of the government or increase inflation in order to reduce the real value of sovereign debt; or to devalue the new national currency in order to support the domestic export industry. The existence of a single currency for all EMU member countries, however, reduces the ability of these countries to cope with financial difficulties in this (cheap) way through monetary policy. Although the ECB has implemented measures meant to support the banking sectors and governments in the EMU, autonomous national central banks of the vulnerable member countries would probably pursue more expansionary monetary policies. As the economic centrifugal forces in the EMU are growing larger each day, it is no longer a purely hypothetical question as to whether a member country would consider leaving the EMU. As the crisis of the European Monetary System in 1992/93 illustrates, opportunistic governments may rationally decide to reassert national authority over monetary policy if the benefits of dropping out of exceed the benefits of remaining in a fixed-exchange rate regime (Obstfeld, 1994, 1996).

I use data on American Depositary Receipts (ADRs) to study whether financial markets perceive the risk that vulnerable member countries could leave the EMU. ADRs are appropriate in this context since the ADR market provides information about exchange rate expectations. An ADR represents the ownership of a specific number of underlying shares in the home market on which the ADR is written.[79] While the ADR is traded at a U.S. stock exchange and is denominated in U.S. dollars, the underlying European stock is denominated in euros and traded at a stock exchange of the home market in the EMU. Since the ADR and its corresponding underlying stock produce identical cash flows and incorporate equivalent rights and dividend claims, the returns of both types of a company's stocks should be equal in exchange rate-adjusted terms.

An important finding in the literature is that currency crises can have a significant impact on the pricing of ADRs. Many studies conclude that the returns on U.S. dollar-denominated ADRs are negatively affected by currency crises as the devaluation of the local currency depresses the dollar value of the underlying stock (Bailey et al., 2000; Kim et al., 2000; Bin et al., 2004). Pasquariello (2008) finds that the outbreak of a financial crisis typically leads to a disintegration of the local capital market measured by a persistent violation of the law of one price between an ADR and its underlying stock.[80] Arquette et al. (2008) analyze the price spreads between Chinese underlying stocks and their ADRs (or H-

[79] See Karolyi (1998) for an excellent survey on the ADR market.

[80] Another branch of the literature studies how the introduction of capital controls affects ADR pricing (Melvin, 2003; Levy Yeyati et al., 2004; Auguste et al., 2006). These authors find that controls on capital outflows in Argentina 2001/02 led to a premium of the underlying stock price over the ADR price. Using a panel of emerging economies, Levy Yeyati et al. (2009) confirm this result, finding that controls on capital outflows (inflows) lead to persistent price premiums (discounts) of the underlying stock over the ADR.

shares) and find that exchange rate expectations – extracted from forward exchange rates – explain 40% of the variation in the price deviation. The results of the existing literature indicate that currency crises may influence the relative pricing of ADRs and their underlying stocks and that the price spread is correlated with market-traded forward exchange rates.

I contribute to the literature by analyzing whether ADR investors perceive the risk that vulnerable member countries could leave the EMU. Although there are many advantages to membership in the EMU, currency unions restrict national monetary policy (De Grauwe, 2007). Of course, conducting a rule-based monetary policy to fight inflation was the main purpose for creating the EMU (Schelkle, 2005; Segers and Van Esch, 2007). In the light of the subprime lending crisis, however, the EMU impedes the ability of national governments/central banks to cope with financial vulnerabilities. Although the introduction of the euro and membership in the EMU are generally considered to be irrevocable, many authors agree that sovereign states *can* choose to withdraw from the EMU (Cohen, 1993; Scott, 1998; Buiter, 1999; Eichengreen, 2007). Moreover, the new Treaty of Lisbon includes an explicit provision regulating a negotiated withdrawal. Thus, governments of sovereign states may rationally decide to withdraw from the EMU if the benefits of leaving exceed the benefits of remaining in the EMU.

If Greece, Ireland, Italy, Portugal, or Spain were to leave the EMU and introduce new national currencies, these currencies would most likely depreciate against the U.S. dollar (and the euro) as the national governments eased their national monetary policies. From the literature on currency crises, I hypothesize three factors that determine the vulnerability to the outbreak of such a politically induced currency crisis. First, governments may choose to leave the EMU in order to address a domestic banking crisis. If domestic banks are bailed out by providing them with large amounts of the new national currency, inflation rates will increase which may, according to the relative purchasing power parity, lead to a depreciation of the new national currency. Second, governments may leave the EMU in order to solve a sovereign debt crisis. The new national central bank may be pushed to purchase every amount of domestic sovereign bonds in order to guarantee the funding of public deficits. Moreover, higher inflation rates produced by monetary easing may reduce the real sovereign debt burden. Higher inflation rates may, in turn, lead to a depreciation of the national currency. Third, member countries may want to leave the EMU in order to pursue competitive devaluations. By devaluating the national currency – an option which does not exist for EMU member countries – the government can support the domestic export industry.

Withdrawal from the EMU is a political decision. Although this analysis cannot explain the actual choice of policymakers to withdraw from or remain in the EMU, I can evaluate whether ADR investors – who are exposed to capital losses in the case of withdrawal – perceive a risk of withdrawal from the EMU and the vulnerability factors that drive such a risk. I apply a multifactor pricing model which assumes that systematic risk factors are priced in ADR returns. If ADR investors perceive the risk of withdrawal from the EMU cum devaluation *in the future*, they will take this exchange rate risk into account and (*ex ante*) attach a premium to that country's U.S. dollar-denominated ADR returns. This exchange rate risk premium accounts for the risk that the new national currency – in which the original stock would be denominated – may depreciate against the U.S. dollar as a result of leaving the EMU. I hypothesize that the exchange rate risk premium is driven by three vulnerability factors that influence a government's decision to leave/remain in the EMU: 1) the possibility of a twin currency and banking crisis; 2) the possibility of a twin currency and sovereign debt crisis; 3) the incentive to devalue a new national currency competitively. The goal of the paper is to evaluate whether the exchange rate risk premium (priced in ADR returns) is significantly correlated with empirical measures of the hypothesized vulnerability factors.[81] A significant correlation between the vulnerability measure and ADR returns would suggest that

[81] For a similar methodological approach to analyze the determinants of exchange rate risk premiums priced in stock returns, see Bailey and Chung (1995).

ADR investors perceive the risk of withdrawal from the EMU and that this risk is driven by the vulnerability measure tested.

In order to test the hypotheses about the factors that determine the risk of withdrawal from the EMU as perceived by ADR investors, I regress the daily ADR returns on five empirical measures that capture the three types of financial vulnerabilities. I use daily data on 22 ADRs whose underlying stocks are traded in Greece, Ireland, Italy, Portugal, or Spain, in the period January 2007 to March 2009. The panel estimation results largely confirm that the vulnerability measures significantly influence ADR returns in the hypothesized direction, suggesting that the exchange rate risk premium is a composite measure of all vulnerability factors. Higher credit default swap (CDS) premiums and lower stock returns of domestic banks – which indicate higher risk of banking crisis – significantly reduce ADR returns. This finding suggests that ADR investors perceive the risk that member countries with a vulnerable banking system could leave the EMU in order to support their banks using national monetary policy measures. I also find evidence that higher sovereign CDS spreads and sovereign bond yield spreads – which indicate higher risk of sovereign debt crisis – significantly reduce ADR returns. This suggests that vulnerable EMU member countries may leave the EMU in order to address sovereign debt problems. An appreciation of the effective national euro exchange rate – which reflects a higher incentive for competitive devaluation – increases the risk of withdrawal, thereby significantly reducing ADR returns.

The remainder of the paper is organized as follows. Section IV.2 discusses the alternatives to, legal aspects of, and consequences of withdrawal from the EMU. Section IV.3 presents the hypotheses on currency crisis risk drivers. Section IV.4 describes the data and presents the empirical results. Section IV.5 concludes.

IV.2 Alternatives to, legal aspects of, and consequences of leaving the EMU

Although withdrawal from the EMU would entail several benefits (as explained in the introduction), several aspects of the EMU must be considered when assessing the risk of withdrawal. First, there are several ways how vulnerable EMU member countries can get financial support from within the EMU, which may reduce the incentive to withdraw from the monetary union. Second, the legal aspects of withdrawal from the EMU must be taken into account. Third, withdrawal entails several negative as well as positive consequences.

IV.2.1 Alternatives to leaving the EMU

There are several alternative ways to support vulnerable banking sectors, to service sovereign debt, or to reduce the overvaluation of the currency than by withdrawing from the EMU. The European System of Central Banks (ESCB) may provide financial assistance to support troubled banks in the EMU member countries. Although the ECB cannot act as a lender of last resort on the national level, the Treaty Establishing the European Community (TEC) provides that the "ESCB shall contribute to the smooth conduct of policies pursued by the competent authorities relating to the prudential supervision of credit institutions and the stability of the financial system" (Art. 105(5) TEC). This means that the mandate of national banking supervision lies with national authorities, but the ECB/ESCB is responsible for guaranteeing financial stability at the EMU level. In the event of banking crisis in an EMU member country the statute of the ESCB allows the ECB to provide financial resources necessary to avert an EMU-wide banking crisis (ECB, 2005). Thus, the ECB's "Enhanced Credit Support" program meant to support troubled banking systems in the EMU is well in line with the ECB's mandate.[82]

[82] The "Enhanced Credit Support" program was implemented in October 2008 and comprises several non-standard monetary policy measures. First, the ECB began to use a "fixed rate full allotment" tender for all refinancing operations, where the ECB provides eligible banks every amount of central bank liquidity they need at a fixed interest rate. Before this policy change, the ECB used a variable rate tender procedure where only the highest bids for central bank liquidity were considered. Second, the list of securities accepted by the ECB as

Member countries having trouble servicing their sovereign debt may also receive financial help from within the EMU. Although the no-bail-out rule (Art. 103 TEC) precludes the members of the Union from bailing out an EMU member, Article 100(2) of the TEC provides that a member state can get financial assistance from the other member countries if “severe difficulties” arise from “natural disasters or exceptional occurrences beyond its control.” The subprime lending crisis may be classified as an exceptional occurrence since its impact on the economies of EMU member countries has been much more disastrous than recessions in the past. There are several ways to support a member country unable to service its sovereign debt. First, the ECB can buy sovereign bonds of the distressed EMU member country on the secondary market.[83] This step is undertaken by the ECB since the implementation of its “Securities Markets Programme” in May 2010. The ECB’s purchases of vulnerable member countries’ sovereign bonds provides a steady demand for these bonds thereby producing lower bond yields.[84] Recently, bailout packages financed by EMU member countries and the International Monetary Fund have been implemented to save the governments of Greece, Ireland and Portugal from bankruptcy. Sinn and Wollmershäuser (2011) point to a yet overlooked support measure within the eurosystem. They show that the Deutsche Bundesbank (in particular) grants TARGET II credits to the national central banks particularly of the vulnerable EMU member states Greece, Ireland, Portugal, and Spain. These TARGET II credits are generated in order to finance the current account deficits of these vulnerable countries and may diminish in value in the case of a sovereign default of one of the debtor countries. Another possibility to support troubled governments would be to issue a

eligible collateral for refinancing operations was extended. The rating threshold for marketable and non-marketable securities used as collateral was lowered from A- to BBB-. Third, the ECB offered longer-term refinancing operations with maturities of 3, 6 and 12 months. Fourth, the number of financial institutions eligible for fine-tuning operations was extended from 140 to 2,000. Fifth, the ECB supplied foreign exchange swaps to provide EMU banks with foreign currency, particularly U.S. dollars.

[83] This circumvents the outright prohibition of direct lending by the ECB or national central banks to member states (Art. 101 TEC).

[84] Although the ECB does not publish data on the country composition of these bond purchases, most observers believe that Greek, Portuguese and Irish sovereign bonds represent the vast majority of the ECB’ sovereign bond holdings (Belke, 2010).

common eurozone bond where all participating EMU member countries jointly guarantee the debt service of the bond. Such a common eurozone bond with a single interest rate suggests that the risk premiums of all issuing countries would be pooled, thereby decreasing the lending costs for the vulnerable states at the expense of countries with sound public finances.[85]

In order to cope with an overvalued euro, the ECB may intervene at the foreign exchange market to devalue the euro against the currencies of the EMU member countries' major trading partners. Regulations on exchange rate policies of the ESCB, however, are relatively rigid. Art. 111 of the TEC assigns competence in the field of exchange rate policy to the European Council, which can authorize foreign exchange market interventions if "a qualified majority [in the Council is achieved and] on a recommendation from the ECB or from the Commission, and after consulting the ECB" and only if "the objective of price stability" is not at risk. EMU member countries are quite heterogeneous with respect to inflation rates, trade patterns and, thus, the extent of overvaluation of their *national* effective exchange rates. It therefore seems difficult to achieve a majority in the European Council as to whether the euro is overvalued and whether foreign exchange market interventions would lead to inflationary pressure or not. For an individual EMU member country facing an overvalued currency, it seems much easier to leave the EMU and realign a new national currency at an undervalued level than to organize an intervention in the foreign exchange market from within the EMU.

IV.2.2 Legal aspects of leaving the EMU

A country that enters the Third Stage of the EMU – in which the national currency is substituted for euros at an "irrevocably fixed rate" (Art. 123(4) TEC) – loses its sovereignty

[85] De Grauwe and Moesen (2009) propose an alternative arrangement for interest rates in which each participating country pays an individual market-determined interest rate on its part of the eurozone bond. This arrangement avoids the problem of high-interest-rate countries free riding on the low interest rates of countries with sound public finances.

over national monetary policy. This provision prevents the countries that join the EMU from leaving the Union too easily in order to ensure stability.[86] However, many authors argue that sovereign member states *can choose* to leave the EMU (Cohen, 1993; Scott, 1998; Buiter, 1999; Eichengreen, 2007). This view is based on the fact that while the Third Stage of the EMU achieves monetary union, it does not achieve political union. Monetary unions such as the EMU are based on a political consensus among sovereign states, but "so long as member states retain political independence, … one or another government might eventually choose to reassert its monetary autonomy" (Cohen, 1993).[87]

The new Treaty of Lisbon includes a provision outlining voluntary withdrawal which may cause the member countries to re-think the pros and cons of remaining in the eurozone.[88] This new provision makes it clear that membership in the EMU is *not irreversible* but rather an ongoing freely-made choice. Art. 50(2) of the Treaty of Lisbon allows a member country to withdraw from the EMU after notifying the European Council of its intention, negotiating with the other member countries, and concluding the negotiations with a qualified majority of the European Council and with the consent of the European Parliament. Art. 50(2) of the Treaty of Lisbon provides that a withdrawal agreement shall specify the member's "future relationship with the Union." This means that a country may secede from the EMU and still remain a member of the EU (Dougan, 2008). Art. 50(3) of the Treaty of Lisbon provides for automatic withdrawal if a withdrawal agreement between the withdrawing member and the other members fails: the "Treaties shall cease to apply to the State in question" two years after the Council is notified of the state's intention to withdraw and unless the period is extended.

[86] For an excellent overview of the importance of commitment mechanisms for the credibility of the EMU, see Schelkle (2006).

[87] Polling data of the Eurobarometer suggests that a withdrawal from the EMU would be democratically legitimated in several vulnerable member countries. More than 50 percent of the March 2009 polling respondents in Italy, Portugal, and Spain, for example, believed that using national monetary policy would be more effective in resolving the consequences of the subprime lending crisis than the monetary policy conducted by the ECB (Jones, 2009).

[88] See Art. 50(1) of the Treaty of Lisbon.

IV.2.3 Consequences of leaving the EMU

Withdrawal entails several negative as well as positive consequences. In addition to the advantages of an autonomous national monetary policy mentioned in the introduction, a withdrawing member may benefit from reclaiming (national) assets from the ECB. The withdrawing state can seek the return of its share of the ECB's capital and foreign exchange reserves that had been transferred to the ECB when it was established (see Art. 28-30 of the ESCB Statute).

Leaving the EMU would involve several transaction and political costs as well as contractual uncertainties negatively affecting the withdrawing country. For example, some transaction costs include the reprogramming of ATM and vending machine computer codes, the physical delivery of the new currency, costs associated with the re-denomination of wages, capital income, taxes, deposits, loans, and mortgages, and the conversion of prices quoted on the national stock exchanges. On the political side, withdrawal from the EMU could result in a loss of political power in the EU. This could involve diplomatic tensions with the remaining EMU members, or the former EMU-member could be relegated to second-tier status in negotiations over EU issues. Withdrawal could also damage the European integration process since the "EMU is foremost a major step on the road to 'ever closer union' in Europe" (Buiter, 1999). Finally, withdrawal could damage the EMU's credibility negatively affecting the conduct of the ECB's monetary policy.

There are also legal uncertainties involved in an EMU withdrawal. First, if a country withdraws from the EMU so that fiscal deficits can be easily monetized by the national central bank the incentive for excessive public spending will be increased. A likely outcome would be that that the considered country will not meet the Maastricht criteria on fiscal deficits and public debt (any more). In this case, the country could be fined for breaching the Stability and Growth Pact if it does not comply with Council recommendations to address fiscal deficits and/or high public debt. Second, it is not clear whether existing euro-denominated contractual obligations would remain in euros or be re-denominated in the new national currency. In general, the principle of *lex monetae* says that the debtor is obligated to re-pay the debt, which is expressed in the currency of the debtor's country at issuance, in the currency that is the legal tender of the debtor's country at the time of payment. According to Scott (1998), it is not clear whether *lex monetae* applies if the issuer's country, for example Greece, withdraws from the EMU. On the one hand, Greek law may apply, suggesting a re-denomination of debt from euros to the new national currency. On the other hand, EU law – with the euro (the issuing currency) as the legal tender of the EMU – may apply, suggesting no re-denomination. Scott (1998) concludes that the principle of *lex monetae* cannot be applied to withdrawal from the EMU and that the courts would apply the law specified in the contract. For most government bonds, this would be the national law of the withdrawing country, suggesting re-denomination of sovereign debt into the new national currency. In this case, withdrawal from the EMU becomes an attractive option for highly-indebted EMU members. For contracts that specificy foreign or EU law, the legality of re-denomination is uncertain given the lack of precedence for court cases involving withdrawal from an ongoing monetary union.

IV.3 Indicators of currency crisis risk

The political choice to withdraw from the EMU involves costs and benefits. While the transaction, political, and legal costs are assumed to be relatively stable over time, the benefits are functions of the time-variant severity of a banking or sovereign debt crisis and of the degree of overvaluation. Thus, assessing whether financial markets perceive the risk of withdrawal from the EMU requires finding proxies for the financial vulnerabilities driving the decision to leave the EMU.

The following derives from the literature three hypotheses about the dependency between the risk of a currency crisis (i.e. the risk of withdrawal from the EMU cum devaluation) and vulnerabilities stemming from the risk of a banking crisis, the risk of a debt crisis, and the incentive for competitive devaluations. I argue that if ADR investors take these vulnerabilities into account when evaluating the risk that some countries could leave the EMU, ADR returns should be affected by empirical measures capturing these vulnerabilities. In each of the following three sub-sections I first derive the theoretical hypothesis from the literature and then explain how I measure the vulnerability factors empirically by using daily observable market-based measures.

IV.3.1 Twin banking and currency crises

Kaminsky and Reinhart (1999) present empirical evidence that banking and currency crises often occur together. A banking crisis may force the central bank, acting as a lender of last resort, to bail out troubled banks by printing money which, in turn, produces inflationary pressure that can lead to a currency crisis (Diaz-Alejandro, 1985; Velasco, 1987; Calvo, 1998; Miller, 2000). Accordingly, a higher risk of banking crisis should lead to higher currency crisis risk perceived by ADR investors, and thus, to falling ADR returns.

In order to measure the risk of a banking crisis, I employ data on CDS premiums on domestic banks' liabilities and the returns of domestic bank stocks. A CDS represents a financial instrument to hedge against the risk that a bank will default on its debt. Rising CDS premiums thus indicate a higher bank default risk. As I aim to measure the risk of a country-wide banking crisis, I calculate the asset-weighted average of CDS basis points for all domestic banks Credit Market Analysis provides data for. I use CDS with maturities of five years.[89] Table IV.A1 in Appendix IV lists the domestic banks included in the calculation of the average CDS premium index of each country.

Another possibility to approximate the risk of a banking crisis is to use the development of the value of equity of domestic banks. According to Merton (1974), the

[89] Testing CDSs with maturities of one year and three years did not significantly affect the results.

equity of a firm can be interpreted as a call option that enables the shareholders to buy the firm (the underlying asset) by repaying the firm's debt (the strike price). For a given value of debt and asset volatility, a lower (higher) value of equity indicates that shareholders anticipate a higher (lower) probability of default, ceteris paribus. To measure the value of equity of domestic banks, I employ data on the national banking stock sub-index of the Dow Jones Total Market Index for each country.

If ADR investors perceive the risk that governments may leave the EMU in order to address a domestic banking crisis using national monetary policy, I expect higher CDS premiums and lower stock returns of domestic banks – which indicate a higher banking crisis risk – to lead to lower ADR returns.

IV.3.2 Twin sovereign debt and currency crises

Several empirical studies find that sovereign debt and currency crises often occur together (Reinhart, 2002; Dreher et al., 2006; Herz and Tong, 2008). In order to capture the dependency of both types of crises, many theoretical approaches apply a second-generation currency crisis framework, which assumes that the government weights the benefits and costs of defaulting on sovereign debt against the benefits and costs of giving up an exchange rate peg (Bauer et al., 2003; Benigno and Missale, 2004). A general finding is that a twin sovereign debt and currency crisis is more probable if a country's government is highly-indebted. As both types of crises are interrelated, a higher sovereign debt crisis risk should increase the currency crisis risk perceived by ADR investors and thus lead to lower ADR returns.

I employ two variables that measure sovereign debt crisis risk: sovereign bond yield spreads and sovereign CDS spreads. Sovereign bond yield spreads are calculated as the difference between the redemption yield on domestic sovereign bonds and the redemption yield on German sovereign bonds. Sovereign CDS spreads are calculated as the difference between the domestic sovereign CDS premium and the German sovereign CDS premium. I use data on sovereign bonds and CDS with a maturity of five years provided by Datastream.[90]

If ADR investors perceive the risk that governments may leave the EMU in order to address sovereign debt problems using national monetary policy, I expect higher sovereign bond yield spreads and higher sovereign CDS spreads – which indicate higher sovereign debt crisis risk – to lead to lower ADR returns.

IV.3.3 The incentive of competitive devaluations

The incentive of competitive devaluations may serve as another determinant of currency crisis risk. Glick and Rose (1999) find that – as a result of beggar-thy-neighbour exchange rate policies – currency crises tend to spread regionally. An appreciation of the domestic currency against the currencies of a country's export trading partners deteriorates the competitiveness of domestic exporters, which threatens domestic jobs. Opportunistic governments of countries with an overvalued currency have an incentive to leave the EMU and to devalue the new national currency in order to promote export growth. I therefore expect that an appreciation of a country's effective euro exchange rate will increase the risk that the country will leave the EMU, thereby negatively affecting ADR returns.

In order to measure the incentive of competitive devaluations, I compute a daily effective exchange rate (EER) index for each country. Of course, the same bilateral euro exchange rates apply for all EMU member countries. However, the effect of an appreciation of the euro against the pound sterling, for example, has a much more adverse effect on the Irish than on the Italian export industry. This is because exports to the United Kingdom make up about 33 percent of total exports for Ireland and only 11 percent of total Italian exports.[91]

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[90] Testing sovereign bonds and sovereign CDS with maturities of one year and three years did not affect the results.
[91] These numbers are based on the Directions of Trade Statistics database 2007 provided by the International Monetary Fund.

The EER index for each of the five countries, i, $i = 1,..,5$, represents the effective value of the euro against the currencies of country i's 115[92] trading partners by weighting the daily percentage changes of the bilateral euro exchange rates by the amount of bilateral exports.

The EER index is constructed as a chain-linked index for country i on day t, EER_t^i:

$$EER_t^i = \left(1 + I_{t-T}^i\right) \times \left(1 + I_{t-T+1}^i\right) \times \ldots \times \left(1 + I_{t-1}^i\right) \times \left(1 + I_t^i\right), \tag{IV.1}$$

where the percentage change of country i's EER index from day $t-1$ to day t is given by I_t^i. I calculate I_t^i as a weighted arithmetic mean as shown in Eq. (IV.2):

$$I_t^i = \sum_{j=1}^{115} \left(w_j^i \, \frac{e_{j,t} - e_{j,t-1}}{e_{j,t-1}} \right), \tag{IV.2}$$

where $e_{j,t}$ is the bilateral euro exchange rate – measured as the amount of currency units of i's export trading partner j, $j = 1,...,115$, per euro – and w_j^i represents the share of i's exports to j relative to i's total exports to the 115 countries in 2007. Data on bilateral euro exchange rates is taken from Datastream. Data on bilateral exports in 2007 is provided by the International Monetary Fund's Directions of Trade Statistics database. The EER index is used in natural logs. Rising values of the EER index indicate an effective appreciation of the euro against the currencies of the domestic economy's export trading partners and, thus, a deterioration of the competitiveness of domestic exporters.

If ADR investors perceive the risk that governments may leave the EMU in order to devaluate the new national currency competitively, I expect that a higher EER index – which indicates a higher degree of currency overvaluation – will lead to higher risk of withdrawal expected by ADR investors and, thus, to falling ADR returns.

[92] Of course, the EMU countries cannot be considered here. Some small countries are not included due to lack of data on bilateral exports.

IV.4 Empirical analysis

In order to test the hypotheses about the factors that determine the risk of withdrawal from the EMU as perceived by ADR investors, I regress the daily ADR returns on daily observable market-based measures that capture the vulnerabilities as outlined in Section IV.3. I consider 22 ADR/underlying stock pairs from the vulnerable EMU member countries – Greece, Ireland, Italy, Portugal, and Spain – from January 4, 2007 to March 16, 2009. Table IV.A2 in Appendix IV lists the companies included. All data is taken from Datastream.

I use four control variables in the regressions. In order to control for investor sentiments, I use two measures proposed by Arquette et al. (2008). Investor preference for the European stock market over the U.S. stock market is measured by the relative market price/cash flow (P/CF) ratio. The relative market P/CF ratio is calculated by dividing the P/CF ratio of the respective European stock market by the P/CF ratio of the U.S. stock market.[93] Investor sentiment towards an individual company is measured by the relative company P/CF ratio. This is calculated by dividing the European stock's P/CF ratio by the P/CF ratio of the European stock market as a whole.

In each specification, I control for the returns of the underlying EMU stocks and the U.S. dollar/euro exchange rate (defined as the number of U.S. dollars one must pay for one euro). Both controls, by default, determine the ADR returns as ADRs are derivative securities that depend on the value of its underlying stock and on the U.S. dollar value of the currency the underlying stock is denominated in. Table IV.A3 in Appendix IV reports the summary statistics for the variables.

The panel regression model is outlined in Eq. (IV.3):

$$ADR\ return_{it} = \alpha + \sum_k \beta_k x_{kt} + \sum_j \beta_j x_{jit} + \gamma_i + \varepsilon_{it}\ , \qquad \text{(IV.3)}$$

[93] Data on the P/CF ratio of each stock market is taken from the Datastream Global Equity Index of each country provided by Datastream.

where the ADR return of company i on day t is regressed on a constant α, on k variables which do not vary across companies of a country, x_{kt}, i.e., the banking and sovereign debt crisis risk variables, the effective exchange rate index, the U.S. dollar/euro exchange rate return, and the relative market P/CF ratio, and on j company-specific variables, x_{jit}, i.e., the returns of the local stocks and the relative company P/CF ratio. β_k and β_j are the coefficients; γ_i is the company-specific fixed effect; ε_{it} is the error.

Before estimating the panel regression models, I test for unit roots in the variables using the panel unit root tests of Im et al. (2003) and Maddala and Wu (1999).[94] Under the null of each test statistic, the time series contains a unit root. The results of the panel unit root tests can be found in Table IV.A4 in Appendix IV. In the regressions, I include a variable in levels only if the null of a unit root is rejected by both tests, at least at the ten percent level of significance. Variables for which the null of a unit root cannot be rejected are used in first differences in the estimations as indicated by a Δ in the results table. I consequently use the CDS premiums of domestic banks, the sovereign CDS spreads, the sovereign yield spreads, the effective exchange rate index, and the investor sentiment variables in first differences.

In order to test the hypotheses, I estimate eight specifications. In each specification, I include the effective exchange rate index, the returns of the underlying stock, and the U.S. dollar/euro exchange rate returns. In each specification, I use one of the two vulnerability measures for banking crisis risk and sovereign debt crisis risk, respectively. The four possible combinations of financial crisis risk variables are tested in specifications I to IV. While specifications Ia to IVa do not include investor sentiment variables, specifications Ib to IVb do. In each specification, I include company dummies to control for fixed company-specific effects in the determination of ADR returns.[95] The t-values are computed using robust

[94] Chapter V provides a short overview of (panel) unit root tests.
[95] I used the Hausman (1978) specification test to determine whether or not a random effects model would be more appropriate than the applied fixed effects model. The results of the Hausman test indicate that the null

standard errors clustered by company to control for possible heteroskedasticity and serial correlation in the residuals for a company across time.

Table IV.1 displays the results of the panel estimations. Overall, the results indicate that the ADR returns significantly respond to changes in the vulnerability measures in the hypothesized direction. This suggests that ADR investors attach an exchange rate risk premium to ADR returns to account for the risk that ADR prices will plunge should an EMU member country introduce a new devalued national currency. Thus, the risk of a currency crisis, as perceived by ADR investors, rises with increases in the risk of a banking crisis, the risk of a sovereign debt crisis, or the incentive to devalue competitively. This suggests that ADR investors perceive the risk that vulnerable member countries might leave the EMU in order to address these financial problems using national monetary policy.

I find robust evidence that higher CDS premiums of domestic banks, which indicate a higher banking crisis risk, significantly reduce ADR returns. I also find weak statistical evidence that lower bank stock returns, which indicate a higher default risk of domestic banks, are associated with falling ADR returns. Thus, ADR investors perceive the risk that governments of vulnerable member countries could leave the EMU in order to bail out domestic banks by using national monetary policy. Seemingly, ADR investors expect that such a withdrawal from the EMU would be associated with inflationary pressure and a depreciation of the new national currency.

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hypothesis of no difference between the fixed and random effects coefficients is significantly rejected, indicating that the fixed effects model is more appropriate.

Table IV.1: Regression results

Dependent variable: *ADR returns*		Ia	IIa	IIIa	IVa	Ib	IIb	IIIb	IVb
Vulnerability Measures									
Banking crisis risk variables	CDS premiums of domestic banks (Δ)	-0.018	-0.018	---	---	-0.018	-0.018	---	---
		(-3.29)***	(-3.32)***			(-3.29)***	(-3.30)***		
	Stock returns of domestic banks	---	---	0.037	0.030	---	---	0.032	0.025
				(2.02)*	(1.64)			(1.88)*	(1.42)
Debt crisis risk variables	Sovereign yield spreads (Δ)	-1.370	---	-1.379	---	-1.270	---	-1.313	---
		(-2.33)***		(-2.23)**		(-2.17)**		(-2.17)**	
	Sovereign CDS spreads (Δ)	---	-0.068	---	-0.061	---	-0.068	---	-0.061
			(-6.56)***		(-4.91)***		(-6.46)***		(-4.91)***
Effective exchange rate index (logs) (Δ)		-1.216	-1.070	-1.204	-1.158	-1.185	-1.038	-1.193	-1.145
		(-6.39)***	(-5.62)***	(-6.82)***	(-6.61)***	(-6.80)***	(-5.92)***	(-7.02)***	(-6.79)***
Control variables									
Local stock returns		0.604	0.598	0.592	0.591	0.598	0.591	0.588	0.587
		(18.98)***	(18.62)***	(14.96)***	(14.89)***	(18.73)***	(18.36)***	(15.10)***	(15.02)***
Exchange rate returns (USD/EUR)		1.538	1.407	1.525	1.477	1.517	1.386	1.517	1.467
		(11.44)***	(10.55)***	(12.60)***	(12.24)***	(12.10)***	(11.09)***	(13.01)***	(12.61)***
Relative company price/cash flow ratio (Δ)		---	---	---	---	-6.16E-04	-5.82E-04	1.06E-4	-8.7E-05
						(-0.11)	(-0.11)	(0.02)	(-0.02)
Relative market price/cash flow ratio (Δ)		---	---	---	---	0.076	0.077	0.065	0.070

					(1.91)*	(1.92)*	(1.77)*	(1.89)*
Constant	-6.30E-04	-6.14E-04	-6.25E-04	-6.08E-04	-6.33E-04	-6.18E-04	-6.29E-04	-6.12E-04
	(-17.53)***	(-16.74)***	(-17.29)***	(-16.48)***	(-17.51)***	(-16.73)***	(-17.35)***	(-16.63)***
R-squared	0.450	0.455	0.448	0.451	0.451	0.456	0.449	0.452
p-value F-statistic	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
No. of observations	9475	9475	9475	9475	9475	9475	9475	9475

Note: This table presents the results of the panel regressions (see Eq., IV.3) for the period January 4, 2007 to March 16, 2009. t-values in parentheses based on robust standard errors clustered by company. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively. Company fixed effects are included in each specification.

I find robust evidence that higher sovereign bond yield and CDS spreads, which indicate higher sovereign debt crisis risk, significantly reduce ADR returns. This result suggests that ADR investors perceive the risk that vulnerable member countries could leave the EMU in order to let the national central bank act as a lender of last resort for the highly indebted government by purchasing domestic sovereign bonds or by reducing the real value of public debt via the inflation tax.

The regressions results also support the competitive devaluations hypothesis. An appreciation of the euro – as indicated by a rising national effective exchange rate – significantly reduces ADR returns. This result indicates that ADR investors perceive the risk that higher overvaluation of the euro against the currencies of a country's export trading partners increases the incentive for the government to leave the EMU and devalue the domestic currency competitively in order to support the domestic export industry.

In order to assess the relative importance of the vulnerability measures for explaining the exchange rate risk premium priced in ADR returns, I relate the estimated coefficients to a one standard deviation-change in each respective variable. The coefficient for stock returns of domestic banks, for example, ranges from 0.032 to 0.037 depending on the specification on which the significant coefficient is based. A decrease in stock returns of domestic banks by one standard deviation – being 3.90% (see Table IV.A3) – reduces ADR returns by 0.12%, to 0.14%. Accordingly, a one standard deviation increase in CDS premiums of domestic banks, or sovereign yield spreads, or sovereign CDS spreads, or in the effective exchange rate index translates to a decrease in ADR returns by 0.19% to 0.20%, by 0.08% to 0.09%, by 0.23% to 0.25%, or by 0.42% to 0.50%, respectively. The standardized impact of the vulnerability measures on ADR returns is quite small as explained in the following. The standardized measures are based on a one standard deviation-change in the variables recorded during the relatively tranquil observation period. If a member country were to actually leave the EMU, its sovereign yield spread, for example, would most likely increase by much more than one standard deviation, i.e. by more than 0.07%. Thus, the standardized impact of vulnerability measures on ADR returns cannot be used to estimate the potential capital losses of ADR investors resulting from an EMU withdrawal. Instead, it can be used to assess the relative importance of these vulnerability measures for explaining the ADR investors' perceptions of the risk of withdrawal from the EMU.

The effective exchange rate index (measuring the overvaluation of the euro at the national level) has the largest standardized impact on ADR returns. This suggests that ADR investors perceive a considerable misalignment of the euro exchange rate for some vulnerable member countries. Introduction of a new, devalued national currency in order to promote export growth appears to be the most significant argument in favor of withdrawing from the EMU. The impact of the banking and sovereign debt crisis risk variables on ADR returns is similar.[96] ADR investors seem to believe that the risk of withdrawal is driven equally by possible banking and sovereign debt crises. This finding seems reasonable as a considerable part of (implicit) public debt creation of some vulnerable EMU member countries (such as Ireland) can be attributed to the financing of bank bailouts, thereby linking the rise in sovereign debt crisis risk with the severity of the banking crisis. An interesting finding is that the CDS-based vulnerability measures have a larger standardized impact on ADR returns than the non-CDS-based vulnerability measures, i.e., bank stock returns for banking crisis risk and sovereign bond yield spreads for sovereign debt crisis risk. ADR investors seem to prefer CDS-based measures to derive crisis expectations since the primary purpose of CDS is to hedge against the risk of bank or sovereign defaults. The alternative measures reflect default risk-related information less precisely, making them less effective in assessing the risk of withdrawal.

With respect to the control variables, the results largely confirm the findings of previous papers. Higher returns of the local stock and the U.S. dollar/euro exchange rate

[96] The CDS premiums of the banking and sovereign debt crisis measures have a similar standardized coefficient. The standardized impacts of bank stock returns and sovereign yield spreads are also similar.

significantly increase ADR returns. This suggests an efficient pricing of ADRs, whose price depends on the value of the underlying stock and the value of the currency in which the underlying stock is denominated. For the investor sentiment variables, I obtain mixed results. While the relative company P/CF ratio is insignificant for all specifications, the coefficient for the relative market P/CF ratio is significantly positive.

IV.5 Conclusions

I find that financial market indicators reflecting the risk of a banking crisis, the risk of a sovereign debt crisis, and the incentive for competitive devaluations significantly influence ADR returns in the hypothesized direction. This suggests that ADR investors perceive the risk that some of the vulnerable countries studied might leave the EMU. However, although I cannot derive explicit probabilities of withdrawal, the likelihood of such withdrawals is probably rather small since the current institutional framework and the alternative channels of financial assistance from within the monetary union deter most governments from exiting the EMU. Moreover, the transaction costs, contractual uncertainties, and loss of political prestige may offset the economic benefits of an EMU withdrawal. I believe, however, that an EMU withdrawal is not purely hypothetical and that ADR investors price the risk of withdrawal with good reason. Firstly, the new provision on withdrawal in the Treaty of Lisbon provides an easy way to leave the EMU. Reluctant members would not have to fear open-ended negotiations with the other EMU member countries that could result in an unfortunate consensus.[97] Secondly, it remains an open question whether mutual assistance within the EMU (such as supranational bailout funds) would be applied if the banking sector or national budget of a large EMU member country, such as those of Spain or Italy, broke down since granting financial assistance could jeopardize the stability of the whole EMU. European solidarity has its limits. This suggests that withdrawal from the EMU could be beneficial for

[97] With the new provision, the Treaties cease to apply to the withdrawing member after two years if no decision is reached.

both the withdrawing country and the remaining members of the EMU. Thirdly, addressing financial problems using national monetary policy has the advantage that the government retains sovereignty over the national budget.

The findings of this paper can help policymakers judge the sustainability of the EMU as perceived by ADR investors. Higher correlations between ADR returns and vulnerability measures in the future suggest that ADR investors perceive a higher risk of withdrawal from the EMU. Thus, the ADR market can be used as an early warning system for the stability of the EMU. Pro-EMU governments in particular will be interested in preventing withdrawals from the EMU as their re-election could be jeopardized in the event of actual withdrawals. The standardized coefficients can also be instructive for assessing the relative importance of the different vulnerability factors. Monitoring the correlation between ADR returns and the vulnerability measures can help prevent withdrawals if policymakers are able to address financial vulnerabilities *within* the EMU. However, time will show how long policymakers in the EMU will continue with the implementation of even more anti-crisis measures. The recent rescue measures of the ECB's "Securities Markets Programme", for example, are relatively controversial as the ECB's holdings of risky sovereign bonds may lead to less political and financial independence of the ECB. The decision to implement the "Securities Markets Programme" has revealed the conflicts of interest within the ECB's Governing Council. In an interview with Le Monde, ECB President Trichet mentioned that the May 9, 2010 decision in the ECB Governing Council regarding the implementation of the "Securities Markets Programme" was made with "an overwhelming majority" as opposed to the usual "unanimous decision".[98] Later on, on February 11, 2011 Axel Weber, President of Deutsche Bundesbank, resigned, indicating that he was no longer willing to support the anti-crisis policies of the ECB.

[98] See http://www.ecb.europa.eu/press/key/date/2010/html/sp100531_1.en.html.

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IV. Appendix

Table IV.A1: Domestic banks included in the national CDS premiums indices

Country	Included domestic banks
Greece	EFG Eurobank Ergas[a], National Bank of Greece[a]
Ireland	Allied Irish Banks, Anglo Irish Bank, Bank of Ireland
Italy	Banca Italease, Banca Siena, Banca PPO Italiana, Banca PPO Di Milano, Unicredito Italiano,
Portugal	Banco Commercial Portugues, Banco Espirito Santo
Spain	Banco Intl. Finance, Banco Bilbao Vizcaya Argentaria, Banco Popular Espaniol, Banco Sabadell, Banco Santander, La Caja de Ahorros

[a] Included thru June 26, 2007.

Table IV.A2: List of included ADR/underlying stock pairs

Country	Included ADR/underlying stock pairs
Greece	Alpha Bank, Coca-Cola HBC, Hellenic Telecom, National Bank of Greece
Ireland	Allied Irish Banks, Bank of Ireland, CRH, Elan, Icon, IONA Technologies[a], Ryanair
Italy	Benetton Group, Eni, Fiat, Luxottica
Portugal	Energias de Portugal, Portugal Telecom
Spain	BBVA, Banco Santander, Endesa[b], Repsol YPF, Telefonica

Note: Information on ADRs is taken from the ADR website of The Bank of New York Mellon (www.adrbny.com); [a]Data only available thru September 12, 2008 due to de-listing. [b]Data only available thru January 24, 2008 due to de-listing.

Table IV.A3: Summary statistics

Variable	Mean	Standard deviation	Minimum	Maximum
ADR returns	-0.143	3.580	-57.031	46.687
CDS premiums of domestic banks (Δ)	0.717	10.687	-250.433	98.733
Stock returns of domestic banks	-0.326	3.904	-29.107	29.789
Sovereign yield spreads (Δ)	1.63E-03	0.067	-1.267	0.924
Sovereign CDS spreads (Δ)	0.123	3.757	-28.000	52.000
Effective exchange rate index (in logs) (Δ)	0.022	0.410	-2.329	2.821
Local stock returns	-0.161	3.521	-60.799	39.204
Exchange rate returns (USD/EUR)	0.012	0.690	-3.844	4.027
Relative company price/cash flow ratio (Δ)	-2.00E-03	0.180	-5.580	3.418
Relative market price/cash flow ratio (Δ)	-5.71E-04	0.015	-0.090	0.081

Table IV.A4: Results of the panel unit root tests

	IPS t-statistic	MW-Chi2
ADR returns	-47.628***	1686.31***
CDS premiums of domestic banks	9.112	7.455
	(-39.563) ***	(1378.13) ***
Stock returns of domestic banks	-49.846***	1770.12***
Sovereign yield spreads	10.455	10.112
	(-72.173) ***	(2576.36) ***
Sovereign CDS spreads	4.076	61.245 **
	(-46.014) ***	(1413.96) ***
Effective exchange rate index (in logs)	1.889	17.261
	(-40.055)***	(1314.51)***
Local stock returns	-51.375***	1859.44***
Exchange rate returns (USD/EUR)	-35.429***	1126.33***
Relative company price/cash flow ratio	-4.652	225.419***
	(-53.314) ***	(1796.97) ***
Relative market price/cash flow ratio	-4.026	104.708***
	(-65.592) ***	(2353.32) ***

Note: This table presents the panel unit root test statistics of Im et al. (2003) (the IPS average t-statistic) and of Maddala and Wu (1999) (the MW Chi2 distributed average p-value) for the respective variable in levels and in first differences (in parentheses). Under the null of both test statistics the variable contains a unit root. Test results for variables in first differences are reported in parentheses. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively. For the order of the autoregressive correction, I use the Akaike Information Criterion (AIC).

Chapter V

Overview of panel unit root tests

A time series is defined as strictly stationary if the joint distribution of a process does not change in time (Maddala and Kim, 1998, p. 9). That is, the parameters characterizing the distribution of a process, $X_{t_1}, \dots, X_{t_n}$, do not change when the series is shifted by an arbitrary value τ, $X_{t_1-\tau}, \dots, X_{t_n-\tau}$ for all $t_1, \dots, t_n$ and τ. The most widely used concept of stationarity is weak or covariance stationarity (Maddala and Kim, 1998, p. 9). A process is said to be weakly or covariance stationary if its mean, variance, and autocovariance are constant, i.e. do not depend on time *t*:

$$E(X_t) = E(X_{t-\tau}) = \mu = constant, \tag{V.1}$$

$$var(X_t) = var(X_{t-\tau}) = \sigma^2 = constant, \tag{V.2}$$

$$cov\left(X_{t_1}, X_{t_2}\right) = cov\left(X_{t_1-\tau}, X_{t_2-\tau}\right) = \gamma = constant,\text{[99]} \tag{V.3}$$

for all τ. Non-stationary or unit root processes have time-varying distribution parameters. In order to demonstrate the properties of stationary versus non-stationary processes, let us consider the processes x_t and y_t:

$$x_t = \rho x_{t-1} + u_t\ , \quad |\rho| < 1, \tag{V.4}$$

$$y_t = y_{t-1} + v_t\ , \tag{V.5}$$

[99] Note that the covariance depends on the interval $t_2 - t_1$ for which the covariance is computed but not on the point in time *t* when it is computed.

where the error terms u_t and υ_t are white noise processes, i.e. they are assumed to be independently identically distributed with zero mean and constant variance, $u_t \sim (0, \sigma_u^2)$ and $\upsilon_t \sim (0, \sigma_\upsilon^2)$. The independence assumption implies that the errors are not correlated across time, i.e. $E(u_t u_{t+\phi}) = 0$ and $E(\upsilon_t \upsilon_{t+\phi}) = 0$ for $\phi \neq 0$.

Both x_t and y_t are autoregressive processes. The y_t process is called a random walk, which is a special case of the x_t process for $\rho = 1$. While the random walk y_t is a nonstationary (or unit root) process with time-variant distribution parameters, x_t is stationary with asymptotically time-invariant distribution parameters as shown in the following.

Both processes can be expressed in terms of past disturbances:

$$x_t = \rho^t x_0 + \sum_{i=0}^{t-1} \rho^i u_{t-i}, \tag{V.6}$$

$$y_t = y_0 + \sum_{i=0}^{t-1} \upsilon_{t-i}. \tag{V.7}$$

For simplicity, it is assumed that the initial values of the processes are zero, i.e. $x_0 = 0$ and $y_0 = 0$.

The means of the processes are:

$$E(x_t) = 0, \qquad \text{(V.8)}$$

$$E(y_t) = 0. \qquad \text{(V.9)}$$

The variances of the processes are:

$$var(x_t) = E\big(x_t - E(x_t)\big)^2$$

$$= \sum_{i=0}^{t-1} \rho^{2i} (u_{t-i})^2 = \sum_{i=0}^{t-1} \rho^{2i} \sigma_u^2 \quad \rightarrow \frac{1}{1-\rho^2} \sigma_u^2 \ \text{ for } \ t \rightarrow \infty \tag{V.10}$$

$$var(y_t) = E\big(y_t - E(y_t)\big)^2$$

$$= \sum_{i=0}^{t-1} (v_{t-i})^2 = t\sigma_v^2 \tag{V.11}$$

The autocovariances of the processes are:[100]

$$\gamma_\tau^x = E\big[\big(x_t - E(x_t)\big)\big(x_{t-\tau} - E(x_{t-\tau})\big)\big]$$

$$= E\left[\left(\sum_{i=0}^{t-1} \rho^i u_{t-i}\right)\left(\sum_{i=0}^{t-\tau-1} \rho^i u_{t-\tau-i}\right)\right]$$

$$= E[\rho^\tau u_{t-\tau}\rho^0 u_{t-\tau} + \rho^{\tau+1} u_{t-\tau-1}\rho^1 u_{t-\tau-1} + \cdots + \rho^{t-1} u_1 \rho^{t-\tau-1} u_1]$$

$$= \sum_{i=0}^{t-\tau-1} \rho^{2i+\tau} u_{t-\tau-i}^2 \qquad \rightarrow \frac{\rho^\tau}{1-\rho^2}\sigma_u^2 \text{ for } t \rightarrow \infty \tag{V.12}$$

$$\gamma_\tau^y = E\big[\big(y_t - E(y_t)\big)\big(y_{t-\tau} - E(y_{t-\tau})\big)\big]$$

$$= E\left[\left(\sum_{i=0}^{t-1} v_{t-i}\right)\left(\sum_{i=0}^{t-\tau-1} v_{t-\tau-i}\right)\right]$$

$$= E[v_{t-\tau}v_{t-\tau} + v_{t-\tau-1}v_{t-\tau-1} + \cdots + v_1 v_1]$$

$$= (t-\tau)\sigma_v^2 \tag{V.13}$$

The means are time-invariant for both processes. However, the (asymptotic) behavior of the variances and autocovariances differs between both processes. While the variances and autocovariances are asymptotically constant for the stationary process x_t, they increase in time (t) for the non-stationary/unit root process y_t.

The time dependence of non-stationary variables' distribution parameters may lead to "spurious regressions" in empirical applications (Gujarati, 1995, p. 724). Based on Monte Carlo simulations Granger and Newbold (1974) present evidence that regressions using non-stationary variables can produce spurious results. They find that even if the dependent and

[100] Note that the assumption of independently distributed error terms implies that $E(u_t u_{t+\phi}) = 0$ and $E(v_t v_{t+\phi}) = 0$ for $\phi \neq 0$.

independent variables in a regression are totally unrelated random walks, the t-statistic of the regression coefficient indicates a significant relationship for the majority of simulated cases. This empirical result was subsequently analyzed theoretically by Phillips (1986) who proves that for regressions involving non-stationary variables the t-statistic does not have a limiting distribution but diverges as the sample size grows.[101] That is, the empirically measured t-statistic rejects the null hypothesis of no relationship between the dependent and the independent non-stationary variable too often and, consequently, the critical values drawn from the theoretical distribution of the t-statistic cannot be applied. Entorf (1997) extends the study of Phillips (1986) to a panel setting showing that the divergent behavior of the empirical t-distribution also applies to panel data underlining the rationale to test for stationarity also in panel data sets in order to avoid the problem of spurious regressions.

In order to detect whether a time series contains a unit root (i.e. whether it is non-stationary) a number of unit root tests have been developed. The basic idea of unit root tests is to test the null hypothesis of $\rho = 1$ (i.e. the process contains a unit root/follows a random walk) against the one-sided alternative of stationarity $\rho < 1$:[102]

$$x_t = \rho x_{t-1} + u_t\,, \quad \text{with } H_0\colon \rho = 1 \text{ against } H_1\colon \rho < 1. \tag{V.14}$$

This test equation can be rewritten as:

$$\Delta x_t = \omega x_{t-1} + u_t\,, \quad \text{with } H_0\colon \omega = 0 \text{ against } H_1\colon \omega < 0, \tag{V.15}$$

where $\Delta x_t = x_t - x_{t-1}$, $\omega = \rho - 1$.

[101] Further theoretical treatments of the problem of spurious regressions can be found in Durlauf and Phillips (1998), Marmol (1995) and Tsay and Chung (2000).

[102] From a theoretical point of view, testing the null hypothesis of an explosive unit root process with $\rho > 1$ or a "countercyclical" unit root process with $\rho \leq -1$ would of course also be of interest. However, such types of unit root processes are very rare events in empirical applications and that is why they are not considered in the overwhelming majority of unit root tests (Wooldridge, 2006, p. 640).

One of the most popular and widely used unit root tests is the Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1979).[103] The test equation of the ADF unit root test equation is:

$$\Delta x_t = \omega x_{t-1} + \alpha + \delta t + \sum_{i=1}^{N} \beta_i \Delta x_{t-i} + u_t\,, \quad \text{with } H_0\colon \omega = 0 \text{ against } H_1\colon \omega < 0. \qquad \text{(V.16)}$$

The ADF unit root test controls for a possible constant α, time trend δt, and autoregressive terms $\sum_{i=1}^{N} \beta_i \Delta x_{t-i}$ in the test equation.[104] The OLS estimate for $\widehat{\omega}$ and its standard error $\mathrm{se}(\widehat{\omega})$ can be used to test the null hypothesis of the presence of a unit root ($H_0\colon \omega = 0$) against the alternative of stationarity ($H_1\colon \omega < 0$) using the t-statistic $t^{\omega} = \widehat{\omega}/\mathrm{se}(\widehat{\omega})$. Dickey and Fuller (1979) show that t^{ω} does not follow a conventional t-distribution but the so-called Dickey Fuller distribution, for which Dickey and Fuller (1979) compute critical values.[105]

A number of tests have been developed in order to test for unit root in panel datasets with *j=1,…,J* cross section units observed over *t=1,...,T* periods.[106] In this dissertation I use the panel unit roots tests of Im et al. (2003) and Maddala and Wu (1999). Both tests are panel extensions of the time series ADF test. For both tests, the ADF test equation is estimated for each cross section unit *j=1,…,J*: [107]

$$\Delta x_{jt} = \omega_j x_{jt-1} + \alpha_j + \delta_j t + \sum_{i=1}^{N} \beta_{ji} \Delta x_{jt-i} + u_{jt}\,. \qquad \text{(V.17)}$$

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[103] Other popular unit root tests not considered here include, for example, the Phillips Perron test (Phillips and Perron, 1988) or the Kwiatkowski Phillips Schmidt Shin test (Kwiatkowski et al., 1992). I focus on the ADF test since the panel unit root tests used in this dissertation are panel versions of the ADF test.
[104] The optimal lag length N in the test equation may be determined using the Akaike or Schwartz information criteria.
[105] Based on a larger set of simulations, MacKinnon (1996) tabulates the critical values of the Dickey Fuller t-statistic for a larger set of sample sizes and assumptions concerning the test equation.
[106] Entorf (1997), for example, shows that spurious regressions are also an issue for panel datasets underlining the rationale to test for unit roots also for panel data.
[107] Similar to the standard ADF test discussed above, this test equation controls for a constant α_j, time trend $\delta_j t$, and autoregressive terms $\sum_{i=1}^{N} \beta_{ji} \Delta x_{jt-i}$.

A variable may contain a unit root for some cross section units, while for others it may not. Therefore, the null and alternative hypotheses of both the Im et al. (2003) and the Maddala and Wu (1999) panel unit root tests can be written as:

$$H_0: \omega_j = 0, \quad \text{for all } j,$$

$$H_1: \begin{cases} \omega_j = 0 & for\ j = 1,2,\dots,J_1, \\ \omega_j < 0 & for\ j = J_1+1, J_1+2,\dots,J. \end{cases} \text{[108]} \tag{V.18}$$

The panel unit root test of Im et al. (2003) relies on averaging the t-values of each cross section unit $t_j^{\omega} = \widehat{\omega}_j/\mathrm{se}(\widehat{\omega})_j$ estimated from Eq. (V.17):

$$\overline{t_{JT}^{\omega}} = \sum_{j=1}^{J} t_j^{\omega} \Big/ J. \tag{V.19}$$

Im et al. (2003) show that after appropriate standardizations the averaged ADF t-statistic $\overline{t_{JT}^{\omega}}$ has an asymptotic standard normal distribution.

The Maddala and Wu (1999) test is based on combining the p-values of the ADF t-statistics of each cross section. That is, based on the ADF test equation for each cross section unit (Eq., V.17) the ADF t-statistic, $t_j^{\omega} = \widehat{\omega}_j/\mathrm{se}(\widehat{\omega})_j$, is computed. The p-value of the t-statistic, π_j^{ω}, is then transformed into $\widetilde{\pi_{JT}^{\omega}}$ as outlined in Eq. (V.20):

$$\widetilde{\pi_{JT}^{\omega}} = -2\sum_{j=1}^{J} \log\left(\pi_j^{\omega}\right) \rightarrow \chi_{2J}^2. \tag{V.20}$$

Maddala and Wu (1999) show that $\widetilde{\pi_{JT}^{\omega}}$ is distributed Chi-squared with 2*J* degrees of freedom.

Under the null hypothesis of the Im et al. (2003) and the Maddala and Wu (1999) panel unit root tests the variable contains a unit in a panel context. A rejection of the null hypothesis suggests that the variable is stationary. In order to avoid the problem of spurious

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[108] The *j* may be reordered if necessary.

regressions I use a variable in levels only if the null hypothesis of a unit root is rejected by both unit root tests.

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