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Troubles in the Euro Area Periphery: The View through the Lens of a Simple Convergence-Sensitive Optimum Currency Area Index*

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Abstract
The concept of an optimum-currency-area (or OCA) index has often been used to assess the relative proximity of various pairs of economies to the ideal of an optimum currency area. In this paper, we suggest improving the construction of the index in several ways, primarily by making it sensitive to real income convergence. Estimation for a sample of 31 advanced or late-stage transition economies for the ten-year period prior to the latest financial crisis confirms that the presence of a process of real convergence generally increases the value of the index and thus speaks against adopting a single currency until the convergence process is largely over. Looking specifically at the position of current peripheral euro area member economies, the index indicates relatively low preparedness of Greece and Ireland for a common currency with Germany: in fact, the preparedness of several Central European late-transition economies seems to have been comparable or even better.

1. Introduction

Since 2010, several peripheral member economies of the euro area have faced significant capital flight and ensuing difficulties as concerns private or official financing or both. These phenomena seem at least partly due to previous policy choices, ranging from a lack of commitment on the union policy level to apply agreed rules (see, for example, Tabellini and Wyplosz, 2006, Schuknecht et al., 2011, and Bordo, 2012) to lax regulation of the financial sector (Gros, 2008) and myopic over-reliance on tax revenues flowing from local construction booms (IMF, 2009). However, tensions in the euro area periphery might also have emerged if the currency union was formed by a group of economies for which a single currency would not make macroeconomic sense because of various structural or (non-monetary) policy asymmetries among the group's members and rigidities in the members' potential non-monetary adjustment mechanisms. Generally speaking, such asymmetries and rigidities make full union-wide stabilization via common monetary policy difficult: they may cause different economies within the union to suffer different shocks at different moments or to feature different transmission of common shocks. Given that within-union nominal exchange rates cannot change to trigger expenditure switching, the result may then be heterogeneity in regional cyclical positions, but also in real exchange rates, i.e., in regional rates of inflation, and thus also in regional real interest rates. These unwelcome structural implications are beyond the realm of

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the common monetary policy and may arise even if that policy, aimed at stabilization of union-wide inflation and output, is conducted completely optimally.[1]

For this one-size-does-not-fit-all reason, regional real interest rates in some of the economies of the euro area periphery became, at some point in time, too low to stabilize these economies (see, for instance, Ahearne and Pisani-Ferry, 2006, and European Commission, 2008). The consequence was more or less excessive domestic credit growth leading, in turn, to undesirable outcomes such as overheating of the economy and/or property bubbles and/or current account deficits exceeding the benign levels that would be consistent with expected economic convergence and thus with intertemporal smoothing of consumption.

The present paper describes a method for shedding some light on the extent to which a given pair of economies exhibits significant asymmetries and rigidities and thus may not be a good candidate for a currency union. Our approach builds on the concept of an optimum currency area index, or OCA index, but suggests several improvements on the standard way of constructing the index.

Generally speaking, the OCA index is the predicted value of exchange rate variability from a regression which relates this variability to a list of explanatory variables or "OCA indicators". The traditional way of gauging exchange rate variability over some period of time for the purposes of calculating an OCA index is to use the *standard deviation* of per-period exchange rate movements. One contribution of this paper to the existing OCA index literature is to point out that this way of gauging exchange rate variability is inappropriate whenever the pair of economies under study features an exchange rate trend—such as when the exchange rate undergoes trend real appreciation due to economic convergence (we provide empirical evidence of such trends in Section 4).[2] We will argue that in that case, it is preferable to operationalize the notion of exchange rate variability as the *mean of the absolute values* of the per-period exchange rate changes, i.e., as the mean of the exchange rate changes observed in each period within our sample time interval, but taking the absolute values of these changes before calculating the mean. This modification, while making the construction of the index slightly more complicated, leads to an index that is applicable in a wider range of contexts without departing from the basic logic of the OCA theory.

Once we make the left-hand side of the regression sensitive to trend real appreciation, we should also enrich the right-hand side list of OCA indicators with an indicator that will explain the existence of such a real exchange rate (RER) trend. For this purpose, we will use the rate of relative convergence in GDP per capita between the two economies. This approach is in accord with the usual interpretation of a longer-term RER trend as being a reflection of real (income) convergence.

We will estimate an OCA index (of the mean absolute value type as noted above) for a sample of advanced as well as late-stage transition economies in the pre-

[1] Nominal exchange rate changes may have weak expenditure switching effects if "local currency pricing" prevails, that is, if prices of imported goods tend to be sticky in the currency of the importing economy rather than the exporting one (see, for example, Corsetti, 2008). Therefore, widespread local currency pricing would weaken the relative attractiveness of staying out of any given currency union.

[2] Throughout this paper, the expressions "appreciation" and "convergence" will be meant to include also their negative-sign opposites, that is, "depreciation" and "divergence," respectively.

crisis period of 1999–2008, the right-hand side consisting of a short list of indicators that, from the point of view of OCA theory, appear crucial. We then calculate specific values of the index for individual economies in the sample vis-à-vis Germany as the anchor and we decompose those values into the contributions of the individual OCA indicators used to calculate the index. As we will show, the results of such an exercise allow one to see to what extent and for what reasons it was or would have been appropriate (or inappropriate) for different economies in the sample to share a single currency with a selected economy, in our case Germany. For example, our results point out more distinctively than those of Bayoumi and Eichengreen (1997a) that as regards macroeconomic preparedness for a currency union with Germany, specifically Greece and Ireland were no better, or were even worse, than several Central European late-transition economies.

The rest of this paper is structured as follows. Section 2 provides a brief overview of the related literature. Section 3 takes a closer look at how RER variability can be measured and suggests a new measure, one that is sensitive to real convergence. Section 4 describes in more detail the sample, the estimation procedure we use, and our specific choice of OCA indicators to be included on the right-hand side of the OCA index regressions, and presents the basic estimation results. The sensitivity of these results to some variations in the specification is studied in Section 5. Section 6 presents and discusses specific values of the convergence-sensitive OCA index for the economies in the sample, and Section 7 contains some concluding remarks.

2. Related Literature

Research on the conditions under which a currency union makes macroeconomic sense is usually presented under the label of the optimum currency area—or OCA—heory (Baldwin and Wyplosz 2006; De Grauwe, 2009; Dellas and Tavlas, 2009). Given the high number of indicators whose values, for a given group of two or more economies, determine whether the group will profit on the macro level from sharing a common currency, economists also started searching for a method of distilling an overall quantitative message from their values—that is, for a method of summarizing the values, in an economically meaningful way, in the form of a single catch-all indicator.

One ingenious attempt to offer such a catch-all indicator is the concept of an OCA index as introduced by Bayoumi and Eichengreen (1997a, 1997b).[3] It is based on the insight (essentially due to Vaubel, 1976) that two economies, whether separated by a non-fixed nominal exchange rate or not, can be viewed as closer to being an optimum currency area if their bilateral exchange rate does not change much in the medium to long term or, more generally, if the exchange rate is subject to less intensive medium- to long-term pressures (Bayoumi and Eichengreen, 1998).

The OCA index methodology proceeds in two steps. First, a cross-section regression is run where exchange rate variability over a certain time period is on

[3] The alternatives include, for example, SVAR-based separation of demand and supply shocks and the study of their correlation in the two economies (Bayoumi and Eichengreen, 1993) and detection of clusters of economies whose mutual similarities indicate that a given cluster might be close to being an OCA (Artis and Zhang, 2001).

the left-hand side and a list of OCA-relevant indicators is on the right-hand side. In this regression, each pair of economies in the sample is one observation. Second, the resulting statistical relationship is used to predict exchange rate variability, that is, the extent to which a specific pair of economies is likely to call for the bilateral exchange rate to be used as an adjustment tool. The more the pair is likely to witness exchange rate pressures, the more difficulties it would face in a common currency union, i.e., without a flexible nominal exchange rate as a primary channel resolving these pressures, leaving all the adjustment to wages and prices.[4]

In particular, Bayoumi and Eichengreen (1997a) estimate OCA indices for 210 pairs of economies drawn from a group of 15 Western European economies, the U.S., Canada, Japan, Australia, and New Zealand separately for each of six (overlapping) 10-year periods covering the time interval 1973–1992. They use standard OLS to regress exchange rate variability (the standard deviation of the change in the logarithm of the end-year bilateral exchange rate) for a given pair i of economies on a list of four explanatory variables:

- asynchronicity of economic cycles (the standard deviation of the difference in the logarithm of real output in the two economies),
- dissimilarity between trade structures (the sum of the absolute differences in the shares of agricultural, mineral, and manufacturing trade in total merchandise trade for the two economies),
- mutual trade links (the mean of the ratio of bilateral exports to domestic GDP for the two economies),
- average size (the mean of the logarithm of the two GDPs).

Asynchronicity of economic cycles should have a positive sign, since less correlated cycles indicate higher incidence of asymmetric shocks and thus more likely changes in the exchange rate. The trade structure dissimilarity indicator is expected to have a positive sign: economies with less similar structures (and thus with less similar structures of trade) are more likely to undergo asymmetric shocks and thus exchange rate changes are, ceteris paribus, expected to be more intensive. The sign should also be positive for average size: smaller economies benefit more from the services (unit of account, means of payment, store of value) provided by a stable exchange rate. For mutual trade links, however, the anticipated sign is negative: economy A which exports a larger part of its output to economy B attracts more of the asymmetric shocks occurring in B via the impact of the shocks on A's exports to B, and vice versa, so that the shocks become more symmetric and thus the exchange rate changes are, ceteris paribus, expected to be less intensive (see Frankel and Rose, 1998, and the literature triggered by that seminal paper).

In the regression for 1983–1992, all four coefficients have intuitive signs and are significant at the 1 percent level. These results are reported to be "broadly consistent" with those pertaining to the earlier five 10-year time periods (Bayoumi

[4] See, for example, Maurel and Schnabl (2011) for the contrary view that in reality, economies find it easier to resolve RER pressures by adjusting domestic prices and wages rather than the nominal exchange rate. Krugman (1993) and Frankel and Rose (1998), in turn, are the key references in the debate on the extent to which, after entering a currency union, economies undergo structural changes such that they need a flexible nominal exchange rate as an adjustment channel more or less than before the entry into the union.

and Eichengreen, 1997a, p. 765). The authors then go on to calculate OCA index values for 14 Western European economies included in the sample versus Germany in 1987 and 1991 and to predict them for 1995. They conclude that especially the UK, Finland, Norway, France, and Denmark had—and would continue to have—high values of the OCA index, indicating a reason for all these economies to hesitate with euro area entry.

Bayoumi and Eichengreen (1997b), using the same sample of economies and focusing separately on three 10-year periods covering the time interval 1963–1992, use alternatively the variability of the nominal or real exchange rate as the dependent variable. They largely confirm the findings of Bayoumi and Eichengreen (1997a). The general approach introduced by Bayoumi and Eichengreen in the above-mentioned papers has been used subsequently by a number of other authors, using similar and/or other explanatory variables and focusing on various time periods and various regions around the globe (Bayoumi, Eichengreen, and Mauro, 2000; Bénassy-Quéré and Lahréche-Révil, 2000; Cincibuch and Vávra, 2001; Komárek, Čech, and Horváth, 2003; Horváth and Kučerová, 2005; Partisiwi and Achsani, 2010).

At this point it may be noted that the implications of the value of the index for the workings of a hypothetical currency union between the two economies may be deeply asymmetric. For example, imagine that Britain forms a currency union with Denmark. In terms of GDP, the British economy is about eight times bigger than the Danish one. Consequently, when one of the two economies is hit by an asymmetric shock and the two diverge as regards inflation and capacity utilization, a common central bank is likely—and rightly so—to steer its interest rates predominantly such as to stabilize the British economy. Most of the unpleasant implications of the non-zero value of the OCA index will then be borne by Denmark. More generally, a given non-zero value of the index is more of a potential problem for a smaller economy because in a given pair of economies, it would be the "junior" union member.

3. Making the OCA Index Sensitive to Real Convergence

An OCA index can be defined generically as exchange rate variability predicted on the basis of a regression of observed exchange rate variability on a list of OCA indicators. A pair of economies is an OCA if for this pair the OCA indicators imply an OCA index value close to zero. The idea is that two economies are an OCA only if they do not experience any substantial exchange rate changes—they find no significant "use" for the exchange rate. The higher the OCA index, the further away the pair of economies is from the ideal of an OCA.

Using the same data set of OCA indicators on the right-hand side of the regression, we can arrive at different OCA indices depending on what specific gauge of exchange rate variability we use on the left-hand side. Bayoumi and Eichengreen (1997a, b) use the simple standard deviation of the per-period changes in the log of the (nominal or real) exchange rate.

Eichengreen et al. (1996; see also Pentecost et al., 2001, and Horváth, 2005) note, however, that it might be useful to focus on per-period exchange rate "pressures", encompassing not only changes in the exchange rate itself, but also the growth rate of domestic narrow money and the short-term nominal interest rate differential.[5] If the research focuses on exchange rate changes over a period short enough to capture the impact of monetary policy stabilization efforts, then this more comprehensive interpretation of per-period exchange rate pressure seems more appropriate—it puts all varieties of exchange rate regimes on an equal footing. To see this, imagine that one of the two economies is hit by a negative asymmetric shock to aggregate demand. In a flexible exchange rate regime the central bank may react to the shock by setting the interest rate sufficiently low and/or by emitting a sufficiently large amount of domestic currency (that is, making a sufficiently voluminous non-sterilized exchange rate intervention) such that the exchange rate depreciates, thereby mitigating the fall in aggregate demand. In a more or less managed exchange rate regime, however, domestic monetary policy may decide to keep interest rates at a higher level compared to the previous case, thus re-directing a part (or even all) of the shock to other, non-exchange rate adjustment mechanisms such as labor market processes or fiscal policy. Analogously, the choice to prevent the exchange rate from depreciating may show up in a lower level of narrow money compared to the case of a flexible exchange rate. The more of the asymmetric negative demand shock is thus re-directed away from the nominal exchange rate, the less the evolution of the interest rate differential or narrow money growth differential will point in the direction of domestic monetary expansion.

Given that we will focus on one-year exchange rate variability, we will stick with the above-described more comprehensive interpretation of per-period exchange rate pressure. Also, we will focus on the *real* exchange rate pressure on the grounds that it is the *real* exchange rate—that is, the nominal exchange rate deflated by the ratio of the price levels—whose stability is the true sign of an OCA.[6]

As already hinted above, our construction of the OCA index will deviate from previous OCA studies in the specific way it summarizes the per-period RER pressures over the whole sample time period to arrive at the *mean* RER pressure. The most straightforward way is to summarize the succession of per-period pressures over the sample time period using (along the lines of Bayoumi and Eichengreen, 2007a) the simple concept of the standard deviation (*SD*) of the per-period values of the exchange rate pressure:

$$SD(p) = \sqrt{\frac{1}{T}\sum_t \left(p_t - \overline{p}\right)^2} \tag{1}$$

where p_t is the RER pressure in period t, that is (in line with what was said above), the sum of the period t values of three elements: the change in RER, the growth rate of domestic narrow money, and the short-term nominal interest rate differential; $\overline{p}$ is the mean value of this sum over all $t = 1, ..., T$ time periods. This concept, however,

[5] Growth of narrow money is typically used as a measure of non-sterilized foreign exchange interventions. Change in official foreign exchange holdings (as a percentage of narrow money), used by some authors, reflects both non-sterilized and sterilized interventions; the latter, however, are generally believed to have no lasting effect on the exchange rate. As a measure of narrow money, different authors use different measures (mostly they report using either M0 or M1). As for short-term interest rates, IMF-reported money market or discount rates are a frequent choice.

[6] In addition, the focus on the real exchange rate, together with using averages of variables over a 10-year period, should ensure that our results are largely independent of the specific nominal exchange rate regimes (or changes therein) that the economies within our purview had in the period under study.

ignores any trend in the economies' bilateral equilibrium RER—a phenomenon that is particularly likely to emerge when one of the two economies exhibits a trend of economic convergence relative to the other one, be it due to the Harrod-Balassa-Samuelson effect, a trend improvement in the terms of trade, or other processes (see, for example, De Grauwe and Schnabl, 2005).

As an illustration, imagine a hypothetical case where one economy appreciates vis-à-vis the other by 2 percent in real terms every year without any disturbances. In this case, all the yearly changes in the bilateral RER are 2 percent, that is, they have the same value and sign; their standard deviation will be zero; the *SD*-based OCA index will come out as zero; and as a result, the two economies will be proclaimed a perfect OCA—in spite of the fact that if the two economies form a currency union, there will be inherent pressure on wages and prices in the first economy to grow 2 percent faster than their counterparts in the other economy.

In contrast, we propose to construct the OCA index such that it also captures the impact of trend real appreciation. Specifically, we suggest constructing the index as the mean absolute value (*MAV*) of the per-period RER pressure:

$$MAV(p) = \frac{1}{T}\sum_t |p_t|$$

where p_t is again the per-period RER pressure. In the above hypothetical case of a perfectly smooth 2 percent yearly real appreciation, while *SD* is zero, *MAV* will come out at 2 percent. In the opposite case of some RER variability but no trend RER appreciation or depreciation, *MAV* will be close to *SD*. In the intermediate case of variability around a trend, *MAV* will tend to be above *SD*: the stronger the trend, the bigger the gap between *MAV* and *SD*.

Naturally, if we provide room for real convergence on the left-hand side of the OCA index regression, we also need to broaden the right-hand side list of regressors by including an indicator of real convergence. For this purpose, we will use (the mean absolute value of) the difference in the rate of growth of per capita GDP. The expected sign of the coefficient on this variable is positive: if a pair of economies undergoes more intensive convergence (or divergence), the mean RER pressures are, ceteris paribus, expected to be more intensive (see, for example, Box 4.4 in IMF, 2000).[7]

4. Data and Estimates

As regards the sample of economies, we take the sample used by Bayoumi and Eichengreen (1997a, b) and extend it to include a group of late-transition economies, arriving at a group of 31 economies. The composition of our sample is shown in *Table 1*: the sample consists of 11 members of the euro area as of 2001 (i.e., the EA12 excluding Luxembourg), five other advanced European economies (Denmark, Norway, Sweden, Switzerland, United Kingdom), five non-European advanced economies (Australia, Canada, Japan, New Zealand, USA) and ten European late-stage transition

[7] We do not assume or assert the presence or absence of any particular pattern of convergence (Islam, 2003) within the pairs of economies in our sample; we just assume that *if* there was some convergence within a given pair of economies during the time period under study, it is likely to have been reflected in the mean RER pressures.

Table 1 Economies in the Sample

euro area		non-euro Western Europe		Central and Eastern Europe		other	
1	Austria	12	Denmark	16	Bulgaria	26	Australia
2	Belgium	13	Sweden	17	Czech Republic	27	Canada
3	Finland	14	Switzerland	18	Estonia	28	Japan
4	France	15	UK	19	Hungary	29	New Zealand
5	Germany			20	Latvia	30	Norway
6	Greece			21	Lithuania	31	US
7	Ireland			22	Poland		
8	Italy			23	Romania		
9	Netherlands			24	Slovakia		
10	Portugal			25	Slovenia		
11	Spain						

economies (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia). This group of late-transition economies is intended to comprise economies which increase the sample heterogeneity in terms of economic structure and convergence without featuring an excessively strong role of the government in the economy or an excessively low stage of financial development, which might complicate the interpretation of our findings.

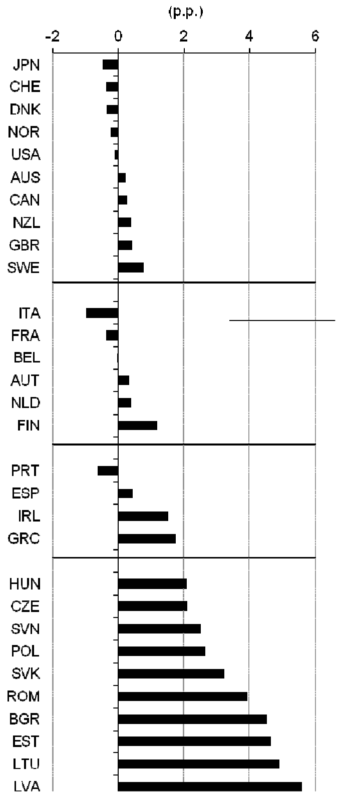
Our sample period is 1999–2008. Starting in 1999 allows us to avoid some statistical subtleties concerning the break in the data for euro area economies before and after the launch of the euro area. Ending in 2008 makes sure that the results are not contaminated by the extraordinary developments after the outbreak of the financial and economic crisis in late 2008.[8]

The sample intentionally mixes economies at different levels of economic development, so that many of the economy pairs within this group can be expected to feature a significant degree of real convergence.[9] Of course, some pairs (especially those where a similar level of economic development has already been achieved) may feature negative real convergence, i.e., real divergence. The intensity of convergence toward, or divergence from, Germany of each of the remaining 30 economies in our sample is shown in *Figure 1*; indirectly, the figure gives an idea of the convergence or divergence processes in all the pairs of economies in the sample. The individual economies are presented in four clusters: ten advanced economies, six members of the euro area, four economies on the southern periphery of the euro area, and ten Central and Eastern European transition economies. As *Figure l* shows, in 1999–2008 all ten transition economies included in our sample have clearly been on a path of convergence toward Germany.

[8] The first signs of the upcoming crisis were felt as early as the second half of 2007 and throughout 2008. Nevertheless, in order to cover a 10-year period, which seems to be the minimum for the focus of this study, we include both these years in the sample, assuming that the data from 2007 and 2008 may still largely adhere to the standard (that is, non-crisis) economic relationships that we are trying to map. We thank an anonymous referee for pointing this issue out.

[9] More generally, a certain degree of heterogeneity of the sample in terms of economic structures and stages of development should allow identification of the impact that differences among economies have on medium-term exchange rate variability.

Figure 1 Average Yearly Growth of GDP per Capita Based on PPP in Current International Dollars, Excess (in p.p.) over Germany, 1999–2008



Sources: IMF, author's calculation.

In our regression explaining the exchange rate pressures (i.e., variable *MAV*), we will start with three regressors.[10] One is the convergence indicator introduced in Section 3 and abbreviated as *PCG* (the expected sign is positive). Our second regressor is an indicator of the dissimilarity of the productive structures of the two economies (positive expected sign), abbreviated as *STR* and calculated as the sum of the absolute values of the differences between the two economies in the shares of agriculture, industry, and services in total value added. *STR* is meant to replace Bayoumi and Eichengreen's dissimilarity of the economies' structures of trade, since *STR* as we define it above seems a more direct and comprehensive measure of the differences between the productive structures of the two economies (the implications of replacing *STR* with dissimilarity of trade structures are shown in the sensitivity analysis in the next section). Finally, we will include the intensity of the mutual trade links between the two economies (negative expected sign), abbreviated as *TRADE* and defined in the same way as in Bayoumi and Eichengreen (1997a, b)—see Section 2.

[10] Details on the construction of, and data sources for, all the variables used in this paper are provided in the *Appendix*.

Conversely, we will *not* include in our regressions two indicators that Bayoumi and Eichengreen (1997a, b) and many of their followers include. First, they include the average of the sizes of the two economies, arguing that smaller economies benefit more from the services provided by a stable exchange rate. Since these services seem to pertain to a stable *nominal* exchange rate, while we focus here on the real exchange rate, we do not include the size indicator in our specifications (some doubts about the significance of this size indicator are signaled by the results of Horváth and Kučerová, 2005, who focus on an RER-based OCA index).

Second, Bayoumi and Eichengreen (1997a, b) include asynchronicity of economic cycles in the two economies on the grounds that economies with less correlated cycles are more likely to undergo asymmetric shocks and thus the mean RER pressures are, ceteris paribus, expected to be more intensive. Our reason for not including cyclical correlation is that we will build the OCA index on three specific OCA indicators listed above, namely, *PCG*, *STR*, and *TRADE*, each of which covers one potentially important source (or absorber in the case of *TRADE*) of asymmetric shocks. These asymmetric shocks then become reflected synthetically in the lack of cyclical correlation. Our suggestion not to use, as a regressor, a synthetic measure of asymmetric shocks side by side with a set of indicators of individual important sources (or absorbers) of these asymmetric shocks seems advisable both conceptually and in order to avoid multicollinearity.

To obtain coefficients with which to compute the OCA indices for various pairs of economies, we will start by estimating the following cross-section relationship:

$$MAV_i = \alpha + \beta_1 PCG_i + \beta_2 STR_i + \beta_3 TRADE_i + \varepsilon_i \tag{2}$$

In this regression, observation i corresponds to economy pair i. The 31 economies in our sample form 31!/[(31–1)!2!] = 31*30/2 = 465 pairs; therefore, our estimation will work with 465 observations, i.e., $i = 1, ..., 465$. *MAV* is the mean absolute value of the per-period RER pressures (concerning the RER between the two economies) in the comprehensive sense described in Section 3. The first two regressors refer, respectively, to two different potential sources of major asymmetric shocks: *PCG* is the mean absolute value of the differences in the two economies' GDP per capita growth rates, while *STR* measures the dissimilarity of the productive structures of the two economies. *TRADE* is the intensity of trade links between the two economies, that is, a channel for making asymmetric shocks more symmetric, and ε is white noise.

The results of the estimation of (2) by OLS are shown in column A of *Table 2*.[11] The coefficients for all three right-hand side variables have the expected signs and are statistically significant at the 1 percent level: more potential for asymmetric shocks from the two major sources we study (differences in the structure of production, more intensive economic convergence) imply more pressures on the real interest rate as an adjustment tool, while stronger trade links seem to imply weaker asymmetric shocks and thus lower RER pressures.

However, regressions of relationships such as (2) run a significant risk of resulting in biased and inconsistent estimates due to potential endogeneity of some of

[11] All OLS estimates reported in this paper are robust ones, since in all cases, the Breusch-Pagan test rejects the null of homoskedastic errors.

Table 2 Results of the Basic Regression with and without *TRADE*

	(A)	(B)	(C)
dependent variable	*MAV*	*MAV*	*MAV*
RER based on	GDP deflator	GDP deflator	GDP deflator
no. of observations	465	465	465
estimation	robust OLS	GMM	robust OLS
PCG	0.67***	0.73***	0.74***
	(0.00)	(0.00)	(0.00)
STR	0.17***	0.17***	0.17***
	(0.00)	(0.00)	(0.00)
TRADE	-0.39***	-0.05	
	(0.00)	(0.77)	
constant	8.67***	8.15***	8.10***
	(0.00)	(0.00)	(0.00)
R^2 (adj., centered)	0.20	0.19	0.18
Hansen J test *p*-value		0.57	
IVs exogenous?		yes	
endog. test *p*-value		0.01	
TRADE endogenous		yes	

Notes: *P*-values are reported in parentheses. Statistical significance at the 10%, 5% and 1% level is indicated by *, ** and ***, respectively. For information on excluded instruments, see the main text.

the regressors (Horvath, 2005). Intuitively, while exchange rate pressures may, as (2) presumes, be co-determined by shocks whose incidence is captured by the regressors, it is well possible that the causality runs also in the opposite direction, i.e., that exchange rate pressures have an impact on the values of at least some of the regressors.

As regards (2), this reverse causality seems unlikely for *PCG* and *STR*, as both these variables capture long-term properties of the pair of economies. In contrast, reverse causality is well possible for *TRADE*: higher pressures on the bilateral exchange rate may relatively quickly reduce the incentives for the two economies to trade with each other (even though the effect is far from robust empirically—see Clark et al., 2004).

One standard way to tackle possible endogeneity is to use an instrumental variables (IV) estimator. Column B of *Table 2* therefore presents the results of an estimation of (2) in which *TRADE* is treated as endogenous; the *p*-value in the Pagan-Hall test with the null of homoskedastic errors is 0.02 and so (2) is estimated using the two-step feasible efficient generalized method of moments (GMM) estimator rather than the standard 2SLS one.[12]

Three excluded instrumental variables are used: common border, the log of geographical distance in terms of the most important cities/agglomerations, and the average of the logs of the sizes of the two economies in terms of nominal GDP in USD. The instruments are motivated primarily by the standard gravity model of trade and they—or very similar ones—are used as excluded instruments for a trade intensity indicator by other authors as well (e.g., Frankel and Rose, 1998; Horvath, 2005).

[12] The estimation was conducted in Stata using command ivreg2 with options gmm2s robust (Baum et al., 2007).

Table 3 Results of the First Stage of the IV Estimation of Specification (2) with *TRADE* Instrumented

Dependent variable		***TRADE***
no. of observations		465
PCG		0.078***
		(0.00)
STR		-0.00
		(0.84)
common border		2.35***
		(0.00)
log of distance		-1.18***
		(0.00)
average of log of sizes		0.53***
		(0.00)
constant		-9.49***
		(0.00)
centered R^2		0.48
Kleibergen-Paap rk LM statistic: chi-sq(3)		54.60
	p-value	0.00
Cragg-Donald Wald F statistic		132.92
Kleibergen-Paap Wald rk F statistic		36.61
Anderson-Rubin Wald test: F(3,459)		0.40
	p-value	0.75
Anderson-Rubin Wald test: chi-sq(3)		1.21
	p-value	0.75
Stock-Wright LM S statistic: chi-sq(3)		1.22
	p-value	0.75

Notes: *P*-values for the regression coefficients are reported in parentheses. Statistical significance at the 10%, 5%, and 1% level is indicated by *, **, and ***, respectively. For information on excluded instruments, see the main text. For an explanation of all the reported tests of the quality of the IV estimates, see Baum et al. (2007).

The values for the first two instruments were downloaded from the CEPII database (see Mayer and Zignago, 2006) and those for the third one from World Bank's World Development Indicators.

The results of the first stage regression are presented in *Table 3*. The three excluded instruments' coefficients have the expected signs and are significant at the 1 percent level, so they seem highly relevant as instruments for *TRADE*. The *p*-value of 0.00 in the Kleibergen-Paap rk LM test implies that the hypothesis of *TRADE* being underidentified can be rejected at the 1 percent level. The Kleibergen-Paap Wald r k F statistic of 36.61 is higher than the highest Stock-Yogo critical values (suggested as appropriate by Baum et al., 2007) in terms of both maximum IV relative bias and maximum IV size; this implies that the hypothesis of *TRADE* being weakly identified can be rejected at the lowest available levels of probability (5 percent and 10 percent, respectively). The *p*-value of 0.57 in the Hansen J test implies that the hypothesis of overidentification cannot be rejected, that is, the instruments can be viewed as exogenous.[13] All in all, then, the results of the IV estimation of (2) seem fairly reliable.

The one result that we are primarily interested in is the verdict on the endogeneity of *TRADE*: in a robust version of the Hausman endogeneity test, the null hypothesis of *TRADE* being exogenous is rejected (the p-value is 0.01). At the same time, however, the estimated coefficient of *TRADE* is deeply insignificant (its p-value is 0.77). We see that once we move from plain OLS to an estimation that treats the issue of endogeneity of *TRADE* properly, trade links no longer appear very effective as a factor reducing the asymmetry of shocks—at least not in our sample. Our preferred specification thus becomes

$$MAV_i = \alpha + \beta_1 PCG_i + \beta_2 STR_i + \varepsilon_i \tag{3}$$

Robust OLS estimation of (3) results in the coefficients reported in column C of *Table 2*. A comparison of the results of the OLS estimation of (2) and (3) (*Table 2*, columns A and C) confirms that the exclusion of *TRADE* makes almost no difference.

5. Sensitivity Analysis

In this section we briefly discuss the results of estimating five modifications of (3). The first modification concerns the construction of the dependent variable (an alternative to *MAV*), the subsequent three modifications focus on alternative ways of measuring one of the independent variables, namely, differences in the productive structure of the economy (captured above by *STR*), and, finally, one modification looks at how inflation is measured within the calculation of the real exchange rate on the left-hand side of the regression.[14]

When constructing an OCA index such that it is sensitive to trend real appreciation, *MAV* is not the only possibility, of course. One alternative arises if we take inspiration from the way the exchange rate literature (outside the OCA index context) often captures exchange rate variability (e.g., Ghosh et al., 2003; Arratibel et al., 2008). Specifically, we can construct the OCA index as the z-score, that is,

$$Z_i = \sqrt{\frac{SD_i^2 + \overline{p}_i^{\,2}}{2}}$$

where *SD* is the standard deviation of RER pressures, as defined in (1), and $\overline{p}$ is the mean RER pressure.

MAV and *Z* differ in exactly how they capture the RER trend. *MAV* is sensitive only to the average pace of the trend. For a given value of the average trend, *MAV* will be the same whether the RER trends perfectly smoothly or whether it goes through periods of swift changes and periods of stability. In contrast, *Z* will be higher (it will report more intensive "use" of the exchange rate as a means of adjustment and thus less readiness of the pair of economies for a common currency) in the latter, more variable case.

In spite of the differences in construction and sensitivity, the within-sample correlation between *MAV* and *Z* is 94 percent. Not surprisingly, then, the robust OLS

[13] For an explanation of all the reported tests of the quality of the IV estimates, see Baum et al. (2007).

[14] Given that many of the economies in the sample are quite open and may feature large differences between domestic and national income, we re-ran the regression in Column C of *Table 2* with real convergence measured by GNI (per capita based on PPP in current international dollars) rather than GDP; the results are qualitatively similar.

Table 4 Sensitivity Analysis

	(A)	(B)	(C)	(D)	(E)
dependent variable	*Z*	*MAV*	*MAV*	*MAV*	*MAV*
RER based on	GDP deflator	GDP deflator	GDP deflator	GDP deflator	CPI
estimation	robust OLS	robust OLS	robust OLS	robust OLS	robust OLS
PCG	0.57***	0.96***	0.94***	1.15***	0.64***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
STR	0.17***				0.17***
	(0.00)				(0.00)
DC		-1.45**			
		(0.04)			
DC3			-2.74***		
			(0.00)		
DR				-3.83**	
				(0.01)	
constant	8.00***	11.10***	11.26***	10.81***	8.31***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R^2 (adj., centered)	0.15	0.10	0.13	0.11	0.17

Notes: The number of observations is 465 in all cases. *P*-values reported in parentheses. Statistical significance at the 10%, 5%, and 1% level is indicated by *, ** and, ***, respectively. For information on excluded instruments, see the main text.

estimates of (3) with *MAV* or *Z* as the dependent variable (column C of *Table 2* and column A of *Table 4*, respectively) do not differ substantially, only the R^2 is somewhat lower when *Z* is the regressand.

Let's now move on to perhaps a more interesting issue: the impact of using alternative ways to measure differences in the productive structure of the economy. Above we relied on *STR* defined on the basis of the structure of total value added. Most previous studies of the OCA index have, however, used a less direct measure: the structure of exports.

One natural way to look at the structure of exports is in terms of commodity structure; this is actually the usual choice in previous OCA index studies. The most straightforward choice is to replace *STR* by *DC*, defined as the sum of the absolute values of the differences between the two economies in the shares of their exports in each of the nine single-digit SITC categories. Bayoumi and Eichengreen (1997a, 1997b, 1998) and Horvath (2005, 2007) actually use a modification of *DC* that we will label here as *DC3*: the sum of the absolute values of the differences between the two economies in the shares of their exports *in each of three aggregates* of the nine single-digit SITC categories, the three aggregates being agricultural (SITC 0, 1, and 4), mineral (SITC 2 and 3), and manufacturing (SITC 5–9) trade in total merchandise trade.

The results when *STR* is replaced in (3) by *DC* or *DC3* appear in *Table 4*, columns B and C, respectively. While the constant and the coefficient on *PCG* do not change much and remain significant, the coefficients on *DC* and *DC3* come out as (statistically significant and) negative, that is, with a sign opposite to what would be expected theoretically. It appears that differences in the commodity structure of two economies' exports are a less reliable indicator of overall differences in the productive structure of the two economies (at least for the purposes of explaining exchange rate pressures within the OCA index) than the direct indicator, *STR*. We obtain essentially the same picture when *STR* is replaced by *DR* (*Table 4*, column D) defined analogously to *DC* but focusing on differences in the regional—rather than commodity—structure of the two economies' exports across four broad regions of the world (advanced economies, Africa, developing Asia, and emerging Europe and CIS).

Another test of sensitivity was to look at what happens if the real bilateral exchange rate (used to compute *MAV*) is calculated from the nominal one using the differential in consumer price index growth rather than in GDP deflator growth. The results are shown in column E of *Table 4*. A comparison with column C of *Table 2* reveals that the impact is very small.

6. Applying the Convergence-Sensitive OCA Index

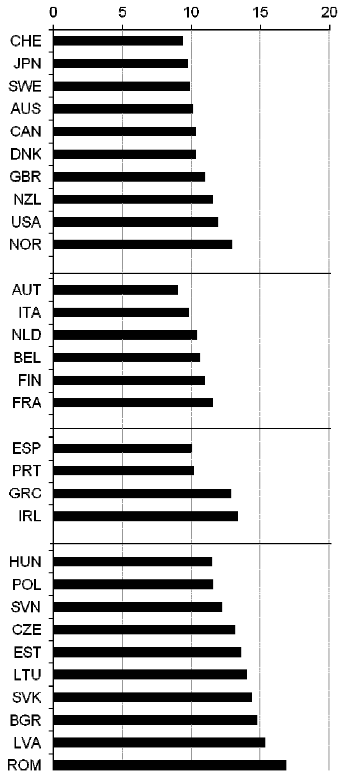
For a given time period and a given pair of economies, the OCA index is the value of the regressand in an OCA regression (such as (3)) that we obtain after we plug the actual values of the regressors pertaining to the time period under study into the estimated regression. The results of this exercise for each economy in our sample and Germany as the reference economy in each pair, using estimates of regression (3), are shown in *Figure 2*. A lower (higher) value in the figure indicates that exchange rate pressures due to differences in the structure of the two economies and due to mutual economic convergence or divergence can be expected to be weaker (stronger).

Of course, the values of R^2 at or below 0.20 that we obtain in our regressions imply that we have to take the estimates' implications very cautiously. Certainly, the values of the index should not be viewed as realistically assessing the "fundamental" or "expected" extent of exchange rate pressures in a given pair of economies; the values should rather be used only as a qualitative, ordering tool and, moreover, our conclusions based on them should be taken as preliminary only. We return to this issue in the conclusion.

With these caveats in mind, the observations that we can make on the basis of *Figure 2* seem intuitively plausible. First, Greece and Ireland, that is, two of the four euro area periphery economies that have recently faced the most serious capital flight problems, feature by far the highest values of the index in the club. This can be taken as an indication that if there is a group of euro area member economies for which entry was not advisable from a macroeconomic point of view (assuming Germany is the dominant economy in the union), this group consists primarily of Greece and Ireland; in contrast, the entry of Portugal and Spain into the union seems less precarious in macroeconomic terms—at least relative to other euro area members—and their recent funding troubles seem more attributable to other factors (such as excessive fiscal laxity) and/or to contagion from Greece and Ireland.

In fact, as regards a single currency with Germany over the period 1999–2008, Greece and Ireland seem to have been no better candidates (or even worse ones) than several Central European economies (Hungary, Poland, Slovenia, and the Czech Republic). It may also be noted that, of the six Central and Eastern

Figure 2 Values of the OCA Index Based on Estimation of Regression (3)



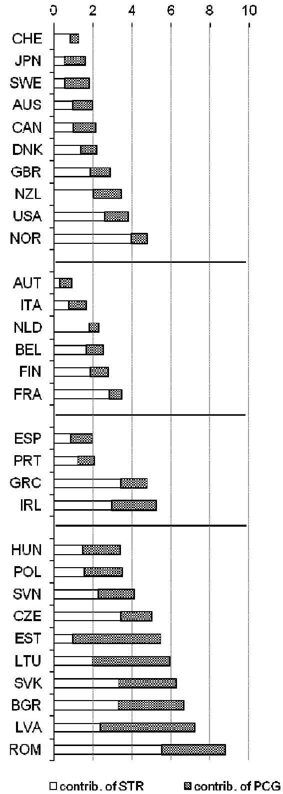
Notes: In all cases the anchor economy is Germany. A lower value indicates that weaker exchange rate pressures can be expected to arise due to differences in the productive structures of the two economies and due to mutual economic convergence or divergence.

Source: Author's calculation.

European economies that have tied their currencies tightly to the euro via a currency board or a similar hard peg (Bulgaria, Latvia, Lithuania) or have actually entered the euro area recently (Estonia, Slovakia, Slovenia), only one (Slovenia) exhibits an OCA index value below the (Irish) maximum recorded for the 12 economies forming the original euro area. This means that for the remaining five economies, fixation of their currencies to the euro does not seem to be a particularly good idea in macroeconomic terms, at least taking Greece and Ireland as a benchmark.

To gain more insight, in *Figure 3* we decompose the value of the index into the contributions of the individual regressors (leaving aside the constant). The figure shows that, for example, while the value of the whole OCA index is only marginally lower for Greece than for Ireland, the relative strength of the two components of the index is rather different for the two economies: Greece faced greater structural differences (from Germany), while Ireland had to cope with more intensive developments in terms of convergence vis-à-vis Germany (actually, divergence upwards from it).

Figure 3 Contributions of *STR* and *PCG* to the OCA Index Based on Estimation of Regression (3)



Note: In all cases the anchor economy is Germany.
Source: Author's calculation.

For Finland and France, the two economies that also feature relatively high values of the OCA index among the euro area members and thus have also run a relatively elevated risk of getting into trouble, *Figure 3* hints that the dominant problem has been structural differences, especially in the case of France. Finally, while for some of the Central and Eastern European economies (such as the Czech Republic and Romania) the difference-in-structure component of the index is also high, for most of them the dominant driver of high index values is the convergence component.

For the sake of completeness, *Table 5* juxtaposes the ranking of various European economies by the value of our convergence-sensitive OCA index with the ordering implied by the values of a (convergence-insensitive) OCA index as computed by Bayoumi and Eichengreen (1997a); in both rankings, Germany is taken as the anchor economy. We can see that within the group of Western European economies covered by the table, our convergence-sensitive OCA index produces a similar relative ranking of the non-troubled six euro area member economies. As

Table 5: Ranking by OCA Index

based on regression (3) (time period: 1999-2008)	based on Bayoumi and Eichengreen (1997a) (time period: 1995)
Austria	Netherlands
Italy	Austria
Switzerland	Belgium
Sweden	Ireland
Spain	Switzerland
Portugal	Greece
Denmark	Sweden
Netherlands	Italy
Belgium	Portugal
Finland	Spain
UK	France
France	Denmark
Norway	Norway
Greece	Finland
Ireland	UK

Notes: For any given pair of economies, only one economy is shown; the other economy in the pair is always Germany. Economies with the lowest OCA index values are at the top. The four troubled economies on the euro area periphery are shaded.

regards the troubled euro area periphery economies, however, our index places them generally lower in the table, that is, it indicates less relative readiness for a common currency with Germany. We should bear in mind, however, that this direct comparison of the two rankings is very tenuous: among other things, Bayoumi and Eichengreen's (1997a) ranking referred to 1995 (rather than the 2000s) and the underlying regression's left-hand side contained simple nominal exchange rate variability (rather than comprehensive real exchange rate pressures).

7. Conclusion

In this paper, we proposed to assess the relative appropriateness of the (actual or potential) decision to share a single currency using an optimum currency area index that is sensitive to economic convergence between two economies. We looked at the message of such an index for the euro area periphery economies, which have suffered a dramatic capital flight in recent years.

Our main econometric result (robust to some variations in the specification) is that when we want to explain the evolution of RER pressures in a group of 31 advanced and late-stage transition economies, real convergence turns out to be a statistically significant factor. This finding suggests that the OCA index should be constructed so that it is sensitive to real convergence, especially if we intend to apply it to a group of economies that is likely to feature some within-group real convergence.

On the policy level, the values of the OCA index that we obtain using the above insights indicate that in at least two of the troubled economies on the euro area periphery—Greece and Ireland—the troubles may have been due partly to entering a currency union in which these economies were likely to be subject to significant asymmetric shocks. Real exchange rate pressures caused by these shocks then possibly led to deviations of real interest rates from equilibrium levels, contributing to a chain of unsustainable developments resulting in the recent capital flight and macroeconomic destabilization. Among the remaining euro area members, the index indicates a relatively high risk of such troubles for France and Finland as well, while the troubles actually witnessed by Spain and Portugal seem more due to other factors.

A caveat is in order here, though: while the index as we construct it builds upon the existing literature and corrects some of its imperfections, the above conclusions are tentative. The empirical methodology used in this paper takes into account only a handful of the very basic OCA indicators and so it should be viewed rather as a sketch of an appropriate method for building a full-blown OCA index, built on other relevant indicators as well. Only then can the index be viewed as a reliable estimate of "fundamental" or "expected" medium-term exchange rate pressures, while the residual in the OCA index regression can then be taken as a reliable assessment of "non-fundamental" shocks to the exchange rate in a given time period.

An obvious avenue for future research is thus to enrich our OCA index regressions with still other factors pointed out by the OCA framework. These include potential sources of asymmetric shocks or of asymmetries in the transmission of shocks, such as fiscal policy (if pro-cyclical) or differences in the structure of the financial sector or in the structure of imports or consumption (see Corsetti, 2008), as well as potential channels of adjustment, such as fiscal policy (if counter-cyclical), flexibility of the labor market (labor mobility, wage flexibility) and of the product market, etc. Needless to say, even after future research comes up with an OCA index that covers all the major OCA indicators, the OCA index framework will be just one of several possible approaches to the complex issue of the macroeconomic desirability of forming a currency union.

Another caveat is that the (essentially normative) macroeconomic perspective on which we focus here does not necessarily have much in common with the overall practical perspective of actual policy makers. Therefore, the OCA index—however sophisticated and all-encompassing its construction and calculation—is not necessarily able to explain or predict countries' actual choices as regards the exchange rate regime with much precision. For example, while our empirical results indicate that—to the extent that Germany can be taken as a proxy for the euro area as a whole—Hungary might be a better candidate for membership in the euro area than some of the union's current members, this is far from suggesting that Hungary is likely to switch to the euro any time soon.

Actual exchange rate regime choices are governed by a rich array of considerations; the OCA framework, whether summarized in the form of an OCA index or not, is likely to be just one part of this array. Given this, we believe that making the OCA index sensitive to real convergence, as is suggested in this paper, is a step in the direction of enhancing the credibility of the OCA index as a tool that can help practical policy makers take sound decisions.

APPENDIX

Construction of Variables and Sources of Data

The variables are presented in the order in which they appear in the main text.

$$MAV_i = \frac{1}{T}\sum_{t=1}^{T}\left|p_{it}\right|$$

where i indexes all the pairs of economies in the sample,
t indexes all the years in the sample period (T = 10 for the period 1999–2008),
p_{it} is the yearly pressure on the RER in the i-th pair of economies in year t, that is, an unweighted average of
(a) the RER change (using yearly GDP deflator growth rates in both economies and the change in the log of the yearly average of the bilateral nominal exchange rate's monthly averages),
(b) the difference in yoy growth rates of currency in circulation (a measure of the net non-sterilized FX intervention in a given year for a given bilateral nominal exchange rate), and
(c) the differential in the yearly averages of short-term interest rates in both economies (mostly the 3M interbank interest rate).

Sources: IMF, Thomson Reuters Datastream, author's calculation.

$$PCG_i = \frac{1}{T}\sum_{t=1}^{T}\left|\Delta \log GDPpc_{jt} - \Delta \log GDPpc_{kt}\right|$$

where *GDPpc* is GDP per capita based on PPP in current international dollars,
i, t, j, and k have the same meaning as in DR_i.

Sources: IMF, author's calculation.

$$STR_i = \frac{1}{T}\sum_{t=1}^{T}\sum_{s=1}^{3}\left|share^s_{jt} - share^s_{kt}\right|,$$

where i indexes all the pairs of economies in the sample,
t indexes all the years in the sample period (T = 10 for the period 1999–2008),
j and k are the two economies forming pair i,
$share^s$ is the share of a given economy's agricultural (divisions 1–5 of ISIC, rev. 3), industry (divisions 15–37 of ISIC, rev. 3) and service (divisions 50–99 of ISIC, rev. 3) output in that economy's total value added.

Sources: Thomson Reuters Datastream, author's calculation.

$$TRADE_i = \frac{1}{T}\sum_{t=1}^{T}\left(share_{jkt} + share_{kjt}\right)/2$$

where $share_{lm}$ is the share of economy l's exports to economy m in economy l's GDP,
i, t, j, and k have the same meaning as in DR_i.

Sources: World Bank, Thomson Reuters Datastream, author's calculation.

$$Z_i = \sqrt{\frac{SD_i^{\,2} + \overline{p}_i^{\,2}}{2}}$$

where $SD = \sqrt{\frac{1}{T}\sum_t \left(p_t - \overline{p}\right)^2}$,

$\overline{p}$ is the mean value of p_{it} over the sample period,

i, t, and p_{it} have the same meaning as in MAV_i.

Source: Author's calculation.

$$DC_i = \frac{1}{T}\sum_{t=1}^{T}\sum_{c=1}^{9}\left|share_{jt}^{c} - share_{kt}^{c}\right|$$

where i indexes all the pairs of economies in the sample,

t indexes all the years in the sample period ($T = 10$ for the period 1999–2008),

j and k are the two economies forming pair i,

$share^c$ is the share of a given economy's exports within single-digit SITC category c in that economy's total merchandise exports.

Sources: UN (ComTrade), author's calculation.

$$DC3_i = \frac{1}{T}\sum_{t=1}^{T}\sum_{c=1}^{3}\left|share_{jt}^{c} - share_{kt}^{c}\right|$$

where i indexes all the pairs of economies in the sample,

t indexes all the years in the sample period ($T = 10$ for the period 1999–2008),

j and k are the two economies forming pair i,

$share^c$ is the share of a given economy's exports within agricultural (SITC 0, 1, 4), mineral (SITC 2, 3) and manufacturing (SITC 5–9) trade in that economy's total merchandise exports.

Sources: UN (ComTrade), author's calculation.

$$DR_i = \frac{1}{T}\sum_{t=1}^{T}\sum_{r=1}^{4}\left|share_{jt}^{r} - share_{kt}^{r}\right|$$

where i indexes all the pairs of economies in the sample,

t indexes all the years in the sample period ($T = 10$ for the period 1999–2008),

j and k are the two economies forming pair i,

$share^r$ is the share of a given economy's exports to region r in that economy's total exports and the values of $r = 1, ..., 4$ refer to (1) advanced economies, (2) Africa, (3) developing Asia, and (4) emerging Europe and CIS, respectively.

Sources: Thomson Reuters Datastream, author's calculation.

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