Do Demand Curves for Currencies Slope Down? Evidence from the MSCI Global Index Change

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Abstract

Traditional portfolio balance theory derives a downward sloping currency demand function from limited international asset substitutability. Historically, this theory enjoyed little empirical support. We provide direct evidence by examining the exchange rate effect of a major redefinition of the MSCI international equity index in 2001 and 2002. The index changes implied large changes in the representation of different countries in the MSCI world index and therefore produced strong exogenous equity flows by index funds. Our event study shows a strong announcement effect in which countries with a decreasing equity representation vis-a-vis the U.S. depreciated against the dollar.

1 Introduction

To what extent do exogenous demand shocks move financial market prices? This question - generally referred to as the resilience of a market - has been examined extensively for individual equity prices.[1] Much less is known about the resilience of macroeconomic prices like the exchange rate. Yet exchange rates are particularly important for most economies and their alleged misalignment is at the core of a large literature on external imbalances. Moreover, imperfect exchange rate resilience is at the heart of the traditional portfolio approach to exchange rates (Kouri (1983), Branson and Henderson (1985)), which derives a downward sloping demand curve for foreign balances from imperfect international asset substitutability. Historically, the portfolio balance approach to exchange rates enjoyed little empirical support. But the growing quantitative importance of equity flows has recently revived interest in the portfolio channel of exchange rate theory. While the correlation structure between capital flows and exchange rate movements has been the subject of much empirical research, causal inference is hampered by a lack of clear identification. While flows may trigger exchange rate movements, flows themselves may be induced by investor trend chasing behavior.

This paper examines a unique natural experiment in which the effects of flows on the exchange rate can be measured for truly exogenous portfolio flows. On December 10, 2000, a redefinition of the MSCI international equity indices was announced and then implemented in two steps on November 30, 2001 and May 31, 2002. The index redefinition led to a considerable reweighting of many countries in the global MSCI index. Such a change in the representation of a country has important consequences for international portfolio managers who benchmark their equity holdings against the MSCI index. Approximately 500 billion dollars may be directly indexed to MSCI equity indices. Given that the global MSCI index plays the role of the global market portfolio, an up- or downweighting of a country can be expected to trigger an exogenous capital in- or outflow. This natural experiment allows us to identify exogenous international capital flows.

We show that capital flows by themselves do substantially move exchange rates. In particular, we provide direct evidence on the limited resilience of the exchange rate market to exogenous demand shocks. We show that the exchange rate impact of the reallocation of equity induced

[1] We use the term "resilience" here to denote the price impact with respect to uninformative demand shocks as opposed to market depth which refers to the price impact of general order flow (from both informed and uninformed investors).

by the index redefinition is significant in both statistical and economic terms. The exchange rate return differential between the 17 least and the 17 most downweighted countries exceeds 3 percent over a 20 day event window around the announcement day of the index change. The corresponding average weight change for the two sample groups is -15 percent and -70 percent, respectively.

Our paper contributes to the existing debate on the determinants of exchange rate, providing evidence in favor of an equity market channel, i.e. that exogenous capital flows do indeed move exchange rates. Understanding the quantitative impact of equity flows on exchange rates is not only important for international portfolio managers, but also for policy makers. Monetary authorities for example need to gauge the resilience of the exchange rate market if they wish to affect the exchange rate through sterilized open market purchases. Perfect exchange rate resilience render sterilized exchange rate intervention ineffective.

A second contribution of the paper consists in exploring the limits of arbitrage in the foreign exchange market. The relative long delay between the announcement and the implementation of the index change turn the index redefinition also into an experiment on the limits of intertemporal foreign exchange (FX) arbitrage. Perfect arbitrage implies that the entire exchange rate effect should be concentrated around the announcement date of the index change, while imperfect arbitrage allows for a simultaneous systematic effect on the implementation date. We show that the FX arbitrage is indeed imperfect since we find a statistically significant effect for both implementation dates. But surprisingly, the implementation effects have opposite signs. The first implementation date appears to be characterized by excessive risk arbitrage, while the second date is marked by insufficient arbitrage on the part of the FX speculators. This finding is consistent with expectational errors or coordination problems among speculators, but cannot be explained by capital constraints on the part of the speculators.

The paper is structured as follows. In the following section, we discuss the testable hypotheses. In Section 3, we discuss the literature. Section 4 describes the institutional background and provides summary statistics on our experiment. In Section 5, we explain the statistical methodology. We undertake nonparametric tests, a cross-sectional analysis and panel regressions to measure the exchange rate and equity price impact of the index redefinition. The results are presented in section 6.1 for the announcement day and in section 6.2 for the implementation dates. A brief conclusion follows.

2 Hypotheses

We now develop three hypotheses and testable restrictions which help us structure our empirical analysis. The index redefinition presents a natural experiment in which the equity flows result from exogenous rebalancing needs of the global index funds. This implies that these flows are not related to asymmetric information shocks or other endogenous shocks. The event study therefore allows us to assess directly the so-called resilience of the exchange rate market, namely the elasticity of the price with respect to uninformative and exogenous demand shocks. We formulate hypothesis H1 as the resilience hypothesis:

H1: Complete exchange rate resilience to index change

Complete asset substitutability implies no exchange rate impact for the reallocation by index funds neither around announcement nor implementation of the index change.

A resilient exchange rate implies that portfolio managers do not have to account for an exchange rate impact of their portfolio reallocations. But it also means that central banks cannot manipulate the exchange rate through sterilized open market interventions. The alternative hypothesis is limited resilience of the foreign exchange market. In that case, the MSCI index change can have a measurable exchange rate impact, which may occur either around the announcement or the implementation dates. Any systematic effect on the implementation dates implies the existence of unexploited risk arbitrage opportunities. Therefore, under perfect intertemporal risk arbitrage, the reallocation effect on the exchange rate should be concentrated exclusively around the announcement date. No systematic effect should occur on the implementation date. We refer to this as the perfect risk arbitrage hypothesis:

H2: Incomplete resilience and perfect risk arbitrage

Incomplete asset substitutability implies an exchange rate impact for the reallocation by index funds. Countries which are up-weighted (down-weighted) in the index experience an exchange rate appreciation (depreciation). Perfect risk arbitrage implies that this exchange rate impact occurs entirely on the announcement date. No exchange rate effect occurs on the implementation date.

Under Hypothesis H2, a credible announcement about future sterilizes intervention should have the full of effect even on the announcement day. The exchange rate market is then semi-strong form efficient even with respect to such policy announcements. [2]

Finally, we discuss the possible breakdown of intertemporal arbitrage. This may be due to the fact that capital constraints on the part of the speculators limit arbitrage (Vishny and Shleifer (1997)). In that case, the exchange rate adjustment on announcement is only partial and the residual adjustment coincides with the actual equity reallocated around the implementation dates. Alternatively, perfect arbitrage may fail because of expectational errors of the speculators. These may either over- or underestimate the amount of capital reallocated by index funds or miscalculate the inventory accumulation of other speculators. The latter amounts to coordination failure of the speculators. Witness to this coordination failure is what Peter Lockyer, head of risk management at Merrill Lynch Investment Managers, declared on the eve of the second implementation: "It will be very interesting to see exactly what happens. Active fund managers, passive fund managers and hedge funds will all want to benefit from these changes at others' expense. This means having to second-guess when and what these other investors will do. The effect may be to push certain key stocks in an unexpected direction." (Financial Times, May 17, 2001). Expectational errors may lead to either insufficient or excessive arbitrage subsumed in the following hypothesis:

H3: Incomplete resilience and imperfect risk arbitrage

Incomplete asset substitutability implies an exchange rate impact for the reallocation of index funds. Imperfect arbitrage generates an announcement effect and an implementation effect. If the arbitrage failure results from *insufficient arbitrage,* up-weighted (down-weighted) countries see their exchange rates appreciate (depreciate) on the implementation dates. If, instead, the arbitrage failure results from *excessive arbitrage,* up-weighted (down-weighted) countries see their exchange rates depreciate (appreciate) on the implementation dates.

The exact nature of the arbitrage failure has very different policy implications. Arbitrage failures due to capital constraints are expected to become less important as the hedge fund

[2] An example of such an annoucement is the Plaza Accord in September 1985 when G5 countries promised to intervene in currency markets to obtain a devalued dollar.

industry grows. If imperfect arbitrage originates in coordination failure of the speculators, then more risk capital will not remedy the arbitrage failure. Also public announcements with respect to future exchange rate interventions can potentially be more destabilizing than surprise interventions if the ensuing speculative behavior leads to exchange rate overshooting as a consequence of excessive arbitrage.

3 Literature

3.1 Event Studies on Price Pressure

Our own work is methodologically related to event studies on changes in the composition of national stock indices. These event studies have focused on the S&P500 index and the impact of stock in- and exclusions on the respective stock price. The main finding is that index inclusions (exclusions) increase (decreases) share prices (Garry and Goetzmann (1986), Harris and Gurel (1986), Shleifer (1986), Dillon and Johnson (1991), Beniesh and Whaley (1996), Lynch and Mendenhall (1997)). Most similar to our study, Kaul et al. (2000) examine index reweighting for stocks in the Toronto Stock Exchange 300 index and find that upweighted stocks experience a persistent positive price effect.

While the short-term price effect of index inclusion is non-controversial, the persistence of the price effect is debated. Shleifer (1986) argues that when a firm is added to the S&P500, its stock price permanently increases by 2.79 percent. These findings are consistent with Garry and Goetzmann (1986) and Beneish and Whaley (1996) who do not find a reversal of the short-term announcement return. On the contrary, Harris and Gurel (1986), and Lynch and Mendenhall (1997) provide evidence for reversal. Massa, Tong and Peyer, (2004) help to reconcile these results by showing that companies optimally offset the initial reason for the increase in stock prices by increasing the supply of shares. This arbitrage activity by the company affects the long-run stock performance and helps to explain why for some cases there is no price reversal.

While the exogenous nature of the index changes makes these studies appealing, the price effect itself allows for at least three different interpretations. First it might come from a pure "demand effect" resulting from limits to arbitrage (Shleifer (1986, 1990)). Additions to the index induces more demand for a particular stock and pushes up the stock price. Only under perfect stock substitutability could the demand effect be arbitraged away in a riskless manner.

A second interpretation argues in favor of an "information effect" related to the index inclu-

sion. The index addition provides new information to the market that is directly impounded into prices. This interpretation is supported by recent findings on analysts behavior around additions (Denis, McConnell, and Ovtchinnikov (2003)). A third interpretation highlights the "liquidity effect". An index addition increases the liquidity of a particular stock and reduces therefore its trading costs, which should be reflected in a price increase. Scarce and contradictory evidence has been found on the latter effect.[3] For macroeconomic prices like the exchange rate, only the demand effect appears to be plausible. Limited exchange rate resilience presents therefore more clear-cut evidence in favor of limited asset substitutability than price effects documented for individual stocks.

3.2 Time Series Evidence on Price Pressure

Apart from the event studies above, a broader literature assesses whether demand and supply shocks correlate with individual stock price returns. Studies on block purchases and sales of stocks as well as the trades of institutional investors have consistently uncovered evidence of temporary price pressure on individual securities conditional upon unusual demand or supply (Lakonishok, Shleifer and Vishny (1991,1992), Chan and Lakonishok (1993, 1995)). In the international finance literature, Froot, O'Connell and Seasholes (1998) have shown that local stock prices are sensitive to international investor flows, and that transitory inflows have a positive future impact on returns. Focusing on mutual funds, Warther (1995) and Zheng (1999) have documented that investor supply and demand effects may aggregate to the level of the stock market itself. Goetzmann and Massa (2002) show that, at daily frequency, inflows into S&P500 index funds have a direct impact on the stocks that are part of the index. Generally, the results in this literature are contingent on the identification assumptions which are implicitly or explicitly made. Hence, in contrast to the event studies cited in the previous subsection, causal inference remains problematic.

3.3 Price Pressure for Exchange Rates?

The traditional portfolio approach to exchange rates has viewed assets in different currencies as imperfect substitutes (Kouri (1983), Branson and Henderson (1985)). This implies typically a

[3] For example, Beneish and Whaley (1996) find a permanent increase in the trading volume but only a temporary decrease in the quoted spread. This leads them to reject the liquidity hypothesis. On the contrary, Hegde and McDermott (2003) show a long-term sustained increase in the liquidity of the added stocks and argue that it can be explained in terms of a reduction in the direct cost of transacting.

downward sloping demand also for foreign exchange balances. Historically, the portfolio balance theory enjoyed little empirical support.[4] The main contribution of our paper is to test its key hypothesis - that is limited exchange rate resilience due to imperfect substitutability of international equity - directly in a natural experiment. This is important since the tremendous growth of international equity flows has recently revived the interest in the asset market approach to exchange rate. Hau and Rey (2003) provide microfoundations to the portfolio balance theory in a dynamic incomplete market framework. They derive a positive correlation between capital flows and exchange rate returns and find empirical support for the model implications in recent data. Froot and Ramadorai (2004) use a simple VAR framework to document very persistent exchange rate effects related to U.S. institutional in- and outflows. Pavlova and Rigobon (2003) and Hau and Rey (2004) use model-based identification assumptions to assess the role of capital flows for exchange rate movements. In all these studies causal inference is contingent on the validity of the identification assumptions.

Evans and Lyons (2002a, 2002c) develop models of FX trading in the presence of dispersed information. They argue that the empirically strong correlation between FX order flow and exchange rate returns is due to the fact that order flows proxy for aggregate information flows. In a related paper, they show that price impact per dollar traded is about 10 percent higher per news announcement in the previous hour (Evans and Lyons (2002b)). The MSCI index change in our setting is unlikely to represent a source of macroeconomic information and therefore allows us to abstract from the "information-based price impact hypothesis".

The resilience of the exchange rate is also at the core of a literature on the effectiveness of central bank interventions (Edison (1993)). Recent studies based on microeconomic data provide evidence that central bank interventions indeed create a price effect. Payne and Vitale (2003) show price pressure effects for interventions by the Swiss central bank. Dominquez (2003) documents a short-term daily and intra-day volatility effect related to central bank intervention. However, these studies on central bank interventions are inherently ambiguous about the nature of the exchange rate effect. Besides the traditional "portfolio effect" of the intervention, a so-called "signalling effect" provides an alternative interpretation of the data: central bank interventions may reveal information about the bank's future monetary policy. By contrast, the redefinition of the MSCI global equity index in our experiment is devoid of a signalling. We can

[4] For a survey of the relevant literature, see Rogoff (1984) and Hodrick (1987).

thus measure the "portfolio effect" directly.

4 Institutional Background

4.1 MSCI and its Index Maintenance

Morgan Stanley Capital International Inc. (MSCI) is a leading provider of equity (international and U.S.), fixed income and hedge fund indexes. The MSCI Equity Indexes are designed to be used by a wide variety of global institutional market participants. They are available in local currency and U.S. Dollars (US$), and with or without dividends reinvested.[5] MSCI's global equity indexes have become the most widely used international equity benchmarks by institutional investors. Close to 2,000 organizations worldwide currently use the MSCI international equity benchmarks. Over US$ 3 trillion of investments are currently benchmarked against these indexes worldwide and up to US$ 500 millions are directly indexed. The indexes with the biggest impact are the MSCI ACWI (All Country World Index), which includes 50 of developed and emerging equity markets, the MSCI World Index (based on 23 developed countries), the MSCI EM (Emerging Markets) Index (based on 27 emerging equity markets), the MSCI EAFE (Europe, Australasia, Far East) Index (based on 21 developed countries outside of North America), the MSCI Europe (based on 14 EU countries (except Luxemburg), plus Norway and Switzerland).

Over time, MSCI's methodology has evolved in order to ensure that the equity index series continue to properly represent these markets and maintain its benchmark character. The design and implementation of the index construction is based on a broad and fair market representation. In theory, a total market index, representing all listed securities in a given market, would achieve this goal. However, in practice, a total market index including all the stocks would be difficult to use as a benchmark for the international investors. Therefore, MSCI builds up the indexes from industry group level by restricting itself to securities which are truly replicable in global institutional portfolios of reasonable size. To maintain the goal of broad and fair market representation and reflect the evolution of the underlying markets, the indexes must be reviewed regularly, which comprises inclusions and exclusions of index components. [6]

[5] Aggregating individual securities by different criteria MSCI creates a broad base of indexes such as Global, Regional and Country Equity Indexes, Sector, Industry Group and Industry Indexes, Value and Growth Indexes, Small Cap Equity Indexes, Hedged and GDP-weighted Indexes, Custom Equity Indexes, Real Time Equity Indexes.

[6] The index maintenance can be described by three types of reviews. First, there are annual full country index reviews (at the end of May) in which MSCI re-assesses systematically the various dimensions of the equity universe

MSCI commits in its published guidelines to the principles of transparency and independence from outside interests. All reviews and changes are announced at least two weeks in advance or as early as possible prior to their implementation. Only in rare cases are events announced during market hours for same or next day implementation.[7] While these above index revisions are part of a periodic review, we now describe the transition to the new index methodology which marked an exceptional redefinition of all of MSCI's equity indices.

4.2 The New Index Methodology

To better insure investibility and replicability of its indexes, MSCI has recently started to focus only on the free float instead of total market capitalization for each stock and to include other restrictions like Foreign Ownership Limits (FOLs) in different countries. On December 10, 2000, MSCI announced that it would adjust all its equity indexes for free float and increase target market representation from 60 percent to 85 percent. In order to reduce any abrupt market impact, MSCI also announced a two-step procedure for the transition. The equity indices should adjust 50 percent towards the new index on November 30, 2001 and the remaining adjustment was scheduled for May 31, 2002.

The new methodology differs from the previous equity index definition in two main points: a stock selection based on freely floating capital (as opposed to market capitalization) and an enhanced (or broader) market representation. MSCI defines the free float of a security as the proportion of shares outstanding that is available for purchase by an international investors. In practice, limitations on the investment opportunities of international institutional are common due to so-called "strategic holdings" by either public of private investors. Given that disclosure requirements generally do not permit a clear determination of what is a "strategic" investment objectives, MSCI classifies shareholdings based on grouping investor types into strategic and non-strategic investors. Freely floating shares include those held by households, investment funds, mutual funds and unit trusts, pension funds, insurance companies, social security funds and security brokers. The non-free float shares include the holdings of strategic shareholders

for all countries. Second, there are quarterly index reviews (at the end of February, August, November), in which other significant market events are accounted for (e.g. large market transactions affecting strategic shareholders, exercise of options, share repurchases, etc.). Thirdly, ongoing event-related changes like mergers and acquisitions, bankruptcies or spin-offs are implemented as they occur.

[7] A more descriptive text announcement is sent out to clients for significant events like additions and deletions of constituents and changes in free float larger than US$ 5 billion or with an impact of more than 1% of the constituent's underlying country index.

such as governments, companies, banks (excl. trusts), principal officers, board members and employees. Moreover, non-free float is also defined in terms of foreign ownership restrictions. Such Foreign Ownership Limits (FOLs) can come from law, government regulations, company by-laws and other authoritative statements. MSCI free float-adjusts the market capitalization of each security using an adjustment factor referred to as the Foreign Inclusion Factor (FIF). For securities subject to FOLs, the FIF is equal to the lesser of the FOL (rounded to the closest 1 percent increment) and the free float available to foreign investors (rounded up to the closest 5 percent increment above 15 percent and to the closest 1 percent below a 15 percent free float). Securities with an FIF of less than 15 percent across all share classes are generally not eligible for inclusion to the MSCI indexes.[8]

The second goal of the equity index modification was an enhanced market representation. In its new indices, MSCI targets a free float-adjusted market representation of 85 percent within each industry group and within each country, compared to the 60 percent share based on market capitalization in the old index. Because of differences in industry structure, the 85 percent threshold may not be uniformly achieved. Moreover, the occasional over- and under-representation of industries may also imply that the aggregate country representation may deviate from the 85 percent target.[9]

The overall index rebalancing effect is illustrated in Figure 1, which plots the percentage change in index weight for each country in the 'all country world index' (ACWI) as a function of the initial weight. It shows that most countries were in fact downweighted, and many by a considerable amount in percentage terms. The most important beneficiaries of the new methodology are the U.S. with a percentage weight increase of 12 percent, followed by the U.K. with an increase of 10.9 percent and Ireland by 11.4 percent. The main losers in percentage terms are Columbia with a decrease by -98.3 percent, India by -97.1 percent, and the Czech Republic by -96.7 percent.

The initial sample consists of the 50 countries in the MSCI ACWI. We exclude the U.S. as the Dollar constitutes our reference currency. We also remove Turkey and Argentina because these countries experienced major currency crisis during the period of our analysis. Since the 11 countries in the Euro zone share one common exchange rate, we aggregate these observations

[8] Exceptions to this general rule are made only in significant cases, where exclusion of a large company would compromise the index's ability to fully and fairly represent the characteristics of the underlying market.

[9] MSCI's bottom-up approach to index construction may lead to a large company in an industry group not being included in the index, while a smaller company from a different industry group might be included.

into one so that the old (new) weight equals the sum of the 11 country weights in the old (new) index. The final sample consists of 37 countries with exchange rate data, of which 10 are from developed and 27 are from emerging markets. Summary statistics are reported in Table 1. Three countries, namely China, Malaysia and Hong Kong, maintained their currencies pegged to the U.S. Dollar. We therefore excluded these 3 currencies from our sample, which leaves us with 34 countries.

Did the announcement of the major index revision take the market by surprise? There were certainly prior rumors about the free float adjustment. In July 2000, for example, the cover story of "Pensions & Investments" stated that "Morgan Stanley Capital International may change the way it weights companies in its indexes, a move with huge consequences for institutional investors". We highlight that any information leakage about the index change prior to the start of our event window should tend to decrease the actual announcement effect we expect to find.

5 Statistical Analysis

An index tracking fund confronted with the change of the index should generally rebalance its portfolio at or around the time of the implementation of the index revision. This timing will minimize the tracking error relative to the valid index. However, any possible price impact of the rebalancing may provide an incentive for a more gradual move to the new index. Moreover, risk arbitrageurs are likely to anticipate the price impact of the index trackers and front-run their reallocation. The stronger the intertemporal risk arbitrage, the more price impact we expect around the announcement date relative to the implementation date. A price impact on both the announcement date and the implementation date suggests imperfect intertemporal arbitrage. We can therefore study the price impact in relationship to the weight change for the announcement date as well as for the two implementation dates.

Our exogenous and independent variable is the change in the index weight of a country. The relative index reweighting Δw is expressed in percentage terms (relative to the midpoint) as:

$$\Delta w_i = \frac{w_i^n - w_i^o}{\frac{1}{2}\left(w_i^n + w_i^o\right)}$$

where w_i^o and w_i^n represent, respectively, the old and new index weight of country i. For $\Delta w_i > 0$ we register an increased weight of country i in the index, which should come with an appreciation

of its currency relative to other currencies. Because of the predominant role of the U.S. dollar currency in the global MSCI index, we express all exchange rate changes in dollar terms (foreign currency per dollar). Hence

$$\Delta e_i^s = \log E_{t+s} - \log E_{t-s},$$

denotes the (log) dollar exchange rate return over an event window of s (trading) days around the date t. For $\Delta e_i^s < 0$ country i experiences a currency appreciation.

The following statistical analysis proceed in three steps. First, we carry out a non-parametric Fisher test as the most robust inference. The Fisher test verifies if the ranking of the percentage weight change Δw_i and the exchange rate change Δe_i^s are uncorrelated. No distributional assumptions are made.[10] Second, we run a cross-sectional OLS regression where the errors are assumed to follow a normal distribution. The currencies which are upweighted should on average experience an appreciation relative to the dollar, hence Δe_i^s should decrease. We therefore expect a negative coefficient for the regressor Δw_i. Third, we perform panel regressions where we use both the intertemporal and cross-sectional structure of the data to identify the exchange rate impact of equity reallocations.

An ideal data structure would allow us to measure the exchange rate impact conditional on the day on which the actual portfolio reallocation occurs. Such a panel data structure would certainly allow much more powerful statistical inference than the purely cross-sectional approach. Unfortunately, high frequency equity flow data is generally not available. However, we can indirectly identify the days of enhanced equity reallocation by looking at the intra-EMU equity returns only. All EMU countries share one common exchange rate, but their respective equity market will still be affected by the MSCI weight change. We can therefore propose a "reallocation indicator" which measures to what extend intra-European equity returns, R_{ijt}, are explained on a given day by individual stock weight changes Δw_{ij}. Our "flow indicator" is defined as the OLS coefficient capturing the average stock return effect on a given day t:

$$\begin{aligned} R_{ijt} &= \gamma_{0t} + \gamma_{1t}\Delta w_{ij} + \epsilon_{jt}, \qquad \forall i \in \text{EMU} \\ FlowInd_t &\equiv \widehat{\gamma}_{1t} \end{aligned}$$

The flow indicator, $FlowInd_t$, is estimated separately for every day based on the cross section of

[10] We also highlight that a common correlation of all exchange rates with the dollar does not affect the validity of the Fisher test. Such correlation will only imply a common level effect and should not alter the ranking of each exchange rate change relative to the ranking of the weight change.

intra-EMU stock returns. It is worth noticing that all the equity returns are measured in Euros so that no exchange rate effect enters our proxy. Furthermore, we assume that the global and the intra-EMU equity reallocation activity are correlated so that the proxy constructed from the European equity market returns can be used as a proxy for the global reallocation activity.

The intertemporal identification of the global reallocation activity from intra-EMU equity return data permits a more powerful panel specification since it introduces both cross-sectional as well as intertemporal variability. In particular we can interact the flow indicator with the percentage index weight change, Δw_i, in the following panel regression:

$$\Delta e_{it} = \alpha_0 + \alpha_1 \Delta w_i + \alpha_2 \left[FlowInd_t \times \Delta w_i \right] + \mu_{it}.$$

We note that exchange change Δe_{it} are negative for a local currency appreciation against the dollar. Therefore, the can reject the hypothesis H1 of "complete exchange rate resilience" is the coefficients α_1 or α_2 are significantly negative. By construction, the regressor $FlowInd_t \times \Delta w_i$ is characterized by perfect positive or negative serial correlation across countries. The standard errors on the coefficients therefore need to be corrected for correlation across panels.

5.1 Announcement Effect

The announcement of the new index methodology and of the time table for the transition to the new index took place on December 10, 2000. It seems plausible that some information leakage about the index change occurred prior to the actual announcement. The exchange rate impact might therefore not be limited to the announcement day itself. Also information diffusion and the interpretation of the announcement itself may occur with a time lag. We therefore opt for a symmetric 20 day event window around the announcement date.

In a first step, we split the sample of 34 countries into two subsamples containing the 17 least downweighted countries and the 17 most downweighted countries. Figure 2 shows an equally weighted exchange rate index representing the average exchange rate effect for each subsample. Clearly, least downweighted countries experienced a relative exchange rate appreciation relative to the dollar represented by the steeper decline of the exchange rate index. The gap in the exchange rate across the two groups grew continuously over the 20 trading day window around the announcement day. Both information leakage as well a slow information diffusion may explain the gradual nature of the exchange rate effect. Figure 2 also gives insights into the economic significance of the exchange rate effect. Over the 20 day window, a more than 3

percent exchange rate gap occurs. The average percentage weight change in the sample of least downweighted countries is -15 percent, while the average percentage weight change in the subsample of most downweighted countries is -70 percent. We conclude that the economic significance of the exchange rate effect is considerable.[11]

Next we discuss its statistical significance. Table 2, column (1) presents the results of a Fisher median test for the two subsamples. For every country, we compute cumulative currency changes over a 20 day window, Δe_i^{20}. The null hypothesis is that both the up- and downweighted subsample should be drawn from populations with the same median currency changes. The two-sided (one-sided) probability that the medians are equal across groups is 0.5 percent (0.3 percent). Thus, the Fisher test strongly rejects the hypothesis that exchange rate changes and weight changes are statistically independent.

As an alternative methodology, we use a OLS regression. We regress the cumulative currency changes, Δe_i^{20}, on the weight changes, Δw_i, and a constant. The results are displayed in Table 3, column (1). The slope coefficient is negative and significant at the 0.1 percent level using robust standard errors. The negative slope indicates that currencies with a weight increase tend to appreciate. The significant negative constant reflects a depreciation of the dollar against most sample currencies. The regression R^2 is 15.3 percent, a remarkably good fit as far as currency returns are concerned. The regression is illustrated in Figure 3 where the currency cumulative changes Δe_i^{20} are plotted against the country weight changes Δw_i together with the regression line.

Finally, we turn to the panel estimation. In order to use the panel structure of the exchange rate data, we need a proxy variable for global exchange rate reallocations. The flow indicator variable, $FlowInd_t$, defined in the previous section represents such a proxy. It assumes that (1) the daily intensity of the equity reallocations for EMU countries can be measured by the covariance of the individual stock returns, R_{ijt}, and the stock weight changes, Δw_{it}, and that (2) the European flow intensity proxies for the global flow intensity for the ACWI.

We report the results of the feasible generalized least squares regression (FGLS) in Table 4, column (1). The estimation allows for heteroskelastic errors and error correlation across panels.[12] The coefficient α_1 for the weight change, Δw_i, captures the pure cross-sectional effect.

[11] Any information leakage about the index change pior to event window implies that we tend to underestimate the exchange rate effect. The 3 percent exchange rate impact is therefore best interpreted as a lower bound on the exchange rate effect around the announcement day.

[12] A total of $(34 \times 33)/2 + 34 = 595$ covariances are estimated.

It is correctly signed and its magnitude for the daily returns exceed (after multiplication by 20 for length of the window) the value of the pure cross-sectional regression in Table 3. The *z-statistic* shows a high level of statistical significance. The coefficient α_2 on the interaction term, $FlowInd_t \times \Delta w_i$, measures slope of the weight change as a function of intertemporal variations in the flow intensity. The coefficient has the expected negative sign and its high level of statistical significance justifies the proposed panel structure.

In summary, all the three statistical procedures deliver statistically very significant effects in the 20 day window around the announcement day of the index change. Upweighted countries experience a relative appreciation of their currency against the dollar. Experimentation with event windows of different size (namely 10, 15, or 25 days) give also statistically significant results, suggesting that our results are robust to variations of the window size. The evidence on the announcement effect clearly indicates limited resilience of the exchange rate to exogenous capital flows.

5.2 Implementation Effect

The change in the index methodology took place in two steps. On November 31, 2001, half of the change was implemented for the existing index constituents and all the new constituents were added at half of their final weight. The rest of the change was implemented on May 31, 2002.

As in the case of the announcement effect, we first undertake a Fisher median test to examine the difference of the two subsamples of up- and downweighted countries. The Fisher test is carried out separately for the first and second implementation date and reported in columns (2) and (3) of Table 2, respectively. The first date shows no statistical difference in the exchange rate behavior across the subsamples. However, for the second implementation date, we find again a systematic appreciation of the upweighted relative to the downweighted countries at a 5 percent significance level. The cross sectional OLS regression reported in Table 3, columns (2) and (3), confirm the results. For the first implementation date we even find a positive, though statistically insignificant, point estimate for the exchange rate effect. This implies that the exchange rate movement has the opposite direction of the index fund flows. For the second implementation date we find that exchange rates and index fund flows move in the same direction.

We now turn to the panel estimates. These provides additional power since the flow indicator

variable proxies for the particular days within the event window in which equity reallocation was presumably more intense. The results are reported in Table 4, columns (2) and (3). They are qualitatively similar to the OLS results. But the positive effect for the first implementation date is now confirmed at a high level of statistical significance. Both coefficients α_1 and α_2 are positive. This shows that upweighted countries experienced a depreciation instead of an appreciation. This surprising results is not only evidence of imperfect arbitrage, but can be interpreted as evidence of excessive risk arbitrage. In expectation of a sizeable appreciation of upweighted countries, speculators presumably accumulated foreign exchange inventories in excess of the reallocated index fund capital. When the excessive inventories were released on the implementation date, the excess supply of speculative capital led to the observed currency depreciation. The exchange rate behavior on the first implementation date is therefore hard to reconcile with the idea of limited availability of speculative capital. However, the second implementation date shows again the opposite effect in the panel regression. Here, upweighted countries experience a statistically significant appreciation.

In summary, both implementation dates provide evidence for limited exchange rate resilience and moreover imperfect arbitrage. Around the first date, we find exchange rate movements in opposite direction to the capital flow of index funds, while for the second date the index capital flow and the exchange rate movement share the same direction. This suggests that speculation was excessive on the first date and insufficient on the second date. Speculative coordination failure or collective misjudgment about the size of the index fund flows can explain both observations. The hypothesis of insufficient speculative capital availability can only account for the exchange rate behavior on the second date.

5.3 Stock Return Effects

The evidence on the exchange rate on the first implementation date is somewhat surprising. Countries receiving index fund inflows are characterized by a depreciation instead of an appreciation in a symmetric 20 day event window. In the previous section, we interpreted this as evidence of excessive risk arbitrage behavior. However, if arbitrage fails, this should show up also in the respective equity markets. We therefore examine if equity market returns also show evidence of arbitrage failure.

Table 5 reports the cross-sectional OLS regression of individual MSCI AWCI stock returns

on the individual stock weight changes. In panel A, stock returns are measured here in local currency in order to exclude any exchange rate effect. We therefore look at arbitrage possibilities from the perspective of a local investor. In panel B, we measure the stock returns in U.S. dollars. Table 5, column (1), shows a statistically significant announcement effect in both local currency and U.S. dollars. That is, individual stocks whose weight in the new index increases registered excess returns around the announcement of the new index methodology.[13]

More interesting still is the stock price effect for the two implementations dates reported in columns 2 and 3. Surprisingly, we find for both dates a statistically significant negative stock price effect for the upweighted stocks. This result mirrors the exchange rate effect found for the first implementation date. We interpret this again as evidence of imperfect arbitrage. Excessive inventory accumulation in anticipation of a stock price increase may have been dumped into the market inducing a stock price decrease. We also note that while this excessive speculation occurred on both implementation dates in the equity market, it occurred only once in the FX market. The positive implementation effect for equity returns is also evident if the returns are expressed in dollar terms instead of local currency returns. Hence there is also failure of perfect arbitrage from the perspective of an international investors concerned about dollar returns. As additional robustness check, we also include the MSCI AWCI return on the right-hand side of the stock regression in order to control for the systematic component of the excess return. This control did not alter the results. Also, the change of the size of the windows around the event (i.e., 10, 15, 25 days) did not alter the qualitative conclusions.

Reverse implementation effects are consistent with evidence from stock inclusions in the S&P500 index. After 1989, S&P separated the announcement from the implementation dates. Beneish and Whaley (1996) report abnormal negative returns around the implementation date for index inclusions. They interpret the negative return as evidence that risk arbitrageurs overestimate the demand by index funds. These results of partial announcement return reversal upon implementation are confirmed by Lynch and Mendenhall (1997) for the same S&P 500 data. Excessive arbitrage behavior may be a general problem in rare events such as preannounced index changes where the scope for learning is limited.

[13] We note however that the announcement date of December 10, 2000 did not contain the list of stocks which would actually be included in the new index. Full list of included stocks was only generated on May 11, 2001 and publicly communicated on May 19, 2001. The 20 day window may therefore reflect only a part of the price adjustment due to the index change. We also found a statitically significant price increase for upweighted stocks around May 11, but do not report it here.

6 Conclusions

The exchange rate reaction to exogenous capital flows has long been an open issue in international finance. Empirical work suffered from a lack of clear identification of capital flow shocks. The growing quantitative importance of international equity flows has at the same time revived interest in the traditional portfolio channel of exchange rate determination. The MSCI global index redefinition announced on December 10, 2000, provides an ideal natural experiment to examine the impact of clearly exogenous equity flows on a large number of exchange rates. We find statistically and economically strong evidence in favor of limited exchange rate resilience. Over a 20 day window around the announcement day, the 17 upweighted (or least downweighted) countries appreciate relative to the 17 most downweighted countries by on average more than 3 percent.

This experiment also allows us to examine the extent to which systematic arbitrage profit opportunities remained unexploited on the two implementation dates of the index change, namely on November 30, 2001, and May 31, 2002. The previous literature on the limits of arbitrage has highlighted the insufficiency of speculative capital as a possible arbitrage impediment (Shleifer and Vishny (1997)). We find that this interpretation is at odds with the evidence in the price effect on implementation dates. The first implementation date is characterized by exchange rate movements in opposite direction to index fund flows. Imperfect arbitrage therefore seems to originate in an overestimation of the size of the index fund flows or in a coordination failure in the inventory policy of the speculators. The same type of arbitrage failure seems to occur also in the underlying equity returns on both implementation dates. Only the exchange rate behavior on the second implementation date is compatible with limits on the amount of speculative capital.

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Table 1:

Summary Statistics

For the sample countries we report summary statistics on the percentage country index reweighting Δw_i and the dollar exchange rate return Δe_i^{20}. Individual stock returns for stock j (also in local currency) are denoted as Δr_{ij}^{20} and the corresponding percentage weight change by Δw_{ij}. Exchange rate, index and individual stock returns are measured over a 20 day window around (1) the announcement day of the index reweighting, (2) the first implementation date of the 50 percent partial adjustment towards the new index, (3) the second implementation date for the remaining 50 percent adjustment towards the new index. Turkey and Argentina were excluded from the exchange rate statistics because of exchange rate crisis in the data period 2000-2002.

		Obs.	Mean	S.D.	Min	Max
Δw_i	Percentage index weight change	34	−0.428	0.333	−0.983	0.109
Δw_{ij}	Percentage stock weight change	2436	−0.104	1.178	−2	2
(1) Announcement						
Δe_i^{20}	Dollar exchange rate return	34	−0.026	0.041	−0.097	0.036
Δr_{ij}^{20}	Local currency stock return	2412	−0.033	0.144	−1.435	0.446
$FlowInd_t$	Flow indicator	20	0.000	0.003	−0.005	0.007
(2) First Implementation						
Δe_i^{20}	Dollar exchange rate return	34	−0.002	0.039	−0.066	0.183
Δr_{ij}^{20}	Local currency stock return	2432	0.0121	0.131	−2.665	1.035
$FlowInd_t$	Flow indicator	20	−0.001	0.004	−0.009	0.007
(3) Second Implementation						
Δe_i^{20}	Dollar exchange rate return	34	−0.007	0.041	−0.060	0.157
Δr_{ij}^{20}	Local currency stock return	2430	−0.056	0.111	−0.860	0.450
$FlowInd_t$	Flow indicator	20	−0.001	0.003	−0.006	0.007

Table 2:

Nonparametric Test for Independence of Index Reweighting and Exchange Rate Change

The sample countries are split into two groups of (relatively) up- and downweighted countries and into two groups of appreciating and depreciation countries relative to the U.S. dollar. The Fisher test evaluates the likelihood of observed association under the null hypothesis that there is no relationship between the two sorting criteria. The change rate change is measured over a 20 day window around (1) the announcement day of the index reweighting, (2) the first implementation date of the 50 percent partial adjustment towards the new index, (3) the second implementation date for the remaining 50 percent adjustment towards the new index. Turkey and Argentina were excluded from the index countries because of exchange rate crisis in the data period 2000-2002.

	(1)	(2)	(3)
	Announcement	First Implementation	Second Implementation
20 Day Window around	10/12/2000	30/11/2001	31/05/2002
Fisher's exact test			
Two-sided test	0.005	1.000	0.038
One-sided test	0.003	0.500	0.019
Number of obs.	34	34	34

Table 3:

Cross-Sectional Exchange Rate Regression

We perform a cross-sectional OLS regression of the (log) exchange rate change, Δe_i^{20} (expressed in dollars per local currency), on the percentage weight change of each country in the MSCI all country index, Δw_i. The exchange rate change is measured over a 20 day event window around (1) the announcement day of the index reweighting, (2) the first implementation date of the 50 percent partial adjustment towards the new index, (3) the second implementation date for the remaining 50 percent adjustment towards the new index. Turkey and Argentina were excluded from the index countries because of exchange rate crisis in the data period 2000-2002. T-tests are in parentheses. They are calculated using White's heteroscedasticity robust standard errors.

$$\Delta e_i^{20} = \alpha_0 + \alpha_1 \Delta w_i + \mu_i$$

	(1)		(2)		(3)	
	Announcement		First Implementation		Second Implementation	
20 Day Window around	10/12/2000		30/11/2001		31/05/2002	
α_0 (constant)	−0.050	(−4.68)	0.010	(0.79)	−0.029	(−3.49)
α_1	−0.051	(−2.83)	0.029	(1.63)	−0.051	(−2.14)
Number of obs.	34		34		34	
R^2	0.160		0.062		0.172	

Table 4:

Exchange Rate Panel Regression

We perform a FGLS panel regression of the daily (log) exchange rate change, Δe_{it} (expressed in dollars per local currency), on the percentage weight change of each country in the MSCI all country index, Δw_i, and on an equity reallocation proxy, $FlowInd_t$, interacted with the percentage weight change. The panel data covers a 20 day event window around (1) the announcement day of the index reweighting, (2) the first implementation date of the 50 percent partial adjustment towards the new index, (3) the second implementation date for the remaining 50 percent adjustment towards the new index. Turkey and Argentina were excluded from the index countries because of exchange rate crisis in the data period 2000-2002. We report z-statistics in parentheses. They are calculated allowing for heteroskedasticity and cross-panel correlation.

$$\Delta e_{it} = \alpha_0 + \alpha_1 \Delta w_i + \alpha_2 \left(FlowInd_t \times \Delta w_i\right) + \mu_{it}$$

	(1)		(2)		(3)	
	Announcement		First Implementation		Second Implementation	
20 Day Window around	10/12/2000		30/11/2001		31/05/2002	
α_0 (constant)	−0.0023	(−13.93)	0.0004	(2.25)	−0.0014	(−10.56)
α_1	−0.0041	(−18.68)	0.0020	(6.08)	−0.0030	(−8.72)
α_2	−0.0029	(−9.07)	0.0014	(4.51)	−0.0010	(−1.78)
Number of obs.	680		680		680	
Number of groups	34		34		34	
Number of periods	20		20		20	
$\chi^2(2)$	503.3		39.8		183.7	

Table 5:

Individual Stock Return Regression

We perform a cross-sectional OLS regression of the (log) return of stock j in country i expressed in local currency of country i in Panel A and U.S. dollar returns in Panel B on the percentage weight change of each stock in the MSCI all country world index, Δw_{ij}. The stock return is measured over a 20 day event window around (1) the announcement day of the index reweighting, (2) the first implementation date of the 50 percent partial adjustment towards the new index, (3) the second implementation date for the remaining 50 percent adjustment towards the new index. T-tests are in parentheses. They are calculated using White's heteroscedasticity robust standard errors.

$$\Delta r_{ij}^{20} = \alpha_0 + \alpha_1 \Delta w_{ij} + \mu_{ij}$$

Panel A: Individual Stock Returns in Local Currency						
	(1)		(2)		(3)	
	Announcement		First Implementation		Second Implementation	
20 Day Window around	10/12/2000		30/11/2001		31/05/2002	
α_0 (constant)	−0.032	(−10.99)	0.011	(4.13)	−0.058	(−25.64)
α_1	0.010	(3.77)	−0.012	(−5.43)	−0.011	(−5.40)
Number of obs.	2412		2432		2434	
R^2	0.007		0.012		0.014	

Panel B: Individual Stock Returns in U.S. Dollars						
	(1)		(2)		(3)	
	Announcement		First Implementation		Second Implementation	
20 Day Window around	10/12/2000		30/11/2001		31/05/2002	
α_0 (constant)	−0.006	(−2.21)	0.011	(4.06)	−0.008	(−4.10)
α_1	0.009	(3.42)	−0.014	(−6.00)	−0.046	(−19.66)
Number of obs.	2412		2432		2434	
R^2	0.006		0.014		0.008	

Figure 1: The percentage weight change of a country in the MSCI ACWI index is plotted against the log level of the country's weight prior to the index redefinition. The sample countries are Australia (AU), Brazil (BR), Canada (CN), Chile (CL), Colombia (CT), Czech Republic (CZ), Denmark (DK), Egypt (EY), Hungary (HN), India (IN), Indonesia (ID), Israel (IS), Japan (JP), Jordan (KN), Korea (KO), Mexico (MX), Morocco (MC), New Zealand (NZ), Norway (NW), Pakistan (PK), Peru (PE), Philippines (PH), Poland (PO), Russia (RS), Singapore (SG), South Africa (SA), Sri Lanka (CY), Sweden (SD), Switzerland (SW), Taiwan (TA), Thailand (TH), United Kingdom (UK), United States (US), Venezuela (VE), and the Euro Area (EU).

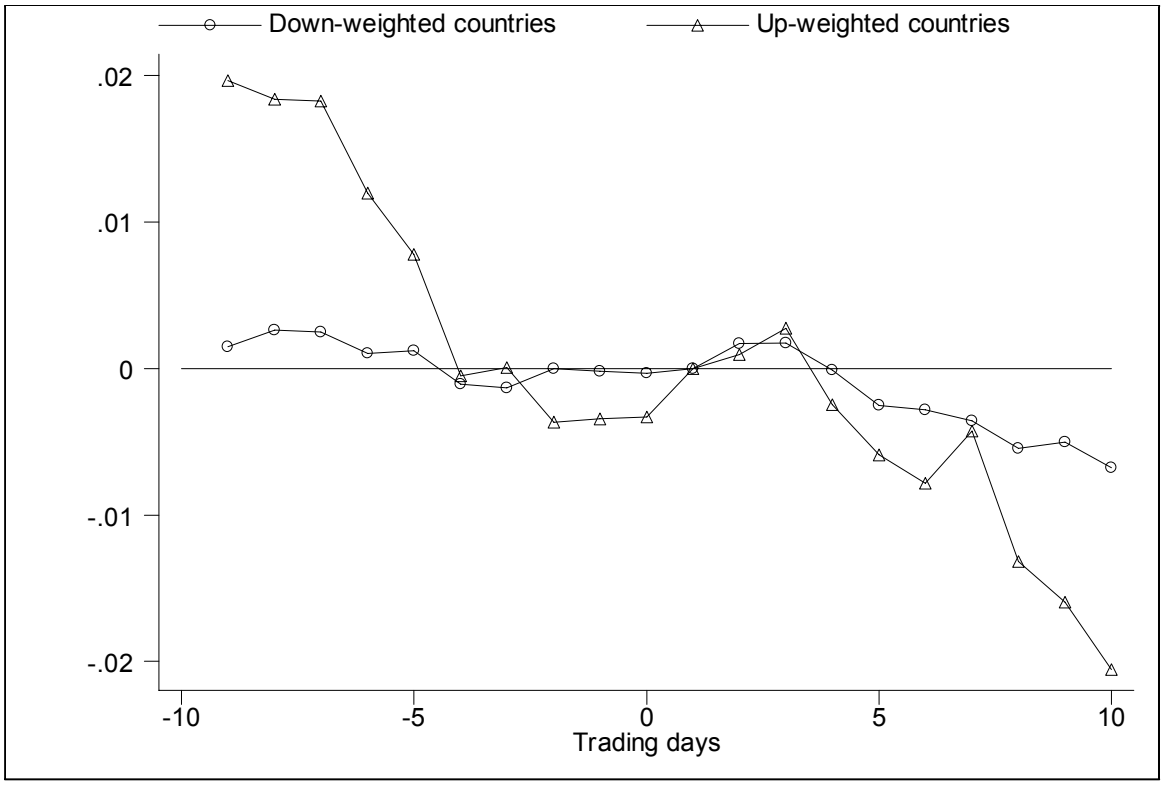

Figure 2: The average cumulative exchange rate return (relative to the dollar) are plooted for two portfolios of 17 upweighted and 17 downweighted countries for an event window of 20 trading days around the announcement of the MSCI index redefinition on December 10, 2000. For the event day, the cumulative returns are normalized to be zero.

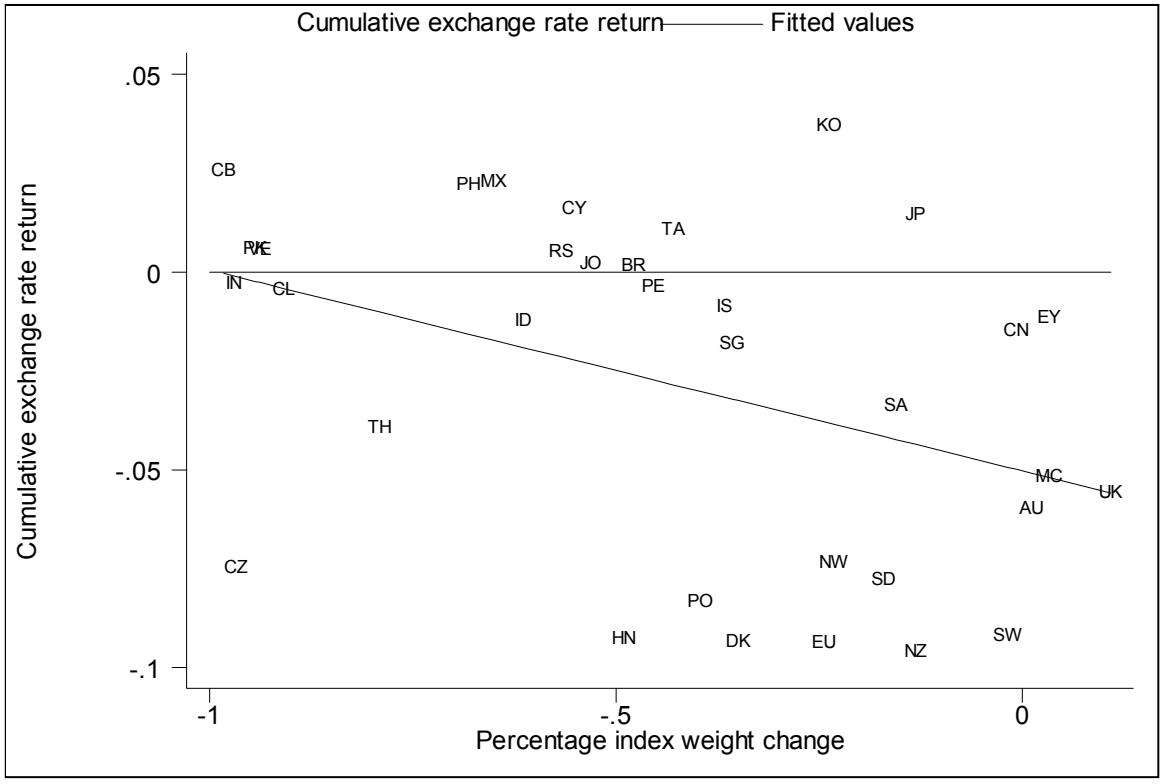

Figure 3: A country's exchange rate depreciation relative to the dollar is plotted against the percentage change in the country's weight in the MSCI index. The exchange rate effect is measured for a event window of 20 trading days around the announcement day of the index change.