A statistically-based classification of de facto exchange rate regimes

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Abstract

The paper offers a new de facto classification of the exchange rate regimes. The new algorithm for classifying regimes is presented and applied to advanced, emerging and developing economies in the period from 1995 to 2014. The well-known classifications were not constructed with the use of formal statistical tools except for the classification developed by Levy-Yeyati and Sturzenegger (2005). Following their approach, this paper employs several techniques of cluster analysis but with certain important differences including the separate treatment of financially open and financially closed economies. To classify the former group, the trimmed k means method is used, whereas the latter group is classified with the k-nearest neighbour method. Moreover, foreign exchange reserves and exchange rate are treated symmetrically, standardization of main variables captures changes in the international context, and the classification is a two-way classification and is more up-to-date. The comparison of our classification with three most common classifications reveals that there are differences between them stemming from the differences in methodology and period coverage. The simple measure of overall consistency for the most similar classification is well below 80% but above 60% for the least similar classification.

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JEL Classification: F33, F31, C38, C82

1 Introduction

The choice of an exchange rate regime is one of the focal issues in international macroeconomics: suffice it to say that, according to one of the most prominent hypotheses, structural flaws of the interwar gold standard made the Great Depression so severe and prolonged (Bernanke and James, 1991). More recently, Obstfeld and Rogoff (2000) explained that the exchange rate is 'the single most important relative price, one that potentially feeds back immediately into a large range of transactions.' In his survey paper, Rose (2011, p. 671) claimed, however, that 'such choices [of the exchange rate regime] often seem to have remarkably little consequence. Exchange rate regimes are flaky: eccentric and unreliable.'

We think that confusion about ramifications of exchange rate regime choices – at least part of it – stems from the difficulties economists encounter when they attempt to classify actual exchange rate regimes. On the one hand, Obstfeld and Rogoff (1995) argued that 'the spectacular expansion of world capital markets' made the fixed exchange rate a 'mirage.' On

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the other hand, Calvo and Reinhart (2002) discerned the 'fear of floating' syndrome. More generally, declared (de jure) and actual (de facto) exchange rate regimes may differ: using Levy-Yeyati and Sturzenegger's (2005) terminology 'words' do not have to match 'deeds.'

Economists have been rather economical with the employment of statistical tools to classify exchange rate regimes. Out of the well-known classifications only the one developed by Levy-Yeyati and Sturzenegger (2005) was constructed with the usage of formal statistical methods (cluster analysis). We follow their approach, although we modify it in several respects. The analysis is carried out separately for financially open and financially closed economies; information conveyed in foreign exchange reserves and in exchange rates is treated symmetrically; standardization is done for each year separately; the exchange rate regime classification is in principle a two-way classification; and it is also more up-to-date.

2 Empirical strategy and data

Empirical strategy employed consists of seven steps. First, it is important to identify the reference currency. For example, the exchange rate of Danish krone against the US dollar is highly volatile, but it is fixed against the euro. Thus, in order to establish the reference currency, we followed the approach similar to McKinnon and Schnabl's (2004) and, using regression analysis, compared variability of exchange rates of a given currency against the US dollar, euro, Japanese yen, and British pound (in some cases we included Australian dollar, South African rand, Indian rupee and SDR).

Second, the country-year observations were split into two groups with respect to the openness to capital flows. The rationale behind the split is based on the macroeconomic trilemma stating that if the capital account is closed, monetary authority can retain monetary autonomy even though it engages in stabilization of the exchange rate. Moreover, focusing on financially open countries makes the problem of differences between market and official exchange rates less important (see Reinhart and Rogoff, 2004, and Shambaugh, 2004). The country-year observations above the median of Chinn-Ito index of capital openness were defined as financially open (Chinn and Ito, 2006).

Third, all variables used to build the classification were standardized. Standardization was constrained in two ways: it was applied to the set of observations selected in the previous step, and performed for each year separately. The reason behind the latter constraint was that the behaviour of economies in the face of global shocks is different from that in normal times.

Fourth, the cluster analysis was used to detect homogeneous groups of country-year observations. As there were quite a few outlying observations (mainly isolated outliers

according to García-Escudero et al. 2010), i.e. country-years with an extremely large change of exchange rates or foreign exchange reserves, we used trimmed k-means method. The trimmed k-means method allows for removing a certain fraction of the "most outlying" data, and, this way, a strong influence of outlying observations can be avoided and robustness naturally arises. The trimming approach to clustering was proposed in Cuesta-Albertos et al. (1997) and Gallegos (2002). Trimming can also be used to highlight interesting anomalous observations.

Fifth, one of the clusters obtained grouped quite a few observations with low variability of both exchange rate and foreign exchange reserves. These are characteristic for calm times. Following Levy-Yeyati and Sturzenegger (2005), we called this group 'inconclusives' and applied the k-means algorithm to such observations. The objective was to isolate peggers from floaters in this group and to extend the groups obtained in the previous step.

Sixth, the k-nearest neighbour method was used to classify countries that were relatively closed to capital flows. The method is based on finding the k nearest objects in a reference set and taking a majority vote among the classes of these k objects. Clusters obtained in the fourth step were used as the reference set, and thus a country closed to capital flows in a given year was classified to the most frequently represented category in the closest neighbourhood.

Seventh, the country-year observations that were not classified as either peggers or floaters were added to one of these groups. When the average absolute monthly change in the exchange rate was less than 0.01% (larger thresholds were also considered), a country-year was considered to peg its currency. Additionally, some countries 'under pressure' were reclassified as peggers/floaters if in the adjacent years they pegged/floated their currencies.

The sample covered 183 countries analysed in the period 1995-2015, i.e. a maximum of 3,843 country-year observations. The classification was based on five variables: capital openness index (developed by Chinn and Ito, 2006), two measures of exchange rate variability (the average absolute monthly change and standard deviation of monthly change), and two measures of foreign exchange reserves variability (the average absolute monthly change and standard deviation of monthly change). Due to limited data availability, the sample included 3,068 observations.

3 Empirical results

The examination of monthly exchange rates resulted in finding that the US dollar was by far the most prevalent reference currency – its 'share' was above 63%. The euro was found to be a base currency for slightly less than 30% of country-year observations. In eight cases

a different currency was identified as a reference currency: Australian dollar for Kiribati, South African rand for Botswana, Lesotho, Namibia, Swaziland, Indian rupee for Bhutan and SDR for Libya and Myanmar. Four cases of a switch from one currency to another were observed in our sample: Algeria switched in 2003 from euro to US dollar, Lithuania and Sao Tome and Principe switched from the US dollar to euro in 2002 and 2008 respectively, and Latvia switched from the SDR to euro in 2005.

In order to obtain homogenous clusters of country-year observations with the trimmed k-means method, we made two choices: the number of clusters was set to four and the fraction of observations to be trimmed of was set to two per cent. The former choice was motivated by theoretical considerations: with basically two variables, i.e. exchange rate variability and reserves variability, out of which each can take a 'low' or 'high' value, one should expect four different clusters: 'low/low', 'low/high', 'high/low' and 'high/high.' The silhouette measure for four clusters was 0.54 and was only slightly lower than for three or two clusters (0.61 and 0.57, respectively). Fewer than four clusters, however, seemed to be rather difficult to justify from both logical (see above) and economic points of view (for instance Levy-Yeyati and Sturzenegger (2005) had five clusters, although they did not report any statistical measure for that choice). In the latter choice we followed Levy-Yeyati and Sturzenegger (2005) and trimmed two per cent of the most outlying observations.

The results of cluster analysis for financially open country-years are illustrated in Figure 1. The axes represent the first two principal components: the first one corresponds to the volatility of the exchange rate and the second one to the volatility of foreign exchange reserves. After exclusion of the outliers (34 obs.), four groups were identified. Two of them are straightforward to decipher. Peggers (green crosses) experienced low exchange rate variability and above normal variability of foreign exchange reserves (308 obs.), whereas floaters (dark blue x's) had the opposite characteristics (389 obs.). Interestingly, we isolated the group of observations with even greater exchange rate variability than that characteristic for floaters and foreign reserves variability comparable to that characteristic for peggers (blue diamonds; 81 obs.). According to Levy-Yeyati and Sturzenegger (2005) – who obtained a similar cluster – such observations constitute a group of countries under intermediate exchange rate regimes (e.g. dirty float). It seems, however, that the group includes countries that were under strong foreign exchange market pressure (if not in an overt currency crisis) rather than countries that placidly managed their exchange rates. Moreover, one would expect the managed exchange rate to display on average lower variability than the freely floating rate. This is not the case here. Thus, contrary to Levy-Yeyati and Sturzenegger (2005), we

prefer to call this group ‘under pressure.’ The most numerous group (845 obs.), however, included country-year observations with below normal variability of both exchange rate and foreign reserves. Such characteristics are displayed by both peggers and floaters in calm times. Thus, the group consists of ‘inconclusives’ (red triangles), and the question about its true composition remains open. In order to narrow down the degree of inconclusiveness and in line with the methodology used by Levy-Yeyati and Sturzenegger (2005), we applied the simple k-means method (the outliers had been already excluded in the previous step) to divide this group into three categories: peggers (353 obs.), floaters (298 obs.) and deep inconclusives (194 obs.).

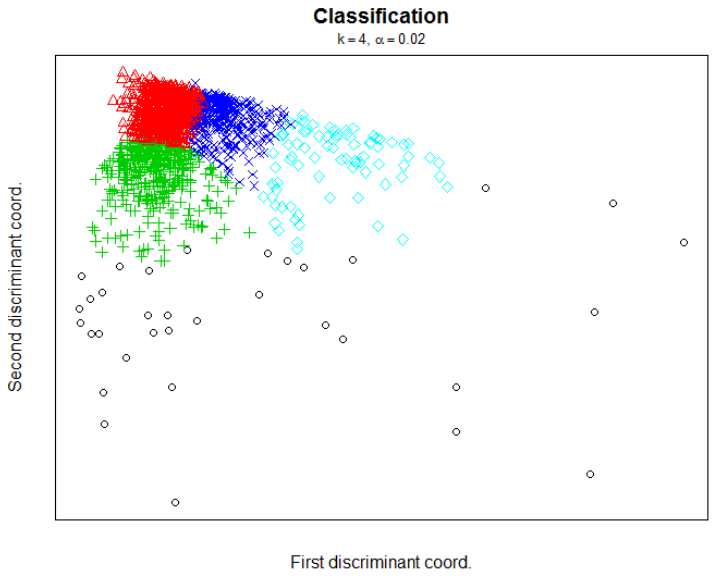

Fig. 1. Clusters of financially open country-years.

So far our procedure was directed at financially open economies which constituted 1,657 country-year observations. The remaining 1,411 observations referred to countries that were relatively closed to capital flows. As explained in the previous sections, these were classified with the k-nearest neighbour method. We tried from two to 20 neighbours and found out that the fraction of wrong classifications for a learning set (created from financially open countries) was the lowest for 13 neighbours. Thus, k parameter was set to 13 and financially closed economies were divided into peggers, floaters, inconclusives, countries ‘under pressure’ and outliers. The overall results of this and previous steps are reported in Table 1 in columns three and four. In the last step we moved 304 country-years from inconclusives, ‘under pressure’ or outliers to peggers (285 obs.) or floaters (19 obs.) if such a change was

uncontroversial. Two distinct criteria were used: (1) the country-year was reclassified as a pegger if the average absolute monthly change of the exchange rate was less than 0.01% (230 obs.) or (2) the country-year 'under pressure' was reclassified as a pegger (55 obs.) or a floater (19 obs.) if in the adjacent years it belonged to such a category. The final results are tabulated in columns five and six in Table 1. Overall, we identified more peggers (54.0%) than floaters (34.4%). This result was driven by relatively low incidence of floating exchange rate regime (25.2%) and high incidence of fixed rate arrangements (61.7%) in financially closed countries. In countries with open capital account the corresponding fractions were much closer one another (42.2% and 47.4%, respectively). This finding is in line with the conjecture that can be derived from the macroeconomic trilemma: when capital flows are controlled, it is more attractive for monetary authorities to maintain *de facto* fixed exchange rate as it does not require scarifying monetary autonomy. Interestingly, the category 'under pressure' is more frequent when a country is financially closed (4.4% vs. 0.8%). This could be an indication that the effectiveness of capital controls is limited, and that such barriers do not isolate an economy from foreign exchange market pressure.

Category	**Financial openness**	**Classification after:**			
		Steps 1-6		**Step 7**	
Peggers	open	1371	661	1656 (54.0%)	785 (47.4%)
	closed		710		871 (61.7%)
Floaters	open	1035	687	1054 (34.4%)	699 (42.2%)
	closed		348		355 (25.2%)
'Under pressure'	open	262	81	76 (2.6%)	14 (0.8%)
	closed		181		62 (4.4%)
Inconclusives	open	280	194	182 (5.9%)	125 (7.5%)
	closed		86		57 (4.0%)
Outliers	open	120	34	100 (3.3%)	34 (2.1%)
	closed		86		66 (4.7%)

Notes: 'open': Chinn-Ito index not less than 0.4, 'closed': Chinn-Ito index less than 0.4.

Table 1. Details of classification of exchange rate regimes.

Our classification as such is rather difficult to interpret. In order to shed more light on it, we compared it with other exchange rate regime classifications. Three popular classifications were taken into account. We considered the classification developed by Levy-Yeyati and

Sturzenegger (2005) since they adopted quite a similar approach to ours, i.e. they used statistical tools to distinguish alternative regimes. It was natural to take into account the classification tabulated by the IMF, because it is used in the literature as a kind of a reference point. A detailed work by Reinhart and Rogoff (2004) on exchange rate arrangements with its emphasis on market vs. official exchange rates is also quite popular in the literature on the international economics.

Examining the degree of consistency between alternative classifications, Klein and Shambaugh (2010, p.47) transformed each classification to a dichotomous division into pegs and non-pegs and then – for each pair of classifications – calculated the percentage of observations that were classified in the same way. We followed a similar, although not exactly the same, approach. First, we mapped alternative classifications into pegs and floats. In Levy-Yeyati and Sturzenegger's classification and in ours we retained the category of inconclusives and omitted the outliers. In our classification cases 'under pressure' were omitted. In two other classifications both hard and soft pegs were merged into pegs, whereas intermediate and freely floating regimes were combined into floats ('freely falling' and 'dual market in which parallel market data is missing' categories were omitted).

In Table 2 our classification is compared to the one by Levy-Yeyati and Sturzenegger (2005) for the overlapping period of both classifications, i.e. 1995-2004. The degree of consistency can be traced out on the main diagonal, whereas off-diagonal elements correspond to divergence between classifications. For example, out of 803 country-year observations recognized by our algorithm as pegs, 724 were classified in the same way by Levy-Yeyati and Sturzenegger (2005). This is more than 90%. The remaining observations were classified either as floats (51) or as inconclusives (28) – the corresponding 'shares' were 6.4% and 3.5%, respectively. There was less consistency with respect to floats: less than two-thirds of our floats were classified in the same category by Levy-Yeyati and Sturzenegger. This finding is, at least to a certain extent, the result of mapping intermediate regime into pegs. If instead they are treated as floats – i.e. in line with a dichotomous division into pegs and non-pegs used by Klein and Shambaugh (2010, p. 47) – the consistency between floats rises to 80.7% and that between pegs drops to 74.7% (not reported).

The comparison between our classification and those developed by the IMF and Reinhart and Rogoff (2004) is depicted in Table 3. The common period covered by all these classifications is from 1995 to 2010. The consistency of our classification with the IMF's one is lower for pegs (61.3%) and higher for floats (78.9%) in comparison to the consistency with Levy-Yeyati and Sturzenegger's classification. This effect tends to be even stronger if we

adopt Klein and Shambaugh's (2010) mapping (54.6% and 81.0%, respectively; not reported). In turn, the consistency between our classification and the one developed by Reinhart and Rogoff (2004) was the highest for pegs (94.5%) and the lowest for floats (57.3%). Like with Levy-Yeyati and Sturzenegger's classification, however, this finding can be reversed if the alternative mapping of Klein and Shambaugh (2010) is used with coefficients 64.5% and 92.8% (not reported).

		LYS Classification			
		Inconc.	**Peg**	**Float**	∑
Our Classification	Inconc.	13	61	6	80
		16.3%	76.3%	7.5%	
	Peg	28	724	51	803
		3.5%	90.2%	6.4%	
	Float	1	169	296	466
		0.2%	36.3%	63.5%	

Table 2. New classification against LYS classification.

			IMF Classification			**RR Classification**		
			Peg	**Float**	∑	**Peg**	**Float**	∑
Our	Classification	Peg	698	441	1139	1167	68	1235
			61.3%	38.7%		94.5%	5.5%	
		Float	164	614	778	325	436	761
			21.1%	78.9%		42.7%	57.3%	

Table 3. New classification against IMF and RR classifications.

The coefficient of overall consistency can be calculated as the number of observations on the main diagonal to the total number of observations. Using such a measure, we found out that our classification is the most similar to the one developed by Levy-Yeyati and Sturzenegger (76.6%), slightly less similar to the Reinhart and Rogoff's classification (75.0%), and the least similar to that of the IMF (64.1%). This result holds if we limit comparison just to pegs and floats (i.e. omit inconclusives) or/and apply Klein and Shambaugh's (2010) mapping (the relevant coefficients for this mapping were 73.3%, 70.4% and 61.1%, respectively).

Conclusion

The paper offers a new de facto classification of the exchange rate regimes adopted by both advanced economies and emerging and developing economies in the period from 1995 to 2014. We borrowed the idea of applying statistical tools, i.e. cluster analysis, to identify actual exchange rate regimes from the study by Levy-Yeyati and Sturzenegger (2005). Their study remains – to the best of our knowledge – the only one in the literature on exchange rate regimes in which cluster analysis techniques were applied. Our approach, however, differs from theirs in several respects. Its main distinctive feature is that we separated financially open countries from those that were closed to capital flows. Other differences include: 1) a symmetric treatment of foreign exchange reserves and exchange rate; 2) a standardization that provides consistency between country-years in turbulent and normal times; 3) a basically two-way classification into pegs and floats; 4) more up-to-date results.

Not surprisingly, we found that our classification is different from the one worked out by Levy-Yeyati and Sturzenegger (2005). It is also different from two other popular classifications developed by the IMF and Reinhart and Rogoff (2004). The comparison of our classification with the others is not straightforward as alternative classifications use different categories and cover different periods. A simple measure of consistency between classifications, however, revealed that our classification is the most similar to the one developed by Levy-Yeyati and Sturzenegger (2005), a bit less similar to the one worked out by Reinhart and Rogoff (2004) and the least similar to the IMF.

There are two main avenues of further research. First, our classification requires some refinements, e.g. the intermediate exchange rate regime category is missing in it. Second, the new classification can be used to establish how different (if at all) peggers are from floaters and whether Rose's (2011) scepticism about the exchange rate regime was well-founded.

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References

Bernanke, B., & James, H. (1991). The Gold Standard, Deflation, and Financial Crisis in the Great Depression: An International Comparison. In Hubbard, R.G. (ed.), *Financial Markets and Financial Crises*. Chicago: University of Chicago Press for NBER, 33-68.

Calvo, G. A., & Reinhart, C. M. (2002). Fear of floating. *The Quarterly Journal of Economics*, *117*(2), 379-408.

Chinn, M. D., & Ito, H. (2006). What matters for financial development? Capital controls, institutions, and interactions. *Journal of Development Economics*, *81*, 163-192.

Cuesta-Albertos, J. A., Gordaliza, A., & Matran, C. (1997). Trimmed k-Means: An Attempt to Robustify Quantizers. *The Annals of Statistics*, 553-576.

Gallegos, M. T. (2002). Maximum likelihood clustering with outliers. In: Jajuga K, Sokolowski A, Bock HH (eds.) *Classification, clustering and data analysis: recent advances and applications.* Springer-Verlag, Berlin, pp 247–255.

García-Escudero, L. A., Gordaliza, A., Matrán, C., & Mayo-Iscar, A. (2011). Exploring the number of groups in robust model-based clustering. *Statistics and Computing*, *21*(4), 585-599.

Ilzetzki, E., Reinhart, C. M., & Rogoff, K. S. (2011). The country chronologies and background material to exchange rate arrangements into the 21st century: Will the anchor currency hold. Available at personal. lse. ac. uk/ilzetzki/data/ERA-Country_ Chronologies_2011. pdf (accessed on January 31, 2017).

Klein, M. W., & Shambaugh, J. C. (2010). *Exchange rate regimes in the modern era*. MIT Press.

Levy-Yeyati, E., & Sturzenegger, F. (2005). Classifying exchange rate regimes: Deeds vs. words. *European Economic Review*, *6*(49), 1603-1635.

McKinnon, R., & Schnabl, G. (2004). The East Asian dollar standard, fear of floating, and original sin. *Review of Development Economics*, 8(3), 331-360.

Obstfeld, M., & Rogoff, K. (1995). The Mirage of Fixed Exchange Rates. *Journal of Economic Perspectives*, *9*(4), 73-96.

Obstfeld, M., & Rogoff, K. (2000). The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?. *NBER Macroeconomics Annual 2000, 115(1),* 339–90.

Reinhart, C. M., & Rogoff, K. S. (2004). The Modern History of Exchange Rate Arrangements: A Reinterpretation. *The Quarterly Journal of Economics*, *119*(1), 1-48.

Rose, A. K. (2011). Exchange rate regimes in the modern era: fixed, floating, and flaky. *Journal of Economic Literature*, *49*(3), 652-672.

Shambaugh, J. C. (2004). The effect of fixed exchange rates on monetary policy. *The Quarterly Journal of Economics*, *119*(1), 301-352.