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Determining global currency bloc equilibria

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Determining global currency bloc equilibria

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The study presents an empirical strategy for determining global currency bloc equilibria. The procedure includes, first, a nested logit estimation of the combined determinants of currency regime and anchor currency choice; second, a test for a welfare-maximising regime decision, in which estimates of the relative welfare of alternative regimes are inferred from the results of the first step estimation; third, taking the path dependency of regime choice into account, a currency bloc equilibrium is derived. In equilibrium, the dollar bloc is somewhat smaller and the euro bloc larger than at present. Counterfactual exercises assess among others the potential for a renminbi bloc.

Keywords: Currency Bloc Equilibrium, Anchor Currency Choice, Nested Logit, Additive Random Utility Model

JEL-Classification: F02, F31, F33, E42, C25

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Determining global currency bloc equilibria

1. Introduction

The current world economy is shaped by two major currency blocs, the US dollar bloc and the euro bloc, which coexist with numerous currencies that are left floating to various degrees. Optimum currency area (OCA) theories provide an economic rationale for a country's decision on being part of one of the blocs or of choosing a more flexible currency regime. If each country has taken this decision in a way that maximizes its welfare, the world could be characterized as a global currency bloc equilibrium. However, the empirical determination of such an equilibrium poses a challenge for research.

This study proposes a formal empirical welfare-related strategy for determining an equilibrium country composition of the currency blocs of the world. Thus, it re-considers the objective of Alesina *et al* (2002), who, in their study on "Optimal currency areas", investigate whether "natural currency areas emerge from an empirical investigation" (p 303). They check for a large number of countries whether various country-specific OCA indicators suggest that the country in question may belong to the US dollar area or the euro area. Instead of using a formal econometric strategy, any formal benchmark or a test of the country assignment decision, however, Alesina *et al* (2002) simply compare the values of theoretically plausible OCA indicators across countries in order to single out those which may belong to one currency area or the other.

A related strand of literature focuses solely on the cross-country co-movements of shocks in order to identify economies which may sensibly form a common currency area. According to several OCA theories, a highly positive shock correlation reduces the costs of a common currency. Empirical applications use various benchmarks to determine whether the estimated shock correlation is sufficient for a common currency, *inter alia* a comparison with the shock correlation among US regions (*cf* Bayoumi and Eichengreen, 1993), a test on the significance of the correlation coefficient (*cf* Eichler and Karmann, 2011), and a cointegration test for output series across countries (*cf* Cheung and Yuen, 2005). These benchmarks may be open to criticism, however, since they are unrelated to any welfare considerations and depend on the strategy for

identifying the shocks. Moreover, these studies ignore the results of a second strand of literature, which investigates empirically the impact of various OCA criteria on currency regime choice, and which is surveyed by Klein and Shambaugh (2010) and von Hagen and Zhou (2007).

In fact, if welfare considerations play a role in currency regime choice, the relative welfare of alternative regimes for a given country may be inferred from the relationship between observed currency regime choices and their OCA determinants. This is the basic idea which the present study exploits for the purpose of developing a strategy for the empirical determination of a global currency bloc equilibrium. In so doing, it addresses the critical issues mentioned above.

In a first step, the influence of OCA variables on exchange rate regime and anchor currency choice is estimated. This part of the analysis relates to the empirical literature on currency regime choice mentioned above.[1] Still, the present analysis needs to go beyond those earlier studies, because in focusing on currency regime choices, they usually do not distinguish between different anchor currencies, and, therefore, say nothing about the determinants of currency bloc affiliation. As an exception, Meissner and Oomes (2009) explicitly consider anchor currency choice but their sample ends in 1998, the year before the euro was introduced.[2] Since then, the situation has changed fundamentally because, now, there are two major currency blocs instead of just one.

A further contribution made by this part of the paper is methodological: The anchor currency choice options are conditional on a decision on an exchange rate peg in the first place. This obvious nesting structure of the modelled decision suggests using a nested logit approach for estimation. The approach allows the isolation of factors that distinguish US dollar bloc from euro bloc countries. It is found that OCA criteria and related structural variables are significant determinants of countries' currency regime and anchor currency choices.

[1] Note that, in line with this literature, the present study deviates from Alesina *et al* (2002) and related papers by considering currency blocs that are less strictly defined than being just currency unions. The difference simply concerns the intensity of the anchoring commitment.

[2] Interestingly, Meissner and Oomes (2009) find only weak support for the symmetry of GDP co-movements playing a role in anchor currency choice: The analysis of three anchor currencies yields results according to which co-movements are insignificant in one case, significant with the incorrect sign in the second case, and significant with a correct sign only in the third case.

As a second step, the study is, to my knowledge, the first to propose an intuitive welfare-related empirical test on the relative desirability of a given country adhering to a given currency bloc or exchange rate regime. The testing procedure exploits the fact that the estimated model is found to be consistent with an additive random utility model (ARUM) interpretation. This implies that countries choose the regime that provides the greatest welfare, while the welfare functions depend additively on the explanatory variables. For a few countries, however, the estimated relative welfare of the prevailing regime is largely generated by an error term. In these cases, the structural explanatory variables may suggest that a change in the currency regime significantly increases their estimated welfare.

As a third step, the study adopts a currency bloc equilibrium definition from Alesina and Barro (2002) and presents an algorithm which determines such an equilibrium empirically. The algorithm identifies the estimated welfare-maximising currency regime and anchor currency choices for each country. It takes account of the effects which a regime decision of one country may exert on the optimal choice of all the other countries. Subsequently, it is explored how the computed currency bloc equilibrium is affected by a number of counterfactual economic policy initiatives. The policy shocks include the adoption of a euro (dollar) peg by some European Union (American) countries which currently allow their currencies to float, and the termination of the use of the US dollar as an invoice currency for oil exports. A final exercise assesses the renminbi's potential for becoming the core of a third major currency bloc.

The next chapter defines and describes present-day currency blocs. Chapter 3 details the econometric strategy. Chapter 4 presents the results of an empirical analysis of currency regime and anchor currency choice. Chapter 5 contrasts the prevailing regimes with the optimal choices. A global currency bloc equilibrium is computed in Chapter 6. Chapter 7 discusses the repercussions of counterfactual economic policy decisions for the equilibrium, and Chapter 8 concludes.

2. Currency blocs: classification and the *status quo*

An investigation into currency bloc composition first requires a definition of a currency bloc.

Definition: *A country is a member of a* ***currency bloc*** *if its currency's bilateral exchange rate against each third country's currency moves proportionally to the corresponding bilateral exchange rate of the core country of the currency bloc.*

The present study assigns countries which belong to a currency bloc in the above sense to the coarse category "peg" and all the remaining countries to the coarse category "float". Because of the present dominance of the US dollar and the euro as anchor currencies, only the US dollar and the euro bloc are explicitly modelled. All the remaining pegs, including those to currency baskets, are combined in the residual category "peg to another currency". This leaves a classification into the four categories: floating exchange rate, peg to the US dollar, peg to the euro, and peg to some other currency.

The core country of the US dollar bloc is obviously the United States. In line with studies such as Bayoumi and Eichengreen (1993), Germany is used as the core country of the euro bloc. The currency regimes of these two countries are considered as floats by definition and are not investigated further. A classification scheme is necessary to assign all the remaining countries to one of the four categories. For this purpose, the present analysis uses the IMF's *de facto* classification of exchange rate arrangements.[3] Starting with the 1999 volume, the IMF's "Annual Report on Exchange Arrangements and Exchange Restrictions" contains information on *de facto* exchange rate regimes. As outlined in the compilation guide chapter of these reports, countries are required to notify their exchange rate regime to the IMF. If this *de jure* regime is empirically confirmed over at least six months, the *de jure* classification is adopted in the *de facto* classification; otherwise, the regime is reclassified according to the empirical results. Apart from being a *de facto* classification, the IMF classification scheme lends itself to the analysis by being up to date and by its comprehensive coverage of the countries of the world. The fact that the authorities' effective decisions play a role is beneficial, since they will be modelled as being a reaction to the structure of their countries' economy.

[3] Rose (2014) is another recent study which uses the IMF's exchange rate classification scheme. Alternative schemes have been developed, notably by Levy-Yeyati and Sturzenegger (2003), Reinhart and Rogoff (2004), Shambaugh (2004), and, more recently, Dubas *et al* (2010).

In accordance with the above definition, the following IMF exchange rate arrangements indicate that a country is part of a currency bloc: "no separate legal tender", "currency board", "conventional peg", "stabilized arrangement" and "pegged exchange rate within horizontal bands". All the countries which the IMF classifies accordingly are grouped into the coarse "peg" category and thus into a currency bloc. Member countries of the European Monetary Union (EMU) are, of course, treated as belonging to the euro bloc as well.[4] Non-EMU countries which the IMF classifies as having an exchange rate arrangement different from those enumerated above are subsumed in the category "float". The observation period has been chosen to start in 1999 because this was the year in which the euro, the anchor currency of the euro bloc, was introduced.[5]

Figure 1 shows the geographic distribution of the US dollar bloc and the euro bloc in 2012, the final year of the observation period. US dollar bloc members are displayed in dark grey and euro bloc members in a medium shade of grey. Names of euro bloc countries are written in italics. Countries and territories shown in light grey (or not depicted at all) either belong to one of the categories "float" or "peg to another currency", or they are not included in the sample due to data deficiencies.[6]

The map shows that, apart from the USA, the US dollar bloc often comprises smaller countries of Central America, the West Indies, the northern part of South America, a cluster of mostly oil-exporting countries in the Arabian peninsula and Central Asia and a group of other countries including Angola, Hong Kong, Ukraine or Vietnam. In most of the years until 2009, China belonged to the US dollar bloc, too. The euro bloc is obviously concentrated on Europe and includes, apart from EMU member states, countries that participate in the Exchange Rate Mechanism II, and several Balkan countries. A second group of euro bloc members are countries in Africa which are mostly former French colonies.

[4] Since 2007, the IMF has classified the exchange rate arrangement of the EMU countries as "independently floating" because the authorities let the euro float against other currencies. Until 2006, however, the IMF applied the category "exchange arrangement with no separate legal tender" to them.

[5] Year 1999 regime data, for example, are taken from the year 2000 issue of the IMF's "Annual Report on Exchange Arrangements and Exchange Restrictions" because, due to the publication lag, data provided in a given annual issue are generally assigned to the previous year in the present study.

[6] A list of the 165 countries and territories included in the sample is given in Appendix 1.

Turning to the evolution of the two major currency blocs in the period since 1999, it turns out that the euro bloc was extremely stable compared with the US dollar bloc. The only countries that left the euro bloc – intentionally or not – were Hungary and Croatia. In contrast, 38 countries from all over the world left the US dollar bloc at least once during this period. The large number of exits from a dollar peg, however, do not imply that there was a decline in the number of countries limiting the flexibility of their currency vis-à-vis the US dollar; instead, the number of dollar bloc countries and territories in the sample increased from 27 in 1999 to 38 in 2012.

3. Econometric strategy

3.1 A nested logit approach for the combined estimation of currency regime and anchor currency choice

The first step of the strategy for an empirical determination of a global currency bloc equilibrium is the modelling and estimation of the individual countries' combined currency regime and anchor currency choice. Given the classification into the four categories described in the previous chapter, the consideration of whether to join (or leave) a currency bloc needs to be taken within a framework as shown in Figure 2. This involves two interrelated issues: First, the decision on a specific currency regime and, second, given that a peg has been chosen, the decision on a specific anchor currency. The issue of anchor currency choice arises only conditional on a decision on a limit to exchange rate flexibility. A proper estimation method for cases where decisions have a clear nesting structure, like the one in Figure 2, is the nested logit, which goes back to McFadden (1978, 1981).

For a description of the present nested logit framework, assume that all the regressors vary across countries, but not across alternatives, and that a flexible exchange rate (alternative 4) is the base category for currency regime choice, the first-level decision. Denote the probabilities p of country i ($i = 1, \dots, N$) choosing a pegged (P) or a floating (F) exchange rate as p_{iP} and $p_{iF} = 1 - p_{iP}$, respectively. Without loss of generality, assume, further, that the option to choose an anchor currency other than the US dollar or the euro is the base category for anchor currency choice, the second- level decision. Given that country i decides to peg its exchange rate, denote the probabilities of choosing the euro as anchor currency (alternative 1), the US dollar (alternative 2), or

some other currency (alternative 3), as $p_{i1|P}$, $p_{i2|P}$, and $p_{i3|P} = 1 - p_{i1|P} - p_{i2|P}$. Then, the overall probabilities of country i choosing one of the four options are given in a nested logit framework by

$$p_{i1} = p_{i,peg\_euro} = p_{iP} \times p_{i1|P} = \frac{\exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)}{1 + \exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)} \cdot \frac{\exp(\mathbf{x}_1'\boldsymbol{\beta}_1 / \tau)}{\exp(I)}, \tag{1}$$

$$p_{i2} = p_{i,peg\_dollar} = p_{iP} \times p_{i2|P} = \frac{\exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)}{1 + \exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)} \cdot \frac{\exp(\mathbf{x}_2'\boldsymbol{\beta}_2 / \tau)}{\exp(I)}, \tag{2}$$

$$p_{i3} = p_{i,peg\_other} = p_{iP} \times p_{i3|P} = \frac{\exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)}{1 + \exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)} \cdot \frac{1}{\exp(I)} \tag{3}$$

and

$$p_{i4} = p_{i,float} = p_{iF} = \frac{1}{1 + \exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)} \tag{4}$$

where $\sum_{j=1}^{4} p_{ij} = 1$ for each i, $\mathbf{z}$ is a vector of explanatory variables for the first-level decision, currency regime choice, $\boldsymbol{\alpha}$ is the corresponding parameter vector, $\mathbf{x_1}$ and $\mathbf{x_2}$ are two vectors of explanatory variables for the second-level decision, anchor currency choice, $\mathbf{x_1}$ ($\mathbf{x_2}$) determining the choice of a peg to the euro (the US dollar) over a peg to some other currency, $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ denote the corresponding parameter vectors, τ is the dissimilarity parameter for the fixed exchange rate options and I the inclusive value of choosing a peg,

$$I = \ln\left[1 + \exp(\mathbf{x}_1'\boldsymbol{\beta}_1 / \tau) + \exp(\mathbf{x}_2'\boldsymbol{\beta}_2 / \tau)\right]. \tag{5}$$

A FIML approach can be used to estimate the nested logit. Define four binary variables, y_{ij} (j = 1, ... , 4), for each country i such that y_{ij} = 1 if alternative j is chosen and y_{ij} = 0 otherwise. Then, the FIML estimator maximizes the log likelihood

$$\ln \mathrm{L} = \sum_{i=1}^{N} \sum_{j=1}^{4} y_{ij} \ln p_{ij} \tag{6}$$

with respect to $\boldsymbol{\alpha}$, $\boldsymbol{\beta_1}$, $\boldsymbol{\beta_2}$ and τ.

3.2 An ARUM interpretation of the results

A sufficient condition for the nested logit model to be consistent with an additive random utility model (ARUM) interpretation is $0 \leq \tau \leq 1$ (*cf* Börsch-Supan, 1987, p 49). In this case, country *i*'s welfare of choosing alternative *j* is given by

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{7}$$

where ε_{ij} is an iid error and V_{ij} is the deterministic component of country *i*'s welfare. In the present setting, the deterministic component of welfare from choosing a floating exchange rate is normalized to zero, $V_{i4} = 0$. For the three options that involve a currency peg,

$$V_{i1} = \mathbf{z}'\boldsymbol{\alpha} + \mathbf{x}_1'\boldsymbol{\beta}_1, \tag{8}$$

$$V_{i2} = \mathbf{z}'\boldsymbol{\alpha} + \mathbf{x}_2'\boldsymbol{\beta}_2 \tag{9}$$

and

$$V_{i3} = \mathbf{z}'\boldsymbol{\alpha}. \tag{10}$$

The nested logit differs from a simple multinomial logit in that, here, the multinomial logit's assumption of independence of irrelevant alternatives is relaxed. While a multinomial logit would treat the residuals in (7) from all the four alternatives as being independent of each other, the nested logit allows them to be correlated. If the estimated model is consistent with an ARUM interpretation, the dissimilarity parameter τ can be interpreted as $\tau = \sqrt{1-\rho}$, and ρ is the corresponding correlation coefficient for the three options that involve a currency peg.

3.3 A Wald test of the relative desirability of a country's chosen regime

After having estimated the influence of explanatory variables on currency regime and anchor currency choice, the crucial challenge for obtaining a global currency bloc equilibrium is to develop a measure that, given the estimation results, suggests for each country whether the chosen regime really is the most desirable one. Such a measure should define desirability purely from the perspective of the country in question.

Alesina *et al* (2002) and empirical studies of the shock co-movement literature compare a country's value of a specific OCA indicator to some benchmark and draw

conclusions about the desirability of the country's affiliation to a given currency area. By this line of reasoning, they implicitly assume that, depending on its OCA indicator value, the country in question either has chosen an economically optimal regime or, alternatively, it may have taken a policy decision that does not maximize its economic welfare, for instance because policymakers' utility maxima differ from social welfare maxima, because of political inertia or because short-term or non-economic reasons prevent a regime choice that is socially optimal from an economic point of view.

Exploiting the ARUM framework, these ideas can be formalized. If an ARUM interpretation of the estimated model is admissible, a country's exchange rate regime and anchor currency choice can be viewed as the outcome of a rational welfare-maximising decision. According to equation (7), however, the estimated value of relative welfare of alternative j, U_{ij}, is composed of two parts: first, deterministic welfare, V_{ij}, that is explained by the regressors of the model and, second, an error term, ε_{ij}. If the error is large, deterministic welfare V_{ik} of an alternative regime k, may be larger than deterministic welfare V_{ij} of the prevailing regime j. Large errors can occur, of course, when the model ignores important explanatory variables. Under the assumption that the model has been correctly specified, however, a finding that $V_{ik} > V_{ij}$ indicates – in line with the literature's reasoning – that the country in question has failed to choose the socially optimal currency regime or anchor currency.

Using the estimation results, it is testable whether deterministic welfare V_{ik} of regime k is significantly larger than the deterministic welfare V_{ij} of regime j that prevails in country i, ie whether the estimated model would suggest a change in the exchange rate regime or the anchor currency for country i. A Wald test statistic for

$$H_0\text{: } \hat{V}_{ik} - \hat{V}_{ij} = 0 \tag{11}$$

against H_1: $\hat{V}_{ik} - \hat{V}_{ij} > 0$ is given by

$$W = \frac{\left(\hat{V}_{ik} - \hat{V}_{ij}\right)^2}{\hat{Var}\left(\hat{V}_{ik} - \hat{V}_{ij}\right)} \sim \chi^2_{df=1} \tag{12}$$

and

$$\hat{Var}\left(\hat{V}_{ik} - \hat{V}_{ij}\right) = \hat{\mathbf{\Gamma}}'\hat{\mathbf{\Sigma}}\hat{\mathbf{\Gamma}} \tag{13}$$

where

$$\hat{\boldsymbol{\Gamma}} = \left[\left. \frac{\partial \left(V_{ik} - V_{ij} \right)}{\partial \boldsymbol{\theta}} \right|_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}} \right], \tag{14}$$

$\boldsymbol{\theta} = \left(\boldsymbol{\alpha}' \quad \boldsymbol{\beta}_1' \quad \boldsymbol{\beta}_2' \quad \tau \right)'$ and $\hat{\boldsymbol{\Sigma}}$ denotes the estimated covariance matrix of $\boldsymbol{\theta}$. Note that the application of a test is a comparatively restrictive procedure to identify regime changes because it requires the deterministic welfare of the alternative regime to be statistically *significantly* larger than the one of the prevailing regime.

4. Estimates of currency regime and anchor currency choice

4.1 Explanatory variables

An estimation of the econometric model (1) to (6) requires a set of explanatory variables for the first-level decision on currency regime choice, the vector **z**, and a set of explanatory variables for the second-level decision on anchor currency choice, the vectors $\mathbf{x_1}$ and $\mathbf{x_2}$. Since the objective of the econometric model is to investigate the effects of the fundamental long-term structural determinants, the econometric model focuses, in particular, on variables which are related to optimum currency area (OCA) theory.[7] Overviews of the empirical OCA literature, which examine variables that may be included in vector **z**, are given *inter alia* by Klein and Shambaugh (2010) as well as von Hagen and Zhou (2007). A recent study by Meissner and Oomes (2009) specifically considers determinants of anchor currency choice in the era prior to the introduction of the euro, ie variables that may be included in vectors $\mathbf{x_1}$ and $\mathbf{x_2}$.

Following the literature, the determinants of currency regime choice (vector **z**) are chosen to comprise (the log of) real GDP expressed in purchasing power parities as a proxy for the degree of international economic integration in goods and factor markets, and (the log of) real *per capita* GDP expressed in purchasing power parities as an

[7] In studies such as Poirson (2001), Juhn and Mauro (2002) and von Hagen and Zhou (2007), the list of explanatory variables is extended beyond OCA criteria to include political factors and variables related to the importance of real versus nominal shocks. These variables cannot contribute, however, to an explanation of anchor currency choice. Moreover, Levy-Yeyati *et al* (2010) have demonstrated the exclusive relevance of OCA criteria for the regime choice of both industrialized and non-industrial countries. Finally, we follow Alesina *et al* (2002) in ignoring variables related to financial markets and Klein and Shambaugh (2010, p 87) in ignoring macroeconomic variables such as inflation or the volatility of the real exchange rate that could be highly endogenous to the exchange rate regime choice. The selection of variables additionally depends on their availability for most of the countries of the world because stable results of a nested logit regression require a sufficiently large sample.

indicator for production and/or consumption diversification.[8] OCA theory suggests that a higher real GDP (real GDP *per capita*) reduces (raises) the welfare from a peg in equations (8) to (10), which amounts to a negative (positive) sign of the corresponding α parameter.[9,10]

The determinants of anchor currency choice (vectors $\mathbf{x_1}$ and $\mathbf{x_2}$) include, first, trade integration within a currency bloc, which Meissner and Oomes (2009) identify as a central determinant of anchor currency choice in the post Bretton Woods era. It is important to note that it is not simply trade with the country that issues the anchor currency but trade with all the bloc members that is expected to govern anchor currency decisions (see Yehoue, 2004). Trade integration with a given currency bloc is measured as trade of country *i* at time *t* with all the (other) countries that belong to the bloc at time *t* as a fraction of country *i*'s total trade. Given the data on anchor currency choice at time *t*, on exports *X* to all destination countries *k* and on imports *M* from all origin countries *k*, the trade share *S* of country *i* with the US dollar (*USD*) bloc at time *t* is computed as

$$S_{i,t}^{USD} = \frac{\sum_{k \in USD(t)} X_{i,k,t}}{\sum_{k} X_{i,k,t}} \cdot \frac{\sum_{k} X_{i,k,t}}{\sum_{k} X_{i,k,t} + \sum_{k} M_{i,k,t}} + \frac{\sum_{k \in USD(t)} M_{i,k,t}}{\sum_{k} M_{i,k,t}} \cdot \left(1 - \frac{\sum_{k} X_{i,k,t}}{\sum_{k} X_{i,k,t} + \sum_{k} M_{i,k,t}} \right) \quad (15)$$

and the trade share with the euro bloc analogously. For each country, such trade shares have been computed for both blocs for each of the years 1999 to 2012. The trade share for the euro bloc is included in vector $\mathbf{x_1}$ and the trade share for the dollar bloc in vector $\mathbf{x_2}$. In both cases, theory would suggest a positive coefficient.[11]

The log of great circle distance between a given country's capital and the location of the central monetary policy authority of each currency bloc is used as a second determinant of anchor currency choice. Log distance to Frankfurt has been included in

[8] A description of data sources for the explanatory variables is given in Appendix 2.

[9] Note that the sign of the α coefficients is equal to that of the corresponding marginal effects because the first decision level (peg versus float) of the nested logit has just two alternatives. The same is true of all the $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ coefficients of those variables that enter either vector $\mathbf{x_1}$ or vector $\mathbf{x_2}$ but not both.

[10] For the corresponding OCA theories, see, for example, Kenen, 1969, McKinnon, 1963, Pang and Tang, 2014. Robustness checks show that including trade openness yields insignificant coefficients while replacing real GDP by population yields results that are virtually identical to those presented here.

[11] Fischer (2011) investigates the issue of potential endogeneity of the trade share in the present framework. He provides evidence that causality runs from the trade share to regime choice.

vector $\mathbf{x_1}$ and log distance to Washington, DC, in vector $\mathbf{x_2}$. Both coefficients should be negative because a small distance may imply high factor mobility (*cf* Mundell, 1961), more symmetric co-movements of business cycles (*cf* Alesina and Barro, 2002), more similar consumption patterns (*cf* Corsetti, 2010) and more similar preferences concerning the conduct of monetary policy (*cf* Haberler, 1970). The percentage of net oil exports in total exports, a variable which is set to zero for all net oil importers, is included in both $\mathbf{x_1}$ and $\mathbf{x_2}$. Because oil is invoiced in US dollars, a dollar peg would stabilize exports, and thus public revenues of oil exporters. As a final explanatory variable, a colony dummy enters vector $\mathbf{x_1}$. The dummy is set to one if the country in question has still been governed by one of the euro bloc countries after 1959. It is expected to have a positive β coefficient (*cf* Klein and Shambaugh, 2010).

4.2 Estimation results

The last column of Table 1 shows the results for the coefficients of the pooled estimation of the econometric model (1) to (6). Robust standard errors have been obtained by clustering observations by countries. For comparison, results for the cross-sectional estimates in 2000 and 2012, respectively, are presented as well. In a non-linear model like the present one, the sample averages of the marginal effects may be more instructive than the coefficient estimates, especially concerning their economic significance. These marginal effects of each variable on each alternative are therefore presented in Table 2.

Tables 1 and 2 show that the explanatory variables contribute significantly to explaining exchange rate regime and anchor currency choice. The signs of all the effects correspond to their expected values. The probability of choosing a fixed exchange rate is low if a country's real GDP is relatively high, and it is high if the country is relatively rich in terms of real GDP *per capita*. Given that a country decides on a peg, the probability of choosing the euro as anchor currency increases if a country trades extensively with euro bloc members and it decreases with the distance of the country's capital from Frankfurt am Main, the location of the European Monetary Union's central bank. Similarly, having a large trade share with members of the dollar bloc increases the probability of a country belonging to the dollar bloc itself, and being located far from Washington, DC, reduces this probability. Finally, having been a colony of one of the

euro bloc members considerably increases the probability of using the euro as an anchor currency.

Most of the coefficients are highly significant. An exception to this is the coefficient for the distance from Washington, DC, whose sign coincides with theoretical predictions, but it is significant only in individual years such as 2000. This suggests that the US dollar is used as an anchor currency on a global scale, while the euro is more of regional importance as an anchor currency. Fischer (2011) shows, however, that this outcome is due entirely to the group of countries which peg their currencies only temporarily to the US dollar, while no comparable group exists in the euro bloc. If this group is eliminated from the sample, the coefficient for distance from Washington, DC, becomes highly significant.

The other variable which is statistically insignificant is the share of net oil exports in total exports. Since this variable is included as a regressor in both the euro and the US dollar peg equations, the isolated consideration of each of the two coefficients might not reflect the variable's importance. According to a Wald test, however, the equality of the two estimated parameters cannot be rejected (*cf* Table 1). Although the probability of choosing the US dollar as anchor currency is mostly found to rise and that of the euro to fall if oil accounts for a larger percentage of a country's net exports (*cf* Table 2), the validity of the relationship remains unconfirmed. This is consistent with the results of Rafiq (2011), who shows that the benefits of a dollar peg for oil-exporting economies are doubtful, because the peg does not insulate them from terms-of-trade shocks.

The estimate of the dissimilarity parameter τ amounts to 0.3. Likelihood ratio tests firmly reject the hypothesis that τ equals 1. This implies that a simple multinomial logit approach without any nesting structure would have been inappropriate, and the use of the current nested logit structure is confirmed. The fact that τ lies in the interval [0; 1] implies, moreover, that the currently observed pattern of exchange rate regime and anchor currency choice can be interpreted as an outcome of an ARUM maximisation on the part of the countries in the sample where the welfare functions are defined as in (7) to (10) and $V_{i4} = 0$.

5 Optimal currency regime and anchor currency choice

Having established the relation between regime choice and its determinants, this section investigates whether, conditional on the estimated model, the regime for any given country is chosen optimally. If the corresponding hypothesis is rejected for some countries, the present global currency bloc composition obviously deviates from the equilibrium which the model would suggest.

Figure 3 gives an impression of the distribution of the estimated probabilities of choosing currency regime options. Each point in the graph represents one country, and its location in the large triangle reflects the combined estimated probabilities of choosing a dollar peg, a euro peg or a regime of floating exchange rates as of 2012. If estimation results suggest a 100% probability of choosing a float, the point is located at the top corner of the triangle; if the probability of choosing a US dollar (euro) peg is 100%, the point is located at the lower left-hand side (right-hand side) corner of the triangle.[12] More precisely, assume that each of the three corners of the equilateral large triangle is located at a unit distance from the triangle's geometric centre. Then, the coordinates of a point for country *i* are given by

$$\left[\left(\hat{p}_{i1} - \hat{p}_{i2}\right)\cdot\cos(\pi/6);\quad \hat{p}_{i4} - \left(\hat{p}_{i1} + \hat{p}_{i2}\right)\cdot\sin(\pi/6)\right], \tag{16}$$

where p_{ij} is given by equations (1), (2), and (4). The shape and colour of the points indicate the currently chosen regimes: a brown dot for a float, a green triangle for a peg to the US dollar, and a blue diamond for a peg to the euro. In an ideal world, the brown dots should therefore be located near the top corner of the large triangle, the small green triangles near the lower left-hand side corner, and the blue diamonds near the lower right-hand side corner.

Considering the distribution of probabilities, there are (1) countries that are estimated to belong quite unambiguously to one of the currency blocs or to the "float

[12] The two figures ignore one of the regime options of our classification: the peg to a currency other than the US dollar and the euro and the corresponding probabilities p_{i3}. The reason for the exclusion of this alternative is that, being a base category for the peg regimes, it has not been explicitly modelled. A peg to the South African rand, for instance, should include at least the distance from Pretoria and the share of trade with South Africa as explanatory variables. Since there are very few observations for such a peg, this is obviously not possible. For the countries that peg to a currency basket, which are also assigned to category 3, another problem arises: Their basket usually includes a significant amount of US dollars and euros, which the analysis has not accounted for either. Thus, the estimated probabilities for this category will not be particularly meaningful, and are therefore ignored in the figure.

corner" and (2) countries whose probabilities of choosing either one of the two pegs or a floating exchange rate regime are quite similar. The lack of points in the lower central part of the large triangle implies, however, that, once a country decides on a regime of fixed exchange rates, the estimated model leaves hardly any uncertainty about the question of which anchor currency the country should choose.

Comparing the model's predicted regime choice with the one which is actually observed, the figures suggest that most countries have chosen the predicted currency regime. However, there are some countries for which this is obviously not true. Therefore, Wald tests as described in equations (11) to (14) have been used to determine for all countries whether the estimated relative deterministic welfare of any alternative regime is significantly larger than the corresponding welfare of the prevailing regime. The countries for which such a result has been found are indicated by their ISO codes in Figure 3.

First, there is a group of countries that currently allow their exchange rates to float, for which a peg to the euro would, however, significantly increase their estimated relative welfare.[13] These countries are Iceland (a country that has been considering introducing the euro for some years now), Switzerland, the Czech Republic (being an EU member, it is expected to introduce the euro as soon as it fulfils the relevant criteria), Croatia (another EU member state and already temporarily classified as having a euro peg in 2007 and 2009), Albania, Norway, Sweden and Hungary (two further EU members).

Given the recent frictions in the EMU, it may be noted that, according to the estimates, none of the EMU member states would significantly increase its welfare by leaving the union. While unsustainable fiscal and wage policies have obviously contributed to problems such as the temporarily high sovereign debt yields of countries like Greece or Portugal, the fundamental structure of their economies is not at odds with these countries' general decision to use the single currency.

The regression yields three cases where a country that is not part of the US dollar bloc is estimated to significantly gain welfare from joining the bloc: the Seychelles,

[13] The results bear no implications concerning potential misalignments of the currencies considered. An assessment of those issues requires a different methodological approach, which is discussed *inter alia* in Cheung *et al* (2009) or Fischer and Hossfeld (2014).

Jamaica (one of the very few countries in the West Indies that is not part of the bloc yet), and Singapore. The list of countries still supports Alesina *et al*'s (2002) finding that "... Latin American countries are by no means a clear dollarization bloc". Posen's (2008, 2009) claim that the US dollar's importance as anchor currency is evidenced by the fact that several countries which should obviously join the euro bloc refrain from doing so is corroborated by the present results for the euro bloc. Since it is also found, however, that the dollar bloc does not differ from the euro bloc in this respect, the results as a whole are inconsistent with Posen's argument.

Finally, there is a group of mostly US dollar bloc countries that would gain significantly from letting their currencies float. These are the Democratic Republic of the Congo, Zimbabwe, Viet Nam, Yemen, Tajikistan, Cambodia, Ukraine, Laos, Bolivia, Angola, Georgia, Iraq and Chad, a euro bloc country.

6. Currency blocs in equilibrium

For the derivation of a global currency bloc equilibrium, the equilibrium currency area definition of Alesina and Barro (2002) is slightly adjusted:

Definition: *A **global currency bloc equilibrium** is achieved if for each currency bloc both the following criteria are fulfilled: (1) None of the countries currently in the bloc is able to raise its estimated welfare significantly by leaving the bloc and (2) none of the countries currently outside of the bloc is able to raise its estimated welfare significantly by joining the bloc.*

The determination of such an equilibrium is less trivial than might be thought because the equilibrium is not necessarily attained if all the countries for which a significantly suboptimal choice has been computed are simply assumed to adopt the regime that has been estimated to provide the greatest welfare for them. The reason why this would not necessarily end up in equilibrium is that the trade share with a given bloc changes by definition for most countries in the sample as soon as a country enters or leaves the bloc. As elaborated in Yehoue (2004) and Meissner and Oomes (2009), the process of pegging or de-pegging of one country's currency exerts a network externality on all the others. If a country *i* adopts a peg to the US dollar, for instance, the welfare of

a dollar peg rises for all the other countries that trade with *i* because the enlargement of the dollar bloc has increased their share of trade with this bloc.

As a consequence of the described network externalities, any currency bloc equilibrium is path-dependent. The current regime and anchor currency choice of a country affects the welfare of future regime decisions of other countries. On the one hand, this stabilises currently dominant currency blocs;[14] on the other, it implies that a regime switch of a sufficiently large country or group of countries may initiate a cascade of further regime changes of the same type. Path dependency may thus increase the probability of equilibria which are corner solutions. If, at the start, some countries are assumed to leave a given currency bloc, this may result in an equilibrium where, after a self-reinforcing cascade of exits, the bloc is entirely dissolved. If some countries are, instead, assumed to join a given bloc, an equilibrium may result where all the countries in the world are clustered in this bloc.

Because of the path dependency, any calculation of a currency bloc equilibrium, as is suggested by the estimated model, depends on the chosen algorithm for regime adjustment. This section presents results for an algorithm whose basic mechanism is that, in each round, that country is assumed to adopt a new regime for which the probability of the regime shift increasing the estimated welfare is highest among all countries, given that this probability is greater than 95%. Trade shares and estimated relative welfare are adjusted in each round.[15] Table 3 shows the path to the currency bloc equilibrium that the algorithm yields. Figure 3 reflects the situation at the start of the adjustment path.

A comparison of Table 3 and Figure 3 reveals that, in spite of the path dependency, only one of the countries initially estimated to gain significantly from a change away from its 2012 currency regime, Singapore, has kept its original regime in the new equilibrium. For Singapore's equilibrium outcome, path dependency plays a role. Singapore's welfare gain of becoming a member of the US dollar bloc is reduced in the course of adjustment to the equilibrium so much that it becomes insignificant as

[14] In this sense, "the dollar has the advantage of incumbency", as Eichengreen (2011, p 124) puts it.
[15] Appendix 3 provides an exact description of the algorithm.

soon as it is assumed that Vietnam floats its currency in round 3.[16] The estimated model suggests, therefore, that Singapore only achieves a significant welfare gain from switching to a US dollar peg if Vietnam remains part of the dollar bloc (which the model advises against).

The effects of path dependency may happen to be relatively small because only countries whose share in world trade is modest are assumed to change the regime (*cf* Table 3). For a further exploration of this hypothesis, the currency bloc constellation in 2009 may be considered where China is still classified as being part of the US dollar bloc. The analysis shows that, then, Canada's welfare would increase significantly if it adopted a peg to the US dollar, a result which depends entirely on China being part of the bloc as well. Still, even when China is assumed to loosen its peg to the dollar (as the model suggests and as it did in reality), no major cascade of dollar bloc exits ensues. The results show that path-dependency's importance should not be overstated, nor can it be ignored.

A global currency bloc equilibrium is reached after 23 rounds (*cf* Table 3). The equilibrium is not a corner solution, that is the two currency blocs still exist and the number of countries with flexible exchange rates has hardly changed. However, the US dollar bloc is smaller in equilibrium than at present. In contrast, the euro bloc has grown in the course of adjustment to the equilibrium, primarily because further European countries have adopted a euro peg. This does not imply, however, that countries have switched directly from a dollar peg to a euro peg. Instead, countries that abandoned a dollar peg have generally turned to a float, while previously floating countries have adopted a euro peg. In line with Alesina *et al* (2002), the equilibrium composition of the euro bloc includes most of western and central Europe, but – in contrast to their results – only a fraction of Africa.

[16] Technically speaking, Singapore's *p*-value of the Wald test on the equality of the two regimes rises above the 5% significance level. Another reflection of path dependency is the low *p*-value for the regime change of Norway in round 19 (*cf* Table 3). As soon as Sweden is assumed to peg its currency to the euro in round 18, the welfare gain of Norway also entering the euro bloc increases dramatically, and the *p*-value on the equality of the float's and the euro peg's welfare drops considerably from 0.009 to 0.0005.

7 Effects of counterfactual economic policy decisions

This chapter considers the effects of counterfactual economic policy decisions on the estimated path to the global currency equilibrium shown in Table 3, which is used as a benchmark. Technically, the policy measure is first introduced, after which the algorithm described in Appendix 3 is run until the currency bloc equilibrium is reached.

7.1 A country deliberately joins one of the currency blocs

Although Poland and the UK are European Union member states, they have not pegged their currencies to the euro.[17] In the global currency bloc equilibrium derived in the last chapter, the estimated welfare of joining the euro bloc is greater for both countries than that of any other option including their current float. Neither for Poland nor for the UK, however, does the probability of an increase in welfare in the case of an adoption of a euro peg exceed 95%. The counterfactuals investigate whether the deliberate adoption of a peg to the euro by one of these countries eventually raises the estimated welfare of a peg for another country beyond the 95% significance level. It is found that, compared to the benchmark equilibrium, this is only the case for Serbia. All the other obvious European candidates whose currencies are floating currently (eg Norway, Sweden, the Czech Republic or Hungary) are already euro bloc members in the benchmark currency bloc equilibrium.

Similar counterfactuals consider what happens if one of the NAFTA countries Canada or Mexico pegs its currency to the US dollar. It is found that such a step hardly affects the baseline equilibrium. However, the adoption of a dollar peg by Mexico alters the benchmark equilibrium in the sense that Canada joins the dollar bloc as well.

7.2 Oil-exporting countries stop using the US dollar as an invoice currency

Currently, the US dollar is used as the invoice currency for oil exports. In recent years, there have been discussions in some countries about whether this could or should be changed.[18] It may therefore be of interest to investigate the repercussions of a

[17] Under the Treaty on the Functioning of the European Union, it is assumed that member states will introduce the euro as soon as the European Council of Heads of State or of Government decides that they fulfil the relevant convergence criteria. The UK and Denmark negotiated an exemption from this rule.

[18] Eichengreen, 2011, p 12, notes that, until now, a majority of OPEC countries have rejected such an idea. Nevertheless, Khan (2009) reports for the Middle East, where many countries peg their currencies to the dollar and, at the same time, are net oil exporters, that "there is considerable

counterfactual in which oil-exporting countries stop using the dollar as the invoice currency. Technically, this has been done, first, by setting the parameters of the percentage of oil in total exports and its variances and covariances to zero and, then, re-computing a new currency bloc equilibrium.

Since the net oil export parameter in the baseline estimate is insignificant, it might be expected that the counterfactual arrives at virtually the same equilibrium as the baseline scenario. According to the results, the switch in invoice currency raises Azerbaijan's and Turkmenistan's estimated welfare gain of de-pegging its currency from the dollar to significant levels. Moreover, Chad chooses to remain part of the euro bloc in the new counterfactual equilibrium.

7.3 Former colonial ties no longer bind

In the estimations, the parameter of the dummy for former dependency on one of the euro bloc countries is highly significant. However, for most countries, several decades have passed since they gained political independence. Network effects will have played a role in maintaining ties between former colony and colonial power. The counterfactual of this section assumes that these ties no longer bind. Technically, a new equilibrium is computed much like in the previous section after having set the parameter and covariances of the colony dummy to zero. In the resulting counterfactual equilibrium, nearly all the African countries that presently peg their currencies to the euro have left the euro bloc.[19] All of these countries have adopted a regime of flexible exchange rates.

7.4 The potential of China's renminbi to serve as the core of a third major currency bloc

The rapidly rising importance of China in the global economy has sparked discussions on a bigger international role for the Chinese currency, the renminbi. The Chinese authorities themselves have contributed to the discussion. In March 2009, for instance, Governor Zhou of the People's Bank of China gave a speech, in which he proposed a reform of the international monetary system. Eichengreen (2011, pp 144-

discussion in the region about reducing the dominance of the dollar and increasing the relative importance of the euro" (p 139). In an analysis of this issue, Louis *et al* (2010) find that an anchor to a currency basket may be superior to a dollar peg for the countries of the Gulf Cooperation Council.

[19] The only exceptions are Gabon, Equatorial Guinea and the island states of Cabo Verde and São Tomé and Príncipe.

145) cites *inter alia* "China's currency swap agreements ... as a way for it to signal its ambitions". This suggests exploring the potential of the renminbi to become the anchor currency for a group of countries and, thus, the core of a new currency bloc. The counterfactual focuses on whether the economic structure of the country considered is conducive to a renminbi peg.[20]

For a world with three, rather than two currency blocs, the model requires some slight adjustments. The decision tree in Figure 2 is expanded by adding a fourth branch called "peg to the renminbi" for the category "anchor currency choice". The econometric model (1) – (5) is extended by a further equation

$$p_{i5} = p_{i,peg\_rmb} = p_{iP} \times p_{i5|P} = \frac{\exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)}{1 + \exp(\mathbf{z}'\boldsymbol{\alpha} + \tau \cdot I)} \cdot \frac{\exp(\mathbf{x}_5'\boldsymbol{\beta}_5 / \tau)}{\exp(I)} \qquad (17)$$

and the inclusive value defined in equation (5) is replaced for (1) – (4) and (17) by

$$I = \ln\left[1 + \exp(\mathbf{x}_1'\boldsymbol{\beta}_1 / \tau) + \exp(\mathbf{x}_2'\boldsymbol{\beta}_2 / \tau) + \exp(\mathbf{x}_5'\boldsymbol{\beta}_5 / \tau)\right], \qquad (18)$$

where $\mathbf{x_5}$ denotes the vector of explanatory variables for choosing the renminbi as anchor currency, $\boldsymbol{\beta_5}$ is the corresponding parameter vector and p_{i5} is the probability for country i of choosing a renminbi peg.

The set of explanatory variables included in vector $\mathbf{x_5}$ is compiled along the lines of those of vectors $\mathbf{x_1}$ and $\mathbf{x_2}$. Vector $\mathbf{x_5}$ thus includes for each country its share of net oil exports in total exports, the great circle distance between its capital and Beijing, its trade with China as a percentage of total trade, and a colony dummy which is set to 1 for Hong Kong and 0 elsewhere. Since a counterfactual is considered, the parameters in vector $\boldsymbol{\beta_5}$ cannot be estimated, but must be imposed instead. Below, results of a counterfactual are presented, in which the estimated parameters for the euro bloc are imposed on China, $\boldsymbol{\beta_5} = \hat{\boldsymbol{\beta}}_1$. Modelling the renminbi analogously to the euro might be

[20] Several recent studies have provided evidence that the renminbi already exerts some influence on the exchange rates of various Asian countries (for an early example, see Ho *et al*, 2005). The influence appears still to be so small, however, that the IMF does not yet classify any currency as anchored to the renminbi. For the renminbi to become a significant anchor currency at all, additional adjustments on the part of the Chinese authorities would obviously be necessary, notably the establishment of renminbi convertibility.

rather plausible because the Chinese currency would be in a situation similar to that of the euro, a contender for the role of the incumbent, the US dollar.[21]

The results for the counterfactual currency bloc equilibrium suggest that Hong Kong and Mongolia have pegged their currencies to the renminbi. How does the prospect of a continuation of the increase in trade between China and its partners relative to trade in the rest of the world affect this result? In order to assess this question, exports and imports of China have been progressively multiplied, while the trade of the rest of the world has been kept constant. It turns out that there is some potential for a larger renminbi bloc if trade intensity with China continues to increase disproportionally. In a new equilibrium based on the assumption that the trade of China has risen to five times its 2012 magnitude relative to the rest of the world, several other countries have joined the renminbi bloc including Australia, New Zealand, South Korea, Singapore, most Central Asian economies and some Pacific and African countries. The path to the equilibrium would be characterized by a cascade of countries drawn into the new renminbi bloc by the entry of some larger trade partners such as Australia. Still, the counterfactuals suggest that China still has a long way to go before the renminbi gains the potential to rival the US dollar as an anchor currency even if convertibility of the renminbi were to be established.

8. Conclusions

The study presents an econometric strategy for determining a global currency bloc equilibrium. The strategy is based on the proposition that estimates of the relative welfare of alternative regimes for any country can be inferred from the relationship between observed currency regime choices and their determinants. As a first building block of the strategy, a nested logit regression is therefore used to estimate the effects of

[21] The present counterfactual also requires a modification of the algorithm that determines the currency bloc equilibrium. This is necessary because there are no compelling values available that could be imposed on the covariances between the parameters in $\boldsymbol{\beta}_5$ and the other parameters of the model. This implies that the covariance matrix $\hat{\boldsymbol{\Sigma}}$ in equation (13) cannot be determined and, consequently, a Wald test cannot be performed. In the previous exercises, however, the algorithm assumed that a country switches its currency regime only if the Wald test indicates at least a 95% probability that the switch will raise the country's welfare. Since the application of the Wald test is impossible in the present counterfactual, the algorithm has been adjusted to allow a switch of the currency regime as long as the probability of country *i* choosing an alternative regime (ie pegging its currency to the renminbi) is higher than the probability of keeping its current currency regime. Note that this is a much looser condition than the one used so far. An equilibrium might therefore be expected where a relatively large group of countries has joined the renminbi bloc.

long-term structural economic variables on the combined currency regime and anchor currency choice for a large sample of economies in the 21st century. It is found that OCA-related variables exert a substantial influence on this decision. Trade integration, for instance, plays a major role for both the dollar bloc and the euro bloc countries. The distance from the location of the central monetary authority of the two blocs, Washington, DC, and Frankfurt am Main, respectively, is a significant factor for anchor currency choice with regard to the euro bloc, but not the dollar bloc.

As a second building block of the strategy, the study proposes a test on the equality of relative welfare that a given country derives from alternative exchange rate regimes or anchor currencies. A rejection implies that, based on the estimated model, one of the regimes imparts a significantly greater welfare than the other. If the superior regime differs from the prevailing one, the present global currency bloc composition deviates from the equilibrium which the model would suggest.

Based on the estimated model and the tests, the study proposes an algorithm for the derivation of a global currency bloc equilibrium in the spirit of Alesina and Barro (2002). The algorithm accounts for path dependency which results from the fact that a change in currency bloc composition affects the incentive for joining or leaving the bloc. It is found that, in equilibrium, the US dollar bloc is smaller and the euro bloc is larger than at present. The equilibrium is characterised by several Asian and African countries having de-pegged from the US dollar and additional European countries having adopted a fixed exchange rate vis-à-vis the euro. In spite of fundamental methodological differences, the results are broadly in line with those of Alesina *et al* (2002).

Finally, the strategy can be used for counterfactual exercises which explore, for instance, the potential for the formation of a renminbi bloc or the effects of an erosion of the US dollar's role as an invoice currency for oil exports. The analysis suggests, for example, that the potential for a renminbi bloc is still limited. It may become substantial, however, if Chinese trade with the rest of the world continues to increase disproportionally. The counterfactual investigation of such a case yields the interesting result that the accession of some larger economies to the renminbi bloc would trigger a cascade of other countries joining the bloc.

The question remains as to which factors prevent an adjustment towards the estimated currency bloc equilibrium. While one of the reasons could simply be institutional inertia, factors that have not been included in the analysis may also have inhibited a further adjustment. Concerning the relative weight of the two large currency blocs, two such factors are currently under discussion. Eichengreen (2011, p 130) puts forward the idea that an expansion of the international role of the euro is being slowed down by the fact that the euro is a currency without a unified state. As a second reason against a further rise of the euro, Posen (2008, 2009) picks up a point made by Strange (1980), claiming that a lack of military power is preventing a further expansion of the euro area.

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Appendix 1: List of countries and territories included in the sample

Afghanistan (since 2002), Albania, Algeria, Angola, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin (since 2000), Plurinational State of Bolivia, Bosnia and Herzegovina (since 2000), Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Democratic Republic of the Congo, Costa Rica, Côte d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia (since 2000), Georgia, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Islamic Republic of Iran (since 2000), Iraq (since 2004), Ireland, Israel, Italy, Jamaica (1999-2001 and since 2006), Japan, Jordan, Kazakhstan, Kenya, Republic of Korea, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Liberia (since 2000), Lithuania, Luxembourg, Macedonia, Madagascar, Malawi, Malaysia, Maldives (since 2001), Mali, Malta (since 2000), Mauritania, Mauritius, Mexico, Republic of Moldova, Mongolia, Montenegro (since 2005), Morocco, Mozambique, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman (until 2011), Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar (since 2000), Romania, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, São Tomé and Príncipe (since 2001), Saudi Arabia, Senegal, Serbia (since 2005), Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia (since 2000), Solomon Islands, South Africa (since 2000), Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Tajikistan, United Republic of Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine (since 2000), United Arab Emirates, United Kingdom, Uruguay, Uzbekistan, Vanuatu, Bolivarian Republic of Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.

Appendix 2: Data sources for explanatory variables

Real GDP: Series "GDP, PPP (constant 2011 international $)"; annual data; source: World Bank, WDI, downloaded on 14.05.2014.

Real *per capita* GDP: Series "GDP per capita, PPP (constant 2011 international $)"; annual data; source: WDI, downloaded on 14.05.2014.

Trade with the US dollar (euro) bloc as a fraction of total trade: For each year, two full DOTS cross-country matrices have been downloaded, one showing the exports of each country to all destination countries, and the other showing the (c.i.f.) imports of each country from all origin countries; annual data; source: IMF, DOTS April 2014.

Distance: Great circle distance between a given country's capital and Washington, DC, Frankfurt am Main or Beijing measured in kilometres as computed on the website http://www.timeanddate.com/worldclock/distance.html.

Share of net oil exports in total exports: Series "Oil trade balance", W...TBO, divided by series "Value of exports of goods & services", W...TX; annual data; source: IMF, WEO May 2014. For the following countries, it is assumed that they were net oil importers over the sample period: Afghanistan, Armenia, Fiji, Kyrgyz Republic (as suggested by an older TBO series), Samoa (as suggested by an older TBO series), Togo (prior to 2008, as suggested by an older TBO series), Tonga, Uzbekistan. For Azerbaijan, gross instead of net oil exports are used.

Dummy for former euro bloc colony: CIA, World Fact Book, https://www.cia.gov/library/publications/the-world-factbook/index.html.

Appendix 3: An algorithm for the determination of a global currency bloc equilibrium

The trade shares that are used in the first round of the loop are based on the currently prevailing currency regime and anchor currency choices.

1) Given the estimation results, equations (8) and (9) as well as $V_{i4} = 0$ are used to compute for each country the deterministic welfare of having flexible exchange rates, adopting the US dollar as anchor currency or pegging the currency to the euro.[22] Subsequently, it is determined for each country whether a regime different from the prevailing one yields an increase in relative welfare.
2) If this is the case, Wald tests along the lines of equations (11) – (14) are employed to determine whether the welfare gain from switching to another regime or anchor currency is significantly different from zero. In line with convention, significance is evaluated at a 5% level. The results for the first two steps have already been applied to current regime choices in chapter 5.
3) Given the pool of countries selected in step 2, the algorithm identifies that country for which the computed *p*-value is the lowest, ie for which there is the highest probability that a change in the exchange rate regime or currency anchor would increase welfare.
4) It is assumed that the country selected in step 3 adopts the regime or anchor that has been estimated as being the optimal one in terms of welfare.
5) Step 4 has changed the composition of at least one of the currency blocs. Given the new currency bloc composition, equation (15) and an equivalent equation for the euro bloc have been used, therefore, to calculate trade shares for each country with each of the blocs anew.
6) Based on the new trade shares, the loop re-starts in step 1 by computing the relative deterministic welfare for each country. The loop stops if the global currency bloc equilibrium, as defined in chapter 6, is achieved.

[22] For reasons given in footnote 12, pegs to currencies other than the US dollar and the euro are ignored in the calculations.

Table 1: Nested logit model for exchange rate regime and anchor currency choice

		2012	2000	Pool
z	GDP	-0.283***	-0.375***	-0.341***
		(-3.97)	(-4.87)	(-5.56)
	GDP per capita	0.669***	0.941***	0.839***
		(3.69)	(4.70)	(5.40)
$\mathbf{x_1}$	Oil export share	-0.171	-0.386	0.013
		(-0.24)	(-0.46)	(0.02)
	Distance(Frankfurt)	-0.190**	-0.159**	-0.165***
		(-2.40)	(-2.53)	(-2.98)
	Trade(EUR) share	4.94***	3.10***	3.66***
		(3.12)	(2.81)	(3.33)
	Colony (EUR)	1.87**	1.81**	1.74**
		(2.34)	(2.56)	(2.47)
$\mathbf{x_2}$	Oil export share	0.461	0.461	0.319
		(0.80)	(1.38)	(0.81)
	Distance(Washington)	-0.003	-0.054**	-0.019
		(-0.13)	(-2.14)	(-1.26)
	Trade(USD) share	2.24**	1.89**	1.84***
		(2.15)	(2.55)	(3.34)
τ		0.337	0.231	0.290
$p(\tau = 1)$		0.007	0.0001	
$p(oil(\mathbf{x_1}) = oil(\mathbf{x_2}))$		0.419	0.347	0.633
N_1 (peg EUR)		40	33	529
N_2 (peg USD)		38	28	481
N_3 (peg other)		8	13	131
N_4 (float)		78	85	1130

Variables and coefficients as defined in chapters 3 and 4; *z*-values in parenthesis; *** significant at 1% level, ** significant at 5% level. "Pool" = data for 1999-2012 is pooled; in the pooled estimation, computation of robust standard errors is based on 165 country clusters; "$p(\tau = 1)$" gives *p*-values of an LR test on $\tau = 1$; "$p(oil(\mathbf{x_1}) = oil(\mathbf{x_2}))$" gives *p*-values of a Wald test on the equality of the two oil export parameters, the one in the US dollar bloc and the one in the euro bloc equation.

Table 2: Estimated average marginal effects on the probability of choosing a given exchange rate regime or anchor currency; percentage points

		2012	2000	Pool
GDP	peg EUR (p_{i1})	-2.03	-2.82	-2.55
(increase by 1%)	peg USD (p_{i2})	-2.96	-2.90	-3.21
	peg other (p_{i3})	-0.71	-1.46	-0.96
	float (p_{i4})	5.70	7.18	6.73
GDP per capita	peg EUR (p_{i1})	4.79	7.07	6.28
(increase by 1%)	peg USD (p_{i2})	6.99	7.28	7.91
	peg other (p_{i3})	1.67	3.67	2.37
	float (p_{i4})	-13.46	-18.01	-16.57
Distance(Frankfurt)	peg EUR (p_{i1})	-2.31	-2.48	-2.35
(increase by 1%)	peg USD (p_{i2})	0.66	0.49	0.69
	peg other (p_{i3})	0.28	0.80	0.43
	float (p_{i4})	1.36	1.19	1.23
Distance(Washington)	peg EUR (p_{i1})	0.01	0.17	0.08
(increase by 1%)	peg USD (p_{i2})	-0.06	-1.24	-0.45
	peg other (p_{i3})	0.02	0.66	0.18
	float (p_{i4})	0.03	0.42	0.18
Oil export share	peg EUR (p_{i1})	-0.04	-0.07	-0.01
(increase by 1 PP)	peg USD (p_{i2})	0.10	0.12	0.07
	peg other (p_{i3})	-0.03	-0.04	-0.03
	float (p_{i4})	-0.04	-0.01	-0.03
Trade(EUR) share	peg EUR (p_{i1})	0.60	0.48	0.52
(increase by 1 PP)	peg USD (p_{i2})	-0.17	-0.10	-0.15
	peg other (p_{i3})	-0.07	-0.16	-0.09
	float (p_{i4})	-0.35	-0.23	-0.27
Trade(USD) share	peg EUR (p_{i1})	-0.08	-0.06	-0.08
(increase by 1 PP)	peg USD (p_{i2})	0.47	0.43	0.42
	peg other (p_{i3})	-0.16	-0.23	-0.17
	float (p_{i4})	-0.23	-0.15	-0.17
Colony (EUR)	peg EUR (p_{i1})	28.83	37.07	32.84
("colony" instead of	peg USD (p_{i2})	-10.92	-12.13	-12.70
"no colony")	peg other (p_{i3})	-3.25	-7.21	-4.60
	float (p_{i4})	-14.65	-17.73	-15.53

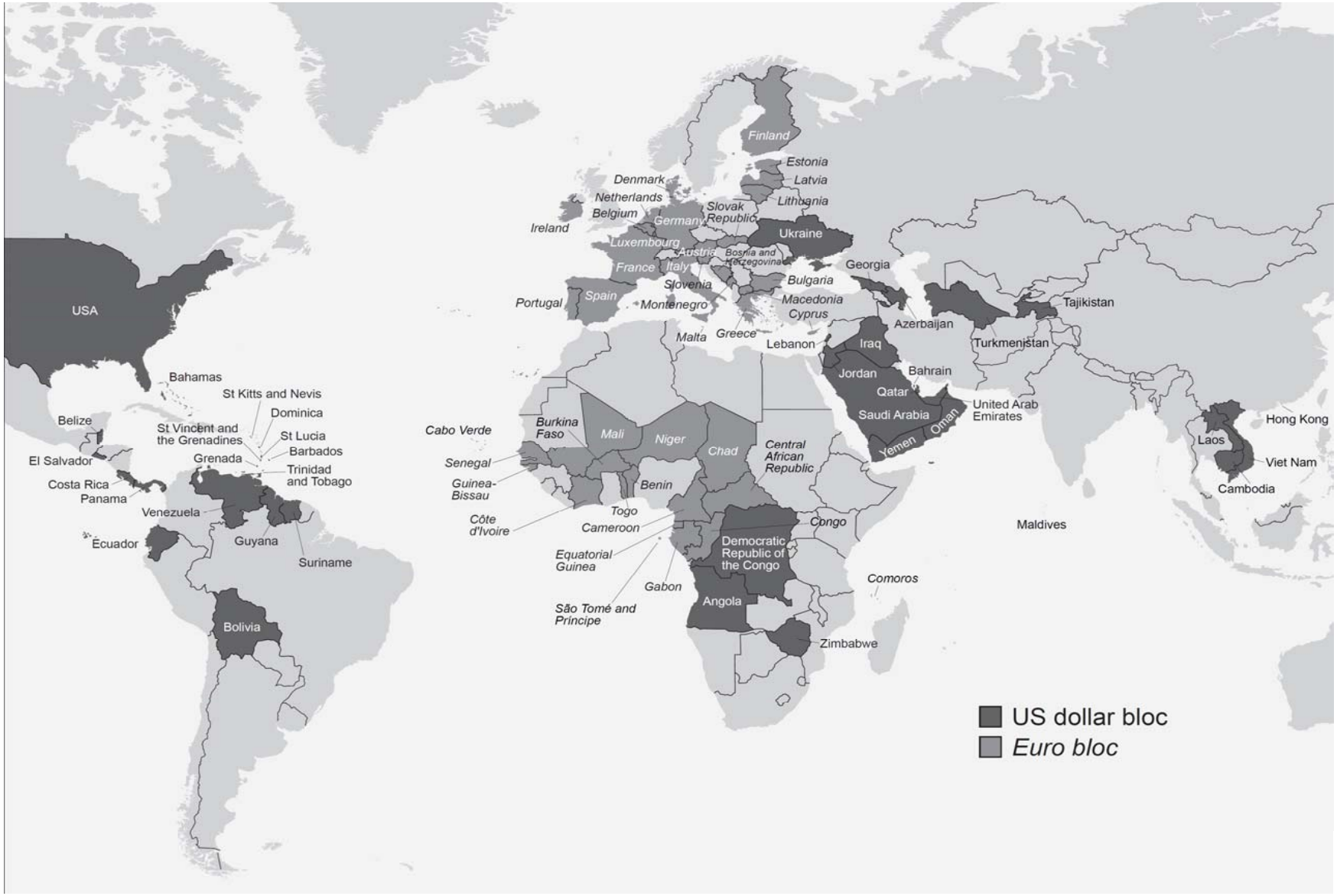
"Pool" = data for 1999-2012 are pooled; *PP* = percentage point.

Table 3: The path to a global currency bloc equilibrium starting from the currency bloc constellation as of 2012; algorithm based on the estimates for the pool

Round	Country	Current regime	New regime	*p*-value in %
1	Democratic Republic of the Congo	peg(USD)	float	0.000007
2	Zimbabwe	peg(USD)	float	0.00008
3	Viet Nam	peg(USD)	float	0.0002
4	Yemen	peg(USD)	float	0.0004
5	Cambodia	peg(USD)	float	0.0005
6	Tajikistan	peg(USD)	float	0.0007
7	Ukraine	peg(USD)	float	0.003
8	Seychelles	float	peg(USD)	0.009
9	Iceland	float	peg(EUR)	0.01
10	Laos	peg(USD)	float	0.01
11	Switzerland	float	peg(EUR)	0.02
12	Bolivia	peg(USD)	float	0.03
13	Croatia	float	peg(EUR)	0.11
14	Czech Republic	float	peg(EUR)	0.21
15	Angola	peg(USD)	float	0.47
16	Albania	float	peg(EUR)	0.56
17	Hungary	float	peg(EUR)	0.85
18	Sweden	float	peg(EUR)	0.90
19	Norway	float	peg(EUR)	0.05
20	Georgia	peg(USD)	float	0.95
21	Jamaica	float	peg(USD)	2.02
22	Chad	peg(EUR)	float	3.20
23	Iraq	peg(USD)	float	3.30

The path to the equilibrium is computed according to the algorithm described in chapter 6. The "new regime" is the regime that has been estimated as providing the highest deterministic welfare based on a currency bloc constellation as given in the corresponding round of the algorithm. The *p*-value refers to a country-specific Wald test on the equality of the estimated deterministic welfare values of the current and the "new" regimes. Only those cases are considered in which the estimated deterministic welfare of the new regime is higher than that of the current regime.

Figure 1: Map of the two major currency blocs in 2012



Note: The map shows those countries and territories of each of the two currency blocs which are included in the sample.

Figure 2: Decision tree on currency regime and anchor currency choice

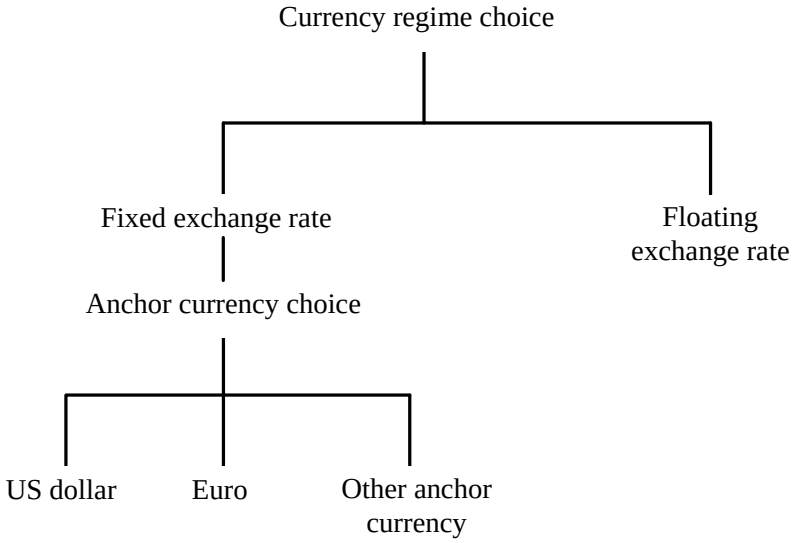
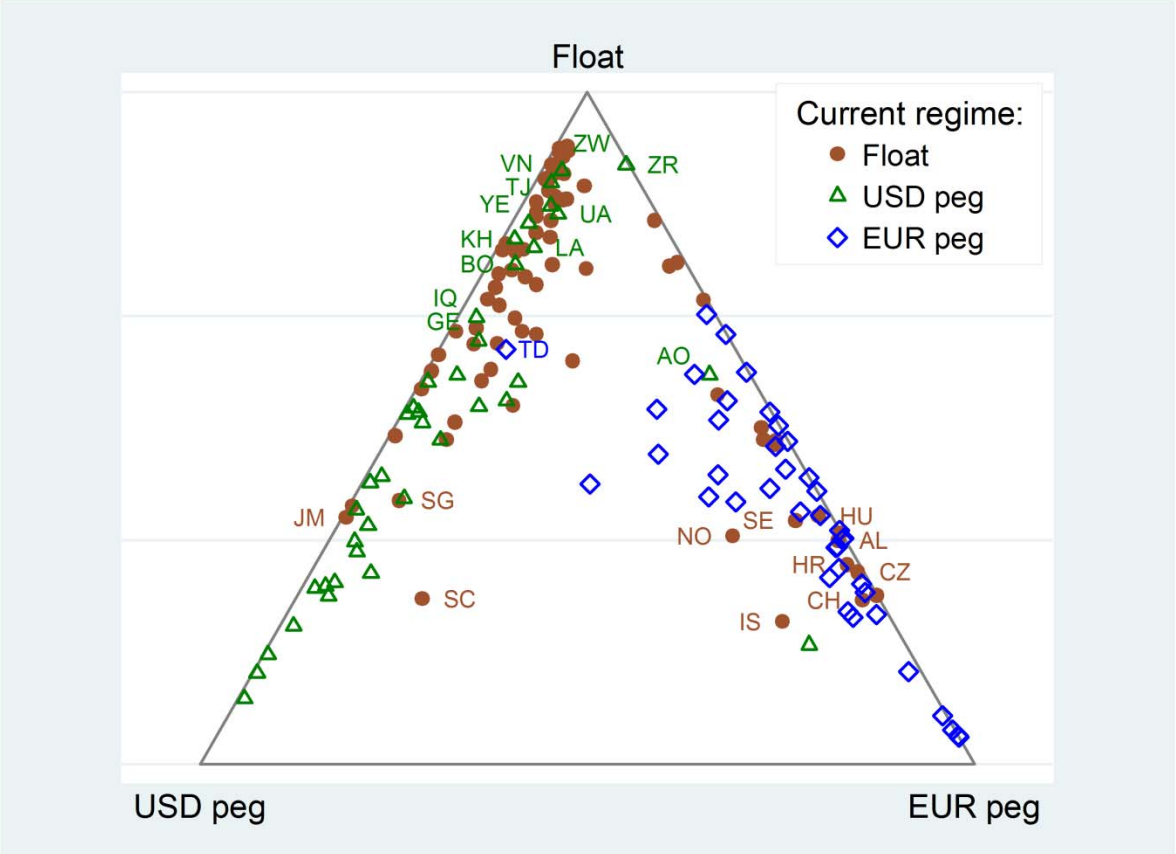


Figure 3: Probabilities of choosing regime options as estimated using pooled data for 1999 – 2012; currency bloc constellation as of 2012



Note: Country ISO codes: AL = Albania, AO = Angola, BO = Bolivia, CH = Switzerland, CZ = Czech Republic, GE = Georgia, HR = Croatia, HU = Hungary, IQ = Iraq, IS = Iceland, JM = Jamaica, KH = Cambodia, LA = Laos, NO = Norway, SC = Seychelles, SE = Sweden, SG = Singapore, TD = Chad, TJ = Tajikistan, UA = Ukraine, VN = Vietnam, YE = Yemen, ZR = Democratic Republic of the Congo, ZW = Zimbabwe.