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Optimum currency area theory: evidence from post-Soviet countries and implications for Eurasian Economic Union

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ABSTRACT

In this article the theory of optimum currency area is applied to post-Soviet and other selected countries. The study finds smaller exchange rate variability when the economies are closely linked by bilateral trade, are subject to similar shocks both on aggregate and at the industry level, have similar inflation rates, are open and smaller in economic size, and have higher labour migration as proxied by remittance flows. The estimation results also substantiate that the US dollar plays a dominant role as an anchor currency. Next, the study shows that economic fundamentals suggest limited prospects of a common currency for post-Soviet countries, particularly for the Eurasian Economic Union (EAEU). It is also found that Moldova, among the post-Soviet countries, better approximates an optimum currency area with Russia. Further, when the government debt-to-GDP ratio is taken into account, only Kazakhstan from the EAEU member countries stands out as having positive prospects for forming a common currency area with Russia.

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Introduction

On 1 January 2015, the Russian Federation, Belarus and Kazakhstan founded the Eurasian Economic Union (EAEU), as a successor to the Customs Union originally formed by them in 2011. Two smaller former Soviet Union republics joined the EAEU: the Republic of Armenia on its inception date, and Kyrgyzstan on 12 August 2015.

Economic unions, as a higher form of integration, assume free movement of factors of production, free trade area and unified trade conditions with third parties. The monetary union is the next – and until now the highest – stage of economic integration of sovereign states. It took about 50 years for the European Union (EU) to introduce the euro; however, many of its member states have preserved their currencies. Although the founding treaty of the EAEU does not explicitly call for a common currency, it highlights the importance of implementing harmonised macroeconomic policies. At the same time, various media and expert groups, mostly based in Russia, regularly discuss a soon-to-be-introduced common currency in the EAEU. Even official statements have been made in this regard, but without mentioning any particular date (Falyahov, 2014). Although the majority of these discussions are speculative in

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nature, we consider it important to conduct a rigorous study and evaluate whether the economic fundamentals of the EAEU member states call for a common currency area.

Thus, in this article, we scientifically investigate the prospects of such a currency union. In particular, we analyse the problem from a purely economic perspective by studying the relationship between observed exchange rate variability (as well as the variability of exchange market pressure, the index of intervention) and optimum currency area (OCA) characteristics.

As two extreme cases, countries can either implement a flexible exchange rate policy, or peg it to a specific currency or weighted basket of currencies. Having a currency pegged to another currency closely resembles the situation of being in a common currency area. The traditional theory of an OCA was set up by seminal contributions by Kenen (1969), McKinnon (1963) and Mundell (1961). In a nutshell, the basis of the OCA approach is to identify the main economic characteristics that justify the boundaries of the currency area. In a series of articles, Bayoumi and Eichengreen (1993, 1997a, 1997b, 1998) provide an empirical strategy to analyse OCAs.

In their more recent works, Bayoumi and Eichengreen (1997a, 1997b, 1998) construct an OCA index to predict the variability of an exchange rate between a pair of countries based on variables such as symmetry of shocks, openness and trade linkages. In particular, the authors claim that because examining the currency regime and trying to explain this dichotomous (or, at most, categorical) phenomenon through a set of economic variables is not informative enough, they need to consider the actual variability of the exchange rate. Therefore, they analyse the actual behaviour of the bilateral exchange rate, particularly its standard deviation over a certain period of time (e.g. 10 years).

In this article, we closely follow the methodology developed by Bayoumi and Eichengreen (1997a, 1997b, 1998). Our study uses the annual data of 14 post-Soviet and four other countries, and covers the period from 2000 to 2014. We use OCA explanatory variables, such as mutual trade flows, diversion in economic growth rates, dissimilarity of export composition and economic size. In addition to the standard set of OCA variables used in the relevant empirical literature, we construct two more variables to control for the economic regularities specific to the sample of countries considered. Thus, we contribute to the methodology by controlling for the possible effects of mutual labour migration flows[1] and dissimilarity of export composition for crude oils. We also address the possible endogeneity problem, because rather than mutual trade conditions affecting the exchange rate, the reverse could be the case. We look for valid instruments and apply a two-stage least squares method to control for the reverse causality.

It is worth emphasising the advantage of this approach for our purposes. In general, the readiness of countries for a currency union depends on not only their mutual economic ties, but also on the convergence of the macroeconomic policies implemented. As an example, the conditions for a common currency area in the EU stipulated in the Maastricht Treaty of 1992 called for certain thresholds on inflation, public debt and budget deficit for the member states planning to join the euro area. Clearly, such criteria follow the political decision to enter a currency union. Consequently, one can analyse to what extent such countries converge to the goals set and follow their political decisions. Our approach instead abstracts from this type of policy noise, since the methodology adopted explains the variations in the exchange rate (in exchange market pressure) and behaviour of intervention index by the fundamental economic factors in OCA theory.

The analysis has potential policy implications since it addresses the following question: if the countries considered in the sample period were in the common currency area, to what extent would they be able to successfully implement the policy of stable exchange rates against one another? We realise that the conclusions might change if the analysis were carried out ex post by recalling the endogeneity of the OCA criteria established by Frankel and Rose (1997, 1998). However, this is the type of study one can conduct before observing monetary integration in reality, and to the best of our knowledge, this methodology has not been applied to post-Soviet countries.

We obtain a number of noteworthy results. First, the standard set of OCA variables alone cannot properly explain the behaviour of exchange rate variability (and other dependent variables), resembling the situation of the EU countries in the 1960s. Second, the variables from the extended set of OCA variables and the 'system' variable, measured by the average variability of the currencies of two countries against the US dollar, play a crucial role in explaining the behaviour of dependent variables. In particular, for the exchange rate variability we find that, other things being equal, it is smaller when the economies are closely linked by bilateral trade, are subject to similar shocks, both on aggregate and at the industry level, have similar inflation rates, are open and smaller in economic size, and have higher labour migration. The estimation results also substantiate that the US dollar has a certain dominance as an anchor currency for the considered set of countries. It is also found that, ceteris paribus, when countries are open, have closer bilateral trade links and are more dissimilar with respect to the oil-exporting sector, they experience lower exchange rate variability, but higher exchange market pressures and interventions. In other words, the stability of exchange rates is achieved through interventions in the exchange market by suppressing the pressures so that they are not reflected in the actual exchange rate. Third, we predict the exchange rate variability for post-Soviet countries considered vis-à-vis the Russian rouble. The results indicate that Moldova from the post-Soviet countries better approximates an OCA with Russia. Meanwhile, we find a distinct heterogeneity in exchange rate variability, implied by fundamentals, among the countries and, in particular, among the EAEU member states, with Belarus as an evident example. This result implies limited prospects for a common currency for EAEU member states. Nevertheless, when the total government debt-to-GDP ratio is considered, only Kazakhstan from the EAEU members seems to have positive prospects for a common currency area with Russia.

The remainder of the article is organised as follows. The following section provides a brief literature review. Then, the methodology and data used are described, providing some insight about economic relationships, structural similarities/asymmetries between different pairs of countries. Next, the article presents estimation results and discusses the implications for a common currency area for post-Soviet countries, in particular, for EAEU member states. The final section concludes the article.

Literature review

The term optimum currency area was first used in the seminal work by Mundell (1961).[2] In a currency area, countries irrevocably fix their exchange rates and follow a common monetary policy. Alesina, Barro, and Tenreyro (2003), De Grauwe (2014), Prokopenko, Jafarov, and Gulde (2004) and Sanchis i Marco (2014) provide detailed discussions on the costs and benefits of a monetary union for member countries.

The benefits of such a policy can vary in their nature: for example, the efficiency gains from the elimination of transaction costs, the welfare gains from price stability (De Grauwe, 2014) and the possible economic gains from using a common monetary unit as a reserve currency (Wyplosz, 1997). The costs are mainly associated with the unavailability of monetary policy instruments to respond to country-specific shocks, calling for the deployment of alternative instruments and channels. Mundell (1961) stresses the importance of labour mobility across the currency area regions or flexibility of prices and wages as an alternative adjustment mechanism instead of the exchange rates.

McKinnon (1963) also emphasises the importance of factor mobility among industries and introduces the degree of openness as another criterion for forming a currency area. An open (and as a corollary, small) economy would benefit by joining a common currency area because exchange rate changes would not have a substantial impact on real competitiveness and, moreover, through a higher impact on the overall price index, would diminish the effectiveness of price stability policies. Kenen (1969) considers product diversification as another important criterion for promoting external adjustments. In his view, a sufficiently diversified economy would benefit from a single currency because diversification implies less vulnerability to a variety of shocks and there would be no need for frequent changes in exchange rates. Corden (1972) states that the formation of a common currency area would be costly in case of different preferences over inflation. The importance of similarity of inflation rates has been stressed by Fleming (1971). Alesina and Barro (2002) show that the type of country that has more to gain from giving up its own currency is a small open economy heavily trading with one particular large partner, with a history of high inflation and with a business cycle highly correlated with that of the potential 'anchor'. Vaubel (1976, 1978) proposed the historical need for small exchange rate variability as another important characteristic for joining a currency union.[3] The political will to integrate is also a very important factor, as pointed out by Mintz (1970) and supported empirically by Cohen (1993). However, Frankel and Rose (1997, 1998) study the endogeneity of OCA criteria and find that 'countries are more likely to satisfy the criteria for entry into a currency union after taking steps toward economic integration than before'.

Alesina et al. (2003), based on the theoretical background developed in Alesina and Barro (2002), explore the pros and cons of adopting the dollar, euro or yen in different countries, using the historical patterns of international trade and the co-movements of prices and outputs.

In a series of articles, Bayoumi and Eichengreen quantitatively test the OCA theory. Bayoumi and Eichengreen (1993) analyse whether supply and demand shocks are correlated for EU members over the period 1960–1988, considering Germany as an anchor economy. They use output and price data to identify the aggregate supply and demand disturbances in a structural vector autoregression (VAR) model.

Bayoumi and Eichengreen (1997a, 1997b, 1998) construct different variables such as: asymmetric disturbances to real output; the level of trade linkages; the dissimilarity of export composition; and economic size, quantifying some of the OCA criteria. They explain the standard deviation of bilateral exchange rates over a certain period of time by a set of those OCA variables. Horvath (2005) applies the same methodology to 20 Central and Eastern European countries by providing evidence from the 1990s. Horvath (2007) assesses the readiness of new EU member states to adopt the euro as a common currency.

Our study contributes to the literature on EAEU perspectives and current developments, as well as post-Soviet integration initiatives in general. A few articles have recently analysed various aspects of integration in these territories, which we discuss below.

Tarr (2016) analyses the prospects of the EAEU member states, with particular focus on trade and distribution of integration benefits. Kan, Andreosso-O'Callaghan, and Lenihan (2011) consider the asymmetries in business cycles in the former Soviet states using the structural VAR approach. The research results for the 1995–2005 period do not empirically support the possible monetary integration among the members of the Eurasian Economic Community.[4] Nevertheless, they find some evidence for the Russia–Belarus and, to some extent, the Russia–Kazakhstan pairs. Similarly, Chaplygin, Hallett, and Richter (2006) study the possibility of monetary integration in four ex-Soviet countries (Belarus, Kazakhstan, Russia and Ukraine). Using quarterly data from 1994 to 2003, and following Bayoumi and Eichengreen (1993), they impose long-run restrictions on a simple VAR model to identify demand, supply and monetary shocks for each country. They find that in the case of such monetary arrangements, it will be difficult to handle the lack of symmetry, asymmetric pattern of shocks and lack of market flexibility. Prokopenko et al. (2004) discuss the costs, benefits and challenges of a currency union between Russia and Belarus, with a focus on Belarus. They conclude that, although economically closely linked, these countries do not fulfil OCA criteria. In particular, they are subject to asymmetric shocks.

Uzagalieva (2005) considers the possible fiscal consequences of monetary integration between Belarus, Russia and Kazakhstan with a focus on the importance of seigniorage revenue and its possible distribution methods between the three countries. From the findings of the article, Russia would bear welfare loss since its seigniorage wealth was larger than its equity share in the common monetary area.[5]

Our article utilises the empirical framework of Bayoumi and Eichengreen (1997a, 1997b, 1998), and applies the approach to 14 post-Soviet and four neighbouring countries over the period 2000–2014. The article then evaluates the common currency area prospects for post-Soviet countries with particular emphasis on the countries now part of the EAEU. We also address some issues highlighted in the relevant literature, such as the endogeneity or importance of labour migration. To control for labour migration, we construct a proxy using average remittance flows. We also construct a variable to account for the fact that some of the countries in the region rely heavily on the export of crude oil. These two variables have not been used in any of the empirical articles mentioned above.

To the best of our knowledge, this is the first study to apply the methodology proposed and used by Bayoumi and Eichengreen (1997a, 1997b, 1998) to explain the variability of bilateral exchange rates, the variability of exchange market pressures and the index of intervention for post-Soviet countries, and to draw some conclusions on the possibility of monetary integration.

The methodology and the data

The methodology

We analyse the prospects of a common currency area for the post-Soviet countries by examining the behaviour of the bilateral exchange rate. Since exchange rate movements might be limited because countries use foreign exchange reserves to avoid such

fluctuations, we also examine the extent of interventions and exchange market pressure. As will be seen later, this is of particular relevance for the countries we study here. Exchange rate variability ($SD(\Delta \ln(e_{ij}))$) is calculated as the standard deviation of the change in the logarithm of the end-year nominal bilateral exchange rate between countries *i* and *j*. Following Bayoumi and Eichengreen (1998) and Eichengreen, Rose, and Wyplosz (1996), we measure the intervention with the ratio of change in reserves to narrow money.[6] To determine the pressure, the actual exchange rate changes are adjusted for the intervention influences implemented in the country pairs during the same period. Finally, the intervention index is constructed as one minus the ratio of the standard deviation of exchange rate change to the standard deviation of exchange market pressure.

All three measures – exchange rate variability, intervention index and exchange market pressure – are modelled using a standard and extended set of OCA variables identified in the literature. We also use additional variables that can better explain the variability of bilateral exchange rates and exchange market pressures.

We follow the methodology developed by Bayoumi and Eichengreen (1997a, 1997b, 1998) and estimate the following baseline equation:

$$Y_{ij} = \alpha + \beta_1\ SD(\Delta y_i - \Delta y_j) + \beta_2\ TRADE_{ij} + \beta_3\ DISSIM_{ij} + \beta_4 Size_{ij} + \beta_5 INF_{ij} + \\ + \beta_6\ OPEN_{ij} + \beta_7 REMIT_{ij} + \beta_8\ DISSIMOil_{ij} + \beta_9 DolVar_{ij} + \varepsilon_{ij}, \quad (1)$$

where Y_{ij} is the standard deviation of changes in bilateral exchange rates, or the standard deviation of bilateral exchange market pressures or the index of intervention.[7] $SD(\Delta y_i - \Delta y_j)$ captures the asymmetric disturbances to output, and is measured as the standard deviation of the difference in growth rates of real output between countries *i* and *j*. $TRADE_{ij}$ is the mean of the ratio of bilateral exports to domestic GDP for the two countries, and shows the importance of bilateral trade. $DISSIM_{ij}$ is another measure of asymmetric disturbances, but at the industry level, and is the sum of the absolute differences in shares of food, minerals, metals and manufacturing exports in the total exports.[8] By construction, this measure of export dissimilarity does not include the export of crude oil, although a number of countries in our sample heavily rely on it. To control for this aspect, we calculate the dissimilarity of exports for this sector, $DISSIMOil_{ij}$, as we did for the previous one. $Size_{ij}$ is the mean of the logarithm of two GDPs measured in US dollars (constant 2005 US$). INF_{ij} is the average absolute difference in inflation rates between the two countries *i* and *j* and $OPEN_{ij}$ is the openness, calculated as the average trade (equal to exports plus imports) to GDP ratio for the two countries *i* and *j*. $REMIT_{ij}$ is the average remittance flows between countries *i* and *j*. $DolVar_{ij}$ is the arithmetic average of the US dollar exchange rate variability for each country pair. Note, however, that when the United States is one of the two partner countries, it is set to 0.

The first four explanatory variables in Equation (1) represent the variable set that Bayoumi and Eichengreen (1997a, 1997b, 1998) refer to as *OCA variables*. If two countries have a similar economic structure, in the sense that they are subject to similar output shocks (Kenen, 1969), then the variability of the bilateral exchange rate and exchange market pressure can decrease. Second, the higher degree of trade integration between the economies (McKinnon, 1963) would incentivise efforts for lower exchange rate variability on a bilateral basis. As Eichengreen (1994, p. 80) mentions, the closer the trade links, the greater would be the benefits of using a single currency.[9] Furthermore, closer links are expected to create exchange market pressure and lead to higher

interventions to stabilise the actual exchange rate. The third variable is the asymmetry of shocks at the industry level. The higher the dissimilarity of export composition, the higher is the variability in exchange rate. This is because countries face different shocks at the considered industry levels, implying different patterns of changes in terms of trade via the exchange rate (Kenen, 1969). This might create both exchange market pressures and incentives to intervene. The fourth variable in Equation (1) is economic size. Economic theory suggests that smaller economies might benefit more from adopting a common currency.

Next, we consider four other variables, namely inflation differential, openness, remittances and dissimilarity of crude oil exports; we refer to them as *other OCA variables*. We considered these variables in our review of the OCA literature. The inflation differential measures the difference in inflation rates between the two countries. Similar inflation rates imply lower variability of exchange rates and pressures in the exchange market. According to McKinnon (1963), highly open economies prefer fixed exchange rate arrangements, and hence tend to suppress exchange market pressures through interventions. The next two variables we construct control for specific economic relationships and the structure of our sample of countries (none of the cited empirical articles adopt this approach). Some of the countries in our sample have strong and historical labour migration patterns, evidenced by considerable remittance flows. We use World Bank data on bilateral remittance flows to control for this factor. We construct an average remittance flows variable as a proxy for labour migration/mobility, which can act as another adjustment mechanism to shocks, reducing the observed variability of the exchange rate and market pressures.

The other variable is the dissimilarity in export composition for crude oil, which is expected to increase market pressure, reflected in either higher intervention or higher exchange rate variability. To elaborate on the importance of this variable, consider two countries, one an exporter and the other an importer of crude oil, and assume that oil prices go up. The exporting country would experience currency appreciation pressures, whereas the importing country would experience currency depreciation pressures. If not reflected in actual exchange rates, the pressures imply different motives to intervene, with the result that it would be difficult to hold bilateral exchange rates stable.

The last variable is the so-called system or regime variable (Bayoumi & Eichengreen, 1997a, 1997b, 1998). It is included in the set of explanatory variables, because the actual variability can be explained not only by the individual characteristics of two countries, but also by the prevailing international regime. Since it is constructed using the variability of individual currencies with respect to the US dollar, we include the United States in our sample to control for the countries' mutual economic ties with the United States.

The data

Using annual data, we calculate the variables for the sample covering the period 2000–2014, to obtain 153 observations for 18 countries.[10] We consider all post-Soviet countries (excepting Estonia, which adopted the euro as legal tender in 2011). The other countries considered are the United States, Iran, Mongolia and Vietnam. The last three countries are included in the analysis because they have either expressed clear interest in closer cooperation with the

EAEU (in the form of free trade agreements) or have intensive economic ties with the EAEU. The reason for including the United States has been discussed in the previous subsection.

To calculate the exchange rate variability, the arithmetic average of the US dollar variability, and the inflation differential, we use data from the International Financial Statistics (IFS) published by the International Monetary Fund (IMF). For some countries, whenever the data were not available we used other sources, such as the corresponding central banks and Bloomberg. The dissimilarities of output disturbances, openness and size of an economy have been calculated using data from the World Bank's World Development Indicators. Trade linkages and dissimilarity of exports have been calculated using the International Trade Center (ITC) calculations based on the United Nations Commodity Trade Statistics Database.

Whenever the trade statistics for a given country or given time period are not reported, we use mirror data. We use the World Bank data on bilateral remittance flows to construct a proxy for labour migration.[11] Details on the sources and how the variables are calculated are given in Appendix A.

Table 1 reports the variability of nominal exchange rates for all country pairs in the considered sample. The heavily shaded observations indicate the exchange rate variability greater than or equal to 20%, while the lightly shaded entries indicate the volatility less than 20% and greater than or equal to 8%. The unshaded entries show a volatility of less than 8%. The total number of observations is 153, out of which we have 65 cases corresponding to volatility greater than 20% and 59 cases falling in the middle volatility range.

Belarus, Iran, Turkmenistan and Uzbekistan have highly variable exchange rates against almost every country in our sample. The lowest variability is 2.6%, corresponding to the United States vis-à-vis Vietnam. The variability of the Russian currency against that of Belarus, a member country of the EAEU, is 40%, and ranges approximately from 11% to 13% against other member countries (Kazakhstan, Armenia and Kyrgyzstan). Other EAEU member countries, in respect to each other, have lower variability of exchange rates, with the exclusion of Belarus, as mentioned above.

Panel A of Table 2 reports the exchange market pressures, and, as expected, confirms the patterns observed in the nominal exchange rate variability table above. Note that, for some pairs of countries, the variability of exchange market pressures is more pronounced than the actual variability of the nominal exchange rate. This is particularly true not only for Lithuania and Mongolia. In general, we can conclude that the two measures are different enough to convey additional information.

Much larger variability can be observed in the intensity with which countries have applied interventions to cope with exchange rate fluctuations. As Panel B of Table 2 shows, a large number of countries have a relatively high intervention index despite having low exchange rate variability during the same period.

The data on some of the explanatory variables, briefly discussed below, can be found in Table B1 of Appendix B. For output disturbances note that Azerbaijan exhibits the largest asymmetry of output disturbances among all the countries considered in our sample – the average value across countries is 9.6% – probably due to the over-reliance on oil exports.

As regards the EAEU member states, the asymmetry of output disturbances with respect to each other is smaller for the larger countries – Russia, Belarus and Kazakhstan – and relatively high for Armenia and Kyrgyzstan. The importance of trade linkages, as measured by the average value of exports to the partner country scaled by the corresponding GDP, is

Table 1. The variability of nominal bilateral exchange rates.

	USA	ARM	AZE	BLR	GEO	IRN	KAZ	KGZ	LTU	LVA	MDA	MNG	RUS	TJK	TKM	UKR	UZB
ARM	0.116																
AZE	0.032	0.104															
BLR	0.392	0.362	0.378														
GEO	0.055	0.093	0.055	0.393													
IRN	0.418	0.417	0.411	0.563	0.413												
KAZ	0.082	0.061	0.080	0.382	0.065	0.423											
KGZ	0.075	0.075	0.078	0.387	0.051	0.431	0.051										
LTU	0.098	0.125	0.111	0.392	0.091	0.469	0.093	0.076									
LVA	0.073	0.113	0.082	0.395	0.071	0.457	0.082	0.066	0.039								
MDA	0.086	0.079	0.079	0.385	0.071	0.411	0.045	0.072	0.108	0.092							
MNG	0.078	0.098	0.082	0.383	0.089	0.412	0.082	0.084	0.122	0.114	0.091						
RUS	0.155	0.129	0.156	0.405	0.130	0.439	0.121	0.108	0.128	0.072	0.131	0.136					
TJK	0.119	0.123	0.104	0.315	0.120	0.418	0.105	0.123	0.150	0.130	0.104	0.135	0.182				
TKM	0.260	0.281	0.275	0.503	0.253	0.511	0.276	0.247	0.261	0.270	0.300	0.260	0.270	0.308			
UKR	0.201	0.186	0.207	0.448	0.182	0.478	0.179	0.155	0.182	0.132	0.194	0.184	0.093	0.235	0.241		
UZB	0.257	0.258	0.236	0.313	0.247	0.470	0.256	0.265	0.272	0.253	0.248	0.277	0.293	0.184	0.387	0.347	
VNM	0.027	0.107	0.040	0.378	0.058	0.423	0.080	0.073	0.095	0.067	0.091	0.079	0.155	0.116	0.255	0.202	0.255

Key: USA = United States of America; ARM = Armenia; AZE = Azerbaijan; BLR = Belarus; GEO = Georgia; IRN = Iran; KAZ = Kazakhstan; KGZ = Kyrgyzstan; LTU = Lithuania; LVA = Latvia; MDA = Moldova; MNG = Mongolia; RUS = Russia; TJK = Tajikistan; TKM = Turkmenistan; UKR = Ukraine; UZB = Uzbekistan; VNM = Vietnam.

Table 2. Variability of exchange market pressure and index of intervention.

	USA	ARM	AZE	BLR	GEO	KAZ	KGZ	LTU	LVA	MDA	MNG	RUS	TJK	UKR
Panel A. Variability of exchange market pressure														
ARM	0.151													
AZE	0.103	0.202												
BLR	0.418	0.355	0.375											
GEO	0.084	0.173	0.145	0.357										
KAZ	0.137	0.207	0.183	0.406	0.181									
KGZ	0.088	0.118	0.183	0.358	0.115	0.160								
LTU	0.201	0.261	0.349	0.489	0.319	0.284	0.270							
LVA	0.069	0.140	0.141	0.355	0.129	0.152	0.094	0.268						
MDA	0.055	0.197	0.130	0.390	0.178	0.198	0.155	0.339	0.153					
MNG	0.153	0.283	0.283	0.433	0.239	0.295	0.255	0.377	0.240	0.264				
RUS	0.122	0.148	0.267	0.440	0.231	0.233	0.144	0.295	0.157	0.205	0.263			
TJK	0.249	0.265	0.185	0.425	0.223	0.189	0.210	0.388	0.179	0.171	0.275	0.262		
UKR	0.165	0.208	0.301	0.446	0.261	0.290	0.194	0.334	0.183	0.243	0.287	0.155	0.275	
VNM	0.038	0.205	0.130	0.361	0.154	0.192	0.168	0.306	0.076	0.155	0.240	0.254	0.164	0.278
Panel B. Index of intervention														
ARM	0.236													
AZE	0.685	0.484												
BLR	0.062	−0.021	−0.006											
GEO	0.343	0.463	0.619	−0.099										
KAZ	0.405	0.704	0.563	0.058	0.641									
KGZ	0.143	0.366	0.572	−0.079	0.552	0.679								
LTU	0.509	0.522	0.682	0.199	0.713	0.671	0.719							
LVA	−0.054	0.198	0.417	−0.114	0.449	0.457	0.296	0.856						
MDA	−0.573	0.596	0.394	0.013	0.600	0.773	0.536	0.680	0.397					
MNG	0.491	0.652	0.711	0.114	0.629	0.722	0.671	0.676	0.526	0.657				
RUS	−0.267	0.126	0.417	0.080	0.438	0.483	0.250	0.566	0.539	0.364	0.484			
TJK	0.523	0.534	0.436	0.259	0.461	0.444	0.416	0.614	0.278	0.390	0.509	0.307		
UKR	−0.214	0.103	0.313	−0.003	0.304	0.381	0.199	0.454	0.277	0.200	0.358	0.401	0.145	
VNM	0.302	0.477	0.692	−0.046	0.626	0.586	0.566	0.691	0.108	0.413	0.669	0.391	0.296	0.272

Note: For keys see Table 1.

greatest for the Belarus–Russia country pair. The Ukraine–Turkmenistan pair shows the second highest value, followed by the Tajikistan–Uzbekistan pair. Russia has close trade linkages with Ukraine and Moldova. This measure for Russia is approximately the same with Kazakhstan and Kyrgyzstan, but lower with Armenia. Overall, as one might expect, the general pattern noticed is closer trade linkages with neighbouring countries.

Panel C of Table B1 reports the dissimilarity of commodity composition between the exports of two countries as another proxy for asymmetric shocks, but now at the industry level. In this case, we find no heavily shaded entries for any single country. At the industry level, Armenia faces more asymmetric shocks compared to Moldova, Turkmenistan, the United States and Azerbaijan. However, in comparison with Kazakhstan, Kyrgyzstan and Russia, Armenia faces roughly the same level of asymmetric shocks. Not surprisingly, Russia and Kazakhstan have a similar export composition structure, followed by Belarus and Kyrgyzstan.

Estimation results and discussion

We estimate Equation (1) by applying an instrumental variable approach. Here we are more concerned with the reverse causality problem and explicitly acknowledge that bilateral exchange rate variability per se can determine the changes in trade patterns of our sample countries.[12] In fact, in their more recent work, the previously cited authors (Bayoumi & Eichengreen, 1998) apply an instrumental variable approach, whereas in their earlier work (Bayoumi & Eichengreen, 1997a, p. 199), they state that even if an issue of endogeneity exists, it will not be pronounced, because the analysis is concerned with standard deviations rather than level of bilateral exchange rates.

The standard set of instruments derived from gravity models (log of distance between countries, contiguity and common colonial origin) fail to pass the over-identifying restrictions test. We augment the set of instruments with mutual trade flows for the period preceding our sample period. Owing to data limitations, the earliest we could have gone from our sample period was 1999. As instruments, we also add the average of the actual population of the country pairs and construct a dummy variable that takes the value of 1 if either of the two countries in the pair applied trade limitations to the counterpart country. We re-run the over-identifying restrictions test to confirm as valid instruments the dummy for log of distance, a common border and out-of-sample-period mutual trade. Finally, we calculate the Conditional Likelihood Ratio (Moreira, 2003) to ensure that we do not face weak instrument problems.[13]

Table 3 reports the results for different specifications when the dependent variable is the exchange rate variability. From the first column of the table, OCA variables alone are not significant predictors of exchange rate variability. However, note that these results are comparable with those of Bayoumi and Eichengreen (1997a, 1998) obtained for the set of developed countries (including EU countries) for the 1960s.

Inclusion of the other OCA variables (inflation differential, openness and remittance) improves the model, which can now explain almost half of the cross-country variations.[14] All three variables, as opposed to the first four OCA variables, have significant impact on the dependent variable, with the expected signs. We find that the similarity of inflation rates implies a lower variability of the bilateral exchange rate, and that more open countries tend to have a more stable bilateral exchange rate. The estimation shows that remittance flows tend to decrease exchange rate variability.[15]

Table 3. Instrumental variable estimation results. Dependent variable: exchange rate variability.

	(1)	(2)	(3)	(4)
OCA variables				
$SD(\Delta y_i - \Delta y_j)$	0.105 (0.500)	0.378 (0.375)	0.227 (0.167)	0.339* (0.178)
$TRADE_{ij}$	0.815 (1.748)	1.209 (1.424)	−1.494**(0.731)	−1.388**(0.689)
$DISSIM_{ij}$	−0.096** (0.041)	−0.036 (0.032)	0.024 (0.017)	0.029* (0.017)
$Size_{ij}$	0.008 (0.009)	−0.004 (0.008)	0.027*** (0.004)	0.028*** (0.004)
Other OCA variables				
INF_{ij}	–	1.234*** (0.104)	0.440*** (0.101)	0.431*** (0.102)
$OPEN_{ij}$	–	−0.152*** (0.047)	−0.039 (0.026)	−0.044* (0.025)
$REMIT_{ij}$	–	−0.058* (0.032)	−0.032* (0.019)	−0.034* (0.018)
$DISSIM_{ij}$ for crude oils	–	–	–	−0.021 (0.017)
International regime				
$DolVar_{ij}$	–	–	1.216*** (0.084)	1.234*** (0.088)
constant	0.056 (0.212)	0.345 (0.215)	−0.620*** (0.114)	−0.647*** (0.112)
N	153	153	153	153

Note: Robust standard errors are in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

To some extent, this impact can be considered to be a proxy for labour mobility/migration between countries, which likely acts as another adjustment mechanism to economic shocks, reducing the variability of the exchange rate. Another noteworthy point in specification (2) is that the inflation differential, proxying the differences in effectiveness of monetary policies, turns out to be significant and more important than the standard set of OCA variables.

Next, we include the system variable (specification (3)), which has a significant and positive impact on the dependent variable. This means that the international regime matters for the actual exchange rate policies of individual countries and is reflected in their bilateral rates. Bayoumi and Eichengreen (1997a, 1998) found that the system variable had a significantly positive impact in the 1960s and 1970s, but negative significant impact in the 1980s. Moreover, they found that the size of the positive impacts declined over time. The authors justify these positive and negative dollar rate impacts by the presence and collapse of the Bretton Woods system of monetary arrangements.

In our case, from the estimation results we can conclude that the dollar does have a certain dominance as anchor currency for the considered set of countries, although the countries themselves do not participate in any common system of exchange rate arrangements (like the Bretton Woods system). The exchange rate regimes adopted by the individual countries, reviewed and discussed in the next subsection, support the conclusion.

As soon as we control for the influence of the dollar rate, two of the OCA variables – trade linkages and economic size – show a significant impact. All these variables enter with anticipated signs. We find the exchange rate variability smaller when the countries are smaller in economic size and have tight bilateral trade links.

Finally, we also consider the dissimilarity of the export composition for crude oil (specification (4)). By controlling for the potential differences in the crude oil export sector, which is relevant for our sample of countries, we obtain a significant impact of the dissimilarity of export composition and openness. According to specification (4), which we consider to be the most relevant one, ceteris paribus there is a smaller exchange rate variability when the economies are closely linked by bilateral trade, are subject to similar shocks both on the aggregate and the industry level, have similar inflation rates, are open and smaller in economic size, and have higher labour migration.

We again emphasise that the OCA variables explain the exchange rate variability only when the model is extended to include other relevant variables, such as variability of the US dollar exchange rate and the dissimilarity of crude oil exports. As panels A and B of Table 4 demonstrate, this is also the case when we consider the variability of exchange market pressures and the index of intervention as dependent variables. This demonstrates that not taking into account the exchange rate variability with respect to the US dollar is crucial in our context. However, since the majority of the countries considered in our analysis do not have freely convertible currencies, one might claim that the bilateral exchange rate variability of two non-convertible currencies will not differ from their variability with respect to the US dollar. To address this concern, we also tested whether the bilateral exchange rate communicates additional information. We found that the mean variability of bilateral rates and average rates with respect to the US dollar are statistically different from one another.

Panels A and B of Table 4 report the estimation results when the dependent variables are the variability of the exchange market pressure and the index of intervention. Note that we have to reduce the sample size from 153 to 105 observations when dealing with these variables since the data for Iran, Turkmenistan and Uzbekistan are not available.[16] Also, we consider OLS regressions since our instruments are not valid with these dependent variables. We find that economic size, inflation differential and degree of openness have positive and significant impacts on the variability of exchange market pressure. Remittance flow has a negative and significant effect on exchange market pressure. The system variable is another source of exchange market pressure.

The results in Panel B of Table 4 show that trade linkages and the dissimilarity of export composition for oil have a positive and significant impact on the index of intervention, which increases for small and open economies. The dollar rates and inflation differential have a negative and highly significant impact on the index of intervention.

When comparing the estimation results reported in Tables 3 and 4, one can see that some variables tend to lower exchange rate variability, although, at the same time, they increase the exchange market pressures and index of intervention. In other words, the stability of exchange rates is achieved through interventions in the exchange market by suppressing the pressures so that they are not reflected in the actual exchange rate. We refer to this as 'fear of floating' (first documented by Calvo & Reinhart, 2002). Our estimation identifies several sources of 'fear of floating', such as trade linkages, openness and dissimilarity of exports in the crude oil sector. Ceteris paribus, countries that are open, have closer bilateral trade links, and have more dissimilarities with respect to the oil-exporting sector 'fear of floating' the exchange rate, in other words, are less inclined to liberalise their exchange rate regime.

This impact is significant for openness in all models with all three dependent variables that we consider. The trade variable has the expected positive sign, but is insignificant in the model with exchange market pressure as a dependent variable (Panel A, Table 4). Dissimilarity of crude oil exports has the predicted sign in all models, but is significant only in the model with the index of intervention as a dependent variable (Panel B, Table 4).

Implications for the common currency area

We examined the extent to which OCA variables influence the variability of exchange market pressures, both reflected and not reflected in the actual exchange rate variability,

Table 4. OLS estimation results. Dependent variables: variability of exchange market pressure and index of intervention.

	(1)	(2)	(3)	(4)
Panel A. Variability of exchange market pressure				
OCA variables				
$SD(\Delta y_i - \Delta y_j)$	−0.244 (0.408)	0.148 (0.348)	0.183 (0.319)	0.176 (0.315)
$TRADE_{ij}$	1.036 (0.750)	1.074*** (0.230)	0.379 (0.263)	0.377 (0.265)
$DISSIM_{ij}$	−0.050 (0.038)	0.027 (0.026)	0.036 (0.024)	0.035 (0.025)
$Size_{ij}$	−0.016*** (0.006)	0.001 (0.005)	0.012** (0.005)	0.012** (0.005)
Other OCA variables				
INF_{ij}		0.710*** (0.069)	0.372** (0.180)	0.372** (0.181)
$OPEN_{ij}$		0.149*** (0.043)	0.134*** (0.041)	0.134*** (0.041)
$REMIT_{ij}$		−0.030 (0.020)	−0.040*** (0.011)	−0.040*** (0.011)
$DISSIM_{ij}$ for crude oils				0.001 (0.022)
International regime				
$DolVar_{ij}$			0.615*** (0.214)	0.615*** (0.216)
constant	0.656*** (0.150)	−0.034 (0.164)	−0.309* (0.156)	−0.307** (0.153)
N	105	105	105	105
R^2	0.076	0.6	0.659	0.659
F	2.529	43.729	51.044	45.072
Panel B. Index of intervention				
OCA variables				
$SD(\Delta y_i - \Delta y_j)$	0.936 (1.070)	0.460 (0.921)	0.409 (0.904)	−1.418 (0.951)
$TRADE_{ij}$	1.397 (2.019)	2.531* (1.451)	3.545** (1.449)	3.124** (1.409)
$DISSIM_{ij}$	0.164 (0.104)	0.060 (0.084)	0.048 (0.081)	−0.018 (0.080)
$Size_{ij}$	−0.057*** (0.020)	−0.034* (0.02)	−0.049*** (0.018)	−0.064*** (0.018)
Other OCA variables				
INF_{ij}		−2.013*** (0.227)	−1.520*** (0.370)	−1.350*** (0.342)
$OPEN_{ij}$		0.284** (0.118)	0.306*** (0.113)	0.305*** (0.109)
$REMIT_{ij}$		−0.037 (0.036)	−0.022 (0.039)	−0.024 (0.040)
$DISSIM_{ij}$ for crude oils				0.287*** (0.073)
International regime				
$DolVar_{ij}$			−0.899* (0.509)	−1.080** (0.469)
constant	1.592*** (0.524)	1.015* (0.546)	1.416*** (0.504)	1.855*** (0.485)
N	105	105	105	105
R^2	0.163	0.487	0.504	0.56
F	5.625	15.012	24.905	22.712

Note: Robust standard errors are in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

and find that their impacts are generally consistent with theoretical considerations drawn from the corresponding literature. In other words, on a bilateral basis, if some OCA variables call for a common currency area, they either reduce the variability of the exchange rate (for instance, similarity of experienced shocks) or increase the incentives to intervene and stabilise bilateral exchange rates (for instance, trade links).

Next, we attempt to estimate the variability of the exchange rates that would have been observed due to the set of variables considered. For this purpose, we follow Bayoumi and Eichengreen (1997a) and make in-sample predictions of exchange rate variability based on the estimation results reported in Table 3, specification (4). We perform this exercise for post-Soviet countries taking the Russian rouble as the core currency, with all comparisons vis-à-vis the Russian rouble.

Panel (a) of Figure 1 shows that almost all the points lie below the 45 degree line. This means that the individual country characteristics and other indicators that we consider in our model predict higher exchange rate variability with respect to the Russian rouble than the actual one. Apparently, Belarus, and, to some extent, Tajikistan and Uzbekistan, stand out from the common pattern and selected variables under-predict the actual exchange rate variability. These differences in actual and predicted variability could be attributed to

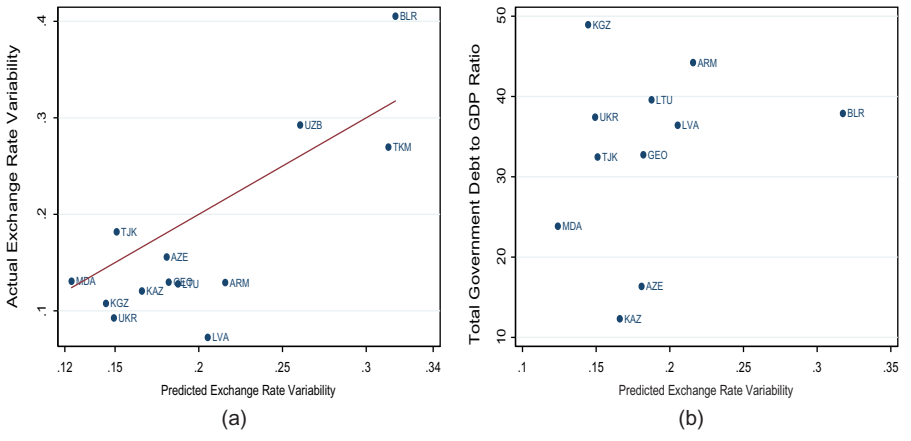

Figure 1. Actual and predicted exchange rate variabilities (a) and total (gross) government debt-to-GDP ratio and predicted exchange rate variability (b).

political or other types of linkages, as well as country characteristics not associated with OCA theory. As the model is based on the OCA theory, it does not enable an explanation of the underlying causes of the mentioned differences.

However, as can be observed from panel (a) of Figure 1, the prediction of the model shows a distinct heterogeneity in exchange rate variability, implied by the economic fundamentals of the countries and, in particular, of the EAEU member states. The difference between the variability predicted for the Armenian dram and Kyrgyzstani som against the Russian rouble is as large as 7%. Kazakhstan is in-between these two cases, but closer to Kyrgyzstan. Moreover, the Belarusian rouble is predicted to have the highest exchange rate variability not only among the EAEU member states, but also among all the countries in panel (a) of Figure 1. In particular, it exceeds the predicted variability of Kyrgyzstan's currency by more than twice.

Therefore, the EAEU member countries could have faced difficulties in maintaining their currency exchange rate stable against the Russian rouble in the sample period had they found themselves in a common currency area or adopted fixed exchange rate arrangements against the Russian rouble. Thus, the fundamentals suggest limited prospects for a common currency for the EAEU member states. Previous studies have also obtained similar findings (see Chaplygin et al., 2006; Kan et al., 2011; Prokopenko et al., 2004).

Our conclusion is consistent with the actual developments in some of these countries. In particular, they experienced currency crises while pegging their currencies to the Russian rouble or to a basket of currencies, or while attempting to smooth excess volatility (see Dabrowski, 2016, for an overview of recent currency crises episodes in post-Soviet countries).

Bayoumi and Eichengreen (1997b) refer to the prediction of exchange rate variability as the OCA index. According to that approach, smaller index values suggest that the two countries better approximate an OCA (Kim & Chow, 2003). We depict the OCA index in Figure 1(a), where the lowest value[17] is for Moldova, and then for Kyrgyzstan, Ukraine and Tajikistan. Hence, from among the 13 post-Soviet countries, Moldova is in a relatively better position to approximate an OCA with Russia.

Meanwhile, we believe that this discussion should also examine countries' fiscal positions. A recent example of Greece shows that differences in the fiscal situation of member countries in a monetary union can become a major problem. The Maastricht criteria, among others, impose requirements on government finance, specifically on the budget deficit and public debt. A similar regulation occurs in the Founding Treaty of the EAEU requiring countries to maintain their debt-to-GDP ratio below 50%. In subsequent discussion we include the total government debt-to-GDP ratio as of 2014. Since we are not interested in the values, in panel (b) of Figure 1 we depict them against the OCA index. The pattern is evident: countries with a high OCA index also have a high government debt-to-GDP ratio.[18] By combining the OCA index with the government debt-to-GDP ratio we can conclude that for our study period, Moldova, Kazakhstan and Azerbaijan stand out as countries in a better position to approximate the optimum currency area with Russia. Note that the government debt-to-GDP ratio for Russia is 11%.

As mentioned above, our model predictions and conclusions are in line with the difficulties that the countries faced in achieving exchange rate stability. Below, we briefly comment on some aspects of the exchange rate arrangements in the EAEU member states and the resulting difficulties they experienced from 2000 to 2014. We use monthly data to better demonstrate the developments in foreign exchange markets. Figure 2 plots the percentage changes in nominal exchange rates (US dollar per national currency) using the end-of-month exchange rates derived from the IFS, IMF database.

As shown in Figure 2, Belarusian and Russian roubles had large devaluations in the sample period, although the former was pegged[19] and the latter was under a managed floating exchange rate regime.[20] The difficulties maintaining the exchange rate peg in Belarus led to 100%, 20% and 40% devaluations in 2000, 2009 and 2011, respectively. Similarly, as the graph depicts, the Russian rouble experienced large devaluations in 2009, 2011 and 2012. Another EAEU member, Kazakhstan, has been conducting a de facto tightly managed exchange rate regime, and, in early 2009, devalued its currency by 20% against the US dollar. The graph shows that the Kazakstani tenge and Russian rouble exhibit similar behaviour between 2000 and 2009, including the large devaluations of comparable magnitudes (caused by the global financial crisis and drop in oil prices).

Figure 2 also makes it evident that the Armenian dram and Kyrgyzstani som fluctuate more freely than the other three countries' currencies. These two countries had de jure freely floating exchange rate regimes, although, according to the IMF annual reports on exchange arrangements and exchange restrictions, de facto regimes differed from de jure ones from time to time.

The analysis clarifies certain difficulties that the EAEU member countries face in achieving exchange rate stability. The argument is more pronounced for specifically those countries that had exchange rate stability policies during the study period. In fact, those policies proved to be unsuccessful during episodes of large devaluations. It is noteworthy that the countries with exchange rate stability policies (also against the Russian rouble) abandoned those policies and ultimately switched to floating exchange rate regimes (Russia in November 2014, Kazakhstan in August 2015 and Belarus in early 2015). To some extent, the mentioned facts confirm our conclusion on the limited prospects of common currency area adoption for EAEU member states.

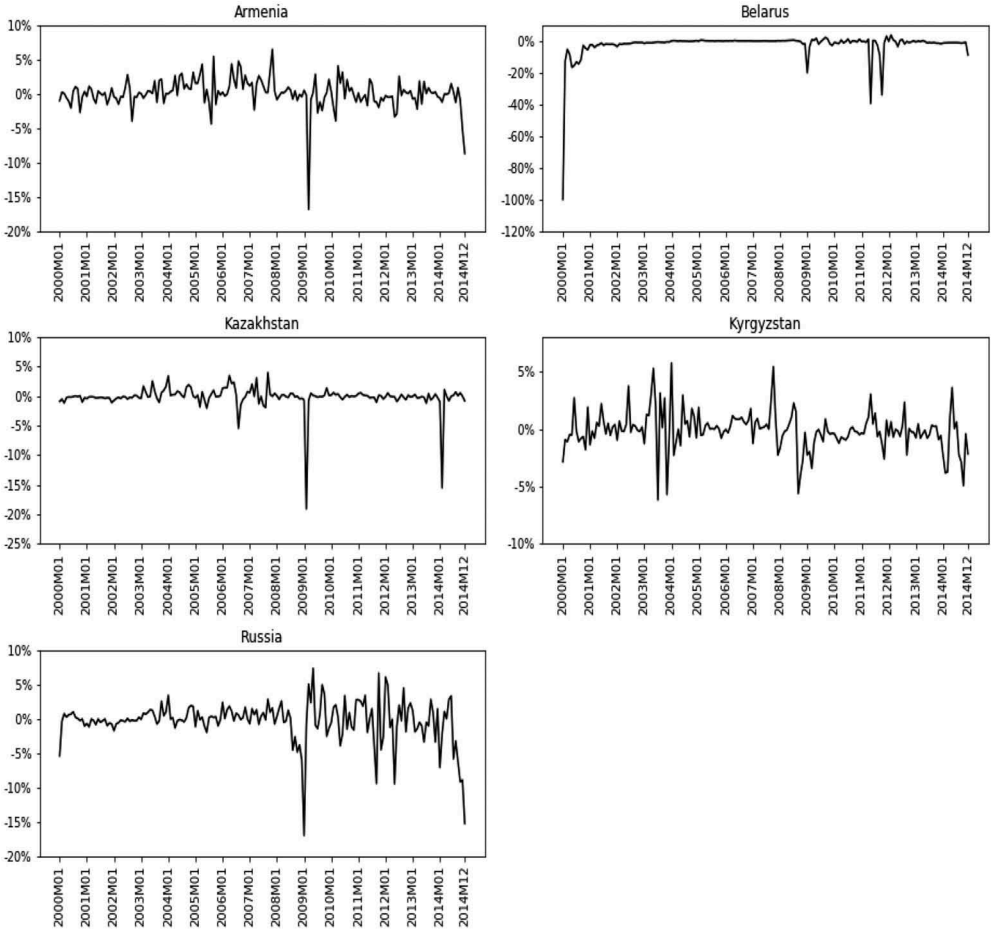

Figure 2. Percentage change of nominal exchange rates (US dollar per national currency) in Armenia, Belarus, Kazakhstan, Kyrgyzstan and Russia (2000–2014).

Concluding remarks

In this article we applied OCA theory to explain observed exchange rate variability, the index of intervention and the variability of exchange market pressure in post-Soviet countries. The estimations show that the standard set of OCA variables exert a significant impact on exchange rate variability only if other OCA variables are included and the average variability of currencies against the US dollar is controlled for. Given our sample of countries with specific economic relationships and structures, we also control for labour migration by proxying it with the average remittance flows between countries and the dissimilarities of crude oil export.

From the estimation results, other things being equal, there is smaller exchange rate variability when the economies are closely linked by bilateral trade, are subject to similar shocks, both on aggregate and the industry level, have similar inflation rates, are open and smaller in economic size, and have higher labour migration. It is also found that, ceteris paribus, when countries are open, have closer bilateral trade links and are more dissimilar with respect

to the oil-exporting sector, they 'fear of floating' the exchange rate. This impact is significant for openness in all the models and with all three dependent variables that we consider.

Using our estimation results, we predict the exchange rate variability for post-Soviet countries, with the Russian rouble as the anchor currency. From the model prediction, based on the fundamental economic factors in OCA theory, Moldova, from among the post-Soviet countries better approximates an OCA with Russia. It also shows that there is a distinct heterogeneity in exchange rate variability, implied by the fundamentals of the countries, in particular, of the EAEU member states, with Belarus as an evident example. Thus, this implies that the fundamentals suggest limited prospects of a common currency for the EAEU member states. Meanwhile, if the government debt-to-GDP ratio is considered, only Kazakhstan from the EAEU member countries seems to show positive prospects of forming a common currency area with Russia.

Notes

1. We control for labour migration by proxying it with the average remittance flows between the countries.
2. For a more detailed literature review an interested reader is invited to refer, for example, to Mongelli (2002) and Tavlas (1993).
3. The lower exchange rate variability might reflect the fact that countries, to some extent, fulfil criteria of an OCA.
4. The Eurasian Economic Community here refers to Russia, Kazakhstan, Kyrgyzstan, Tajikistan, Belarus and Ukraine. For further integration initiatives in the Commonwealth of Independent States (CIS) during the 2000s, see Kan et al. (2011, Table 1).
5. Equity share is determined as the average contribution of GDP and population values to the total GDP and population in the common monetary area. The distribution methods are based on a variation of the exact method to obtain equity share of participating states.
6. This is widely used, although it is not an ideal proxy for intervention. However, Suardi and Chang (2012) find that the 'co-movement between monthly reserves changes and intervention is governed by intervention amount', and they conclude that 'the conditional correlation is stronger when intervention frequency and amount increase', which is likely to be quite relevant for our sample of countries.
7. More details on the variables calculations and data sources can be found in Appendix A.
8. The product groups are based on two-digit HS codes.
9. Likewise, two different currencies which are less variable against each other.
10. For the intervention index and pressure, the number of observations is 105, since no data were available for Iran, Turkmenistan and Uzbekistan.
11. Unfortunately, data are available for only a 5-year period, 2010–2014. However, this still turns out to be of statistical importance, along with being economically important to omit.
12. We perform the Hausman test for endogeneity, both for trade and output, but reject the exogeneity hypothesis for trade.
13. With a p-value = 0.0574, we marginally reject the null hypothesis of the coefficient of the instrumented variable being zero.
14. Here, formally, we refer to the explained variation of the respective OLS model as measured by its R-squared (Table B2, Appendix B).
15. Although data are available only for a 5-year period, 2010–2014, the coefficient on the average remittance flows between pairs of countries still has the expected negative sign and is statistically significant in all specifications.
16. In Appendix B, we report the exchange rate variability OLS estimations both with a full (153) and restricted (105) sample (Tables B2 and B3, respectively). The results prove to be quite robust with respect to the omission of these three countries.

17. It is worth highlighting that the levels of variability are very high in comparison with those obtained for the euro area as given in Horvath (2007). This applies to both actual and predicted variability.
18. The correlation coefficient is equal to 0.23.
19. Belarus had adopted a crawling peg vis-à-vis the Russian rouble at the beginning of 2001 and, in June 2009, pegged its rouble to a currency basket with equal weights assigned to the US dollar, the euro and the Russian rouble.
20. From 1999 to November 2014, the Bank of Russia had a managed floating exchange rate regime, smoothing excess volatility and using the US dollar and euro basket as the operational indicators. Since 10 November 2014, it has abandoned the permissible range of the dual-currency basket, although foreign exchange interventions can still be conducted to maintain financial stability. For more details, one can refer to the 'History of the Bank of Russia FX Policy' from the official website of the Bank of Russia.

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Appendix A. Definitions and calculations of variables

Variable names	Description, notation and the formula	Data source
Variability of exchange rate	Standard deviation of the change in the logarithm of the end-year bilateral exchange rate between countries i and j $(SD(\Delta \ln(e_{ij})))$.	IFS, IMF; Bloomberg and central banks.
Variability of exchange market pressure	Standard deviation of exchange market pressure, defined as the sum of exchange rate depreciation and reserve outflows, scaled by M2 monetary aggregate: $SD(Pressure_{ij}) = SD(\Delta \ln(e_{ij}) + \frac{\Delta(Res_i)}{M2_i} - \frac{\Delta(Res_j)}{M2_j})$	IFS, IMF; Bloomberg and central banks.
Index of intervention	$Intervention_{ij} = 1 - \frac{SD(\Delta \ln(e_{ij}))}{SD(Pressure_{ij})}$	IFS, IMF; Bloomberg and central banks.
Variability of output	Standard deviation of the difference in the growth rates of real output between countries i and j $(SD(\Delta y_i - \Delta y_j))$.	WDI, WB
Trade linkages	The mean of the ratio of bilateral exports to domestic GDP for the two countries, $TRADE_{ij} = \frac{1}{2}\left(\frac{1}{T}\sum_{t=1}^{T}\frac{Ex_{ijt}}{Y_{it}} + \frac{1}{T}\sum_{t=1}^{T}\frac{Ex_{ijt}}{Y_{jt}}\right)$	ITC calculations based on UN COMTRADE Statistics
Dissimilarity of exports	The sum of absolute differences in the shares of food (F), mineral (Mn), metals (Mt) and manufacturing (Mf) export in total export. $DISSIM_{ij} = \sum_{S=F,Mn,Mt,Mf}\left(\frac{1}{T}\sum_{t=1}^{T}\lvert S_{it} - S_{jt}\rvert\right)$	ITC calculations based on UN COMTRADE Statistics.
Size of economy	The mean of the logarithm of the two GDP's measured in US dollars (constant 2005 US$). $Size_{ij} = \frac{1}{2}\left(\frac{1}{T}\sum_{t=1}^{T} y_{it} + \frac{1}{T}\sum_{t=1}^{T} y_{jt}\right)$	WDI, WB
Inflation differential	The average absolute difference in the inflation rates between the two countries i and j $INF_{ij} = \frac{1}{T}\sum_{t=1}^{T}\lvert \pi_{it} - \pi_{jt}\rvert$	IFS, IMF
Openness	Average trade (equal to exports plus imports) to GDP ratio for the two countries i and j $OPEN_{ij} = \frac{1}{2}\left(\frac{1}{T}\sum_{t=1}^{T}\frac{Ex_{it}+Im_{it}}{Y_{it}} + \frac{1}{T}\sum_{t=1}^{T}\frac{Ex_{jt}+Im_{jt}}{Y_{jt}}\right)$	WDI, WB
Remittance flows	Average remittance flows between two countries i and j (mln. US$) $REMIT_{ij} = \frac{1}{T}\left(\sum_{t=1}^{T}\frac{(REMIT_{it}+REMIT_{jt})}{2}\right)$	WB
Variability of US dollar exchange rate	Arithmetic average of the variability of the US dollar exchange rates of each country pair. $DolVar_{ij} = \begin{cases} \frac{1}{2}\left[SD(\Delta e_{it}) + SD(\Delta e_{jt})\right], & when\ i\ or\ j \neq USA \\ 0, & otherwise \end{cases}$	IFS, IMF

Appendix B. Tables

Data on the asymmetry of output disturbances; trade linkages and the dissimilarity of commodity composition of export.

	USA	ARM	AZE	BLR	GEO	IRN	KAZ	KGZ	LTU	LVA	MDA	MNG	RUS	TJK	TKM	UKR	UZB
Panel A. The asymmetry of output disturbances																	
ARM	0.063																
AZE	0.096	0.089															
BLR	0.034	0.058	0.082														
GEO	0.033	0.045	0.087	0.037													
IRN	0.038	0.070	0.088	0.034	0.045												
KAZ	0.026	0.054	0.089	0.035	0.035	0.034											
KGZ	0.041	0.079	0.105	0.049	0.054	0.053	0.049										
LTU	0.049	0.023	0.097	0.050	0.032	0.060	0.043	0.064									
LVA	0.055	0.029	0.090	0.060	0.042	0.068	0.046	0.073	0.026								
MDA	0.035	0.057	0.104	0.039	0.042	0.046	0.038	0.046	0.045	0.057							
MNG	0.044	0.072	0.114	0.053	0.044	0.068	0.057	0.051	0.055	0.065	0.047						
RUS	0.032	0.042	0.088	0.030	0.033	0.043	0.029	0.052	0.032	0.042	0.041	0.055					
TJK	0.019	0.061	0.100	0.035	0.037	0.036	0.024	0.037	0.049	0.057	0.033	0.049	0.035				
TKM	0.048	0.087	0.103	0.052	0.054	0.068	0.063	0.053	0.073	0.082	0.057	0.040	0.061	0.056			
UKR	0.059	0.042	0.101	0.050	0.051	0.061	0.045	0.070	0.036	0.045	0.054	0.070	0.036	0.055	0.087		
UZB	0.030	0.081	0.100	0.040	0.045	0.049	0.047	0.039	0.068	0.076	0.047	0.040	0.052	0.035	0.031	0.077	
VNM	0.014	0.068	0.093	0.031	0.036	0.033	0.028	0.037	0.056	0.062	0.038	0.047	0.038	0.018	0.045	0.064	0.023
Panel B. Trade linkages																	
ARM	0.595																
AZE	1.126	0.000															
BLR	0.226	0.049	0.119														
GEO	0.405	0.865	1.507	0.077													
IRN	0.022	0.381	0.369	0.072	0.063												
KAZ	0.248	0.030	0.232	0.395	0.186	0.603											
KGZ	0.191	0.006	0.053	0.104	0.024	0.106	2.264										

(*Continued*)

(Continued).

	USA	ARM	AZE	BLR	GEO	IRN	KAZ	KGZ	LTU	LVA	MDA	MNG	RUS	TJK	TKM	UKR	UZB
LTU	0.815	0.010	0.038	1.790	0.067	0.071	0.377	0.083									
LVA	0.301	0.015	0.043	1.585	0.036	0.053	0.160	0.120	4.935								
MDA	0.417	0.029	0.046	1.046	0.090	0.006	0.325	0.031	0.145	0.065							
MNG	1.763	0.000	0.001	0.025	0.005	0.005	0.040	0.027	0.006	0.002	0.002						
RUS	0.437	1.185	0.862	11.858	0.594	0.140	2.650	2.318	4.043	1.601	4.708	0.770					
TJK	0.550	0.003	0.128	0.103	0.016	0.128	0.426	0.353	0.066	0.018	0.005	0.014	1.937				
TKM	0.425	0.136	0.856	0.099	0.540	0.256	0.464	0.067	0.017	0.009	0.021	0.000	0.311	0.776			
UKR	0.487	0.182	0.395	2.606	0.529	0.284	0.986	0.099	0.939	0.347	1.626	0.083	5.051	0.105	10.385		
UZB	0.251	0.015	0.087	0.124	0.054	0.178	1.055	1.117	0.080	0.058	0.055	0.030	2.212	6.353	0.231	1.012	
VNM	5.532	0.003	0.027	0.083	0.011	0.028	0.039	0.000	0.017	0.021	0.006	0.021	0.340	0.059	0.009	0.148	0.021
Panel C. The dissimilarity of commodity composition of export																	
ARM	0.803																
AZE	0.816	0.849															
BLR	0.320	0.503	0.576														
GEO	0.837	0.432	0.853	0.534													
IRN	0.782	0.790	0.101	0.544	0.795												
KAZ	0.884	0.681	0.246	0.596	0.643	0.200											
KGZ	0.195	0.641	0.739	0.243	0.674	0.692	0.800										
LTU	0.284	0.552	0.672	0.168	0.570	0.646	0.757	0.176									
LVA	0.273	0.544	0.839	0.267	0.567	0.809	0.750	0.212	0.187								
MDA	0.750	0.862	0.890	0.530	0.556	0.855	0.957	0.599	0.481	0.640							
MNG	1.012	0.778	0.747	0.781	1.063	0.689	0.801	0.901	0.875	1.038	1.189						
RUS	0.747	0.656	0.239	0.460	0.652	0.194	0.169	0.694	0.620	0.647	0.839	0.733					
TJK	1.102	0.627	0.883	0.804	0.709	0.829	0.707	1.001	0.917	0.905	1.134	1.165	0.682				
TKM	0.802	0.844	0.115	0.562	0.841	0.110	0.262	0.726	0.659	0.826	0.877	0.708	0.214	0.883			
UKR	0.892	0.370	0.815	0.576	0.333	0.756	0.600	0.733	0.636	0.626	0.782	1.079	0.613	0.404	0.802		
UZB	0.258	0.558	0.699	0.173	0.597	0.664	0.671	0.199	0.202	0.185	0.624	0.890	0.560	0.882	0.686	0.647	
VNM	0.343	0.695	0.723	0.298	0.555	0.693	0.832	0.229	0.194	0.322	0.437	0.943	0.695	0.985	0.707	0.716	0.327

OLS estimation results. Dependent variable: exchange rate variability.

	(1)	(2)	(3)	(4)
OCA variables				
$SD(\Delta y_i - \Delta y_j)$	0.021 (0.476)	0.356 (0.385)	0.238 (0.167)	0.334* (0.182)
$TRADE_{ij}$	−0.363 (0.790)	0.033 (0.350)	−0.971*** (0.219)	−1.006*** (0.228)
$DISSIM_{ij}$	−0.098** (0.041)	−0.035 (0.033)	0.023 (0.017)	0.027 (0.017)
$Size_{ij}$	0.011 (0.008)	−0.002 (0.007)	0.026*** (0.004)	0.027*** (0.004)
Other OCA variables				
INF_{ij}		1.245*** (0.104)	0.447*** (0.105)	0.437*** (0.107)
$OPEN_{ij}$		−0.141*** (0.047)	−0.045* (0.026)	−0.048* (0.025)
$REMIT_{ij}$		−0.037** (0.018)	−0.041*** (0.014)	−0.040*** (0.014)
$DISSIM_{ij}$ for crude oils				−0.019 (0.018)
International regime				
$DolVar_{ij}$			1.198*** (0.082)	1.218*** (0.087)
constant	0.006 (0.198)	0.290 (0.206)	−0.583*** (0.107)	−0.616*** (0.108)
N	153	153	153	153
R^2	0.056	0.488	0.866	0.867
F	2.623	25.279	138.201	122.456

Note: Robust standard errors are in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

OLS estimation results for smaller sample. Dependent variable: exchange rate variability.

	(1)	(2)	(3)	(4)
OCA variables				
$SD(\Delta y_i - \Delta y_j)$	−0.297 (0.390)	0.138 (0.206)	0.176 (0.140)	0.414*** (0.157)
$TRADE_{ij}$	0.796 (0.972)	0.479* (0.282)	−0.283 (0.297)	−0.228 (0.292)
$DISSIM_{ij}$	−0.087** (0.042)	0.001 (0.017)	0.011 (0.011)	0.019* (0.011)
$Size_{ij}$	−0.002 (0.006)	0.004 (0.004)	0.015*** (0.003)	0.017*** (0.003)
Other OCA variables				
INF_{ij}		1.142*** (0.045)	0.771*** (0.099)	0.749*** (0.100)
$OPEN_{ij}$		0.022 (0.026)	0.005 (0.018)	0.006 (0.017)
$REMIT_{ij}$		−0.011 (0.016)	−0.022** (0.009)	−0.022** (0.010)
$DISSIM_{ij}$ for crude oils				−0.037*** (0.011)
International regime				
$DolVar_{ij}$			0.675*** (0.119)	0.699*** (0.121)
constant	0.258 (0.165)	−0.072 (0.116)	−0.373*** (0.094)	−0.431*** (0.091)
N	105	105	105	105
R^2	0.073	0.863	0.926	0.932
F	1.431	129.462	181.202	164.177

Note: Robust standard errors are in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$