A new global database of *de facto* exchange rate regimes

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Abstract

We measure exchange rate flexibility, identify weights of the currencies that a country pegs against, and estimate dates of structural breaks in the exchange rate regime. These breaks may be caused by a change in volatility, or a change in the weights of the basket. The methodology is fully algorithm based, is implemented using open source software, and is hence replicable. The database offers a continous, single measure of flexibility. The continuous flexibility measure, and its amenability to aggregation, yields new insights into the worldwide evolution of currency flexibility. We also measure the rise of the Euro, and the decline of the US dollar, in global currency arrangements.

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Keywords: Exchange rate regimes.

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Contents

1 Introduction

The gap between the public statements of central banks, about the *de jure* exchange rate regime, and the actual mechanisms in operation, the *de facto* exchange rate regime, have given rise to a literature on identification of the *de facto* exchange rate regime. Beginning with (Calvo and Reinhart, 2002), there has been an attempt to unravel the defacto regime from the data (Levy-Yeyati and Sturzenegger, 2005; Reinhart and Rogoff, 2004; Frankel and Wei, 2008; Frankel and Xie, 2009a). While there are many papers in this literature, there are two prominent database which are updated and available for research: Reinhart and Rogoff (2004) and the IMF classification of *de facto* exchange rate regimes.

This paper contributes to the literature on regime classification in two ways. First, it extends the the fine structure of exchange rate regimes (Reinhart and Rogoff, 2004) to a continous measure of exchange rate flexibility, drawing on Frankel and Wei (1994). As in the Frankel and Wei (1994), it identifies the currencies to which a currency is pegged and the weights placed on each international currency. The methodology of Zeileis, Shah, and Patnaik (2010) is used to identify dates of structural change.

Second, the work makes publicly available a global database, and associated open source software, about the *de facto* exchange rate regime. As a consequence, the same calculations can be undertaken by researchers faced with datasets of the future. In addition, the 'white box' methodology enables analysis and methodological improvement. These features are infeasible with classification mechanisms for the *de facto* exchange rate regime which are based on human judgment.

2 Databases of exchange rate regime classifications

IMF's *de jure* classification of exchange rate regimes was complemented by attempts at *de facto* classifications (Bubula, Inci, et al., 2002; Ghosh, Gulde, and Wolf, 2003). Ghosh, Gulde, and Wolf (2003) construct a "consensus classification". As a continuous measure of exchange rate regime, Ghosh, Gulde, and Wolf (2003) estimates an annual score based on the mean and the volatility of nominal exchange rate changes. Further, the continuous *de facto* measure is one where the square-root of the sum of mean monthly rate of change of the nominal exchange rate squared, and the standard deviation of those monthly changes. This is reclassified into discrete categories (pegged, intermediate and floating) and compared with *de facto* measurement to obtain the consensus score for each country.

Reinhart and Rogoff (2004) propose a data-driven algorithm for identification of *de facto* currency regime that is in operation, using a certain set of rules and definitions:

1. They examine the monthly absolute percent changes. If the absolute monthly percent change in the exchange rate is equal to zero for four consecutive months or more, that episode is classified (for however long its lasts) as a *de facto* peg if there are no dual or multiple exchange rates in place. This allows them to identify relatively short-lived *de facto* pegs as well as those with a longer duration.

2. They compute the probability that the monthly exchange rate change remains within a one percent band over a rolling 5-year period. If this probability is 80 percent or higher, then the regime is classified as a *de facto* peg or crawling peg over the entire 5-year period. If the exchange rate has no drift, it is classified as a fixed parity; if a positive drift is present, it is labeled a crawling peg; and, if the exchange rate also goes through periods of both appreciation and depreciation it is a moving peg.

The database is monthly from January 1946 to December 2007. It was first released in 2004 and then an updated version till 2007 was released in 2009. The new uses parallel market determined exchange rates rather than only the offical exchange rate series. Regimes are classified into seven descriptive categories. A series of numerical constants are embedded in the algorithm – such as five years, 80 percent, four consecutive months, etc. The choice of these parameters is based on the authors' judgement.

Levy-Yeyati and Sturzenegger (2005) classify exchange rate regimes based on international reserves and nominal exchange rates from 1974 to 2004. The dataset is available online. Applying cluster analysis, they classify countries into homogenous groups of observations. This technique is applied to three classification variables namely; exchange rate volatility, volatility of exchange rate changes, and volatility of reserves. This approach is quantitative in nature.

The official *IMF de facto classification* is also available for research. The database is available at a monthly frequency upon request from the IMF. It covers the period 1998-2009. The database has been improved over time.

In the latest release, of 2009, the methodology was modified. It is based on a qualitative classification, rather than an algorithm, and is reported at a monthly frequency. The IMF *de facto classification* described in Anderson, Veyrune, Kokenyne, and Habermeier (2009) follows earlier efforts by IMF staff. The current official IMF classification described in (Anderson, Veyrune, Kokenyne, and Habermeier, 2009) and adopted since early 2009 seeks to address the heterogeneity in classification of *de facto* exchange rate regimes.The methodology relies on consultations with the IMF country desk economists. This, as the authors admit, introduces uncertainity in the classification procedure.

3 Methodology

The estimation strategy used in this paper (Zeileis, Shah, and Patnaik, 2010) builds on this literature in three respects. Exchange rate flexibility is measured as a real number from 0 (high flexibility) to 1 (hard peg). Structural change in the exchange rate regime is addressed using a inferential techniques which yield estimates of break dates to the resolution of the week. Finally, the econometric computations are easily redone using current data, allowing for easy updation of the *de facto* exchange rate regime database.

The point of departure is a linear regression model based on cross-currency exchange rates (with respect to a suitable numeraire). Used at least since Haldane and Hall (1991), this model was popularized by Frankel and Wei (1994) (and is hence also called the Frankel-Wei model). Recent applications of this estimation strategy include Bénassy-Quéré, Coeuré, and Mignon (2006); Frankel and Wei (2007). An independent currency, such as the Swiss Franc (CHF), is chosen as an arbitrary 'numeraire'. If estimation involving the Indian rupee (INR) is desired, the model estimated is:

$$\begin{aligned} d\log\left(\frac{\text{INR}}{\text{CHF}}\right) &= \beta_1 + \beta_2\, d\log\left(\frac{\text{USD}}{\text{CHF}}\right) + \beta_3\, d\log\left(\frac{\text{GBP}}{\text{CHF}}\right) + \beta_4\, d\log\left(\frac{\text{JPY}}{\text{CHF}}\right) \\ &\quad + \beta_5\, d\log\left(\frac{\text{EUR}}{\text{CHF}}\right) + \epsilon \end{aligned}$$

This regression picks up the extent to which the INR/CHF rate fluctuates in response to fluctuations in the USD/CHF rate. If there is pegging to the USD, then fluctuations in the GBP, JPY and EUR will be irrelevant, and we will observe $\beta_3 = \beta_4 = \beta_5 = 0$ while $\beta_2 = 1$. The R^2 of this regression is also of interest; values near 1 suggest reduced exchange rate flexibility.[1]

To understand the *de facto* exchange rate regime in a given economy for a given time period, this OLS regression can be utilised. In order to address *change* in the exchange rate regime, estimation with rolling data windows can be used to obtain an informal sense of how parameters have changed through time. However, this strategy lacks a formal inferential framework for determining changes in the parameters.

The econometrics of structural change can be applied to the analysis of structural change in the Frankel-Wei model. As an example, Frankel and Xie (2009b) discuss the use of the familiar Perron-Bai methodology (Bai and Perron, 2003), for identifying dates of structural change in an OLS regression, for identifying dates of structural change in the exchange rate regime. However, the Perron-Bai methodology treats the OLS coefficients as varying while the residual variance is fixed. In the exchange rate regression, variation in the residual variance is of essence.

In order to address this problem, Shah, Zeileis, and Patnaik (2005); Zeileis, Shah, and Patnaik (2010) extend the Perron-Bai methodology for identifying dates of structural change in an OLS regression to a more general MLE setting, which identifies structural change in the full parameter vector $\theta = (\beta, \sigma_\epsilon)$. Through this, dates of structural change in the exchange rate regime are identified. In each sub-period, the regression R^2 serves as a summary statistic about exchange rate flexibility. This strategy has three advantages:

1. We are able to measure and quantify the fine structure of intermediate regimes, with a real-valued measure of exchange rate inflexibility, the regression R^2.

2. Sharp dates are obtained, at which the exchange rate regime changed. We implement these methods using weekly percentage changes of exchange rates, which yields break dates to the resolution of the week. Through this, for each economy, a time-series of exchange rate flexibility is obtained, of the value of the R^2 which prevailed at a point in time. With estimates in hand for each economy at every point in time, it is easy to compute summary statistics about by averaging these parameters.

3. The number of breaks and the placement of breaks is based on sound inference procedures and can be readily recomputed to utilise current data.

[1]The Deutsche Mark is used as a proxy for the period prior to the EUR. Hence, the term 'DUR' is used instead of 'EUR', to convey the concatenation of the time-series of DEM/CHF rates followed by the EUR/CHF rates.

Table 1 Countries in the database

Region	1991-02-01	1996-02-01	2002-02-01
Asia	19	41	44
Africa	8	33	38
N.America	3	3	3
S.America	8	25	26
Oceania	3	6	8
E.Europe	1	9	9
World	48	129	143

At every point in time, our methodology yields a parameter vector $(\beta, \sigma_\epsilon, R^2)$ that prevails for each economy. These parameters are averaged across a group of economies to obtain a location estimator. Given the small samples, we use bootstrap estimation to obtain confidence intervals. In order to obtain more accurate results, the adjusted bootstrap percentile method is used, which corrects of bias and skewness of the bootstrap distribution (Davison, Hinkley, and Schechtman, 1986).

4 Data

We use daily exchange rate data from Bloomberg for the period February 1991 to December 2009. This data is converted to weekly returns data for the analysis. Table 1 describes the number of countries in the data set over time. Currently the data set includes 143 countries. The countries of Europe, US, Japan and the UK whose currencies are international currencies have been excluded from the data set.

5 Examples

5.1 Korea

As an example of this methodology, Table 2 shows the results for Korea. In the period of estimation (from January 1991 till December 2009, i.e. 18 years), six distinct sub-periods are identified. This implies that on average, a sub-period of the exchange rate regime lasted for 3 years. For each sub-period, the first row in the table shows parameter estimates and the next row presents the t statistic.

Table 2 The history of Korea's exchange rate regime, from January 1991 onwards

	Start Date	End Date	R^2	USD	DUR	GBP	JPY	Variance
1	1991-01-11	1995-01-20	0.98	1.01	-0.00	-0.01	-0.02	0.07
2	1995-01-27	1997-11-14	0.83	0.87	-0.06	0.07	0.16	0.42
3	1997-11-21	1998-09-11	0.15	-1.03	1.27	1.17	-0.09	7.58
4	1998-09-18	2006-05-19	0.70	0.63	0.18	0.06	0.31	0.81
5	2006-05-26	2008-02-22	0.79	0.84	0.33	0.01	-0.15	0.27
6	2008-02-29	2009-12-25	0.28	0.44	0.52	0.12	-0.27	3.10

In the early period (from 11 January 1991 onwards), the Korean Won was pegged to the USD. The R^2 was 0.98, the USD coefficient was 1.01 and the other coefficients were insignificant.

On 27 January 1995, Korea moved towards greater flexibility with a drop in the R^2 to 0.83. The extent of pegging to the USD also declined with a coefficient of 0.87, and a small weightage for the JPY is visible. These estimates for the 1st and 2nd periods are consistent with evidence for pre-crisis Korea such as Fukuda (2001).

During the Asian crisis, Korea experienced a dramatic change in the exchange rate regime starting from 21 November 1997, where the R^2 dropped to 0.15. The coefficients on the USD, the EUR and the JPY are not significant while the coefficient on the GBP was significant at a 10% level.

From 18 September 1998 onwards, there was a reversion to an intermediate regime, with an R^2 of 0.70, a coefficient of 0.63 for the USD, and coefficients of 0.18 and 0.31 for the EUR and the JPY respectively. Even though *de jure* inflation targeting was put into place, South Korea seems to have implemented a basket peg and intervened heavily in the Won-Dollar market. While Korea did exhibit 'fear of floating' after the crisis subsided, it did not go back to extent of exchange rate rigidity of either Period 1 ($R^2 = 0.98$) or Period 2 ($R^2 = 0.83$).

Between 26 May 2006 and 22 February 2008, the basket peg changed with weight on the USD increasing from 0.63 in the previous period to 0.84. The coefficient on the JPY dropped sharply.

On 29 February 2008, Korea shifted to a floating exchange rate regime with an R^2 of 0.28. This date of structural break was sixteen days before the failure of Bear Stearns and well before the Lehman crisis.

Figure 1 shows the time-series of the KRW-USD exchange rate, with vertical lines showing the estimated break dates.

Figure 1 Korean bilateral rate to the US dollar with structural breaks

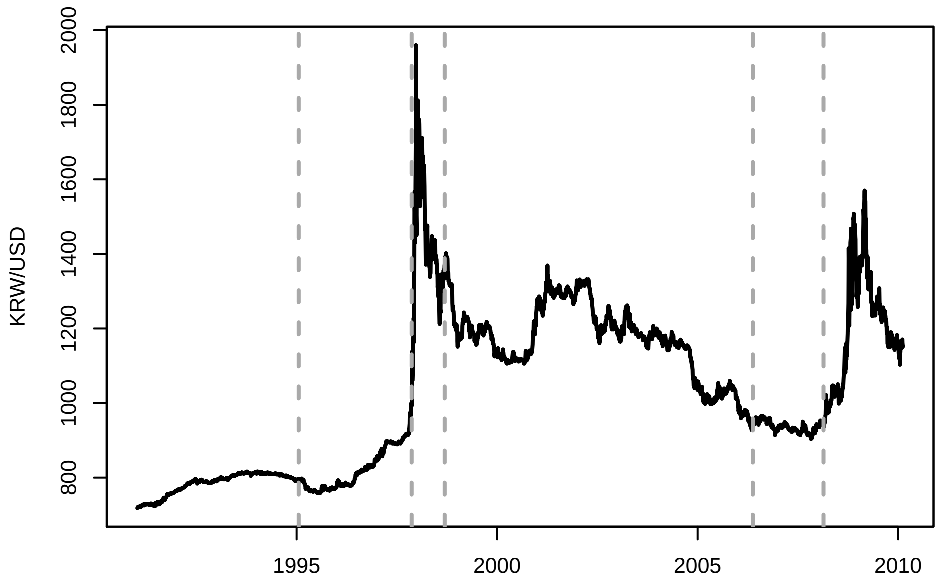


Table 3 The history of Singapore's exchange rate regime, from January 1991 onwards

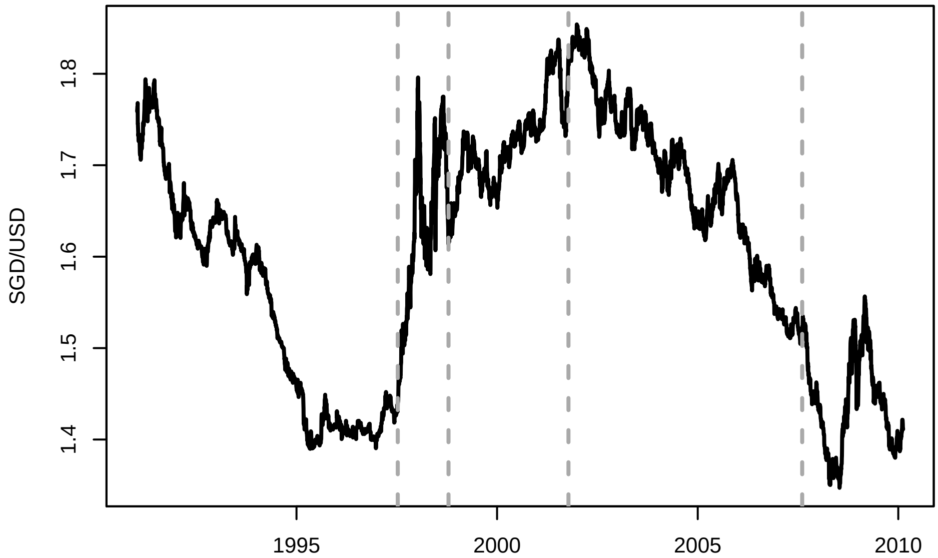
	Start	End	R^2	USD	DUR	GBP	JPY	Variance
1	1991-01-11	1997-07-11	0.92	0.78	0.16	0.01	0.10	0.15
2	1997-07-18	1998-10-16	0.22	-0.02	0.32	0.31	0.24	1.28
3	1998-10-23	2001-10-12	0.85	0.77	0.12	0.03	0.09	0.32
4	2001-10-19	2007-08-10	0.89	0.60	0.22	0.04	0.23	0.12
5	2007-08-17	2009-12-25	0.82	0.59	0.29	0.07	-0.02	0.26

5.2 Singapore

As a second example of this methodology, Table 3 shows the results for Singapore. In the period of estimation (from January 1991 till December 2009, i.e. 18 years), five distinct sub-periods are identified, which implies an average length of 3.6 years each.

Singapore adopted a *de jure* 'band, basket, crawl' regime in 1982, wherein the exchange rate is managed by the Monetary Authority of Singapore using undisclosed weights on a basket of currencies. Thus the weights obtained on the international currencies suggest important changes in the exchange rate regime in Singapore. The breaks in the exchange rate regime point to decisions by the Monetary Authority of Singapore to change the slope or the

Figure 2 Singapore's bilateral rate to the US dollar, with structural breaks



width of the band which operate as principle tools of managing the exchange rate.

In the period estimated (from January 1991 till December 2009), there have been five sub-periods of exchange rate regime. In the first period (from 11 January 1991 to 11 July 1997), the R^2 estimated was 0.92. The R^2 dropped to 0.22 during the Asian crisis (18 July 1997 to 16 October 1998). The conventional wisdom (e.g. Goldstein (1998)) suggests that Singapore escaped significant stress in the Asian crisis. However, these estimates show a significant change in the exchange rate regime, with the coefficient on the US dollar going to zero.

Since the Asian crisis, the R^2 has been within the range of 0.82 to 0.89 suggesting that there has been very little change in exchange rate flexibility. However, over the years, the weight on the US dollar has decreased from 0.78 in the first period to 0.59 in the last period (17 August 2007 to 25 December 2009). In the last period, the basket weights shifted in favour of the Euro and the dollar with the Yen out of the basket.

Figure 2 shows the time-series of the SGD-USD exchange rate, with vertical lines showing the estimated break dates.

Table 4 Examples of some well-known dates of structural change of the exchange rate regime

Country	Date	Event	Our date
Brazil	1999-01-16	Break peg	1999-01-15
Turkey	2001-02-15	New Turkish lira	2001-02-16
Sweden	1992-09-01	Float	1992-07-31
China	2005-05-22	Basket crawl	2005-05-22
Malaysia	2005-05-22	Managed Float	2004-05-22

5.3 Comparison against some well-known break dates

Table 4 shows five examples of prominent dates of structural change of the exchange rate regime. Each of these events is compared against the date seen in our database. Given the use of data at a weekly frequency, a mismatch of less than a week is the best that is feasible.

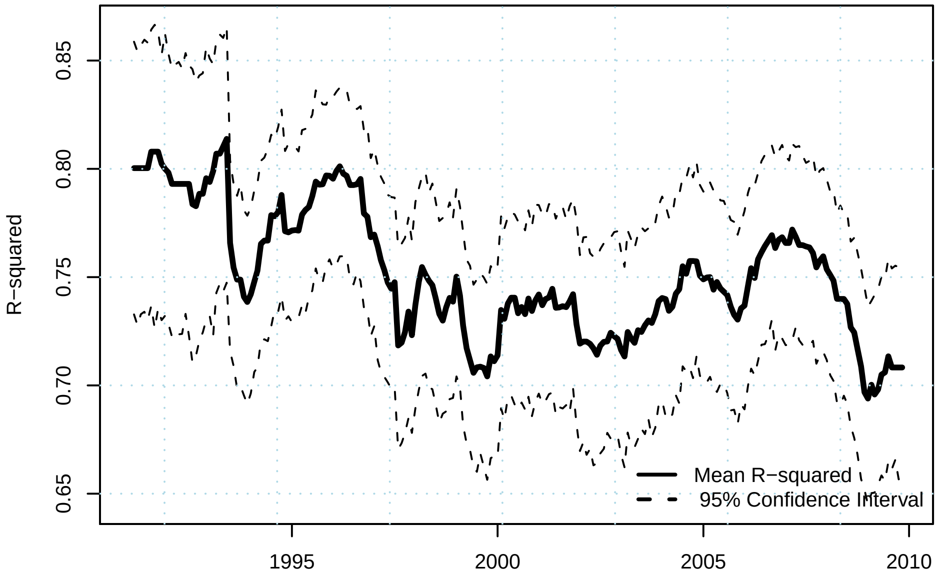
Brazil The *Plano Real* introduced in July 1994, culminated with a currency crisis on 16 January 1999. The real appreciated initially against the U.S dollar as a result of large capital inflows. The quasi- fixed exchange rate regime (*de jure* was dismantled and the exchange rate was allowed to move freely. However, the important change was in the basket weights. During the *Real plan* period, (8 July 1994 to 8 January 1999) the weight on the dollar was 1. However, our results suggest the period right after crisis, the coefficient on the dollar was 0.84 and the Euro gained significance with a weight of 0.39, contrary to the *de jure* claim of a free float.

Turkey The adverse political developments in February 2001 triggered heightened activities in the exchange rate market, with the *de jure* peg to the US dollar being abandoned. Official reserves were depleted by over 30 % with the lira depreciating by 40 % in one week. The *de jure* exchange rate regime was that of a floating exchange rate. Our methodology suggests that the lira has been a floating exchange rate since February 2001.

Sweden The Swedish Krona *de jure* was a managed float since November 1992. However, our methodology suggests that the Krona was *de facto* managed with respect to the Deutsche mark (with a coefficient of 0.65) since July 1992. The unsuccessful referendum held in September 2003 to join the Euro was preceded with a *de facto* peg to the Euro since 27 September 2002 and continued till 10 October 2008.

China The *de jure* basket peg of the yuan to 16 currencies was announced on 22 July 2005. However, our methodology suggests that the yuan became marginally more flexible with an R^2 of 0.97 (from 1.00 in the previous period)

Figure 3 Average R^2 across the world



and the weight on the dollar reduced from 1.0 (9 June 1995 to 15 July 2005) to 0.946 on this day. The peg to the dollar remained.

Malasyia Malaysia announced a change in the exchange rate regime on the same date as China. From being a peg to the dollar since the Asian crisis, the announcement of a managed float has been documented by our methodology. Since 22 July 2005, the R^2 dropped to 0.809 and the ringgit has been managed with a weight of 0.74 on the dollar, 0.26 on the euro and 0.02 on the pound. The yen has had no role in the management of the ringgit by the authorities.

6 Some applications

This database can help us answer many interesting questions about exchange rate regimes and their evolution. In this section, two questions are taken up.

Table 5 Average R^2 across regions

Region	1991-11-01	1999-11-01	2009-11-01
East Asia	0.9866	0.8262	0.7240
Asia	0.8785	0.8309	0.8338
Latin America	0.7726	0.8038	0.8110
Africa	0.7100	0.6124	0.6159
Oceania	0.6005	0.5514	0.4606
E.Europe	NA	0.4228	0.4758

Table 6 Average coefficients across different regions

	1991-11-01		1999-11-01		2009-11-01	
Region	USD	DEM	USD	EUR	USD	EUR
East Asia	0.99	0.02	0.91	0.03	0.80	0.03
Asia	0.91	0.06	0.95	0.05	0.87	0.10
Latin America	0.89	0.07	0.94	0.00	0.89	0.15
Africa	0.59	0.40	0.81	0.17	0.72	0.28
Oceania	0.79	0.16	0.64	0.32	0.55	0.47
E.Europe	NA	NA	0.53	0.35	0.34	0.75

6.1 Exchange rate flexibility

Has there been a rise in flexibility of the exchange rate regime in recent years? Figure 3 and Table 5 suggest no significant increase in flexibility. The null hypothesis of no-change of the mean R^2 between 1991 and 2009 cannot be rejected.

Certain patterns of exchange rate flexibility across continents are discernable. East Asia is the most inflexible, while Africa exhibits a shift towards greater flexibility alongside Asia. Latin America remains inflexible as well.

6.2 Rise of the Euro

The database offers an insight into the weights placed on different international currencies by non-European countries.

The world average value of the USD coefficient was near 0.9 in the period prior to the Asian crisis. There has been a sustained decline from this dollar-centric arrangement. The world average USD coefficient was at 0.75 by late 2009, and the null hypothesis of no-change can be rejected at the 95% level of significance. In late 2009, the biggest values for the USD coefficient were found in Latin America and the smallest average value (of 0.34) was found in Eastern Europe.

Figure 4 The decline of the US dollar

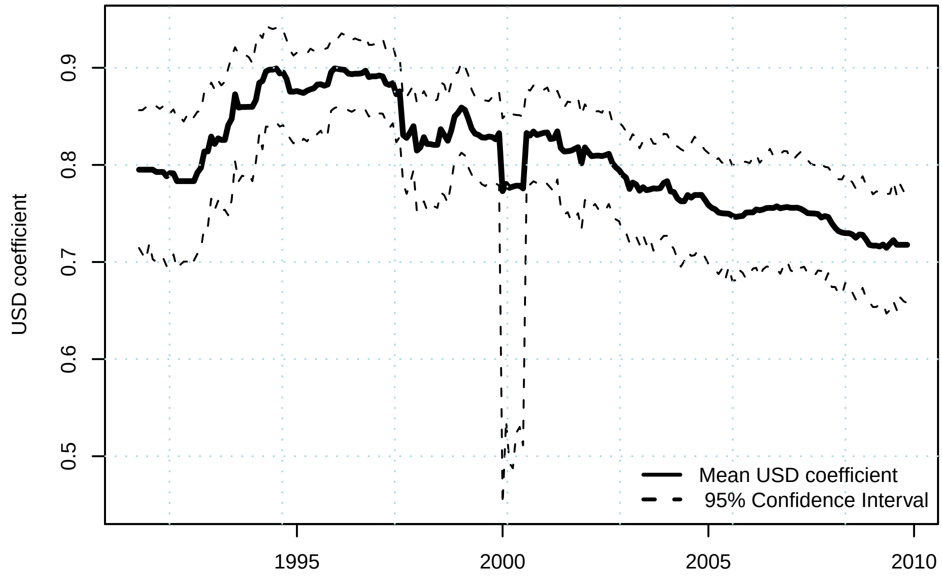


Figure 5 From Deutschemark to Euro

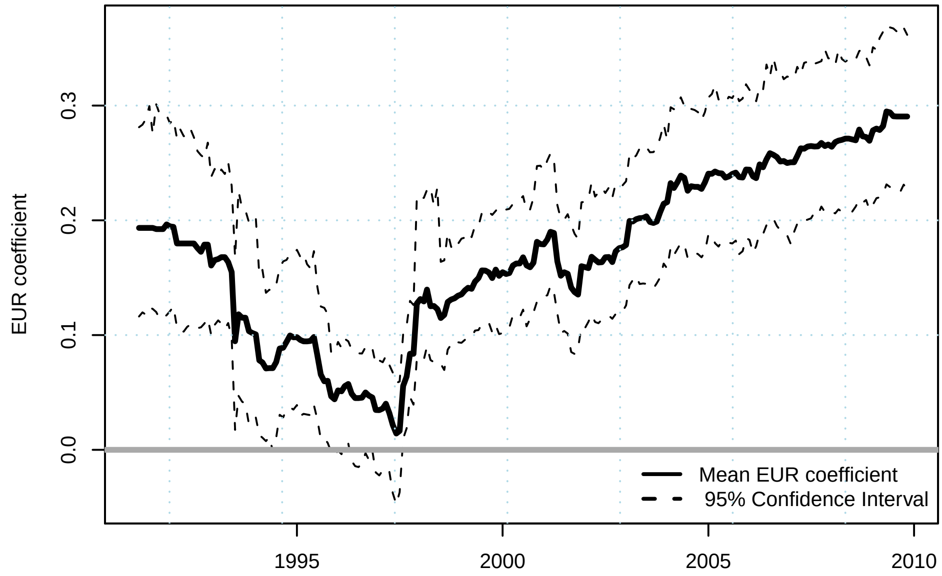


Figure 6 The decline and rebirth of the Pound

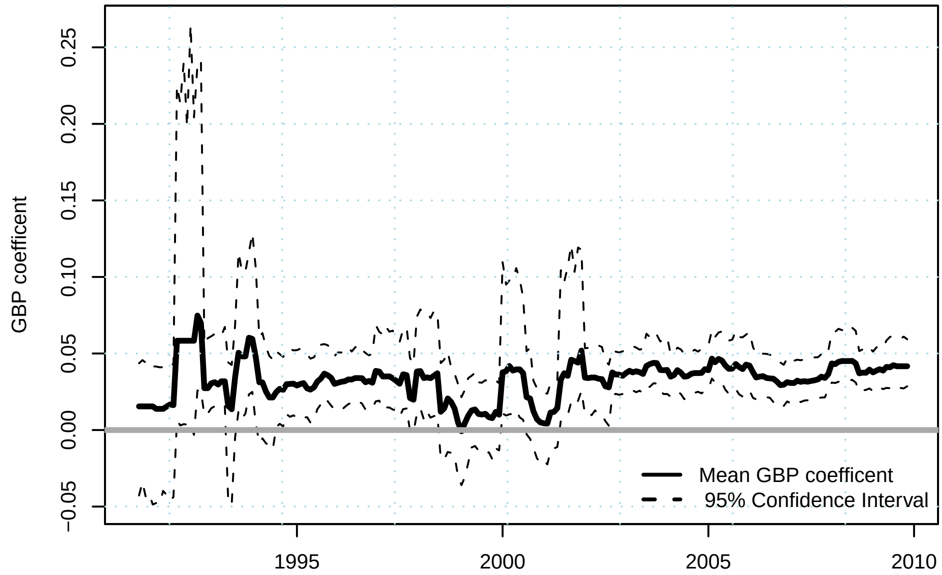
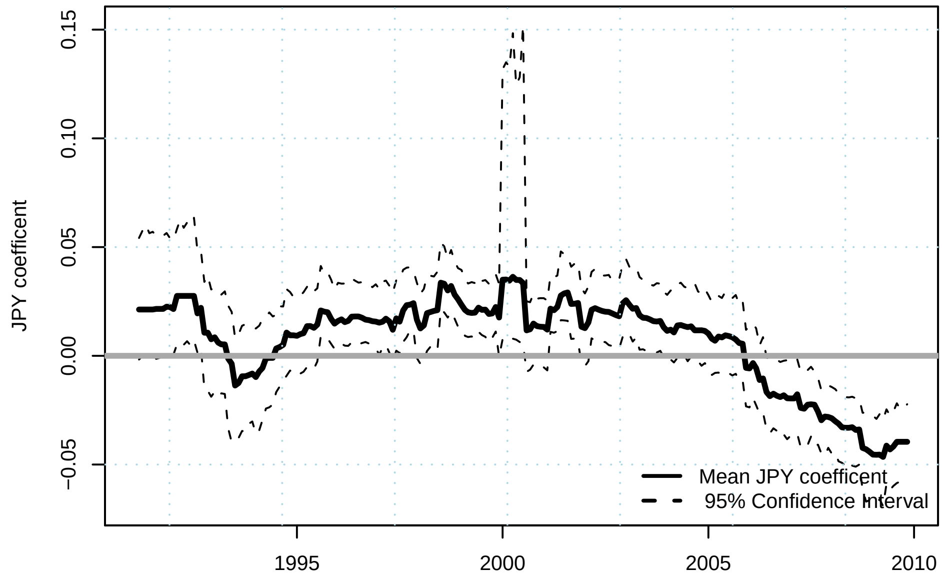


Figure 7 The brief phase of the Yen



The calculations splice the time-series for the Deutsche Mark with data for the Euro after the launch of the Euro. In the early 1990s, the average weight for the DEM was as high as 0.2. The uncertainty surrounding the success of the Euro appears to have been associated with the removal of the DEM and the EUR from basket pegs, to the point where the null hypothesis of a zero value for the mean coefficient cannot be rejected at a 95% level. From 2001 onwards, the average value of the Euro coefficient has risen consistently to a value of 0.3 by late 2009. The role of the Euro in currency arrangements is the most pronounced in Eastern Europe, Oceania and Africa.

With the pound also, a similar pattern of near-zero values is seen in the period around the establishment of the Bank of England as an independent inflation targeting central bank. From 2002 onwards, a small but statistically significant coefficient is visible.

With the Yen, there was a brief period from 1995 to 2004 where the null hypothesis of a zero average coefficient could not be rejected. However, after that, the role of the yen has dropped sharply, with an anomalous negative value seen in recent years.

7 Conclusions and areas for further research

This paper contributes to the literature on classification of exchange rate regimes. We move towards an explicit algorithm to classify regimes, thus eliminating the need for human judgment and thus discretion. This offers consistency in application across countries and across time. The classification is based on sound inferential strategy for dating of structural change. We simultaneously address the issue of currency or basket peg against other currencies and estimate flexibility. This is a replicable methodology and open source code is available free on the internet.[2] Some examples of the applications of this database include Patnaik and Shah (2009) and Patnaik and Shah (2010 (forthcoming)).

One weakness of the database is that while it is clear to see that exchange rate regimes are fixed when the R^2 is above 0.9 and close to one, the values of R^2 associated with a floating rate are not easily defined. These depend on the trade partners, geography and economic links that a country has.

[2]The full source code is available on the web at http://cran.r-project.org/package=fxregime

Some of the criticisms that apply to the Frankel-Wei regression, such as the choice of numeraire, the choice of international currencies (such as the Yen that have lost importance over time), and the questions this raises for consistency of the classification scheme, are also applicable to our methodology. Addressing these issues will strengthen the database further.

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