Institute of Economic Studies, Faculty of Social Sciences
Charles University in Prague

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Michal Skořepa

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Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

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Michal Skořepa[#]

[#] Czech National Bank and
IES, Charles University Prague
E-mail: michal.skorepa@cnb.cz

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Abstract:
A number of authors have used the concept of an optimum currency area (or OCA) index to assess the relative proximity of various pairs of economies to the ideal of an optimum currency area. Alas, a significant deficiency of this approach as used so far is that it provides no room for long-term real income convergence - a frequently observed process that can be viewed as a specific type of long-term asymmetric shock. In this paper, a novel way to construct the OCA index is suggested that is sensitive to any real convergence (or divergence) between the two economies under study. Estimation of this convergence-sensitive OCA index for a sample of OECD economies yields an intuitively plausible result: real convergence gains on significance within the OCA index after an initial sample, a group of advanced OECD economies, is broadened with a group of emerging economies. Applied to the 2001-2008 period, the convergence-sensitive index shows a few Central and Eastern European late-transition economies to be better prepared for a common currency with Germany than several current euro area members.

Keywords: optimum currency area, OCA index, real convergence, real exchange rate, trend appreciation

JEL: E58, F15, F31, O2

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1. Introduction

The optimum currency area (or OCA) theory is essentially a collection of indicators - such as shock symmetry or labor mobility - whose values, for a given group of two or more economies, influence the judgement whether it makes macroeconomic sense for the group to share a common currency (Baldwin and Wyplosz, 2006, De Grauwe, 2009, Dellas and Tavlas, 2009). In view of the high number of these indicators, economists have also been searching for a method of distilling an overall quantitative message from their values - that is, searching 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 OCA index introduced by Bayoumi and Eichengreen (1997a, 1997b).[1] 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 real exchange rate (RER) does not change much in the medium- to long-term or, more generally (and more appropriately), if the RER is subject to less intensive medium- to long-term pressures (Bayoumi and Eichengreen, 1998). A significant statistical relationship between mean RER pressures on the left-hand side of the regression and a list of OCA-relevant indicators on the right-hand side is obtained; this relationships can then be used - together with other considerations, such as possible endogenous effects of monetary integration (Krugman, 1993, Frankel and Rose, 1998) - to assess the extent to which a specific pair of economies is likely to use the bilateral RER as an adjustment tool. The more the pair is likely to witness RER pressures, the more difficulties it would face without a flexible nominal exchange rate as a primary channel resolving these pressures.[2]

The traditional way of gauging mean RER pressures over some period of time for the purposes of calculating the OCA index has been the simple standard deviation of values of per-period RER pressures (Bayoumi and Eichengreen, 1997a, b; Horvath, 2007). The main

[1] Some of the alternatives are, for example, the 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).

[2] See, e.g., 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.

contribution of this paper to the existing OCA index literature is to point out that this way of gauging mean RER pressures is inappropriate whenever the pair of economies under study features a long-term trend in the RER pressures - such as when the mutual RER undergoes long-term real appreciation due to economic convergence.[3] We will argue that in that case, it is preferrable to operationalize the notion of mean RER pressures as the mean of absolute values of per-period RER pressures.

Of course, along with making the left-hand side of the regression sensitive to trend real appreciation, we need to enrich the right-hand side list of OCA indicators with an indicator that would explain the existence of such an RER trend. For this purpose, we will use the rate of relative convergence in GDP per capita among the two economies. This approach is in accord with the usual interpretation of a long-term trend in RER as a reflection of real (income) convergence.

The modifications to the OCA index that we suggest are empirically tested with data pertaining to a group of advanced OECD economies as well as that group broadened with a group of emerging economies in the period 2001-2008. Our results are in line with economic intuition. In the narrower, "rich-economies" sample, income convergence is not useful in explaining the variation in our measure of mean RER pressures. In contrast, adding a group of emerging economies makes the relationship strongly significant. This effect holds even when we measure mean RER pressures with a z-score or when the sample period is lenghtened into 1996-2008. We take these findings to imply that the OCA index should be constructed so that it is sensitive to real convergence.

The next step, calculation of specific values of the convergence-sensitive OCA index for individual economies in the rich-plus-emerging group for the period 2001-2008 reveals that the emerging economies were relatively less well prepared for a single currency with Germany than a convergence-insensitive OCA index would lead us to believe. Even so, however, several Central and Eastern European economies are found to have been better prepared for a single currency with Germany than several current members of the euro area.

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

The rest of this paper is structured as follows. Section 2 takes a closer look at the ways to measure RER pressures and suggest a new measure, one that is sensitive to real convergence. Section 3 describes in more detail the sample, the estimation procedure we use and the estimation results. The sensitivity of these results to some variations in the specification and in the sample is studied in Section 4. Section 5 presents specific values of the convergence-sensitive OCA index for economies in the rich-plus-emerging group in 2001-2008, and Section 6 contains some concluding remarks.

2. Making the OCA index sensitive to real convergence

An OCA index can be defined generically as the exchange rate pressure predicted on the basis of a regression of observed exchange rate pressures on a list of OCA indicators. For a pair of economies that are an OCA, the OCA indicators should imply an OCA index value close to zero. The reason is that two economies that are an OCA do not experience any substantial exchange rate pressures - they have no substantial "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, we can arrive at different OCA indices depending on what specific gauge of mean exchange rate pressures we use. Bayoumi and Eichengreen (1997a, b) use simple exchange rate variability - namely, the standard deviation of per-period changes in the log of the (nominal or real) exchange rate. In the last decade, a number of authors have calculated a (real or nominal) OCA index in this way, using various explanatory variables and focusing on 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).

Eichengreen et al. (1996; see also Pentecost et al., 2001, Horváth, 2005) note that the per-period exchange rate pressure can be constructed in a more comprehensive way, encompassing not only the growth rate of the exchange rate, but also the growth rate of

domestic narrow money and the short-term nominal interest rate differential.[4] This comprehensive interpretation of a per-period exchange rate pressure seems entirely appropriate - it puts all varietes 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. In a flexible exchange rate regime the central bank may accomodate the shock fully by setting interest rate sufficiently low and/or by conducting sufficiently voluminous (non-sterilized) exchange rate interventions. In a more or less managed exchange rate regime, however, domestic monetary policy may decide to re-direct a part (or even all) of the shock to other, non-exchange rate adjustment mechanisms such as labor market adjustment or fiscal policy. The more of the shock is thus decided to be re-directed away from the exchange rate, the more the narrow money data and/or the size of the interest rate differential will point in the direction of domestic monetary restriction.

We will stick with this more comprehensive interpretation of a 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, nominal exchange rate combined with the ratio of price levels - whose stability is the true sign of an OCA.[5]

Where our construction of the OCA index will deviate from previous OCA studies is in the specific way of summarizing the per-period RER pressures over a given time period, arriving at the mean RER pressure. Bayoumi and Eichengreen and their followers all summarize the per-period pressures using the simple concept of standard deviation (*SD*):

$$SD = \sqrt{\frac{1}{T}\sum_{t}(p_t - \overline{p})^2}\ , \qquad (1)$$

where p_t is the per-period RER pressure in period t and $\overline{p}$ is the mean RER pressure over all $t = 1, ..., T$ time periods. This concept, however, ignores any long-term drift in the economies' bilateral equilibrium RER - a phenomenon that is likely to emerge especially when one of the

[4] Growth of narrow money is 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, is generally believed to have no lasting effect on the exchange rate.

[5] Also, the focus on the real exchange rate, together with using averages of variables over an 8-year period, should ensure that our results are largely independent of the specific nominal exchange rate regimes (or their changes) that the economies within our purview had in the period under study.

two economies undergoes long-term economic convergence relative to the other one, be it due to the Harrod-Balassa-Samuelson effect, a trend improvement in terms of trade or other processes (see, e.g., De Grauwe and Schnabl, 2005).

As an illustration, imagine a hypothetical case where one economy appreciates vis-à-vis the other by 2% in real terms every year without any disturbances. In this case, all the changes in the bilateral RER obviously have the same value and sign; their standard deviation will be zero; the *SD*-based OCA index will come out zero; 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 an inherent pressure on wages and prices in the first economy to grow 2% faster than their counterparts in the other economy.

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

$$MAV = \frac{1}{T}\sum_{t}\left|p_t\right|.$$

In the above hypothetical case of a perfectly smooth 2% yearly real appreciation, while *SD* is zero, *MAV* will come out 2%. In the opposite case of some RER volatility but no trend RER appreciation or depreciation, *MAV* will be close to *SD*. In the intermediate case of volatility 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 with an indicator of real convergence. For this purpose, we will use (mean absolute value of) the difference in the rate of growth of per capita GDP, abbreviated as *PCG*. The expected sign of the coefficient on *PCG* is positive: if a pair of economies undergoes more intensive convergence (or divergence), mean RER pressures are, ceteris paribus, expected to be more intensive.[6]

[6] We do not assume or assert 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 bound to have been reflected in mean RER pressures.

To keep the empirical analysis simple, apart from this convergence indicator we will include two core OCA indicators:
- dissimilarity of the structures of the two economies (positive expected sign), abbreviated as *DIX*: economies with less similar structures are more likely to undergo asymmetrical shocks and thus mean RER pressures are, ceteris paribus, expected to be more intensive,
- intensity of trade links between the two economies (negative expected sign), abbreviated as *TRADE*: economies which trade with each other more intensively are less likely to undergo asymmetric shocks and thus mean RER pressures are, ceteris paribus, expected to be less intensive (see Frankel and Rose, 1998, and the literature triggered by that seminal paper).

Bayoumi and Eichengreen (1997a, b) and most of their followers include two other indicators that we will omit. First, they include the average of the sizes of the two economies, arguing that smaller economies benefit more from the services (unit of account, means of payment, store of value) 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.

Second, Bayoumi and Eichengreen (1997a, b) include correlation of economic cycles in the two economies on the grounds that economies with less correlated cycles are more likely to undergo asymmetrical shocks and thus mean RER pressures are, ceteris paribus, expected to be more intensive. Our reason for not including cyclical correlation is that the regression already contains three other OCA indicators listed above, namely, *DIX*, *TRADE* and *PCG*. Each of these three indicators covers one potentially important source of asymmetric shocks that become reflected synthetically in cyclical correlation. Our suggestion not to use, as a regressor, a measure of the asymmetric shocks side by side with several indicators of sources of these asymmetric shocks seems advisable both conceptually and in order to avoid multicollinearity.

3. Data and estimates

We will work with two groups of economies; their specific composition is shown in Table 1. The first, narrower, “rich-economies” group consists of 21 advanced OECD economies. The

second, "rich-plus-emerging" group is the first group broadened with nine emerging economies, mostly Central and Eastern European transition economies. The selection of economies to be included in our analysis was determined by data availability.

The rich-plus-emerging group mixes economies at different levels of economic development. Therefore, many of the economy pairs within this group can be expected to feature a significant degree of real convergence. 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.

--- TABLE 1 ---

To illustrate, Figure 1 shows the growth of GDP per capita relative to Germany over 2001-2008 for the remaining 29 economies in the rich-plus-emerging group. As the figure shows, emerging economies (darker bars) recorded particularly high rates of growth of GDP per capita relative to Germany, the only exception being Mexico. In contrast, developed economies (brighter bars) witnessed much less change in GDP per capita relative to Germany; some of them actually saw a slight fall in the value of this indicator.

--- FIGURE 1 ---

Figure 2 presents a similar overview of all the countries we will study, this time concerning appreciation of the real exchange rate to Germany. Again, we see that most of the nine emerging economies (darker bars) crowd at one end of the whole spectrum - namely, at the appreciation end. Taken together, Figure 1 and Figure 2 confirm the empirically well-confirmed regularity that real convergence tends to go hand in hand with RER appreciation (see, e.g., Box 4.4 in IMF, 2000).

For each dependent or independent variable and each pair of economies in a given group, we compute a single value pertaining to the time period 2001-2008. We then run the following cross-section regression:

$$MAV_i = \alpha + \beta_1 DIX_i + \beta_2 TRADE_i + \beta_3 PCG_i + \varepsilon_i. \qquad (2)$$

In this regression, observation *i* corresponds to economy pair *i*. The 21 economies collected in the rich-economies group can form 21!/[(21-2)!2!] = 21*20/2 = 210 pairs; therefore, regression for the rich-economies group will work with 210 observations, i.e., $i = 1, ..., 210$. Analogically, regression for the rich-plus-emerging group (30 economies) will work with 435 observations, i.e., $i = 1, ..., 435$.[7] *MAV* is the mean absolute value of per-period RER pressures (concerning the RER between the two economies), *DIX* measures dissimilarity of the export structures (commodity-wise) of the two economies, *TRADE* is the intensity of trade links between the two economies, *PCG* is the mean absolute value of differences in the two economies' GDP per capita growth rates and ε is white noise. Details on the construction and data sources for the variables are provided in the Annex.

Basic summary statistics on the three regressors for the two groups in the period 2001-2008 are in Table 2. In line with intuition, the means and standard deviations of all the variables are either similar or higher in the rich-plus-emerging group compared to the rich-economies group. More specifically, the rich-plus-emerging group was, in the sample period, witnessing more RER pressures, slightly weaker trade links and much more commotion as regards relative GDP per capita. The signs of cross-correlations among the regressors mostly confirm economic intuition as well: for example, the negative correlation between TRADE and DIX is broadly in line with the high and rising share of intra-industry trade in total trade worldwide (Turner and Richardson, 2002) as well as with the idea that more intensive trade links increase similarity between economies (Frankel and Rose, 1998). The negative correlation between PCG and TRADE suggests that trade tends to be intensive especially between economies at similiar levels of per capita GDP

--- TABLE 2 ---

Results of estimation of (2) for the rich-economies group as well as the rich-plus-emerging-economies group are shown in Table 3. For the rich-economies group (column A of Table 3), coefficients for both *DIX* and *TRADE* have the expected signs and are highly statistically significant: higher differences in the structure of production and weaker trade links imply more pressures on the real interest rate as an adjustment tool. We would expect a positive sign for *PCG*: a bigger difference in GDP per capita growth would seem to imply more RER

[7] It will actually be 434 observations because data on exports from Mexico to Belgium are not available.

pressures. In fact, however, the coefficient on *PCG* comes out with a negative (and significant) sign.

--- TABLE 3 ---

A more detailed analysis reveals that this puzzling result is driven primarily by data on Greece and Ireland: after these two economies are excluded from the sample (column B of Table 3), *PCG* becomes clearly insignificant. Given that 2001-2008 is generally considered a period during which significant imbalances in both Greece and Ireland were building up (potentially distorting the statistical data behind both *MAV* and *PCG*), exclusion of these two economies seems to make sense. We thus conclude that in the rich-economies group, convergence is not a meaningful factor of RER pressures.

In both the above regressions based on the rich-economies group (including Greece and Ireland as well as excluding them), *TRADE* turns out endogenous. The estimates reported in columns A and B of Table 3 are therefore based on IV estimation in which three excluded instruments are used: common border, common official language, geographical distance in terms of the most important cities/agglomerations. All three instruments are motivated by the standard gravity model of trade and are used as excluded instruments for a trade intensity indicator by other authors as well (e.g., Frankel and Rose, 1998). The values for the three instruments were downloaded from the CEPII database (see Mayer and Zignago, 2006). The same three instruments are used also in the IV regressions reported later on in this paper; in all IV regressions, the instruments' coefficients in the first stage regressions all have the expected signs.

Estimation of (2) in the rich-plus-emerging group brings coefficients that are all significant at least at the 5% level. Compared to the rich-economies group regressions, the impact - in the sense of the absolute value of the coefficient - of both *DIX* and *TRADE* on *MAV* is about half as strong. More importantly, the coefficient on *PCG* now has the theoretically expected sign: more convergence implies more RER pressures.[8]

[8] The importance of PCG in explaining MAV for the emerging economies appears so strong that it easily outweighs the perverse influence of Greek and Irish data on the sign of this relationship that led us to estimate regression (2) also for the rich-economies group without Greece and Ireland. Therefore, results for the rich-plus-emerging group without the two economies are not reported.

The fact that in the rich-economies group regressions, more convergence does not lead to more RER pressures is probably due to there being little scope for and thus little incidence of systematic real convergence among rich economies, as is documented by Figure 1. In contrast, once we take on board also emerging economies, the room for and incidence of real convergence grows and the impact of real convergence on RER pressures in the expected direction surfaces.

In the rich-plus-emerging group, TRADE appears exogenous. It is not immediately clear why TRADE is endogenous in the rich-economies group but exogenous in the rich-plus-emerging group. One possibility would be that trade intensity between members of the former group, unlike the latter, is influenced by overall RER pressures. Alas, existing literature analysing the effect of exchange rate volatility on trade (such as Clark et al., 2004) finds either no material effect at all or more effect for *less* advanced economies (e.g., because these economies' less developed financial markets offer fewer possibilities of exchange rate hedging). Another possibility is that TRADE is measured with error; but again, one would expect a similar extent of measurement error in both groups or a lower one in the rich-economies group. We are thus left with the hypothesis that our regressions miss one or more explanatory variables that are correlated with TRADE and that this omission has more significance in the rich-economies group than in the rich-plus-emerging group. We return to the issue of omitted variables briefly in the conclusion.

4. Sensitivity analysis

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 exchage rate literature (e.g., Ghosh et al., 2003, Arratibel et al., 2008) traditionally - though not in the OCA index context - captures exchange rate volatility, and 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 (see (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 a 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 volatile case. In spite of the differences in construction and sensitivity, the two measures of RER pressures are very closely related within the data set we work with: in the rich-economies group and the rich-plus-emerging group, the correlation between *MAV* and *Z* is 98 % and 97 %, respectively.

Results of estimating (2) with *Z* as the dependent variable instead of *MAV* for the two groups of economies are presented in Table 4. In short, the results do not differ substantially whether we construct the index using mean absolute value (*MAV*) or z-score (*Z*). Given the high degree of correlation between *MAV* and *Z*, this similarity in results should come as no surprise.

--- TABLE 4 ---

The second robustness check we are going to perform concerns the time period. Specifically, we re-run regression (2) for the interval 1996-2008 (summary statistics for this interval are in Table 5) rather than 2001-2008. The results of this regression are collected in Table 6. In the rich-economies regression (column A in Table 6), *PCG* is deeply insignificant, confirming the earlier hypothesis that processes of real convergence are too weak in the rich-economies group to come out as a dominant factor of RER pressures.

--- TABLE 5 ---

--- TABLE 6 ---

In the rich-plus-emerging group (column B of Table 6), on the contrary - and again in line with inuition - real convergence, represented by *PCG*, is an important co-determinant of RER

pressures in the expected sense (positive sign). The counter-intuitive negative sign of *DIX* in the latter regression may be related to the fact that late 1990s were a time when many of the emerging economies included in the rich-plus-emerging group were still building new trading ties after the collapse of the Eastern Block and the ensuing breakdown of much of their old-time trade; as a result, *DIX* data from the 1990s need not be entirely representative of the economies' actual structures.[9]

5. 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 (2)) that we obtain after we plug actual values of the regressors, pertaining to the time period under study, into the estimated regression. The results of this exercise for all economies in the rich-plus-emerging group (with Germany as the reference economy in each pair) for 2001-2008 are shown in Table 7.

--- TABLE 7 ---

The table presents an ordering of all economies according to the value of the index. Focusing on the relative positions of the nine emerging economies that we work with here, it is not such a big surprise that China scores worst in this respect. It is more surprising, however, that four Eastern European economies (Bulgaria, Lithuania, Latvia, Romania) do not score much better than China.[10] While two Central European economies (Poland, Slovakia) occupy the center of the ranking, overtaking Greece and Ireland, another surprise awaits us at the top: one Central European economy (the Czech Republic) is actually closer to forming an optimum currency area with Germany than France, Italy or Finland. Only three euro area member economies (Austria, Belgium and Netherlands) surpass the Czech Republic in the ranking. In other words: looking at the period in 2001-2008 purely from the standpoint of the OCA framework and through the lens of our convergence-sensitive OCA index, we can see that several Central

[9] As another way to check the stability of our basic results displayed in Table 3, we reran regression (2) with the RER pressures calculated on the basis of the GDP deflator as an alternative economy-wide inflation indicator. The results, available upon request, are almost identical.

[10] Moreover, three of these four (Bulgaria, Latvia, Lithuania) are economies that many years ago effectively entered various common currency arrangements (currency boards or at least fixed exchange rates) with the euro area in spite of the fact that euro area's monetary policy is strongly influenced by developments in Germany.

European economies were better prepared for a common currency with Germany than some of the founding euro area members.

To analyze more closely the impact of making the OCA index sensitive to convergence, we should take a convergence-insensitive OCA index as a benchmark and compare its message for the economies under study with what the convergence-sensitive index implies. The question is which of the several forms of the convergence-insensitive index that have appeared in the literature we will choose as the benchmark: various authors have focused alternatively on nominal exchange rate or real exchange rate, studied alternatively simple variability or various comprehensive measures of pressures, used different regressors and data for different time periods and different sets of economies.

Given the considerations in Section 2 above (preference for a real exchange rate perspective; rejection of simple exchange rate variability as the regressand; rejection of cyclical correlation and size as regressors), we think that the most appropriate benchmark is an index obtained by regressing overall RER presures summarized in the form of the standard deviation (rather than mean absolute value) on *TRADE* and *DIX*:

$$SD_i = \alpha + \beta_1 DIX_i + \beta_2 TRADE_i + \varepsilon_i, \qquad (3)$$

where *SD* is given by (1). By comparing implications of the particular benchmark given by regression (3) and those of the convergence-sensitive OCA index based on regression (2), our attention will be focused specifically on the consequences of making the OCA index sensitive to real convergence (in the sense of trend real appreciation). Details of the estimation of (3) for 2001-2008 are shown in Table 8.

--- TABLE 8 ---

The comparison between implications of the two indices is summarized in Figure 3. Under the convergence-insensitive index (vertical axis), emerging economies' positions are mixed fairly evenly with those of rich group members. In contrast, once we modify the index so that it is sensitive to convergence (horizontal axis), emerging economies relative positions' generally increase. We thus see that, in accord with economic intuition, the use of a convergence-sensitive OCA index reveals emerging economies (i.e., economies that tend to gradually close

the income gap with Germany - see Figure 1) to be generally less ready for a common currency with Germany than they would appear if we used a convergence-insensitive index.

6. Conclusion

In this paper, we study the extent to which RER pressures - in the sense of RER changes merged with foreign exchange interventions and changes in the interest rate differential - are explained by a set of OCA indicators. The motivation is that the resulting regression can be used to calculate the OCA index, i.e., the extent of expected RER pressures. A high OCA index indicates that a given pair of economies is far from being an optimum currency area: it "uses" the RER a lot and thus monetary integration cannot be recommended, at least from a macroeconomic point of view.

We summarize the evolution of RER pressures over time as the mean absolute value of RER pressures (rather than simple standard deviation of the values of RER pressures) so that the gauge of RER pressures that we obtain is sensitive to real convergence within a given pair of economies. Along with making the left-hand side of the regression sensitive to real convergence, we add to the right-hand side set of OCA indicators (similarity in the structure of production, trade intensity) a measure of real convergence, namely, a measure of the GDP per capita growth differential.

Our results (robust to variations in the regression) indicate that when we want to explain the evolution of RER pressures in a group of 21 rich-economies OECD economies, real convergence is not a useful regressor. It becomes a highly relevant regressor, however, once we broaden the sample with nine emerging economies. 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 economies that are likely to feature some real convergence.

Application of the convergence-sensitive index to the whole sample in 2001-2008 brings several surprises. First, after convergence is accounted for, some Eastern European economies end up almost as far from being an optimum currency area with Germany as China; a conventional convergence-insensitive index would indicate these economies to be closer to forming an optimum currency area with Germany. Second, even with convergence taken into

account, two Central European economies still appear to be better prepared (at least in 2001-2008) for a common currency with Germany than some of the current euro area members; and the Czech Republic appears to be closer to being an optimum currency area with Germany than most euro area members, the exceptions being Austria, Belgium and Netherlands.

It is important, however, to keep in mind certain limitations of our findings and of the whole OCA index approach. The empirical methodology used in this paper is very coarse and simplistic. The OCA index regressions and the subsequent calculation of specific values of the index for various economies in the sample take into account three particular OCA indicators. A full-blown OCA index should build on other indicators as well. An obvious avenue for future research is thus to enrich the OCA index regression (2) with still other factors pointed out by the OCA framework. These include potential sources of asymmetric shocks, such as fiscal policy (if pro-cyclical) or differences in the structure of the financial sector, as well as potential channels of adjustment, such as fiscal policy (if counter-cyclical) or flexibility of the labor market (labor mobility, wage flexibility). The message provided by such a full-blown OCA index will certainly be more reliable than our present results. Even then, of course, it will be just one of several possible approaches to the complex issue of macroeconomic desirability of forming a currency union.

Also, the (essentially normative) macroeconomic perspective on which we focus here need not 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 - need not be 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 euro area as a whole - the Czech Republic might be a better candidate for membership in the euro area than many of its current members, this is far from suggesting that the Czech Republic 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.

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Table 1: Groups of economies under study

Rich-economies group				Rich-plus-emerging group = rich-economies group plus:	
1	Austria	12	Spain	22	Bulgaria
2	Belgium	13	Sweden	23	China
3	Denmark	14	Switzerland	24	Czech Republic
4	Finland	15	UK	25	Latvia
5	France	16	Australia	26	Lithuania
6	Germany	17	Canada	27	Mexico
7	Greece	18	Japan	28	Poland
8	Ireland	19	New Zealand	29	Romania
9	Italy	20	Norway	30	Slovakia
10	Netherlands	21	US		
11	Portugal				

Table 2: Summary statistics (2001-2008)

	MAV	*DIX*	*TRADE*	*PCG*
rich-economies group				
Mean	1.360293	0.522083	0.011892	0.013084
Std. Dev.	1.300592	0.257152	0.018265	0.005916
Min	0.003732	0.147387	0.000156	0.00415
Max	6.470949	1.261467	0.142607	0.031746
correlation with *MAV*	1	0.4179	-0.2534	-0.1376
correlation with *DIX*		1	-0.2452	0.1284
correlation with *TRADE*			1	-0.2256
rich-plus-emerging group				
Mean	2.358677	0.503554	0.009178	0.029953
Std. Dev.	1.846672	0.232387	0.016171	0.022495
Min	0.003732	0.085985	0.000019	0.00415
Max	8.191473	1.261467	0.142607	0.091981
correlation with *MAV*	1	0.1667	-0.2355	0.3998
correlation with *DIX*		1	-0.2315	0.0688
correlation with *TRADE*			1	-0.1848

Table 3: Details of the basic regressions (2001-2008, dependent variable: *MAV*)

	(A)	(B)	(C)
group	rich-economies	rich-economies without Greece and Ireland	rich-plus-emerging
no. of observations	210	171	434
estimation	IV (2SLS)	IV (2SLS)	OLS
DIX	1.705	1.864	0.870
	(.000)	(.000)	(.014)
TRADE	-34.244	-32.662	-16.318
	(.000)	(.000)	(.002)
PCG	-63.631	-24.566	30.694
	(.000)	(.344)	(.000)
constant	1.710	1.230	1.159
	(.000)	(.003)	(.000)
F	25.69	21.93	36.40
	(.000)	(.000)	(.000)
R^2 (centered)	0.18	0.21	0.20
RMSE	1.171	1.169	1.665
heteroscedasticity?	no	no	no
heteroscedasticity test p-value[a]	.53	.96	.52
TRADE endogenous?	yes	yes	no
TRADE exogeneity test p-value[b]	.0001	.0010	.3502
Anderson CC test p-value[c]	.0000	.0000	
Cragg-Donald Wald F statistic[d]	54.99	41.54	
Stock-Yogo 5 % max IV rel. bias[e]	13.91	13.91	
Stock-Yogo 10 % max IV size[e]	22.30	22.30	

P-values reported in parentheses. For information on the excluded instruments used, see the main text.
[a] H_0: errors are homoskedastic. In the IV estimation and OLS estimation, the Pagan-Hall test and the Cook-Weisberg test was used, respectively.
[b] $\chi^2(1)$ test of exogeneity (H_0: *TRADE* is exogenous) suggested by Baum et al. (2007).
[c] H_0: the endogenous variable (*TRADE*) is underidentified by the instruments.
[d] H_0: the endogenous variable (*TRADE*) is weakly identified by the instruments.
[e] Critical values for the Cragg-Donald Wald F test (the test's null can be rejected if the test statistic exceeds the critical values) - see Stock and Yogo (2005).

Table 4: Details of regressions with *Z* as the dependent variable (2001-2008)

	(A)	(B)	(C)
group	rich-economies	rich-economies without Greece and Ireland	rich-plus-emerging
no. of observations	210	171	434
estimation	IV (2SLS)	IV (2SLS)	OLS
DIX	1.984	2.152	0.878
	(.000)	(.000)	(.021)
TRADE	-35.064	-33.539	-17.363
	(.000)	(.000)	(.002)
PCG	-70.178	-32.137	31.440
	(.000)	(.218)	(.000)
constant	1.773	1.301	1.360
	(.000)	(.002)	(.000)
F	30.54	26.04	33.83
	(.000)	(.000)	(.000)
R^2 (centered)	0.23	0.25	0.19
RMSE	1.182	1.174	1.778
heteroscedasticity?	no	no	no
heteroscedasticity test p-value[a]	.71	.99	.98
TRADE endogenous?	yes	yes	no
TRADE exogeneity test p-value[b]	.0001	.0008	.2335
Anderson CC test p-value[c]	.0000	.0000	
Cragg-Donald Wald F statistic[d]	54.99	41.54	
Stock-Yogo 5 % max IV rel. bias[e]	13.91	13.91	
Stock-Yogo 10 % max IV size[e]	22.30	22.30	

P-values reported in parentheses. For information on the excluded instruments used, see the main text. For detailed comments on the tests (a - e), see notes for Table 3.

Table 5: Summary statistics (1996-2008)

	MAV	*DIX*	*TRADE*	*PCG*
rich-economies group				
Mean	1.694582	0.515007	0.011718	0.014712
Std. Dev.	1.225906	0.242291	0.018049	0.007666
Min	0.019234	0.15274	0.000200	0.00443
Max	6.558047	1.20854	0.148400	0.041573
correlation with *MAV*	1	0.3458	-0.3223	0.1015
correlation with *DIX*		1	-0.2616	0.2708
correlation with *TRADE*			1	-0.1132
rich-plus-emerging group				
Mean	3.594259	0.510806	0.008746	0.028694
Std. Dev.	3.036711	0.225599	0.015858	0.018478
Min	0.019234	0.089560	0	0.00443
Max	14.19668	1.3163	0.1484	0.077926
correlation with *MAV*	1	-0.0154	-0.204	0.2725
correlation with *DIX*		1	-0.2465	0.1774
correlation with *TRADE*			1	-0.2001

Table 6: Details of the pair of regressions for 1996-2008 (dependent variable: *MAV*)

	(A)	(C)
group	rich-economies	rich-plus-emerging
no. of observations	210	434
estimation	IV (2SLS)	robust OLS
DIX	1.152	-1.393
	(.001)	(.006)
TRADE	-31.544	-34.068
	(.000)	(.022)
PCG	-2.028	42.756
	(.850)	(.000)
constant	1.501	3.377
	(.000)	(.000)
F	16.65	16.75
	(.000)	(.000)
R^2 (centered)	0.13	0.11
RMSE	1.138	2.876
heteroscedasticity?	no	yes
heteroscedasticity test p-value[a]	.81	.03
TRADE endogenous?	yes	no
TRADE exogeneity test p-value[b]	.0027	.5570
Anderson CC test p-value[c]	.0000	
Cragg-Donald Wald F statistic[d]	55.69	
Stock-Yogo 5 % max IV rel. bias[e]	13.91	
Stock-Yogo 10 % max IV size[e]	22.30	

P-values reported in parentheses. For information on the excluded instruments used, see the main text. For detailed comments on the tests (a - e), see notes for Table 3. Robust OLS estimation was performed using the HC3 procedure suggested by MacKinnon and White (1985) and further recommended by Long and Ervin (2000).

Table 7: OCA index based on regression (2) for the rich-plus-emerging group, 2001-2008

Netherlands	0.14	Spain	1.45	Ireland	2.02
Belgium	0.18	US	1.49	Greece	2.13
Austria	0.38	Portugal	1.50	Australia	2.20
Czech Republic	**0.42**	Finland	1.59	New Zealand	2.36
Switzerland	0.95	Japan	1.60	**Bulgaria**	**2.81**
France	0.96	**Poland**	**1.61**	**Romania**	**2.88**
Denmark	1.24	**Slovakia**	**1.71**	**Lithuania**	**3.24**
Italy	1.33	**Mexico**	**1.82**	**Latvia**	**3.71**
UK	1.37	Canada	1.87	**China**	**3.83**
Sweden	1.39	Norway	1.95		

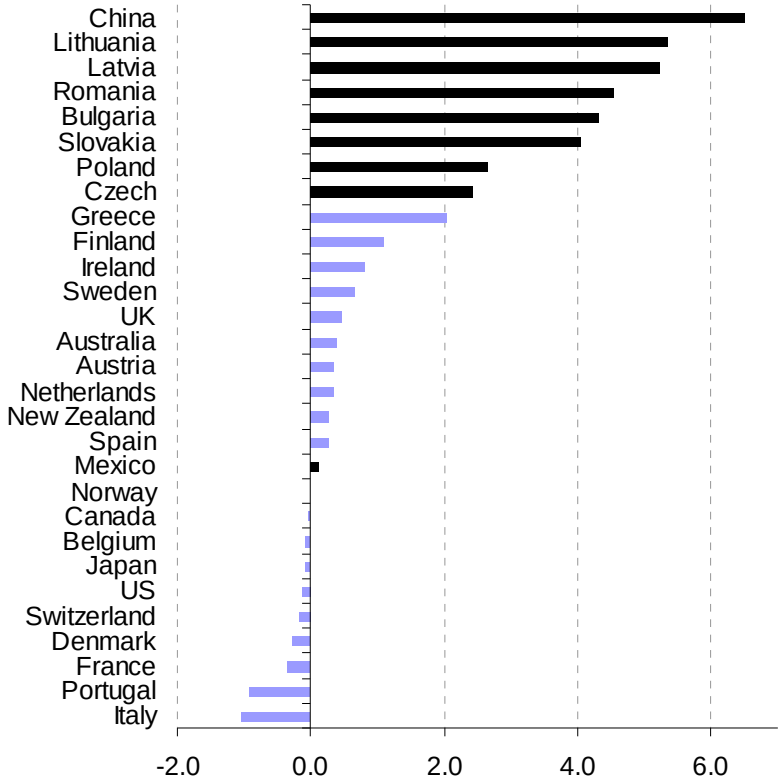
Note: For any given pair of economies, only one economy is shown; the other economy in the pair is always Germany. The pairs are ranked column-wise by the value of the OCA index in an increasing order. Emerging economies (included in the rich-plus-emerging group but not in the rich-economies group) are printed in bold.

Table 8: Details of the pair of regressions with *SD* as the dependent variable (2001-2008, regressor *PCG* excluded)

	(A)	(C)
group	rich-economies	rich-plus-emerging
no. of observations	210	434
estimation	IV (2SLS)	IV (GMM)
DIX	.741	-0.042
	(.000)	(.795)
TRADE	-8.343	-16.161
	(.002)	(.000)
constant	0.339	1.193
	(.000)	(.000)
F	30.14	11.95
	(.000)	(.000)
R^2 (centered)	.16	-.02
RMSE	.4606	.8307
heteroscedasticity?	no	yes
heteroscedasticity test p-value[a]	.43	.00
TRADE endogenous?	yes	yes
TRADE exogeneity test p-value[b]	.0004	.0094
Anderson CC test p-value[c]	.0000	
Kleibergen-Paap rk LM test p-value[c]		.0000
Cragg-Donald Wald F statistic[d]	59.01	111.05
Stock-Yogo 5 % max IV rel. bias[e]	13.91	13.91
Stock-Yogo 10 % max IV size[e]	22.30	22.30

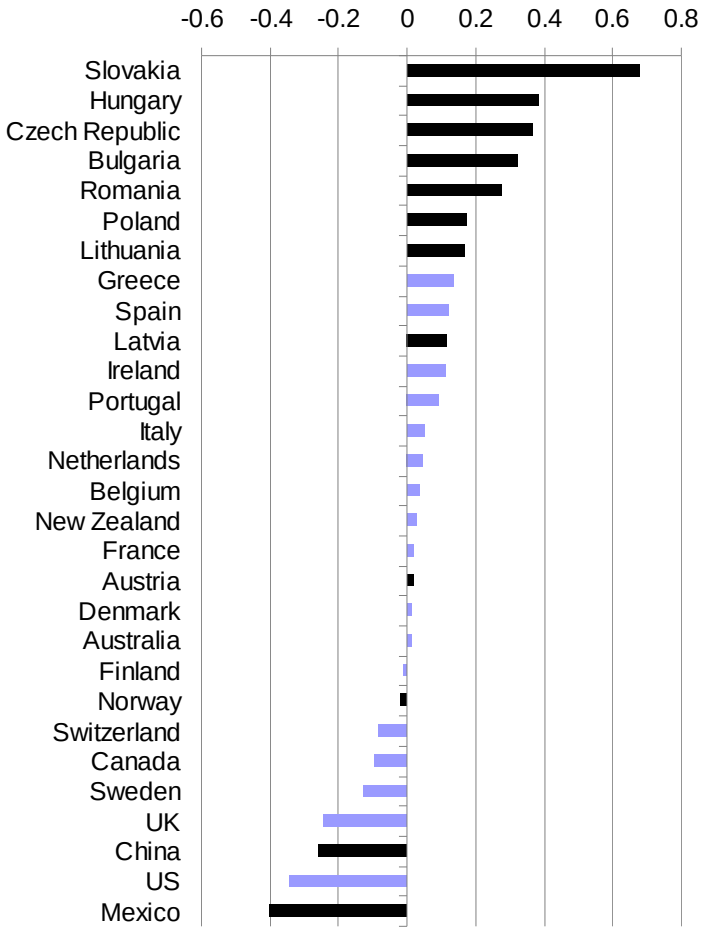
P-values reported in parentheses. For information on the excluded instruments used, see the main text. For detailed comments on the tests (a - e), see notes for Table 3.

Figure 1: Excess (in p.p.) of average yearly growth of GDP per capita at PPP over Germany, 2001-2008



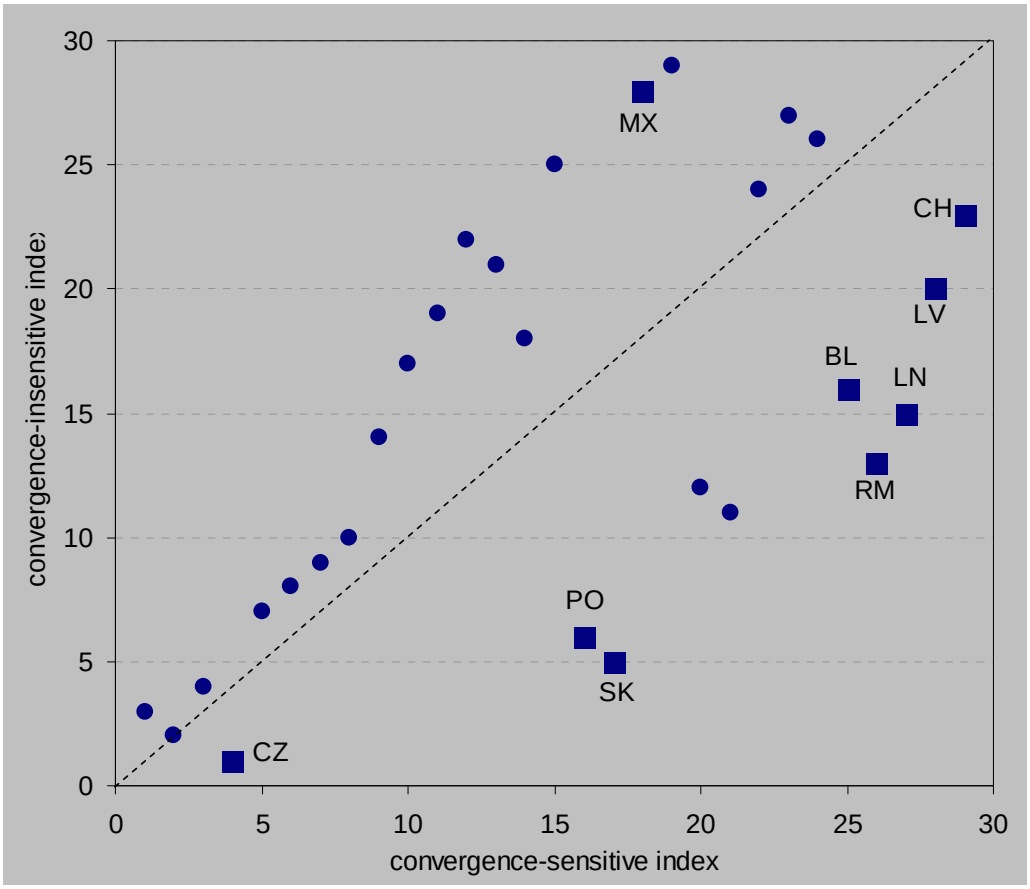
Source: IMF, own calculation.

Figure 2: Cumulative appreciation (in percent) of the real exchange rate to Germany, 2001-2008



Source: IMF, own calculation.

Figure 3: Ranks of economies within the rich-plus-emerging group according to the convergence-sensitive OCA index and the convergence-insensitive OCA index



Note: Both indices refer to 2001-2008 and Germany as the reference economy. Members of the rich-economies group and emerging economies are represented by circles and squares, respectively. CZ = Czech Republic, PO = Poland, SK = Slovakia, MX = Mexico, BL = Bulgaria, RM = Romania, LN = Lithuania, LV = Latvia, CH = China.

Annex: Construction of variables and sources of data

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 = 8 for the period 2001-2008; T = 13 for the period 1996-2008),

p_{it} is the yearly pressure on RER in the i-th pair of economies in year t, that is, an unweighted average of

(a) RER change (using yearly CPI inflation 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.

Sources: IMF, Thomson Reuters Datastream, own calculation.

Z_i

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

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

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

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

DIX_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 = 8 for the period 2001-2008; T = 13 for the period 1996-2008),

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 exports.[11]

Source: UN (ComTrade), own calculation.

[11] While Bayoumi and Eichengreen (1997a) measure dissimilarity in the two economies' structures by looking at trade turnover, we follow Bayoumi and Eichengreen (1997b) and look at exports only, based on the idea that the productive structure of the economy is more precisely reflected by the structure of exports (rather than turnover). However, Bayoumi and Eichengreen (1997a, b) compute their structural dissimilarity indicator using shares of the nine single-digit SITC categories aggregated into three super-categories while we compute *DIX* using simply the shares of the nine categories (note that in the formula for *DIX*, c = 1, ..., 9): we do not see any strong reason to aggregate the categories in any specific way before calculating the shares.

$TRADE_i$

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

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 DIX_i.
Sources: World Bank, Thomson Reuters Datastream, own 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 DIX_i.
Source: IMF, own calculation.

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Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz