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Armenia: An Assessment of the Real Exchange Rate and Competitiveness

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Armenia: An Assessment of the Real Exchange Rate and Competitiveness[1]

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Abstract

This paper uses a range of different methodologies to estimate the equilibrium real exchange rate in Armenia with both single-country and panel estimation techniques. We estimate a country specific autoregressive distributed lag model and then proceed with the estimation of a cointegrated panel consisting of transition economies in Europe and Central Asia. This addresses cross section dependence by using common correlated effects estimators. While our analysis focuses on Armenia, the methods are applicable to a large number of transition economies, and the paper thus provides an overview of methods that can be used to assess a country's equilibrium exchange rate.

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Contents

I. INTRODUCTION

The equilibrium real exchange rate is an important macroeconomic policy indicator since it provides an assessment of a country's external competitiveness. Investigating whether a country's exchange rate is close to its equilibrium value furthermore helps determine future adjustment needs and possible trajectories of economic fundamentals. However, empirical analysis of the equilibrium real exchange rate remains fraught with considerable model uncertainty with different models often yielding conflicting results (Bussiere et al., 2010). Assessing the equilibrium exchange rate is particularly challenging in emerging market and developing economies, given limited data availability, structural breaks, and high macroeconomic volatility. Armenia is an interesting example in this regard, since it experienced one of the highest real GDP growth rates in the world for an extended period, before the global crisis at the end of 2008 resulted in an end of this boom, leading to an enormous drop in output.

This paper uses a range of different methodologies to estimate the equilibrium exchange rate in Armenia in order to strengthen the robustness of the assessment. These include the three measures of equilibrium outlined in the IMF's Consultative Group on Exchange Rate Issues (CGER), namely the macroeconomic balance approach (MB), the external sustainability approach (ES) and the (reduced form) equilibrium real exchange rate approach (ERER). The first two approaches are based on current account misalignment and the level of the exchange rate that will bring the current account back to its norm, the ERER approach estimates the long-run cointegrating relationship between the real exchange rate and its fundamentals. This paper follows the CGER methodologies for the first two approaches but estimates a country-specific single-country equation for the ERER approach. It then proceeds with panel estimation techniques, which address cross-section dependence by using common correlated effects estimators as proposed by Pesaran (2006). In addition, a panel cointegration test that accommodates cross-country common factors is introduced and applied (Pesaran and Tosetti, 2010). While our analysis focuses on Armenia, the methods are applicable to other transition economies, and the paper thus provides an overview of methods that can be used to assess a country's equilibrium exchange rate.

We also complement our econometric estimation with price and non-price indicators of competitiveness. According to the OECD (1992) competitiveness is defined as the "degree to which a country can, under free trade and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the long term." In recent years, several indicators of competitiveness have been published by the World Bank and the World Economic Forum. The paper presents a summary of their findings to analyze whether these indicators support the results from the exchange rate assessment.

The results of this paper point to a loss of external competitiveness in Armenia in recent years. This is indicated by the fall of Armenia's share of world exports and its deteriorating performance in major competitiveness indicators. The loss of competitiveness is also reflected in the exchange rate analysis based on the ERER and panel approaches, which show that the dram was overvalued as of end 2009 by 7-11 percent.

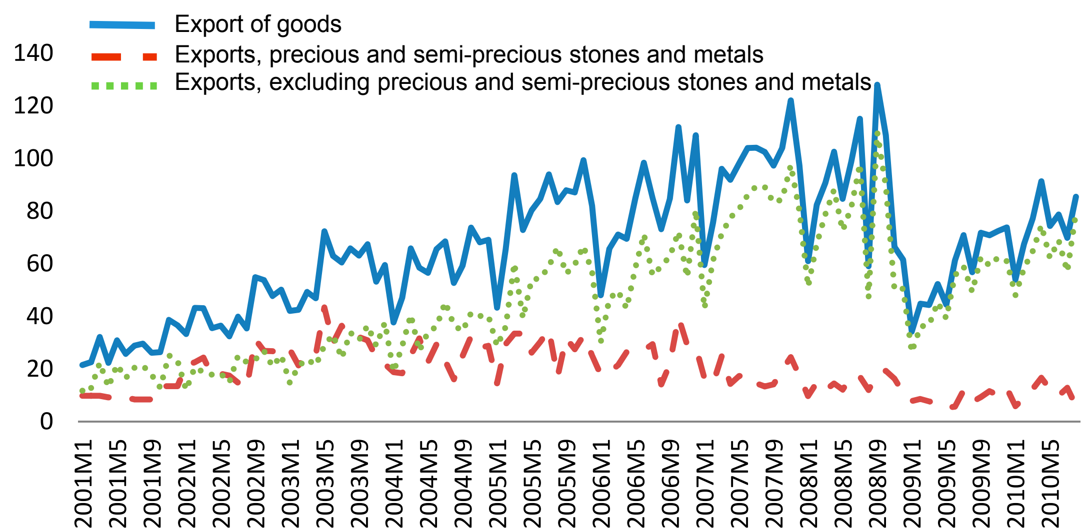
The paper is structured as follows: Section II analyses recent developments in Armenia including its export performance and the evolution of the real effective exchange rate as well as non-price indicators of competitiveness. Section III describes the methodologies and results of the exchange rate assessment. Section IV concludes.

II. Recent Developments

A. Export Performance

Armenia's export volume increased between 2001 and 2008 before falling significantly at the onset of the crisis in late 2008. Since then, export volume has started a modest recovery, but remains at 2003 levels (Figure 1).

Figure 1: Export Volume (millions of USD)



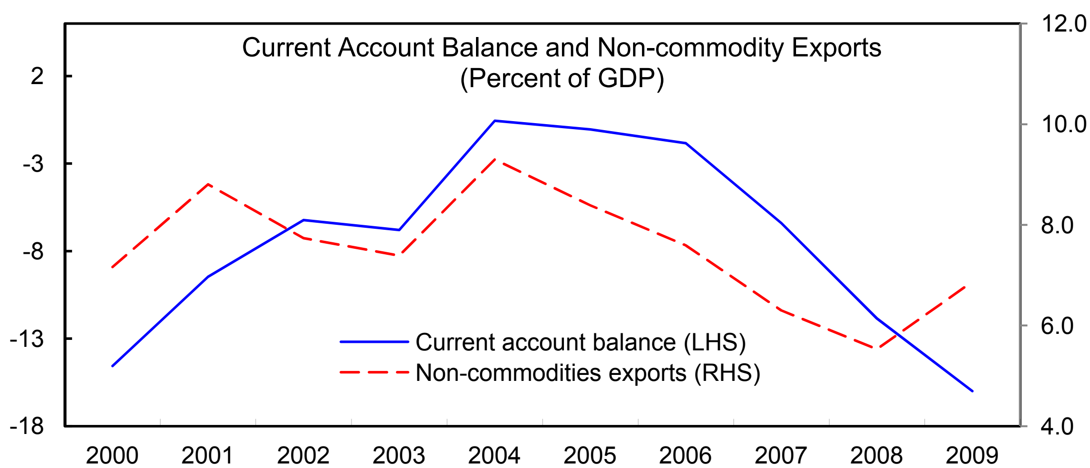
Armenia's export structure has changed in recent years. Table 1 shows exports by products between 2000 and 2009 and indicates that precious and non-precious metals, precious and semi-precious stones and minerals constitute more than 65 percent of exports in those years. There was a shift away from precious stones and metals to non-precious metals and minerals. This shift is likely to be linked to a decrease in exports of the diamond processing industry and could be caused by both price effects and exhaustion of the natural resource. Thus, it is not necessarily a sign of a loss of competitiveness. However, the significant decline in the share of machines, equipment and devices as well as textile products, plastic items and natural and artificial rubber items is a clearer sign of a loss of competitiveness. Only ready food products have become more important as a source of exports.

Table 1: Export Structure by Main Products

Product	Percentage of total exports			
	2000	**2005**	**2007**	**2009**
Precious and semi-precious stones, precious metals	40.8	34.5	18.1	15.1
Non-precious metals	14.9	33.1	33.9	33.1
Minerals	11.5	9.6	15.1	18.9
Machines, equipment, devices	10.4	2.9	3.4	3.0
Ready food products	9.2	9.9	12.5	14.3
Textile products	4.4	3.8	3.1	2.1
Plastic items, natural and artificial rubber items	3.0	0.9	2.7	1.5

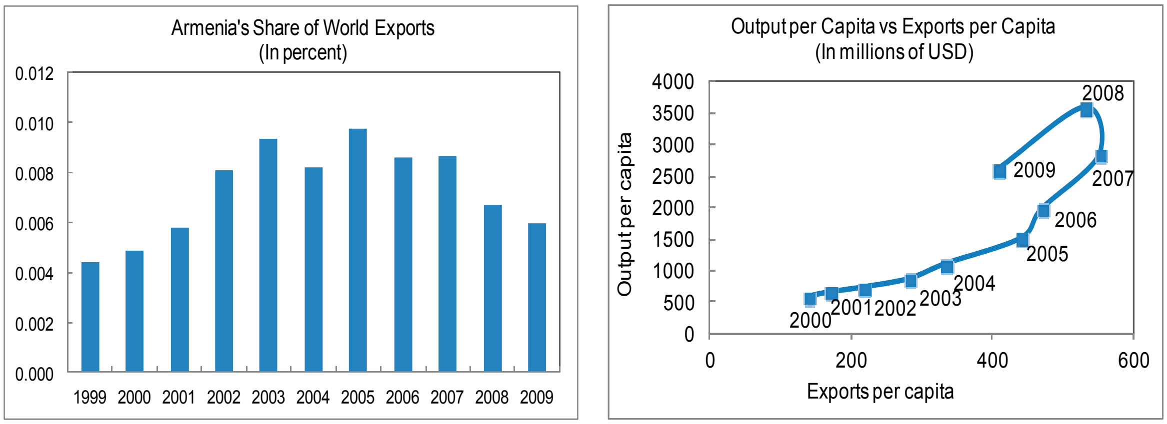
Despite growth of overall export volume, Armenia's current account balance as a percentage of GDP has significantly deteriorated since 2004. This deterioration was in line with a decline in non-commodity exports as a percentage of GDP until 2008. The combination of a deteriorating current account—reaching more than -16 percent in 2009— together with a fall in non-commodity exports, points to a significant loss of competitiveness of the Armenian economy.

Figure 2: Armenia's Current Account and Non-Commodity Exports



This is also confirmed when looking at the share of Armenian exports in world exports, which has decreased significantly since 2007. In addition, the role of the tradable sector has shrunk since 2005 as indicated by decreasing exports per capita with output per capita growing until 2008 (Figure 3).

Figure 3: Indicators of Armenia's External Competitiveness

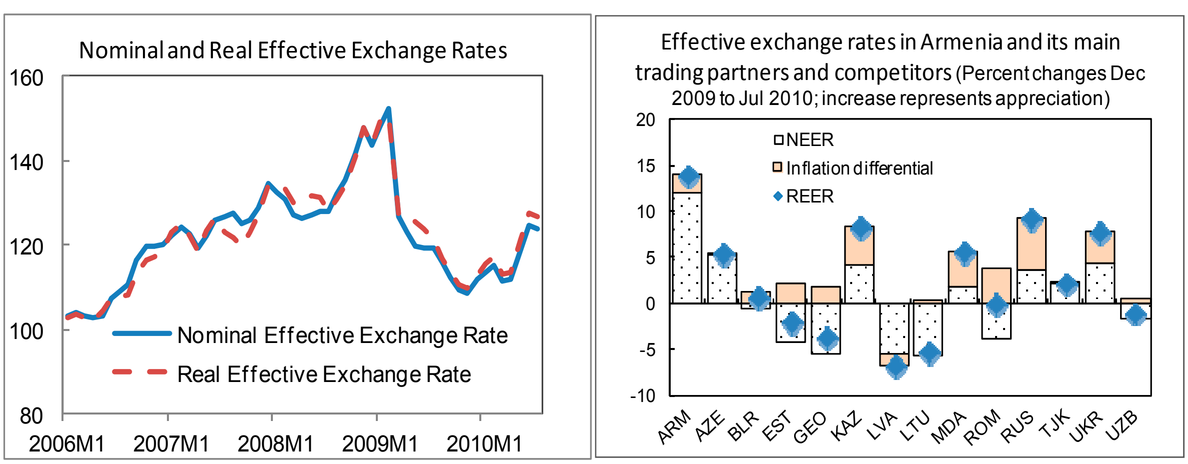


The above indicators thus point to a loss of external competitiveness in recent years. The next section will evaluate how the real effective exchange rate evolved during this period.

B. Price Competitiveness: A Descriptive Analysis

From 2006 until a sizeable nominal depreciation of the Armenian dram in March 2009, the real effective exchange rate (REER) steadily appreciated (Figure 4). This real appreciation, which was accompanied by a nominal appreciation, was mostly the result of large foreign exchange inflows, notably remittances, as well as high export prices, especially of copper and molybdenum (Oomes et al., 2009). In March 2009, Armenia returned to a floating exchange rate regime, and the dram depreciated by 22 percent vis-à-vis the US dollar. This depreciation was both the result of the global crisis, which led to a decrease in demand for Armenian exports as well as a fall in remittances and foreign direct investment, as well as of a significant decrease in the export prices of copper and molybdenum. Recently the dram has shown some upward trend again, and compared to major competitors, it has appreciated the most both in real and nominal terms between December 2009 and July 2010 (Figure 4).

Figure 4: Effective Exchange Rate Developments



As a first approximation, a real effective exchange rate appreciation may be interpreted as a loss of competitiveness since the REER measures the prices of a country's goods relative to its competitors in international markets. However, competitiveness also depends on the distance of the REER from its equilibrium value, and thus an appreciation may not necessarily indicate a loss of competitiveness. For example, an exchange rate appreciation could be linked to an increase in productivity in the tradable sector. According to the Balassa-Samuelson effect, countries with higher productivity growth in the tradable sector experience higher relative prices of non-tradables and therefore an exchange rate appreciation. Such an increase in productivity would raise the underlying equilibrium exchange rate as well as the REER. Thus the resulting appreciation would not necessarily result in an exchange rate misalignment.

Before turning to an analysis in Section III of how the underlying equilibrium exchange rate has changed in Armenia in recent years, Section II will examine non-price indices of competitiveness.

C. Non-Price Competitiveness

According to the World Economic Forum Global Competitiveness report, Armenia ranks well below most Eastern European and many Commonwealth of Independent States (CIS) countries[2]. Armenia was ranked 98 out of 139 countries in 2010, outperforming only Tajikistan and the Kyrgyz Republic[3]. Key constraints in doing business in 2010 were the lack of local competition, extent of market dominance, and the ineffectiveness of anti-monopoly policy. On these indicators, Armenia was ranked at the bottom of the sample (136, 133, and 138 respectively out of 139 countries).

[2] The rankings are calculated from both publicly available data and the Executive Opinion Survey, a comprehensive annual survey conducted by the World Economic Forum together with its network of partner institutes (leading research institutes and business organizations) in the countries covered by the report.

[3] Data for Belarus, Turkmenistan and Uzbekistan are not available.

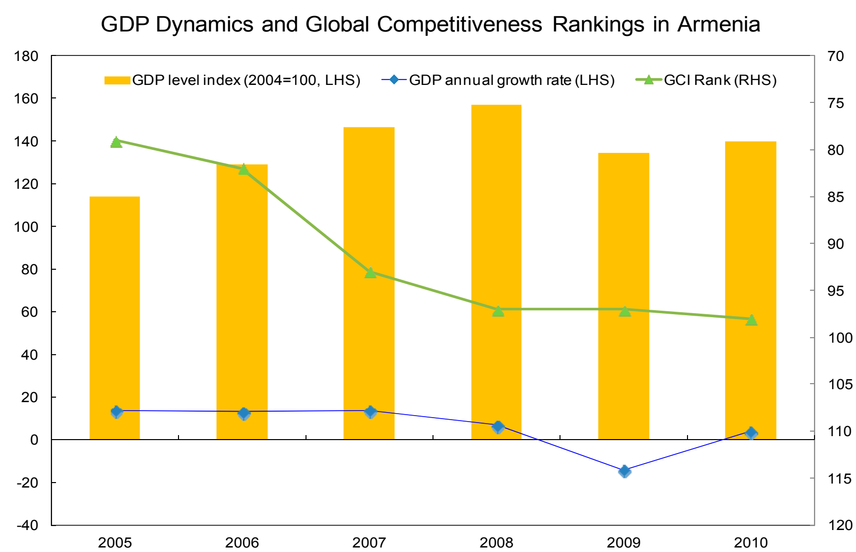
Table 2: World Economic Forum Global Competitiveness Index (GCI)

Country/Economy	GCI 2010		GCI 2009	Change 2009-2010
	Rank	Score	Rank	
Estonia	33	4.61	35	2
Lithuania	47	4.38	53	6
Azerbaijan	57	4.29	51	-6
Russian Federation	63	4.24	63	0
Romania	67	4.16	64	-3
Latvia	70	4.14	68	-2
Bulgaria	71	4.13	76	5
Kazakhstan	72	4.12	67	-5
Ukraine	89	3.90	82	-7
Georgia	93	3.86	90	-3
Moldova	94	3.86	n/a	n/a
Armenia	98	3.76	97	-1
Tajikistan	116	3.53	122	6
Kyrgyz Republic	121	3.49	123	2

Source: 2010 World Economic Forum

Notably, although Armenia's GDP grew by about 12 percent on average during 2005–08, its international competitiveness relative to the rest of the world declined during this period as shown in Figure 5. This confirms that Armenia's growth in those years was not export led but driven by strong domestic demand connected to the boom in the residential construction sector, which was fuelled by remittances inflows. These developments did not strengthen the basis for concurrent or future export growth.

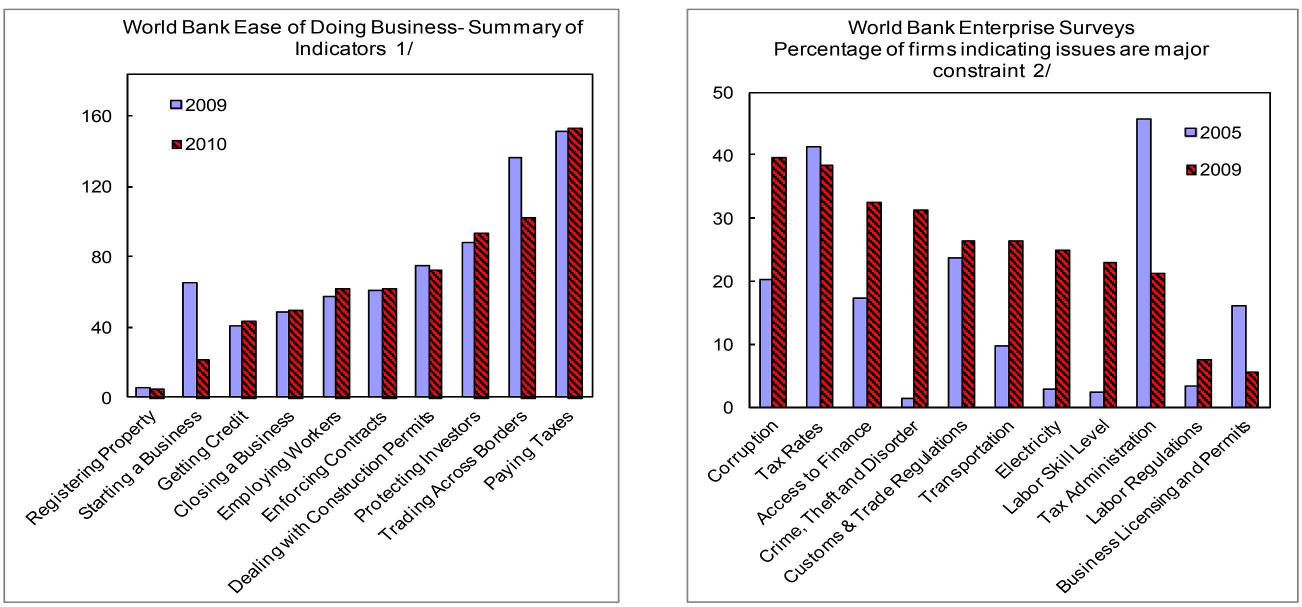
Figure 5: GDP Dynamics and Global Competitiveness Rankings for Armenia



Sources: National authorities, and World Economic Forum.

The reasons for the decline in competitiveness also appear to be related to the difficulties of operating a business in Armenia. The World Bank publishes two indicators related to the business climate. First, there is the Ease of Doing Business Indicator, which is based on a business survey in the economy's largest business city. A high ranking on the ease of doing business index means that the regulatory environment is more conducive to the starting and operation of a local firm. The second indicator is the enterprise survey, which is a firm-level survey of a representative sample of an economy's private sector. The survey covers a broad range of business environment topics including access to finance, corruption, infrastructure, crime, competition, and performance measures. Both indicators show that while starting a business is relatively easy, conducting business is judged to be difficult. As Figure 6 shows, Armenia was ranked 21 out of 183 countries in 2010 in the "starting a business" index, while its position in the "protecting investors" and "paying taxes" indices was significantly lower at 93 and 153, respectively. Furthermore, a majority of businesses indicated that corruption, access to finance, as well as crime, theft, and disorder have recently emerged as major concerns.

Figure 6: World Bank Ease of Doing Business Indicators



1/ Rankings are out of 183 countries, with a lower score indicating greater ease of doing business.
2/ 302 and 374 enterprises are surveyed in 2005 and 2009 respectively.

Interestingly, businesses in a large number of transition economies reported an increase in corruption, crime, theft, and disorder and identified access to finance as a major obstacle in 2009 (Table 3)[4]. Only the Czech Republic did not report a significant deterioration in at least one of those indicators. These developments are very likely the result of the economic crisis in 2008–09. It almost seems as if there was a "general malaise" associated with the crisis that has resulted in worse ratings by survey respondents in those economies. This is not particularly surprising given the sizable decline in growth across the region.

[4] Data for Turkmenistan is not available for the enterprise survey.

Table 3: Enterprise Survey of Selected Transition Economies

Country	*% of Firms Identifying Corruption as a Major Constraint****		*% of Firms Identifying Crime, Theft and Disorder as Major Constraints****		*% of Firms Identifying Access to Finance as a Major Constraint****	
Country	2005	2009	2005	2009	2005	2009
Albania*	32.8	38.0	9.3	22.0	16.6	16.9
Armenia	20.3	39.6	1.3	31.2	17.3	32.6
Azerbaijan	23.0	25.1	2.1	10.5	8.0	23.2
Belarus**	6.9	30.7	2.2	48.0	23.4	32.7
Bosnia and Herzegovina	22.5	35.1	19.4	13.0	15.8	24.6
Bulgaria	20.2	33.5	12.0	24.5	13.0	17.3
Croatia*	17.8	18.9	4.7	9.6	12.8	16.7
Czech Republic	25.5	25.1	16.6	16.8	21.4	23.7
Estonia	3.7	5.4	1.9	8.6	5.0	6.5
Georgia**	23.5	20.4	27.7	36.7	23.2	35.3
Hungary	9.2	20.4	5.4	3.9	25.1	11.7
Kazakhstan	13.7	43.9	4.6	41.5	11.9	31.0
Kyrgyz Republic	33.5	58.9	19.9	42.8	15.1	27.9
Latvia	11.5	33.9	2.9	26.1	2.2	27.7
Lithuania	16.4	38.6	11.0	37.9	7.5	26.9
Macedonia, FYR	38.5	27.1	13.5	25.0	23.0	27.7
Moldova	17.8	40.9	10.1	40.4	19.9	39.1
Poland	20.4	24.1	15.8	22.9	34.2	22.0
Romania	29.9	52.3	14.6	29.9	19.2	36.9
Russian Federation	17.2	50.0	8.0	38.1	13.5	35.0
Serbia	25.0	35.6	14.2	11.8	33.2	27.9
Slovak Republic	13.6	31.1	5.8	24.7	6.0	17.7
Slovenia	4.6	9.8	0.7	15.8	9.0	16.7
Tajikistan**	18.2	37.8	4.5	33.0	3.9	24.8
Turkey**	53.8	42.3	33.5	13.2	47.5	14.3
Ukraine**	24.2	50.2	12.8	43.2	21.7	34.7
Uzbekistan**	8.9	27.2	8.4	43.3	11.3	25.1
Average	20.5	33.2	10.5	26.5	17.1	25.1

**: The 2009 survey is not available; the 2007 survey is used for comparison.*
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Table 3 shows that the percentage of firms identifying corruption, crime, theft, disorder and access to finance as a major obstacle in Armenia significantly exceeds the average percentage of firms reporting these problems across transition economies. Having discussed price and non-price indicators of competitiveness, the next section will evaluate whether there has been a misalignment of the real exchange rate in recent years.

III. Exchange Rate Assessment

A. The Macroeconomic Balance (MB) Approach

Data and econometric methodology

The MB approach measures the exchange rate adjustment needed to shift the underlying current account (CA) to its sustainable level where output is at its potential. In other words, this approach measures by how much the exchange rate should vary to restore external balance, on the assumption of internal balance.

The estimation method consists of three steps. The first step involves the estimation of an equilibrium relationship between the current account balance and a set of fundamentals, which are the determinants of saving and investment. Details on the variables used in estimating this equilibrium relationship as well as data sources can be found in Table A1 in the Appendix. The second step derives the current account norm based on the estimated relationship and projected values of fundamentals up to 2015. The projections of the current account and its fundamentals reported in the WEO database are based on the assumption that there will be some policy adjustment in the future. Thus, the projections and the resulting estimates of misalignment will only be accurate if the projected policy changes take place. This may not always be a realistic scenario and in this case, the estimates of misalignment would be flawed. The third step then measures the required exchange rate adjustment to close the gap between the CA norm and the projected (or underlying) current account. This adjustment is based on the elasticity of the current account to the real exchange rate.

To apply the MB approach to Armenia, we use regression estimates from the CGER MB panel. However, since this panel includes a large number of advanced economies, whose coefficients may be less applicable to Armenia, we also estimate the panel with emerging market economies only.[5]

The results of the panel estimation including 54 advanced and emerging economies[6] are as follows for the period of 1969-2008:

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[5] Data and Stata programs were provided by the IMF Research Department. An overview of the estimation methodology is given by Lee et al (2008).

[6] The advanced economies in the panel are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and USA. Emerging markets are: Algeria, Argentina, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Dominican Republic, Ecuador, Egypt, Estonia, Hong Kong, Hungary, India, Indonesia, Israel, Korea, Latvia, Lithuania, Malaysia, Mexico, Morocco, Pakistan, Peru,

(continued…)

$$\left(\frac{CA}{GDP}\right)_{j,t} = -0.02 + 0.17 \times FB_{j,t} - 0.15 \times OAD_{j,t} - 1.50 \times PG_{j,t} + 0.02 \times RI_{j,t} - 0.07 \times PCG_{j,t} + 0.41 \times LCA_{j,t} \tag{1}$$

where the fundamentals are the fiscal balance (FB), the old age dependency ratio (OAD), population growth (PG), relative income (RI), per capita GDP growth (PCG) and the lagged current account, LCA. The signs of coefficients in the above regression are as expected. A higher fiscal balance raises national saving and thereby increases the current account balance unless there is full Ricardian equivalence, where private saving fully offsets changes in public saving. Furthermore, the coefficients on both the old-age dependency ratio and population growth are negative since a higher share of the economically inactive dependent population is expected to reduce national saving and therefore decrease the current account balance. The relative income and per capita growth variables are included as proxies for the level of development of an economy. Less developed economies, which are mostly characterized by lower relative income and higher per capita GDP growth, are expected to have a lower current account balance. Finally, the lagged current account balance is added to take into account the strong persistence of the current account series.

The following relationship is estimated when only including the 42 emerging market economies in the sample[7]:

$$\left(\frac{CA}{GDP}\right)_{j,t} = -0.02 + 0.20 \times FB_{j,t} - 0.20 \times OAD_{j,t} - 1.40 \times PG_{j,t} + 0.02 \times RI_{j,t} - 0.06 \times PCG_{j,t} + 0.41 \times LCA_{j,t}\,. \tag{2}$$

It can be seen that in the relationship with emerging markets only, the estimated coefficients are very similar to the relationships shown in equation (1).

In order to calculate the exchange rate adjustment needed to bring the CA back to its norm, we use country-specific elasticities of exports and imports to the real exchange rate of 1.22 for imports and -1.08 for exports. These are based on the paper by Tokarick (2010) and are Armenia-specific elasticities. The elasticity of the current account to the real exchange rate then is 0.45 using the average import to export ratios between 1999 and 2009 and the following equation:

$$(\partial CA/GDP)/(\partial RER/RER) = \gamma_x(XGS/GDP) - (\gamma_{M-1)}(MGS/GDP) \tag{3}$$

Philippines, Poland, Romania, Russia, Singapore, Slovakia, Slovenia, South Africa, Sri Lanka, Taiwan, Thailand, Tunisia, Turkey, and Venezuela.

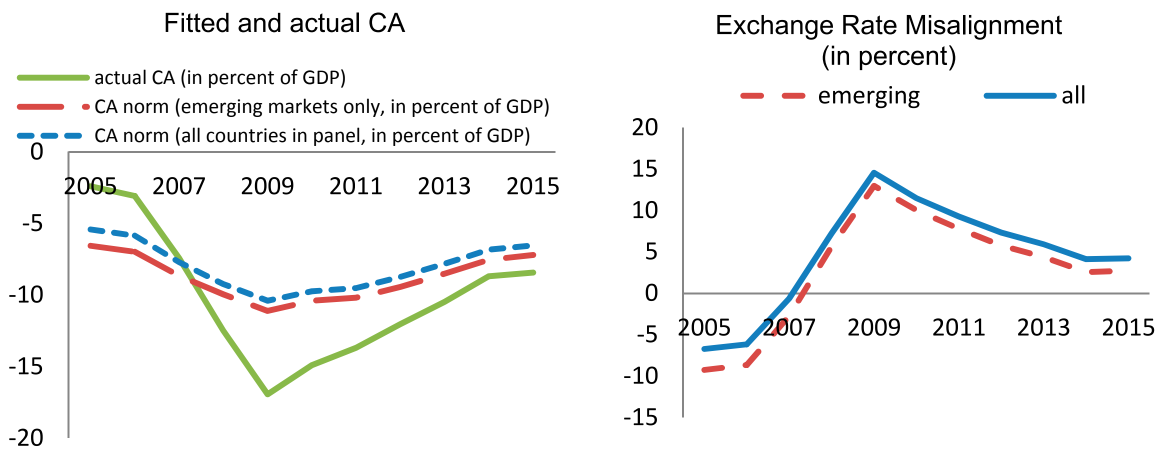
[7] More detailed estimation results are available from the authors upon request.

where RER denotes the real exchange rate and XGS and MGS denote the values of imports and exports respectively.

Results

The results show that with the actual current account projected to improve, in the medium term, the CA norm is close to the current account projection. Again, this result is based on projections that assume significant policy changes in Armenia, including structural changes that improve competitiveness by increasing competition and the business climate. In the medium term, the dram is slightly overvalued, with estimates pointing to a misalignment of 3-4 percent depending on whether results from equation (1) or (2) are used (Figure 7).

Figure 7: Results from the MB Approach



The MB approach is subject to several shortcomings. First, as mentioned above, there is the normative nature of WEO medium term projections, which assume significant policy adjustment. Second, the results from the MB approach are sensitive to small changes in the price elasticities of exports and imports. The panel estimation also applies simple pooled OLS, thereby assuming that coefficients are identical across countries and that regressors are uncorrelated with error terms. This may be unrealistic given the sample of heterogeneous economies, which, for example, includes both oil importers and exporters. The next section will investigate an alternative approach to establish a current account norm in order to assess the robustness of the results from the MB approach.

B. The External Sustainability Approach

Data and econometric methodology

The ES approach is similar to the MB approach in that it also assesses the exchange rate adjustment needed to bring the current account back to its norm. However, the definition of the norm differs between the two approaches. In the ES approach, the current account norm is not derived through an econometric approach but through accounting principles that ensure that the external debt in percent of GDP is stable. The ES approach thus calculates the CA that stabilizes the net external position (NEP) at a benchmark level, generally the last observation. The choice of the benchmark level is therefore to some extent arbitrary and an alternative approach to the CGER methodology would estimate the benchmark level of the NEP on the basis of cross-country and time-series evidence, relating the external asset position to fundamentals such as fiscal policy and demographics.

The NEP covers the external position of a country, covering external liabilities and assets as well as capital inflows and outflows, referring to claims and transactions between a country's residents and nonresidents. Thus, it should not be confused with the net foreign asset position of the central bank, which covers the short-term external position of the central bank only. The NEP series is available from Lane and Milesi-Ferretti (2007), with updated data for Armenia available until 2009.

The level of the CA that stabilizes the NEP is then calculated as

$$CA_{norm} = \frac{g+\pi}{(1+g)(1+\pi)} b \tag{4}$$

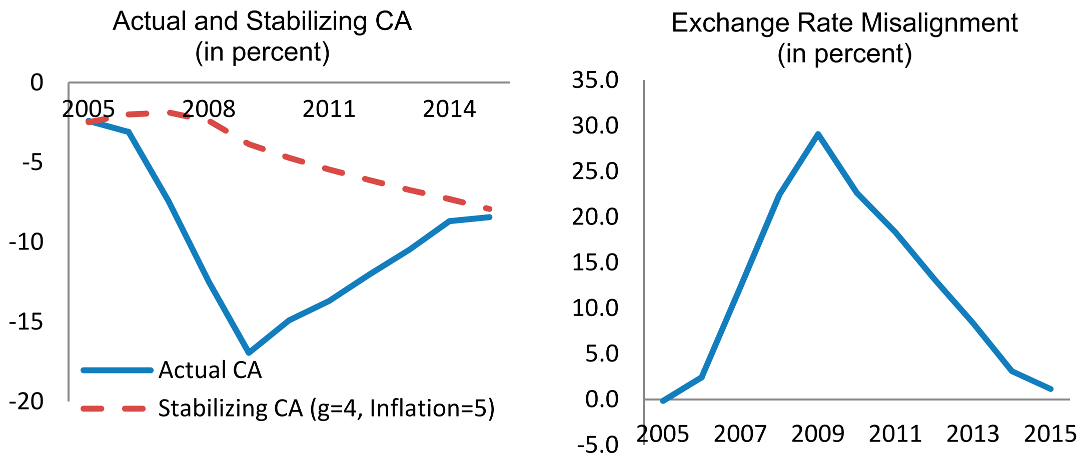
where g is the potential growth rate of real GDP, Π is annual inflation and b is the benchmark NEP/GDP position. Since there is considerable uncertainty about the potential growth rate, the paper will evaluate CA norms under different assumptions about g and Π.

In order to find the exchange rate adjustment needed to bring the actual current account back to its norm, the same measure of elasticity of the current account to the real exchange rate as in the MB approach is used.

Results

Results are very sensitive to different assumptions about potential GDP growth and inflation. This is shown in Table A2 in the Appendix. It can be seen that depending on the inflation and potential output assumptions, estimates of misalignment range from an undervaluation of – 6 percent to an overvaluation of 10 percent in 2015. It is very unlikely that the Armenian economy will return to the high growth rates observed before the crisis, which were the result of an unsustainable boom in the construction sector. Assuming a potential growth rate of 4 percent and an inflation rate of 5 percent, which is within the central bank's target of 4±1.5 percent, in the medium term, the CA norm is close to the actual current account projection (Figure 8). It can be seen that a real depreciation of only 1 percent is needed to close the gap between the actual current account in 2015 and the norm:

Figure 8: Results from the ES Approach



While the advantage of the ES approach lies in its simple and intuitive estimation methodology, it inherits most of the problems from the MB approach in that the derivation of the exchange rate misalignment is highly sensitive to the choice of exchange rate elasticities and the quality of current account forecasts as well as the benchmark level of the NEP. The next section will therefore evaluate a different approach to assessing Armenia's equilibrium exchange rate, which is not based on a definition of a current account norm but on a regression of the real effective exchange rate on its fundamentals.

C. The Equilibrium Real Exchange Rate (ERER) Approach—Single Country Estimation

Data and econometric methodology

The ERER approach aims directly at estimating a reduced-form relationship between the real exchange rate and a set of economic fundamentals. The economic literature has identified several factors as potential medium- to long-run determinants of equilibrium exchange rates. We follow Bussiere et al. (2010) and consider the following variables, with details of data sources and construction outlined in Appendix A2:

- The **severity of trade restrictions**, proxied by openness to trade, which is defined as the sum of exports plus imports as a share of GDP.[8] An increase in openness to trade is viewed as a proxy for lifting existing trade restrictions. One would expect that fewer trade restrictions that are designed to protect domestically produced goods lead to lower domestic prices and thus a depreciation of the real exchange rate. A rise in openness should thus lead to a depreciation of the RER.

[8] This is, of course, only an imperfect proxy. A preferable measure would be a trade restriction index as suggested by Sachs and Warner (1995). However, data limitations prevented us from using such an index.

- **Productivity** proxied by relative per capita real GDP relative to trading partners. This variable captures the Balassa-Samuelson effect. Countries with higher productivity growth in the tradable sector experience higher relative prices of nontradables and therefore an exchange rate appreciation.

- **Government consumption** as a share of GDP and relative to trading partners. An increase in government consumption biased toward nontradables raises the prices of nontradable goods, causing the real exchange rate to appreciate.

- **Government investment** as a share of GDP and relative to trading partners. This variable may capture technological progress, but its impact on the real exchange rate is ambiguous since investments might have a high import content and thus a negative impact on the trade balance.

- **Net international investment position.** An increase in capital flows from abroad implies higher demand for Armenian dram thus causing a real exchange rate appreciation.

- **Terms of Trade,** defined as the ratio of the price of a country's exports over the price of its imports. Armenia to a large extent exports precious and non-precious metals, precious and semi-precious stones and minerals, the prices of which are determined in world markets and subject to significant volatility affecting the terms of trade. An increase in the terms of trade will lead to an improvement in the trade balance and thus a real exchange rate appreciation.

- **Remittances.** The recent empirical literature is inconclusive on the relationship between remittances and the equilibrium real exchange rate. Rajan and Subramanian (2005) find that grant inflows adversely affect a country's competitiveness, by causing a real exchange rate overvaluation reflected in a decline in the share of tradable industries in the manufacturing sector. Elbadawi et al. (2008) also confirm the finding that remittances lead to an exchange rate appreciation. On the other hand, a number of studies on developing economies in Sub-Saharan Africa (Li and Rowe, 2007; Lee, Haacker and Singh, 2009 and Mongardini and Rayner, 2009) find that remittances are associated with a depreciation of the real exchange rate. Remittances generally can be spent on tradables and nontradables. Only spending that increases the demand in the nontradable sector would lead to an appreciation of the exchange rate. If remittances are used to increase competitiveness and ease supply constraints in the non-tradable sector, the real exchange rate would depreciate.

We assume that the real exchange rate is generated from the following dynamic model:

$$LREER_t = c + \sum_{j=1}^{p-1} \varphi_j \Delta LREER_{t-j} + \sum_{s=1}^{k} \sum_{j=0}^{q} \theta_{sj} \Delta x_{s,t-j} + \varepsilon_t \quad (5)$$

where c denotes the constant, LREER is the natural logarithm of the real exchange rate and $\{x_{s,t}\}_{s=1}^{k}$ is the set of fundamentals.

We follow Bussiere et al. (2010) and choose the Autoregressive Distributed Lag (ARDL) approach to cointegration, developed by Pesaran and Shin (1999).[9] This offers two advantages compared to the more traditional Johansen cointegration test and vector error correction model. First, it does not require unit root tests of the individual regressors, the results of which are unreliable in the case of short samples and structural breaks. Regardless of whether the underlying regressors are integrated of order zero or one, the ARDL approach yields consistent estimates. Second, as shown by Pesaran and Shin, the ARDL approach has a superior small-sample performance according to Monte Carlo experiments.

Equation (5) can be rewritten in the following error-correction representation:

$$\Delta LREER_t = \alpha LREER_{t-1} + \sum_{s=1}^{k} \alpha_{sk} x_{s,t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta LREER_{t-j} + \sum_{s=1}^{k} \sum_{j=0}^{q} \theta_{sj} \Delta x_{s,t-j} + c + \varepsilon_t \quad (6)$$

In order to establish whether a long-run level relationship exists among the variables, a bound test developed by Pesaran, Shin and Smith (2001) was performed. This uses an F-test to test for the presence of a long-run relationship between the REER and the fundamentals. Two sets of asymptotic test critical values are provided: one set assuming that all independent variables are integrated of order 1 (I(1)), and the other assuming that they are all stationary (I(0)). These two sets of critical values provide bounds for all classifications of the independent variables into purely I(1), purely I(0) or mutually cointegrated. As long as the F-test lies outside this band, conclusive inference about the existence of a long-run level relationship between the exchange rate and the independent variables can be made without knowing the order of integration of the regressors.

Results

Table 4 shows the estimated long run relationship and chosen lag structure for the ARDL modeling:

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[9] The Microfit package was used to estimate the level elasticities. This package automatically chooses the optimal lag structure according to a specified information criterion, which we specify to be the Schwarz information criterion.

Table 4: Estimated Long Run Coefficients using the ARDL Approach

ARDL(3,0,4,2,3,0,0,4)[10] selected based on Schwarz Bayesian Criterion

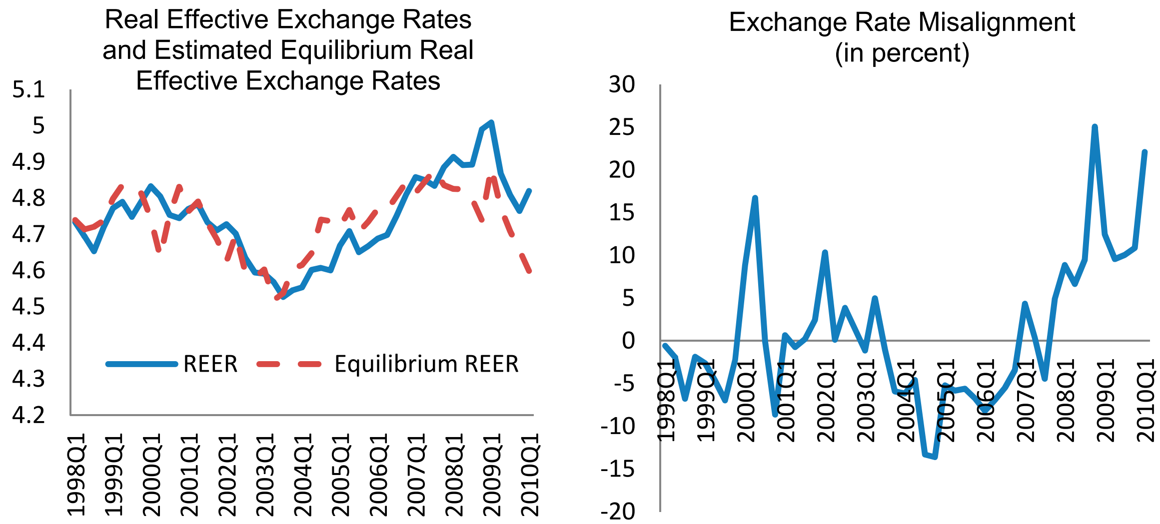
Dependent variable is LREER
45 observations used for estimation from 1999Q1 to 2010Q1

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LTOT	0.032	0.082	0.392[0.699]
LGC	0.368	0.113	3.251[0.004]
LGFC	-0.061	0.076	-0.808[0.428]
LOPEN	-0.684	0.113	-6.041[0.000]
LRGDPPC	0.064	0.060	1.077[0.294]
LREMIT	-0.013	0.045	-0.291[0.774]
NIIP	0.902E-4	0.208E-4	4.335[0.000]
CONSTANT	7.998	0.486	16.446[0.000]

It can be seen that all coefficients that are significant have the correct signs. According to Table 4, government consumption, openness to trade, the net international investment position and the constant are significant at the 1 percent level in influencing the equilibrium exchange rate. An increase in openness reduces the equilibrium exchange rate since it is a proxy for lifting trade restrictions, thereby leading to less protection of domestic goods. An increase in government consumption and the net international investment position both increase the equilibrium exchange rate. Further regression diagnostics are provided in Table A3 in the Appendix, which shows that there is evidence of a long-run cointegrating relationship as evidenced by the significant coefficient on the error correction (ecm) term. The estimated exchange rate misalignment based on the above long-run relationship is plotted in Figure 8. The figure shows that while the dram was undervalued between 2003 and late 2006, it became overvalued sometime in 2007 and has remained so even after the March 2009 depreciation. Since data for 2010 are still preliminary, we use end 2009 as an estimate of the long-term overvaluation, which is estimated to be 11 percent.

[10] The numbers in the brackets denote the number of lags included for each variable. It first refers to the dependent variable, LREER, for which three lags are included and then follows the order of variables in Table 3 (i.e., LTOT (0 lags), LGC (4 lags), LGFC (2 lags), LOPEN (3 lags), LRGDPPV (0 lags), LREMIT (0 lags) and NIIP (4 lags)).

Figure 9: ARDL Approach, Estimated Equilibrium Real Exchange Rates



These results are subject to an important caveat, namely the relatively small sample size (45 observations), which may severely limit the inference results. The next section therefore estimates a cointegrated panel model, which allows heterogeneity among countries in the short run while assuming homogeneity only in the long run. Panel data combine cross-section and time-series data and therefore provide a more appealing structure of data analysis, including better and more precise parameter estimation due to a larger sample size as well as simplification of data modeling (Hsiao, 2005).

D. The Real Effective Exchange Rate Approach—Panel Estimation

Data and econometric methodology

We select 27 transition economies in Central Asia and Eastern Europe for a panel co-integration analysis of the real effective exchange rate: Albania, Armenia, Azerbaijan, Belarus, Bosnia Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russia, Serbia, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. Among them Azerbaijan, Kazakhstan, Russia, Turkmenistan and Uzbekistan are considered to be oil producers and exporters.

Because of these countries' broadly shared geopolitical history and development pattern, a common long-run relationship between the conventional exchange rate determinants and the equilibrium real exchange rate for these countries as a group is likely to exist. Therefore we pool these countries together, assuming that the long-run exchange rate elasticities are homogenous, while allowing short-run dynamics to differ across countries.

The economic fundamentals included in the estimation are the terms of trade (TRT), openness (OPN), real GDP per capita (GDP), government spending (GOV) and national investment (INV). Both the dependent variable, the real effective exchange rate (REER), and the independent variables are converted to natural logarithms. Annual data for our sample countries are available between 1980 and 2009, with most series available from the early 1990s to 2009.[11] A detailed description of data sources and variable construction can be found in Table A4 in the Appendix.

There are several potential techniques for panel cointegration estimation, such as Panel Dynamic OLS (PDOLS), Fully Modified OLS (FMOLS) and Pooled mean group estimators (PMG). However, all of these techniques assume cross-sectionally independent innovations, while PDOLS and FMOLS also assume independence of regressors across countries. The countries in our sample are unlikely to meet these assumptions given that they trade with each other, share resources, and have access to global markets.

The impact of cross-sectionally dependent country-specific errors on dynamic panel estimations could be severe. Phillips and Sul (2003), for example, show that if there is significant cross-sectional dependence in the data and this is ignored in the estimation, the decrease in estimation efficiency can become so large that the pooled (panel) least-squares estimator may provide little gain over single-equation ordinary least squares. Thus, it is crucial to establish whether cross-sectional dependence is present in the data and to use an estimation methodology that produces robust estimates in its presence.

In order to test if country-specific errors are independent across countries, we run the cross section dependence (CD) test (Pesaran, 2004), which is applicable to a variety of panel data models, including stationary dynamic and unit root heterogeneous panels with structural breaks. The CD test is applied using both fixed and random country-specific intercepts. The three test procedures are valid when the number of observations across time (T) is fixed and the number of countries in the sample (N) is large. The CD test can also be used with both T and N large (De Hoyos and Sarafidis, 2006). Detailed test results are reported in the next section.

The test results strongly reject cross section independence in the sample, and we therefore estimate Common Correlated Effects or CCE models (Pesaran, 2006), which accommodate those cross-section correlations. Two types of estimation methods for CCE models are used: common correlated effects mean group (CCEMG) and common correlated effects pooled (CCEP) estimators.

Appendix B provides a technical discussion of CCE estimators. This section will provide a more intuitive explanation. The basic idea behind the CCE estimation procedure is to filter the individual-specific regressors by means of cross-section averages such that asymptotically (as the sample size turns to infinity) the differential effects of unobserved common factors are accommodated. The estimation approach has the added advantage that it can be conducted by ordinary least squares (OLS) applied to an auxiliary regression, where

[11] We thus estimate an unbalanced panel, which given the methodology used in this paper does not raise any issues.

the observed regressors are augmented by cross-section (weighted) averages of the dependent variable and the individual specific regressors.

One important feature of the proposed CCE estimator is its invariance to the (unknown but fixed) number of unobserved common factors when N and T are sufficiently large. The small sample properties of mean group and pooled CCE estimators (CCEMG and CCEP) are investigated by Monte Carlo experiments, showing that the CCE estimators have satisfactory small sample properties even under a substantial degree of heterogeneity and dynamics, and for relatively small values of N and T. Kapetanios et al. (2009) prove that the CCE estimators are consistent regardless of whether the common factors are stationary or nonstationary. They further show that the CCE estimation produces consistent estimates with any fixed number of common factors. Thus, a useful characteristic of CCE estimators is that they can deal with a broad range of cross-section dependence and that they do not require any pre-testing such as specifying the number of common factors.

In order to justify a co-integrated panel estimation, rather than just pooled OLS as in the MB approach, we test for the presence of panel cointegration using the residuals from the CCE estimation. If a unit root is absent from the residual series, panel cointegration is established. We test for the presence of unit roots in the residual series by using cross-section augmented Dickey Fuller (CADF) tests, which filter out the cross-sectional dependence by augmenting the standard augmented Dickey Fuller (ADF) regressions with cross section averages of the time series that is tested (Pesaran 2007).[12] Since these unit root tests accommodate cross-sectional dependence they are referred to as a second-generation unit root tests (Breitung and Pesaran, 2008). We test the robustness of the results from the CADF tests by conducting the Im-Pesaran-Shin (IPS) test for cointegration (Im et al., 2003). The IPS test does not take into account cross-sectional correlations and is thus known as a first generation panel unit root test. The test results not only indicate whether cointegration is present but they can also be used as guidance for model selection since those models with stationary residuals are considered consistent with the model assumption, which is panel cointegration.[13]

Results

First, we evaluate whether cross-sectional dependence is present in our sample, which will determine if CCE models are an appropriate estimation strategy. We consider a number of different combinations of independent variables. The five-regressor model uses TRT, OPN, GDP, GOV and INV as independent variables. The four- regressor model includes TRT, OPN, GDP and GOV while the three-regressor model uses TRT, OPN and GDP.

[12] Methodological details of the test are provided in Appendix B.

[13] It should be noted that we test for the presence of unit roots in the individual series using both CADF and IPS tests. In order to assess the robustness of results from the panel cointegration tests, we also employ Pedroni's (1999, 2001 and 2004) test for panel cointegration. The key assumption of the test is that the source of the cross sectional dependence comes from a single common time effect and that the response to this effect from individual (country) members is similar. This assumption seems appropriate for small open economies responding to common global shocks, which may be the case for some of the countries in our sample.

As shown in Table 5, CD tests strongly reject cross-section independence in our sample, either with or without oil-producing countries in the panel. Thus, the panel needs to be estimated with a methodology that corrects for this dependence between regressors in our sample, justifying the CCE estimation methodology.[14] The cross-section dependence tests are carried out for models with or without deterministic terms such as time trends or the world oil price index. They all strongly reject cross-section independence.

Table 5. Pesaran's Cross-Section Dependence Test

	Five regressor model, full sample	Five-regressor model, oil-producers only	Four regressor model, full sample	Four-regressor model, non oil-producers only	Three-regressor model, full sample	Three-regressor model, nonoil-producers only
Pesaran's CD statistics (fixed effects)	8.18***	9.69***	12.24***	15.35***	15.52***	16.94***
Pesaran's CD statistics (random effects)	8.96***	10.59***	12.20***	16.02***	15.47***	17.21***

*Note: H0: cross-section independence. Large positive test statistics reject the null. *** denotes significance at 1 percent, ** at 5 percent and * at 10 percent levels.*

We then estimate both CCE Mean Group (CCEMG) and CCE Pooled models (CCEP) (Pesaran, 2004). The CCE models can incorporate explicit common factors, such as time trends or the oil price index. Table 6 reports the results with oil prices.[15]As shown in Table 6, the economic fundamentals have the expected signs and most of them are significant at conventional levels. If the terms of trade is significant (models 1a, 2b, 3b, 4b, 5b, 6b), it has a positive effect on the equilibrium exchange rate. An improvement in the terms of trade will lead to an improvement in the trade balance and thus an exchange rate appreciation. Openness to trade is significant at conventional levels in models (1b, 3b, 4b, 5b and 6b) and has a negative effect on the equilibrium exchange rate since it is a proxy for trade restrictions. A decrease in trade restrictions and therefore less protection of domestically produced goods should lead to lower domestic prices and thus an exchange rate depreciation. Real GDP per capita relative to trading partners is significant in models 1b, 2b, 3a, 3b and 4a and has a positive coefficient since it is a proxy of productivity. Government consumption is significant in models 1b and 3b and its positive coefficient captures the effect of government

[14] In addition to the CD test we also try two other testing methods for cross-section dependence, the Free and Friedman tests, both of which confirm the findings from the CD tests. Detailed test results are available from the authors upon request.

[15] Other models with a time trend or without oil prices produce similar results in terms of coefficients. However, models with oil prices provide more stable estimation results across different models of the long run exchange rate. Results for models without oil prices can be obtained from the authors upon request.

consumption biased toward nontradables. CCE models are known for their consistent estimation of the long-run coefficients. If we judge purely from the coefficient significance levels, we may conclude that CCEP models slightly outperform CCEMG models. If we want to pick the model with the most significant coefficients, model (3b) stands out since all of its four regressors are significant. Model (1b) shows similar levels of significance in its coefficients.

We can now test for panel co-integration by establishing whether a unit root is present in the residual series from the twelve CCE models[16]. We perform the CADF test on residuals from the CCE models, after taking out the long-run effects as well as the country specific intercept and oil price effect. As shown in panel A1 in Table 7, the CADF test rejects unit roots in the residuals for all twelve CCE models in at least one of the test specifications. Model (2b) rejects non-stationarity of the residuals at the five or one percent level of significance in all four test specifications. Models (1b), (3a), (3b), (4b) and (5b) reject non-stationarity of the residuals at conventional levels of significance (10 percent or above) in three of the four test specifications.

We also perform IPS tests on these residual series (Panel A2 in Table 7) as a robustness check. We choose IPS panel unit root tests because they accommodate heterogeneity of country-specific slopes better and provide more reasonable model dynamics than other conventional first generation unit root tests such as the Levin, Lin and Chu (2002) test. The results from the IPS tests strongly suggest that all the residuals are stationary and therefore co-integration exists in the panel. These IPS test results, however, only confirm the panel co-integration and do not contribute much to the model selection, as all twelve models yield test statistics that are significant at the 1 percent level.

A significant concern for exchange rate estimation is model uncertainty. For many countries, different approaches yield different coefficients or even opposite results in terms of the direction of exchange rate misalignment. This could be due to weak data quality, short time series as well as the rapidly changing economic structure in the sample countries. All of the above factors present a challenge for the estimation of the long term determinants of real exchange rates for the panel (MCD Working Group on Exchange Rate Assessments, 2008; Bussiere et al., 2010). In Table 8, we list the CCE models' estimation results for Armenia's exchange rate misalignment. The table shows that most of the CCE models generate consistent estimation results in terms of the direction of misalignment, except for Models 1a and 2a. Most of the different estimation results of the misalignment occur between 2005 and 2009. The CCEP methodology is especially stable in terms of the direction of misalignment. Models 1b, 2b, 3a, 3b, 4a, 4b, 5a, 5b, 6a and 6b share similar patterns of misalignment of the exchange rate. If we select models based on the CADF and IPS tests for panel co-integration above, the desirable models would be 2b. As shown in Table 7, all CADF and IPS test specifications based on the residuals of Model 2b show evidence of cointegration at the

[16] As a robustness check we perform CADF and IPS tests on the individual series and Pedroni's (1999, 2001, 2004) cointegration test. The results are shown in Table A4 and A5 in the Appendix and show significant evidence of cointegration and overall support the notion of non-stationarity of the individual series.

5 percent level of significance. CADF residual tests of Models 1b, 3a, 3b, 4b and 5b, also show evidence of cointegration at conventional significance levels in three out of the four test specifications (see Table 7). If we prefer models with the most significant long-run coefficients, our choice will be narrowed down to 3b, and at most 1b. As shown in Table 6, all of the four independent variables in Models 3b are significant and for Model 1b, four of its five regressors are significant. [17]

Thus, models 1b and 3b perform best in the model estimation in terms of significant coefficients. Furthermore, results from the CADF tests show that estimating a cointegrated panel based on these models is sensible given that there is significant evidence of cointegration. Results from these models show that the Armenian dram was undervalued between 2002 and 2006 by an average of 7–9 percent, and beginning in 2007, it became overvalued. For 2009 the results point to an overvaluation of about 7.3–9.2 percent. This is in line with the analysis of the other approaches in the previous sections.

The estimation approach in this section can easily be applied to the other transition economies in the panel with no further estimations needed. The long-run coefficients are identical for all countries. However, different short-term heterogeneous effects would need to be applied to the different countries. The necessary dataset and estimation results are available from the authors upon request.

There are several directions for future research. First, it would be possible to experiment with different economic fundamentals to expand the cointegration space, for example, remittances for our country sample (Mongardini and Rayner, 2009). In addition, to address model uncertainties, one could explore model combination techniques. This would involve estimating a large number of different model specifications and then combining these models with Bayesian averaging techniques, which assume that for a sufficiently large dataset the true model is eventually revealed. Further research could also relax the assumption of long-run homogeneity, which might be too strong for a country group of nearly 30. This can be done by employing some of the latest panel data techniques allowing fixed differences across units and time (Hsiao and Pesaran, 2008).

[17] We notice that Models 1a, 2a, and 3a give different results in magnitude and even directions of the exchange rate misalignment. This might be caused by the fact that CCEMG models tend to perform less desirably than CCEP models for small samples, as Monte Carlo simulations imply (Pesaran, 2006). This is also shown by the decreasing number of significant coefficients in CCEMG models when the number of regressors increases.

Table 6. Cointegrated Panel Estimation Results: Long-Run Coefficients

	Five regressor model, full sample		Five-regressor model, non oil-producers only		Four regressor model, full sample		Four-regressor model, non oil-producers only		Three-regressor model, full sample		Three-regressor model, nonoil-producers only	
	CCEMG (1a)	CCEP (1b)	CCEMG (2a)	CCEP (2b)	CCEMG (3a)	CCEP (3b)	CCEMG (4a)	CCEP (4b)	CCEMG (5a)	CCEP (5b)	CCEMG (6a)	CCEP (6b)
TOT	-0.03 (.15)	0.36*** (.08)	-0.02 (.29)	0.23** (.10)	0.18 (0.12)	0.36*** (0.07)	0.07 (0.22)	0.22*** (0.08)	0.04 (.15)	0.29*** (.08)	0.02 (.22)	0.23*** (.08)
OPN	-0.27 (.23)	-.19*** (.06)	0.20 (.54)	-0.11 (.07)	-0.36 (0.22)	-0.19*** (0.07)	-0.33** (0.18)	-0.13* (0.07)	-0.40** (.20)	-0.23*** (.07)	-0.36** (.17)	-0.15** (.07)
GDP	0.14 (.10)	0.07** (.04)	1.17 (1.05)	0.08* (0.05)	0.2*** (0.07)	0.07* (0.04)	0.14** (0.08)	0.05 (0.04)	0.15 (.08)	0.07 (.05)	0.13 (.08)	-0.02 (.05)
GOV	0.28 (.18)	0.16* (.09)	0.65 (.62)	0.03 (0.07)	0.14 (0.10)	0.15* (0.08)	0.06 (0.07)	0.06 (0.07)				
INV	0.05 (.08)	0.03 (0.07)	-0.55 (.60)	0.05 (0.07)								
Obs	461	461	384	384	461	461	384	384	475	475	395	395
Countries	27	27	22	22	27	27	22	22	27	27	22	22

*Note: The numbers in brackets () denote standard errors. Furthermore *** denotes a two-sided significance level at 1 percent, ** at 5 percent and * at 10 percent.*

Table 7. Tests for Panel Co-Integration (CIPS and IPS)

	Five regressor model, full sample		Five-regressor model, oil-producers only		Four regressor model, full sample		Four-regressor model, non oil-producers only		Three-regressor model, full sample		Three-regressor model, nonoil-producers only	
	CCEMG (1a)	CCEP (1b)	CCEMG (2a)	CCEP (2b)	CCEMG (3a)	CCEP (3b)	CCEMG (4a)	CCEP (4b)	CCEMG (5a)	CCEP (5b)	CCEMG (6a)	CCEP (6b)
CIPS test for residuals after long-run effect and country specific intercept (A1)												
No const or trend												
lag(0)	-1.85***	-2.02***	-1.91***	-2.40***	-1.89***	-1.88***	-1.97***	-2.25***	-1.48	-1.89***	-1.16	-2.00***
lag(1)	-2.76***	-2.72***	-2.26***	-1.84**	-2.86***	-2.72***	-2.61***	-2.40***	-2.68***	-2.55***	-1.71**	-2.19***
Const												
lag(0)	-1.75	-1.88	-1.46	-2.32**	-1.76	-1.67	-1.57	-1.73	-1.28	-1.68	-1.43	-1.80
lag(1)	-2.05	-2.56***	-1.70	-2.34**	-2.07*	-2.54***	-2.08	-1.12*	-1.68	-2.15*	-2.18**	-1.96
IPS test for residuals after long-run effect and country specific intercept (A2)												
const	-10.45***	-10.2***	-7.09***	-9.33***	-9.95***	-9.95***	-8.90***	-9.33***	-9.65***	-9.83***	-9.25***	-7.8***
const + trend	-8.61***	-6.50***	-6.22***	-5.76***	-6.07***	-6.07***	-6.46***	-5.46***	-5.88***	-6.16***	-6.07***	-7.23***

*Note: H0: unit root exists for the tested series (non-stationary); large negative values imply rejection of the null hypothesis. *** denotes rejection at the 1 percent significance level, ** at 5 percent and * at 10 percent. The CIPS statistic are based on a balanced panel (with data 1999-2009), see Pesaran (2007). IPS statistics are based on the full (unbalanced) panel.*

Table 8. Exchange Rate Misalignment (in percent)

Armenia	Five regressor model, full sample		Five-regressor model, non oil-producers only		Four regressor model, full sample		Four-regressor model, non oil-producers only		Three-regressor model, full sample		Three-regressor model, nonoil-producers only	
	CCEMG (1a)	CCEP **(1b)**	CCEMG (2a)	CCEP **(2b)**	CCEMG (3a)	CCEP **(3b)**	CCEMG (4a)	CCEP (4b)	CCEMG (5a)	CCEP (5b)	CCEMG (6a)	CCEP (6b)
2000	2.3	3.4	-10.8	6.1	2.8	3.3	4.2	4.9	4.4	4.9	4.5	6.2
2001	1.4	3.9	-18.9	5.7	-0.8	4.0	0.8	5.0	0.2	3.5	0.6	5.8
2002	-3.6	-1.2	-19.2	-2.4	-4.7	-0.1	-4.4	-0.9	-5.8	-2.6	-5.4	0.6
2003	-10.7	-9.7	-23.0	-12.1	-11.1	-8.8	-11.1	-10.6	-11.6	-10.2	-11.5	-10.1
2004	-12.0	-11.8	-15.6	-13.6	-13.6	-11.3	-14.0	-12.3	-15.2	-13.5	-14.6	-11.7
2005	-7.5	-8.7	-9.0	-9.3	-8.0	-8.1	-7.6	-8.5	-7.4	-8.7	-7.8	-8.2
2006	-3.9	-9.1	5.6	-9.2	-7.2	-9.0	-6.7	-8.2	-6.9	-9.4	-6.9	-8.7
2007	4.8	1.1	-0.1	1.6	0.9	0.8	2.0	2.0	1.5	0.6	2.0	2.5
2008	7.0	7.9	21.5	7.1	11.2	7.3	8.5	5.6	9.7	7.8	8.7	3.7
2009	-0.8	7.3	-18.0	9.2	1.4	7.5	3.6	9.3	3.0	9.0	4.1	11.3

IV. Conclusions

This paper provides a comprehensive overview of several techniques to estimate the equilibrium exchange rate in countries that have undergone significant structural change and experienced high macroeconomic volatility. We illustrate these methods for the case of Armenia. Four different methodologies are used: the Macroeconomic Balance Approach, the External Sustainability Approach, the ERER approach and a Common Correlated Effects Panel Estimation. The paper follows the CGER methodologies for the first two approaches but estimates a country specific single country equation for the ERER approach and then proceeds with cointegrated panel estimation techniques, which address cross section dependence by using the common correlated effects estimators proposed by Pesaran (2006).

The panel estimation accommodates cross-country common effects in every stage of the estimation, from the model estimation to the panel cointegration test. In contrast to the panel approaches assuming cross-country independence of regressors (often known as first-generation panel cointegration estimation), the panel in this paper explicitly models cross-country economic fundamentals' co-movement and is thus more suitable for the set of countries examined, which are likely to be interlinked through their access to global markets and trading with each other.

All of the four approaches show that while the Armenia dram was undervalued between 2003 and late 2006, it became overvalued sometime in 2007 and has remained so even after the March 2009 depreciation. The results of this paper thus point to a loss of external competitiveness in Armenia in recent years. This is reflected not only in the exchange rate analysis, which shows that the dram is currently somewhat overvalued by around 10 percent, but also indicated by Armenia's loss in the share of world exports and its deteriorating performance in major competitiveness indicators.

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APPENDIX

A. Tables

Table A1: MB Approach, Data sources and Variable Construction

Variable	Description	Source
Fiscal Balance (FB)	General government balance relative to trading partners. This variable is constructed according to the following formula: $\frac{GGB}{GDP} - \sum_{i \in Partners} w_i \left(\frac{GGB_i}{GDP_i}\right)$ where GGB is the general government balance, GDP denotes nominal GDP and where i=(Russia, China, Germany, Ukraine, USA) and w(i)= (0.47, 0.16, 0.15, 0.11, 0.10).	WEO
Old Age Dependency (OAD)	Ratio of old age (65 and over) to middle age (30-64): $\frac{POP65UP}{POP3064} - \sum_{i \in Partners} w_i \left(\frac{POP65UP_i}{POP3064_i}\right)$	UN
Population Growth (PG)	$\ln(POP_t) - \ln(POP_{t-1}) - \sum_{i \in Partners} w_i (\ln(POP_{it}) - \ln(POP_{it-1}))$	UN
Relative Income (RI)	Real GDP per capita relative to US real GDP per capita: $\left(\frac{PPPPC}{PPPPC^{US}} - 1\right)$	WEO
Per Capita GDP Growth (PCG)	This is relative to trading partners: $\left(\frac{NGDPRPC_t}{NGDPRPC_{t-1}} - 1\right) - \sum_{i \in Partners} w_i \left(\frac{NGDPRPC_{it}}{NGDPRPC_{it-1}} - 1\right)$	WEO
Current account (CA)	CA/GDP	WEO

Table A2. ES Approach: Exchange Rate Misalignment (in percent) under different assumptions for g and Π

	2005	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Π = 2.5											
high growth(g=6)	0.1	2.6	12.6	22.7	29.5	23.2	18.9	13.9	9.1	3.9	2.0
normal(g=4)	1.3	3.6	13.4	23.8	31.3	25.4	21.5	16.7	12.2	7.3	5.7
low growth(g=2)	2.5	4.5	14.3	25.0	33.2	27.7	24.1	19.7	15.5	10.8	9.6
Π = 4											
high growth(g=6)	-0.7	2.0	11.9	21.9	28.2	21.6	17.1	11.8	6.8	1.5	-0.6
normal(g=4)	0.4	2.9	12.8	23.0	30.0	23.7	19.6	14.6	9.9	4.8	2.9
low growth(g=2)	1.6	3.8	13.7	24.1	31.8	25.9	22.1	17.4	13.0	8.2	6.7
Π = 5											
high growth(g=6)	-1.3	1.5	11.5	21.4	27.4	20.6	15.9	10.5	5.4	-0.1	-2.4
normal(g=4)	-0.2	2.4	12.3	22.4	29.1	22.7	18.3	13.2	8.3	3.1	1.1
low growth(g=2)	1.0	3.3	13.2	23.5	30.9	24.8	20.8	16.0	11.4	6.4	4.8
Π = 6											
high growth(g=6)	-1.8	1.1	11.1	20.9	26.6	19.6	14.7	9.2	3.9	-1.7	-4.1
normal(g=4)	-0.7	2.0	11.9	21.9	28.2	21.6	17.1	11.8	6.8	1.5	-0.6
low growth(g=2)	0.4	2.9	12.8	23.0	30.0	23.7	19.6	14.6	9.9	4.7	2.9
Π = 7											
high growth(g=6)	-2.3	0.7	10.7	20.4	25.7	18.6	13.6	7.9	2.5	-3.2	-5.7
normal(g=4)	-1.3	1.5	11.5	21.4	27.4	20.6	15.9	10.5	5.4	-0.1	-2.4
low growth(g=2)	-0.2	2.4	12.3	22.4	29.1	22.7	18.3	13.2	8.3	3.1	1.1

Table A3: ERER Approach, Data Sources and Variable Construction

Variable	Description	Source
Real effective exchange rate (LREER)	In natural logarithms	Central Bank of Armenia
Openness (LOPEN)	Natural logarithm of value of exports and imports divided by GDP, seasonally adjusted	IFS
Productivity (LRGDPPC)	Natural logarithm of per capita real GDP, relative to trading partners, seasonally adjusted	IFS
Government consumption (LGC)	Natural logarithm of government consumption divided by nominal GDP, relative to trading partners, seasonally adjusted	IFS
Investment (LGFC)	Natural logarithm of government investment divided by nominal GDP, relative to trading partners, seasonally adjusted	IFS
Net international investment position (NIIP)	Seasonally adjusted	National authorities
Terms of Trade (LTOT)	In natural logs, seasonally adjusted	National authorities
Remittances (LREMIT)	In natural logs, seasonally adjusted, percentage of nominal GDP	National authorities and staff calculations

Table A4: Error Correction Representation for the Selected ARDL Model

ARDL(3,0,4,2,3,0,0,4) selected based on Schwarz Bayesian Criterion
****
Dependent variable is dLREER
45 observations used for estimation from 1999Q1 to 2010Q1
****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dLREER1	0.586	0.129	4.5249[.000]
dLREER2	-0.337	0.147	-2.3007[.030]
dLTOT	0.030	0.073	.40582[.688]
dLGC	-0.015	0.061	-.25140[.804]
dLGC1	-0.305	0.083	-3.6587[.001]
dLGC2	-0.236	0.068	-3.4697[.002]
dLGC3	-0.148	0.053	-2.7985[.010]
dLGFC	-0.302	0.093	-3.2516[.003]
dLGFC1	-0.242	0.090	-2.6791[.013]
dLOPEN	0.002	0.083	.019242[.985]
dLOPEN1	0.520	0.128	4.0599[.000]
dLOPEN2	0.233	0.105	2.2121[.036]
dLRGDPPC	0.059	0.057	1.0339[.311]
dLREMIT	-0.012	0.041	-.29057[.774]
dNIIP	0.000	0.000	-.94607[.353]
dNIIP1	0.000	0.000	-4.5068[.000]
dNIIP2	0.000	0.000	-1.4781[.152]
dNIIP3	0.000	0.000	-3.1450[.004]
dCONSTANT	7.349	1.514	4.8551[.000]
ecm(-1)	-0.919	0.166	-5.5447[.000]

****
ecm = LREER -.032270*LTOT -.36783*LGC + .061397*LGFC + .68406*LOPEN -.064338*LRGDPPC + .013104*LREMIT -.9017E-4*NIIP -7.9977*CONSTANT
****

R-Squared	.88858	R-Bar-Squared	.76655
S.E. of Regression	.021772	F-stat. F(19, 25)	8.8146[.000]
Mean of Dependent Variable	.0022387	S.D. of Dependent Variable	.045061
Residual Sum of Squares	.0099546	Equation Log-likelihood	125.5163
Akaike Info. Criterion	101.5163	Schwarz Bayesian Criterion	79.8364
DW-statistic	2.3666		

****
R-Squared and R-Bar-Squared measures refer to the dependent variable dLREER and in cases where the error correction model is highly restricted, these measures could become negative.

Table A5: ERER Panel Approach, Data Sources and Variable Construction

Variable	Description	Source
Real effective exchange rate (RER)	In natural logarithms	IMF
Openness (OPN)	Natural logarithm of value of goods exports and imports divided by GDP	IFS
Productivity (GDP)	Natural logarithm of per capita real GDP, relative to trading partners	IFS
Government consumption (GOV)	Natural logarithm of public consumption divided by nominal GDP, relative to trading partners	IFS
Investment (INV)	Natural logarithm of gross fixed capital formation divided by nominal GDP, relative to trading partners	IFS
Terms of Trade (TOT)	Natural logarithm of terms of trade (goods)	IMF
Oil Price	World oil price index (2005=100)	IMF

Table A6: CADF Test for Unit Roots

Level	**RER**	**TOT**	**OPN**	**GDP**	**GOV**	**INV**
No constant, no trend^						
lag(0)	-2.08	-0.98	-1.45	-2.38	-1.82	-1.57
lag(1)	-1.82	-0.87	-1.64	-1.91	-1.89	-1.65
constant						
lag(1)	-3.39***	0.362	-3.42***	-2.36**	-3.44***	-4.83***
lag(2)	1.11	2.969	-1.94**	-0.09	-1.83**	-0.69
lag(3)	1.08	1.144	-0.89	2.11	6.57	4.36
constant+trend						
lag(1)	-5.91***	-0.45	0.79	-3.89***	-2.12**	-0.28
lag(2)	-2.08**	2.16	3.09	4.87	3.59	2.29
lag(3)	-2.78***	2.10	3.46	7.77	6.91	5.96
First diff						
No constant, no trend^						
lag(0)	-2.43*	-1.95	-2.02	-2.46*	-3.01**	-2.55**
constant						
lag(1)	-8.30***	-5.47***	-4.86***	-7.70***	-8.73***	-4.98***
lag(2)	-3.49***	-0.391	0.30	-0.007	1.14	-0.88
constant+trend						
lag(0)	-10.28***	-7.25***	-12.29***	-7.74***	-9.37***	-7.19***
lag(1)	-6.69***	-0.15	-2.03***	-5.36***	-6.57***	-3.23***
lag(2)	-1.35*	5.35	3.00	-0.24	4.20	1.59

*Note: H0: unit root exists for the tested series (non-stationary); large negative values imply rejection of the null. *** denotes the null is rejected at 1 percent significance level, ** at 5 percent and * at 10 percent.*
^ the tests with no intercept or trend use truncated critical values as the data are balanced and with less data points.

IPS test

	RER	**TOT**	**OPN**	**GDP**	**GOV**	**INV**
level						
IPS ^^	-1.16	0.17	-4.43 ***	-0.24	-3.54***	-.71
Average lag #	1	1	1	2 (with trend)	1	2 (with trend)
First diff						
IPS (Lag # chosen by AIC)	-18.14***	-15.93***	-22.30***	-21.31***	-15.91***	-11.81***

*Note: H0: unit root exists for the tested series (non-stationary); large negative values imply rejection of the null. *** denotes the null is rejected at 1 percent significance level, ** at 5 percent and * at 10 percent.*
^^ constant only, unless indicated otherwise.

Table A7. Pedroni's panel co-integration test (with common time trend):

	Five regressor model, full sample^	Five-regressor model, oil-producers only^	Four regressor model, full sample	Four regressor model, oil-producers only	Three-regressor model, full sample	Three-regressor model, nonoil-producers only
Panel PP	-2.08***	-2.01***	-1.68*	-0.86	-2.83***	-2.26***
Panel ADF	-0.72	-0.44	-2.33***	-2.37***	-2.71***	-2.94***
Group PP	-3.70***	-3.19***	-2.67***	-3.34***	-2.31***	-3.96***
Group ADF	-2.87***	-2.49***	-3.39**	-3.47***	-2.49***	-4.50***

Note: H0: no cointegration for all countries, H1: cointegration exists for some or all countries; large negative values imply the rejection of the null hypothesis. *** denotes significance at 1 percent, ** at 5 percent and * at 10 percent levels. ^: the first test statistic in that column is the Panel V-statistic, instead of the Panel PP-statistic.[18]

B. Technical Appendix

Common Correlated Effects Estimators

The basic idea behind CCE estimators is to augment the explanatory variables by including the cross section means of explanatory and dependent variables to capture the impact of (unobserved) common factors. Pesaran (2006) assumes that the dependent variable y_{it} and independent regressors $\mathbf{x}_{it}$ are generated by[19]:

$$y_{it} = \boldsymbol{\beta}_i{}'\mathbf{x}_{it} + e_{it} \tag{7}$$

$$e_{it} = \boldsymbol{\gamma}_i{}'\mathbf{f}_t + \varepsilon_{it} \tag{8}$$

$$\mathbf{x}_{it} = \boldsymbol{\Gamma}_i{}'\mathbf{f}_t + \boldsymbol{v}_{it} \tag{9}$$

where ε_{it} and $\boldsymbol{v}_{it}$ are independently distributed, but could be correlated across time. $\mathbf{f}_t$ = $(f_{1t,\dots,}f_{mt})$' is a vector of m unobserved common factors. The number (m) of unobserved common factors is unknown, but fixed. Equations (7) ~ (9) can be rewritten as:

$$\boldsymbol{z}_{it} = \begin{pmatrix} y_{it} \\ \mathbf{x}_{it} \end{pmatrix} = \boldsymbol{C}_i'\mathbf{f}_t + \boldsymbol{u}_{it} = \begin{pmatrix} \boldsymbol{\gamma}_i' + \boldsymbol{\beta}_i{}'\boldsymbol{\Gamma}_i' \\ \boldsymbol{\Gamma}_i{}' \end{pmatrix} \mathrm{f}_t + \begin{pmatrix} \varepsilon_{it} + \boldsymbol{\beta}_i'\boldsymbol{v}_{it} \\ \boldsymbol{v}_{it} \end{pmatrix} \tag{10}$$

[18] See Table 1 in Pedroni (1999) for a detailed description of the different tests. The time trend is included to proxy the common factors across different countries.

[19] We have abstracted from observed common factors and deterministic terms in equations (7-9).

given the following assumptions[20]:

$$\boldsymbol{\beta}_i = \boldsymbol{\beta} + \boldsymbol{\epsilon}_i,\ \boldsymbol{\gamma}_i = \boldsymbol{\gamma} + \boldsymbol{\tau}_i,\ \Gamma_i = \Gamma + \boldsymbol{\eta}_i,\ \boldsymbol{\epsilon}_i \sim iid(\mathbf{0}, \boldsymbol{\Omega}_\epsilon),\ \boldsymbol{\tau}_i \sim iid(0, \boldsymbol{\Omega}_\tau),\ \boldsymbol{\eta}_i \sim iid\left(0, \boldsymbol{\Omega}_{\boldsymbol{\eta}}\right).$$

Taking weighted averages of both sides of equation (10) across countries gives

$$\overline{\boldsymbol{z}}_{\boldsymbol{wt}} = \overline{\boldsymbol{C}}'_{\boldsymbol{w}} \mathrm{f}_t + \overline{\boldsymbol{u}}_{\boldsymbol{wt}} \qquad (11)$$

where the upper bars denote the weighted cross section averages, e.g. $\overline{\boldsymbol{z}}_{\boldsymbol{wt}} = \sum_{\boldsymbol{j=1}}^{\boldsymbol{N}} w_j\, \boldsymbol{z}_{\boldsymbol{jt}}$. It can be shown that $\overline{\boldsymbol{u}}_{\boldsymbol{wt}} \rightarrow 0$ and $\overline{\boldsymbol{C}}'_{\boldsymbol{w}} \rightarrow \overline{\boldsymbol{C}}'\ when\ N \rightarrow \infty$, where $\overline{\boldsymbol{C}} = (\boldsymbol{\gamma} + \boldsymbol{\Gamma\beta}, \boldsymbol{\Gamma})$. Thus:

$$\mathrm{f}_t \xrightarrow{p} \left(\overline{\boldsymbol{C}}\overline{\boldsymbol{C}'}\right)^{-1} \overline{\boldsymbol{C}}\, \overline{\boldsymbol{z}}_{\boldsymbol{wt}}\ . \qquad (12)$$

This suggests using $\overline{\boldsymbol{z}}_{\boldsymbol{wt}}$, or a weighted average of y_{it} and $\mathbf{x}_{\boldsymbol{it}}$, as the observable proxies for $\mathbf{f}_t$ in a panel where T and N are both large. Thus, the basic idea behind the CCE estimation procedure is to filter the individual-specific regressors by means of cross-section averages such that asymptotically (as $N \rightarrow \infty$) the differential effects of unobserved common factors are accommodated.

Panel Unit Root Tests: The CADF Test

The panel unit root test statistic of the CADF test, known as the CIPS statistic, is computed separately for each country using the following regression[21]:

$$\Delta y_{it} = a_{i0} + a_{i1}t + a_{i2}y_{i,t-1} + a_{i3}\overline{y}_{(t-1)} + \sum_{j=0}^{p} d_{ij}\Delta\overline{y}_{(t-j)} + \sum_{j=1}^{p} \delta_{ij}\, \Delta y_{i,t-j} + v_{it} \quad (13)$$

where y_{it} denotes the cross-sectional time series to be tested. The upper bars denote the simple cross section averages, i.e. $\overline{y}_{(t-1)} = \frac{1}{N}\sum_{j=1}^{N} y_{j(t-1)}$. The idiosyncratic shocks, v_{it}, are independently distributed both across i and t, have zero mean, variance σ_i^2, and finite fourth-order moments. The CIPS statistics is the simple cross section average of the OLS t-ratios of a_{i2} in the above CADF regression.

[20] The assumption for $\boldsymbol{\beta}_i$in the CCEMG model is $\boldsymbol{\beta}_i = \boldsymbol{\beta} + \boldsymbol{\epsilon}_{\boldsymbol{i}}$ where $\boldsymbol{\epsilon}_i \sim iid(\mathbf{0}, \boldsymbol{\Omega}_\epsilon)$. In the CCEP estimation, $\boldsymbol{\beta}_i = \boldsymbol{\beta}$. Both CCEMG and CCEP estimators satisfy $\boldsymbol{E}(\boldsymbol{\beta}_i) = \boldsymbol{\beta}$, but allow for different rates of mean reversion to the long run equilibrium.

[21] The constant (a_{i0}) and time trend ($a_{i1}t$) are optional.