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Mariarosaria Comunale and Heli Simola

The pass-through to consumer prices in CIS economies: The role of exchange rates, commodities and other common factors

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Contents

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Abstract

This empirical study considers the pass-through of key nominal exchange rates and commodity prices to consumer prices in the Commonwealth of Independent States (CIS), taking into account the effect of idiosyncratic and common factors influencing prices. In order to do that, given the relatively short window of available quarterly observations (1999–2014), we choose heterogeneous panel frameworks and control for cross-sectional dependence. The exchange rate pass-through is found to be relatively high and rapid for CIS countries in the case of the nominal effective exchange rate, but not significant for the bilateral rate with the US dollar. We also show that global factors in combination with financial gaps and commodity prices are important. In the case of large rate swings, the exchange rate pass-through of the bilateral rate with the US dollar becomes significant and similar to that of the nominal effective exchange rate.

Keywords: Commonwealth of Independent States, exchange rate pass-through, commodity prices, dynamic panel data, inflation, exchange rates, cross-sectional dependence, financial cycle.
JEL classification: C38, E31, F31.

Mariarosaria Comunale, orcid.org/0000-0002-7994-5204. Principal Economist, Applied Macroeconomic Research Division, Economics Department, Bank of Lithuania, Totorių g. 4, LT-01121 Vilnius (Lithuania).
Email: MComunale@lb.lt mariarosaria.comunale@gmail.com; phone: +370 5 268 0103.

Heli Simola, orcid.org/0000-0002-8505-8708. Senior Economist, Institute for Economies in Transition BOFIT, Bank of Finland, P.O. Box 160, FI-00101 Helsinki (Finland).
Email: Heli.Simola@bof.fi; phone: +358 10 831 2263.

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1 Introduction

The Commonwealth of Independent States (CIS) countries, a group of twelve former Soviet republics[1], provide an interesting and topical, but relatively little studied object for examining exchange rate pass-through (ERPT). We concentrate only on seven of them (Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Russia, and Ukraine) due to data limitations. During the early 2000s, the CIS countries enjoyed high economic growth combined with relatively high, but slowing inflation. For the most part they maintained inflexible exchange rate policies. Many CIS countries were hit hard by the global financial crisis and since then have experienced substantial fluctuations in their exchange rates followed by rising inflation. Given that some CIS countries recently shifted to inflation targeting in their monetary policy (Armenia in 2008, Georgia in 2010 and Russia in 2014), and several more are planning the shift, policymakers stand to benefit from an improved understanding of the magnitude and timing of effects on prices from exchange rate changes.

The importance of ERPT in inflation trends of the CIS countries has been established in a few previous studies, but literature on the topic is still relatively scarce, especially concerning cross-country ERPT analyses. Although there are obvious limitations related to estimates based on historical data during a regime shift or otherwise exceptional event, establishing baseline estimate as solid as possible can in any case help to assess also the current situation. Therefore, our aim is to providing up-to-date estimates for exchange rate pass-through to the consumer price index (CPI) in CIS countries. To accomplish this, we apply a novel methodology and control for a wider range factors than those mentioned in the literature. In particular, we try to disentangle the impact of common global factors and spillovers in CIS consumer price trends.[2] To our best knowledge, this is the first such study of CIS countries.

Due to their geographic proximity, strong economic links and similar institutional legacies, common factors and spillover effects can be expected to play a significant role in CIS ERPTs. As some CIS countries depend on oil and other commodity export income and others rely heavily on imported energy, they all are also highly vulnerable to changes in global commodity prices. As we want to account for the effects of both idiosyncratic and common factors influencing the consumer prices in the CIS economies, the short time span of the available data limits the use of traditional VAR approach. Thus, we use a factor panel framework instead of the

[1] Ukraine and Turkmenistan have never been formal members. Georgia canceled its membership in 2008.
[2] The common factors here are key and may be related to global crises or other factors which may influence all the countries and partners (i.e. strong cross-sectional dependence).

traditional VAR approach seen in earlier research.[3] For our panel estimation, we use a mean group (MG) estimator augmented in a way that takes into account the heterogeneity in the coefficients across individual countries and also corrects for the presence of cross-sectional dependence (serial correlation in the idiosyncratic errors).

Recent developments in the CIS countries include episodes of strong devaluation, so we also examine for possible asymmetries related to ERPT. As there is currently no similar research in a cross-country setting for the CIS countries, our results provide novel insights into this issue. Moreover, they improve the relevance of our results for the current discussion of ERPT in CIS countries.

We find that exchange rate pass-through is still relatively high and rapid in the CIS countries. When the nominal effective exchange rate index declines by 1 %, the consumer price index increases by 0.12–0.13 % over the next quarter. This effect is quite robust across a variety of specifications and time periods. The pass-through effect roughly doubles after two quarters, and rises to about 0.5 % after four quarters.[4] Common factors and the financial gap also seem to be important in consumer price trends of the CIS countries. Finally, we present evidence of an asymmetrical effect in case of exchange rate *vis-à-vis* the US dollar.

The paper is organized as follows. Section 2 reviews earlier literature on the topic. Our theoretical framework is presented in section 3. Our empirical methodology and data are described in section 4. Section 5 provides our estimation results and discussion for the implications of the results. Section 6 concludes.

2 Literature review

Exchange rate pass-through is defined as the elasticity of local currency prices with respect to the exchange rate. It first affects import prices (Stage 1 ERPT), but then can be passed on to producer (Stage 2 ERPT) and consumer prices (ERPT overall). Normally ERPT should decline along this pricing chain. Assuming markets are perfectly competitive, prices fully flexible, and the law of one price holds, ERPT should be complete (i.e. the import price elasticity w.r.t. exchange rate should be one) and immediate. Deviations from the benchmark situation can cause the pass-through to be incomplete (elasticity less than one) or at least gradual.

The most common theoretical framework applied in depicting the frictions related to ERPT comes from the pricing-to-market literature developed by e.g. Krugman (1986), Knetter

[3] A VAR setup is provided as a robustness check.
[4] In the rest of the paper we will report ERPTs to a 100% change in the exchange rate.

(1989), and Feenstra et al. (1996). In this framework, exporting firms maximize profits by setting their export prices subject to the competitive conditions they face in foreign markets. With some monopoly power, firms can price discriminate across countries, letting their profit margins rather than foreign currency prices fluctuate in response to changes in exchange rates. Adjusting mark-ups gives firms the possibility to ensure a stable market share. Other frictions that can prevent complete and instantaneous pass-through include trade costs such as transport costs, tariffs, and other trade barriers (Obstfeld and Rogoff, 2000) and price stickiness (Devereux and Yetman, 2002; Burstein et al., 2003).

Empirical studies show ERPT is usually incomplete and gradual. Pass-through is highest for import prices and lowest for consumer prices, which include most non-tradables that are unaffected or are less affected by exchange rate changes. Cross-country variation in pass-through is high. Many studies point to higher ERPT in emerging economies than in advanced economies, although it could be that this only reflects differences in the level of inflation between countries (Aron et al., 2014). In any case, the vast body of empirical literature on ERPT mainly deals with industrialized countries. A survey of literature examining ERPT in emerging markets (Aron et al., 2014), finds quite heterogeneous ERPTs, especially at the country level, and that the comparability of results is hindered by differing methodologies and assumptions used in estimations. The authors suggest that the wide variety of ERPT estimates may be due to methodological deficiencies in earlier research as well as a lack of appropriate control variables. Cross-country studies of CIS countries on the subject are rare. The most relevant results to this study are presented in Table A. Roughly speaking; we can say ERPT in emerging markets, for a 100% changes in the exchange rate, has been in the range of 5–20 % after one quarter, 20–30 % after four quarters, and 30–50 % over the longer term.

Table A Earlier estimates of ERPT to CPI in emerging economies. (Q=quarters)

Study, sample, period, exchange rate measure and methodology	ERPT after one quarter	ERPT after two quarters	ERPT after four quarters	ERPT over long term
IMF (2015), 28 EM, 1980–2014, NEER, panel			22%	25% (8Q)
Beckmann & Fidrmuc (2013), 7 CIS countries, 1999–2010, USD, VAR/panel (lt) *			26%	57%
Jimborean (2013), 10 CEE countries, 1996–2010, NEER, panel/single equation by country **	7%			
Kohlscheen (2010), 8 emerging floaters, periods within 1994–2008, NEER, VAR	5%	17%	24%	
Beirne & Biejsterboch (2009), 9 CEE countries, between 1995–2008, NEER, VAR		17%	26%	61%
Mihaljek & Klau (2008), 14 EM, 1994–2006, NEER, single equation by country	12%			
Ca’Zorzi et al. (2007), 12 EM, 1975–2004, NEER, VAR			24%	45% (8Q)
Choudhri & Hakura (2006), 71 countries (52 EM/DM), 1979–2000, NEER, panel	14%		24%	27% (20Q)
Korhonen & Wachtel (2006), 27 EM, 1999–2004, USD, VAR ***			6%	6% (8Q)
Bitans (2004), 13 EU NMS, 1998–2003, NEER, VAR	22%	28%	31%	33% (8Q)
Goldfajn & Werlang (2000), 71 countries (24 EM), 1980–1998, NEER, panel		39%	91%	

* ERPT for four quarters refers to our calculated average.
** ERPT refers to our calculated average from individual country estimations.
*** ERPT refers to our median calculation.

Despite the paucity of papers and varied results of earlier literature on CIS countries in particular, there are indications that the ERPT might be slightly higher for these countries than other emerging markets. The first cross-country comparison that included several CIS countries, Korhonen and Wachtel (2006), estimates VARs for consumer prices in several emerging markets for the period 1999–2004. Their results suggest that exchange rate pass-through is high and relatively rapid in most CIS countries, but there is large heterogeneity among countries. Exchange rate pass-through is also found to be higher in many CIS countries than in other emerging markets, but some of coefficients are of the wrong sign or implausibly high. As these problems seem to be associated mainly with oil-exporting countries, the authors suggest discrepancies might be due to the interaction of oil prices, exchange rates, and inflation.

Beirne and Biejsterboch (2009) and Jimborean (2013) examine ERPT in new EU member states of Central and Eastern Europe (CEE). Beirne and Biejsterboch (2009), using a cointegrated VAR framework for nine CEE countries during 1995–2008, put the average long-term pass-through to CPI at around 60 %. There are noticeable differences across countries, however. They find higher or even complete pass-through for those countries that have fixed exchange rate regimes compared to countries with more flexible regimes. Jimborean (2013) examines ERPT to import, producer, and consumer prices for a panel of ten CEE countries in the period 1996–2010. Using GMM estimation, she establishes statistically significant pass-through only for import prices, both in the short and long run. For consumer prices, she finds, even in the individual country examination, statistically significant pass-through of around 20–30 % in the first quarter for only a few countries.

To our knowledge, the most recent paper examining multiple CIS countries is Beckmann and Fidrmuc (2013). They estimate VARs for consumer prices for seven CIS countries for a short-run estimate of pass-through, then extend the analysis to a panel cointegration framework for long-run analysis. For 1999–2010, they find that the average pass-through after one year was 30–50 % for the dollar and around 20 % for the euro. The long-run pass-through was around 60 % for both currencies. Again, they note wide heterogeneity among CIS countries and the results are not statistically significant for each individual country.

There are several papers focusing on exchange rate pass-through in specific CIS countries, mainly Russia. The studies for Russia, for example, provide quite a wide variety of estimates for ERPT (Dobrynskaya and Levando, 2005; Beck and Barnard 2009; Kataranova, 2010; Ponomarev et al., 2014). The estimates of ERPT to CPI for USD range between 5–40 % after one quarter, and between 20–90 % after four quarters. Faryna (2016) examines Russia and Ukraine, putting the ERPT for Russian CPI at 10–17 % and for Ukrainian CPI at 20–40 % for the dollar, euro and NEER, as well as significant spillover effects from Russia to Ukraine. Several papers deal with the significance of exchange rate pass-through for inflation in other individual CIS countries e.g. Georgia (Samkharadze, 2008).

There is ample research on factors influencing ERPT. A lower inflation rate has been found in numerous papers to be associated with lower ERPT, implying that a credible inflation targeting policy can reduce ERPT (Taylor, 2000; Gagnon and Ihrig, 2004; Bailliu and Fujii, 2004; Bitans, 2004; Choudri and Hakura, 2006; Barhoumi and Jouini, 2008). The impact of the exchange rate regime and volatility of the exchange rate on ERPT has also been examined, but the conclusions are mixed. For emerging markets, higher exchange rate volatility is found to be associated with higher pass-through (Ca'Zorzi et al. 2007; Bussiere and Peltonen, 2008;

Kohlscheen, 2010). Some studies suggest that more flexible exchange rate regime tends to decrease ERPT in emerging markets (Beirne and Biejsterboch, 2009; Coulibali and Kempf, 2010). Aron et al. (2014) argue that this might be related to difficulties in disentangling the effects of the exchange rate regime.

Although ERPT is usually assumed to be linear, there is evidence on asymmetric effects. The asymmetry can be directional with different proportional effects on inflation from currency depreciation and appreciation. Directional asymmetry is associated with strategic considerations or downward price rigidities. The asymmetry can also be related to size, i.e. large movements in exchange rates can lead to proportionally larger changes in domestic prices than smaller movements due e.g. to menu costs. Significant asymmetries have been found for advanced economies (Pollard and Coughlin, 2003; Bussiere, 2013; Campa and Goldberg, 2008). For emerging economies, the evidence is mixed, but it seems that depreciation may lead to stronger ERPT than appreciation and that large devaluations are associated with stronger than proportionate ERPT (Mihaljek and Klau, 2008; Razafimahefa, 2012; IMF, 2015). Among CIS countries, asymmetric effects have been found at least for Russia (Kataranova, 2010; Ponomarev et al., 2014).

3 Theoretical framework

Following the model of Bailliu and Fujii (2004), we create a framework based on the pricing behavior of a profit-maximizing exporting firm. In this case, the exporting firm is from the United States and the import partner is a CIS country. The firm decides the price of its good, taking into account this static maximization function:

$$\max_{p}:\ \pi = \frac{1}{s}\,(p \cdot q) - C(q), \tag{1}$$

where π is the profit to be maximized in US dollars, *1/s* the bilateral exchange rate (measured in units of dollars per one national currency), *p* the price of good in national currency, *q* the quantity of good demanded by the CIS country, and *C(q)* the costs faced by the US firm.

This maximization is solved by a first-order condition:

$$FoC:\ \frac{\partial \pi}{\partial q} = 0 = \left(p \cdot \frac{1}{s}\right) - \frac{\partial \pi}{\partial C(q)} \cdot \frac{\partial C(q)}{\partial q} \tag{2}$$

that gives the optimum price for the good for the US exporting firm to the CIS partner:

$$p^{opt} = MC \cdot s \cdot \mu \,, \tag{3}$$

where *MC* is the marginal cost (= *∂C(q)/∂q*) of the quantity of good q and μ is the markup of price over the marginal cost (= *∂π/∂C(q)*).

Log-linearizing the equation and taking $\eta = -\mu/(1-\mu)$ as the price elasticity of demand for the good (where μ is the mark-up), we have a simple log-linear, reduced-form of the equation, expressed as

$$p_t = \alpha + \beta s_t + \tau w_t + \eta y_t + \varepsilon_t \,, \tag{4}$$

where s is the nominal exchange rate (measured in units of national currency per one dollar), w is a variable for the foreign marginal cost and y is the domestic output gap.[5] The coefficient β thus measures ERPT.

Bailliu and Fujii (2004) estimate this equation with a GMM methodology,[6] which they apply to three dependent variables in first differences: import prices, producer prices, and consumer prices. Prices are regressed on their lags, on country and time dummy variables, on the nominal effective exchange rate, on the exchange rate interacted with two policy dummy variables indicating shifts in the inflation environment in the 1980s and 1990s, respectively, on foreign unit labor cost,[7] and on the output gap. As equation (4) was developed for import prices, the output gap is used to proxy for changes in domestic demand conditions to make it applicable to consumer price inflation. As noted by Bailliu and Fujii (2004), the equation for CPI inflation has all the elements of a backward-looking Phillips curve.

We elaborate a similar model to this standard pass-through specification described in equation (4) for the CPI level (in logs). In our baseline specification, we use as our nominal exchange rate variable NEER *vis-à-vis* 67 partners in order to avoid possible biases related to the use of bilateral rates (Menon, 1995; Aron et al., 2014). As a robustness check, we include instead the bilateral rates between the currency of the country of interest and the USD.

[5] Following Goldberg and Knetter (1997), all variables, except the gaps, are in logs.

[6] The authors stress that the standard estimators for a dynamic panel-data model with fixed effects generates estimates that are biased when the time dimension of the panel is small. Following Judson and Owen (1999), this bias can be sizable even when the number of observations per cross-sectional unit (T) reaches 20 or 30. Therefore, given that the panel-data set in Bailliu and Fujii (2004) has T = 25, the standard fixed-effects model would yield biased estimates. To overcome this problem, we use Arellano and Bond's dynamic panel-data GMM estimator, which also gives unbiased estimations when one or more of the explanatory variables are assumed to be endogenous rather than exogenous.

[7] This is constructed from the real effective exchange rate deflated by unit labor costs, subtracting the nominal effective exchange rate and adding domestic unit labor costs.

As a control for changes in domestic demand conditions, we apply in the baseline specification the standard output gap. The output gap in the equation of profit maximization comes from the quantity of good demanded by the CIS country, based on regular business cycle fluctuations. However, the quantity demanded can be function of longer cycles (see Comunale and Hessel, 2014). Mendoza and Terrones (2012), for example, show that credit booms tend to boost domestic demand and widen external deficits, thereby increasing imports. Similar trends have been seen in CIS countries in recent decades as noted above in section 2. Therefore, we also replace the output gap with its financial counterpart in our alternative specifications.[8] Moreover, as recently pointed out by Gilchrist and Zakrajsek (2015), financial frictions influence the cyclical dynamics of prices.[9] Financial distortions create an incentive for firms to raise prices in response to adverse demand or financial shocks (Gilchrist et al., 2015). Hence, the financial gap/cycle may be a factor to consider in assessing inflation dynamics.

We extend our baseline specification to include a dummy for the *de facto* exchange rate regime, which earlier research suggests can influence ERPT. We also do this to check for the role of commodity prices separately due to their high importance in foreign trade and the domestic economies of most CIS countries. Thus, we also include in most specifications overall commodity prices or non-energy and energy prices separately.

This framework follows the structure of a typical single-equation dynamic panel data model with lagged dependent variables, i.e. the ARDL or Autoregressive Distributed Lag Model. The introduction of lags is crucial in controlling for the dynamics of the process, allowing for price inertia (Bailliu and Fujii, 2004), because it is unlikely that prices completely adjust within one period especially at quarterly frequency (Bussiére, 2007). We also introduce a lagged effect of exchange rates on current consumer prices as in Campa and Goldberg (2005). We use one lag for the dependent variable and one lag for the exchange rate, following the SBIC selection criterion,[10] so that the reaction of prices to a change in the exchange rate will take one period, i.e. three months.

[8] As explained in Claessens et al. (2011a, 2011b) there is a strong relationship between the financial and the business cycle. Thus, having them together as explanatory variables is not in our view the best choice. Moreover, this cannot be done for the financial cycle based on real GDP data, because they would be computed on the same data series.
[9] The paper focuses on producer prices. Inflation declines substantially less in response to a tightening of financial conditions in industries where firms are more likely to face significant financial frictions.
[10] The optimum number of lags has been calculated by SBIC selection criterion (which is based on Schwarz's Bayesian Information Criterion), because it has been proven to work better with any sample size for quarterly data (Ivanov and Kilian, 2001).

The equation is given as

$$p_{i,t} = \gamma_{1i} p_{i,t-1} + \beta_i s_{i,t-1} + \tau_i \, fmc_{i,t} + \eta_i \, gap_{i,t} + \psi_i \, X_{i,t} + \omega_i regime_{i,t} + \varepsilon_{i,t} \quad (5)$$

where *s* is the nominal exchange rate (in our case, a weighted-basket of partner currencies or USD per national currency unit),[11] *fmc* the foreign marginal cost taken as a trade weighted measure of partners' Producer Price Index (PPI), and *gap* the output gap relative to the potential value or the financial gap constructed using a higher lambda in HP filtering the real GDP (400,000 instead of the regular 1,600).[12] We then add commodity prices (*X*), i.e. general commodity prices, non-energy prices or energy prices; and a dummy for the *de facto* exchange rate regime (*regime*). All variables, except the gaps, are in logs.

The aggregate price level and the exchange rate are generally assumed to follow I (1) processes, i.e. not stationary (see test in Section 5 and the results in Table 2). It is common to use a specification with these two variables in first-difference form when estimating an aggregate inflation equation (e.g. Bailliu and Fujii, 2004). We apply equation (5) in levels using an estimator that controls for cross-sectional dependence and is suitable for cointegrated panels (Eberhardt and Teal, 2010), as well as in a robustness check analysis, where we provide it in first differences (also following Eberhardt and Teal, 2010). In the latter, the dependent variable is CPI inflation (first difference of CPI index) and the ERPT is the elasticity of inflation to a 1 % change in the exchange rate.

4 Empirical methodology and data

4.1 Data sources and description

In our empirical analysis, we use data with quarterly frequency that covers the period from 1999Q1 to 2014Q4. We begin with 1999 as most of the 1990s was a turbulent time for CIS countries. It took several years to adjust to the collapse of the Soviet Union and embarking on the transition from planned to market economy. Lack of data limits our study to seven CIS countries: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Russian Federation, and Ukraine.

We use consumer price from the Consumer Price Index (CPI) from IMF International Financial Statistics (IFS, index 2010=100) for all countries but Azerbaijan (for which we use IMF IFS data on percentage change from previous period to construct the index). The bilateral

[11] The sign of the bilateral rate and NEER is therefore expected to be negative. This is taken as 1/s in equation (1).
[12] For more details about financial cycle measures, see Comunale and Hessel (2014) or Comunale (2015b).

exchange rate *vis-à-vis* the USD is taken from the IMF IFS database and defined as national currency per USD, period average. We use instead the number of USD for one national currency unit in order to compare the bilateral rate with the NEER. The NEERs *vis-à-vis* 67 partners are from the database of Darvas (2012). We transform annual data in quarterly frequency data using cubic spline and rebase as an index 2010=100. The NEER here is expressed as the amount of a weighted basket of partner currencies per unit of national currency.

The foreign marginal cost is a trade-weighted average of partner Producer Price Index (PPI). We built the trade weights, *vis-à-vis* the same partners as in the NEER, from IMF Direction of Trade Statistics (DOTS). The data for partner PPIs are from IMF IFS (index 2010=100). The *de facto* exchange rate regime dummy is equal to one when the regime is fixed or intermediate (managed arrangements included). The (annual) information on the regimes is taken from Reinhart and Rogoff (1999–2010)[13] and the IMF's 2011–2014 Annual Reports on Exchange Arrangements and Exchange Restrictions. World commodity prices are from IMF IFS (index 2010=100). We distinguish total commodity prices, non-energy prices, and energy prices.

The output gap and the financial gap are computed using real GDP (index 2010=100) data. The real GDP series have been seasonally adjusted.[14] For Georgia, Kyrgyz Republic, Russian Federation, and Ukraine, the data are taken from IMF IFS. For Armenia, Azerbaijan, and Kazakhstan, they are taken from CISSTAT (with own calculation). The output gap is computed as the difference between actual real GDP and HP-filtered real GDP (the lambda for the HP filter here is equal 1,600, i.e. we have a regular short-term business cycle). As a proxy for a longer financial cycle (Alessi and Detken, 2009; Drehmann et al., 2010), we use a higher value for lambda (400,000) to filter the real GDP data.[15,16]

We include the Openness Index (OI) as a control variable in specification with USD to study the influence of openness toward trading partners outside the CIS. We only do this for

[13] For the exchange rate regime, we use IMF and Reinhart-Rogoff *de facto* exchange rate regime classification (FINE and COARSE, respectively). The 1999–2010 data are taken from Reinhart and Rogoff (http://personal.lse.ac.uk/ilzetzki/IRRBack.htm)

[14] The series have been seasonally adjusted using X11 in RATS, which is an implementation of the Census Bureau's X11 seasonal adjustment procedure.

[15] For details about financial cycle/gaps measures, see Comunale and Hessel (2014) for the euro area or Comunale (2015b) for EU and OECD countries. A comparison with different measures for financial cycle is also provided in these studies (e.g. with lambda set at 100,000 for GDP or domestic demand, as well as a principal component analysis to compute a synthetic indicator).

[16] Even if this measure it may not have the exact same properties of house price cycles or credit cycles, we believe it is the closest proxy given data availability. Indeed, compared to methods for capturing the business cycle or output gap, there is little consensus in how to properly measure the financial cycle. Even our decision to start with 1999 data may affect our efforts to capture a long cycle. However, we should stress here that the role of cyclical components relates to financial behavior in any case. This is especially important for inflation in the pre- and post-global crisis periods. In any case, the results for ERPTs are robust whether we use output gap or our proxy for the financial gap.

specification with USD, since the trade composition is not included in the model (it is in the model that uses the NEER). Following Rogers (2002) our OI is as follows: OI = [Trade with World – Intra-CIS Trade] / GDP. The trade data are taken from IMF DOTS. We apply the same concept to control for the trade within the CIS countries considered. Here, the index is computed as Intra-CIS Trade over GDP. Comparing openness within the CIS and with the rest of the world gives some idea of the role of spillovers and other global factors related to trade.

We also add the quarterly volatilities of NEER and bilateral exchange rate *vis-à-vis* the USD in our baseline. The calculation follows Hau (2002) as in equation (6). The volatilities are built on monthly data with T=4 as a modified version of Hau (2002) to obtain the quarterly frequency. These are defined as the standard deviation for the percentage changes of the REER and NEER over intervals of three months. The data for the USD rates are taken daily and averaged to monthly level. The source is Macrobond FX Spot Rates.[17] For the NEER, the monthly data are taken from the database of Darvas (2012)[18] *vis-à-vis* 41 or 138 partners.[19]

$$VOL_{quarterly,i} = [\frac{1}{T}\sum_i \left(\frac{ER_{t+3,i}-ER_{t,i}}{ER_{t,i}}\right)^2]^{1/2} , \qquad (6)$$

where ER can be either the NEER *vis-à-vis* 41 or 138 partners or the exchange rate *vis-à-vis* the USD.

4.2 Empirical diagnostics and methodology

Two approaches are generally used for estimating exchange rate pass-through. The first group of models includes the (S)VAR (Structural Vector Auto Regressive) models applied e.g. in McCarthy (1999), and the Bayesian versions with Cholesky or sign restrictions e.g. An and Wang (2012), Jovičić and Kunovac (2015) for small open economies, and Comunale and Kunovac (2016) for the euro area and main members separately. These methodologies are applied country by country. The second group uses panel regressions as in e.g. Bailliu and Fujii (2004), and Beckmann and Fidrmuc (2013). The SVAR approach analyzes the impact of exchange rate shocks on prices country by country by using the impulse response functions (IRFs). Its main limitation, for the non-Bayesian traditional VAR, is low effectiveness in short periods of analysis, as in our case. Moreover, our aim here is to build a framework that allows us to look at the

[17] Values represents a 16:00 GMT/BST snapshot of real-time interbank currency exchange rates contributed to GTIS Corporation, part of the FT Interactive Data Group, by leading market-making institutions worldwide.
[18] Dataset version updated at on November 25, 2015.
[19] The list of the partners is available in Darvas (2012).

idiosyncratic and common factors influencing consumer prices in the CIS economies. A panel approach, even within a short observation span, allows us to take these countries as a whole while maintaining their heterogeneity in the coefficients. Indeed, if we were to take into account the full interdependencies inside the panel and the heterogeneous dynamics, we must remember that we cannot estimate our setup unrestrictedly as the number of parameters is greater than the number of data points. We can deal with these issues by imposing restrictions (e.g. Global VARs), a change in the setup (e.g. use a factor model from a panel data setup as in our case), or with a Bayesian VAR by using a partial pooling estimator or a factor structure (e.g. Canova and Ciccarelli, 2013).

In a single-equation panel regression model with lagged endogenous variables, the fixed effects estimator (FE) has been proven inconsistent for finite T (Nickell, 1981). The bias in a dynamic FE estimator only with a large enough T is negligible (Roodman, 2009a). Even if we accept this formulation, however, there is the further problem of endogeneity between the dependent variable and its lag and among explanatory variables such as between exchange rate and output gap.[20] Addressing this issue, we note that the moment conditions of the GMM estimators are only valid if there is no serial correlation in the idiosyncratic errors. In addition, GMM methodologies work only if slope coefficients are invariant across the individuals. In the case of cross-sectional dependence, there are variables and/or residual correlations across panel entities that are normally due to common global shocks (e.g. recession, fiscal crisis) or spillover effects. Cross-sectional dependence (CSD) and heterogeneity in the slopes can lead to bias in tests results (contemporaneous correlation), not precise estimates and identification problems. Sarafidis and Wansbeek (2012) offer two methods to deal with cross-sectional dependent panel data: spatial models and dynamic factor models. In spatial econometrics, you know how entities are correlated, so you model that. A simple case would be to model the neighborhood. In dynamic factor models (a.k.a. interactive models or common factor models), there exists an unobserved common component in the disturbance. This affects modeled entities differently and varies over time.

Using the test developed by Pesaran (2004), we find that the hypothesis of cross-sectional independence in our dynamic panel is strongly rejected. This take use IV-GMM methods off the table, even without mentioning the fact that we also want to maintain heterogeneity across the units.[21] Using the CIPS test, we further find that some variables in our dynamic panel are non-stationary.[22] The exchange rates and the commodity prices are non-stationary in all the series,

[20] See Honohan and Lane (2004), page 4.
[21] We include in the robustness checks the estimations by using a two-step system IV-GMM.
[22] This is a second generation t-test proposed by Pesaran (2007), which is built for analysis of unit roots in heterogeneous panel setups with cross-sectional dependence. Null hypothesis assumes that all series are non-stationary. This

which means we accept the null hypothesis of non-stationarity; while for the dependent variable (log of CPI) we cannot reject the null (See Table 2).[23]

Table 1 Test for cross-sectional dependence: Pesaran test

	Test	Probability
Table 3 – Column 1 – ln_usd; ln_fmc;gapy_sa; ln_comm; regime	18.981	0.000
Table 3 – Column 2 – ln_usd; ln_fmc;gapy_sa; ln_en; regime	18.959	0.000
Table 3 – Column 3 – ln_usd; ln_fmc;gapy_sa; ln_non_en; regime	18.408	0.000
Table 3– Column 4 – ln_neer; ln_fmc;gapy_sa; ln_comm; regime	18.387	0.000
Table 3 – Column 5 – ln_neer; ln_fmc;gapy_sa; ln_en; regime	18.501	0.000
Table 3 – Column 6 – ln_neer; ln_fmc;gapy_sa; ln_non_en; regime	17.877	0.000
Table 4 – Column 1 – ln_usd; ln_fmc;gapfiny_sa; ln_comm; regime	18.815	0.000
Table 4 – Column 2 – ln_usd; ln_fmc;gapfiny_sa; ln_en regime	18.778	0.000
Table 4 – Column 3 – ln_usd; ln_fmc;gapfiny_sa; ln_non_en; regime	18.302	0.000
Table 4 – Column 4 – ln_neer; ln_fmc;gapfiny_sa; ln_comm; regime	18.209	0.000
Table 4 – Column 5 – ln_neer; ln_fmc;gapfiny_sa; ln_en regime	18.303	0.000
Table 4 – Column 6 – ln_neer; ln_fmc;gapfiny_sa; ln_non_en; regime	17.728	0.000

Note: The methods for Pesaran's test for cross-sectional independence are set out in Pesaran (2004). Pesaran's statistic follows a standard normal distribution and can handle both balanced and unbalanced panels. The exchange rates used here are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa* is the output gap; *gapfiny_sa* is the financial gap; *comm* is commodity prices; *en* is energy prices and *non_en* is non-energy prices; *regime* is the dummy for de facto fixed/intermediate regimes. All variables, except the gaps, are in logs.

t-test, based on Augmented Dickey-Fuller statistics as IPS (2003), is augmented with the cross-section averages of lagged levels and first differences of the individual series (CADF statistics). For the dependent variable and its lags, we cannot accept the null. In other cases, it is strongly rejected.

[23] In the case of CPI, we find a p value=0.148, i.e. we are very close to reject the null but not enough statistically at 10%.

Table 2 Stationarity test: second generation t-test by Pesaran (2007) for unit roots in heterogeneous panels with cross-section dependence (CIPS)

Variable		
	Z[t-bar]	p-value
ln_cpi	**–1.043**	**0.148**
ln_usd*	1.411	0.921
ln_neer*	2.037	0.979
ln_fmc	–6.285	0.000
gapy_sa	–6.722	0.000
gapfiny_sa	–3.112	0.001
ln_comm*	12.625	1.000
ln_en*	12.625	1.000
ln_non_en*	12.625	1.000

Note: **Null hypothesis assumes that all series in the panel are non-stationary.** This t-test is also based on Augmented Dickey-Fuller statistics as IPS (2003) but it is augmented with the cross section averages of lagged levels and first-differences of the individual series (CADF statistics).[24] ***means non-stationarity for all series.** The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa* is the output gap; *gapfiny_sa* is the financial gap; *comm* is commodity prices; *en* is energy prices and *non_en* is non-energy prices; *regime* is the dummy for de facto fixed/intermediate regimes. We added 1 lag for *cpi*, *usd* and *neer*. All variables, except the gaps, are in logs.

To overcome the limitations of IV-GMM models, Pesaran and Tosetti (2011) propose three estimators: the CCE (Common Correlated Effects) estimator, the CCEP (its pooled version), and the CCEMG (CCE Mean Group). The last estimator seems most effective in dealing with cross-sectional dependencies in both the case of spatial spillovers and unobserved common factors, and in the case of heterogeneity in slopes. The CCEMG estimator allows for the empirical setup with cross sectional dependence, time-variant unobservable factors with heterogeneous impact across panel members, and fixes problems of identification.

Eberhardt and Teal (2010) offer an alternative estimator to the CCEMG – an Augmented Mean Group (AMG) estimator – that deals with dynamic, cross-sectional dependent panels with heterogeneous coefficients *and* allows for cointegration.[25] The CCEMG treats the set of unobservable common factors as a nuisance, something to be accounted for which is not of particular interest for the empirical analysis. The AMG, in contrast, can be useful for the estimation of CPI, given that common factors here are key and may be related to global crises (i.e. strong cross-

[24] The *pescadf*- command in Stata was built by Piotr Lewandowski of the Warsaw School of Economics Institute for Structural Research.
[25] See also Eberhardt (2012) for some examples and Stata code *xtmg*.

sectional dependence) or spillovers among the CIS countries (i.e. weak cross-sectional dependence). Commodity prices are treated as *observed* common factors in this model, and, given their importance in the countries of interest, explicitly included in the regression as explanatory variables.[26]

Thus, we provide our estimations using the AMG estimator. It takes into account the crucial importance of other global factors and spillovers for CPI. All these various estimators are designed for micro-panel models with "large T, small N" (Roodman, 2009b). Here, we have seven countries and 16 years with quarterly frequency (T=64), therefore we consider that this command fixes the problems of our panel setting.

To explain the chosen estimator, we need to describe a general specification of the factor model. Following Pesaran and Tosetti (2011), this can be written as [27]

$$y_{i,t} = \alpha_i + \delta_i' \boldsymbol{d}_t + \beta_i' \boldsymbol{x}_{it} + \gamma_i' \boldsymbol{f}_t + e_{it}, \tag{7}$$

where $\boldsymbol{d}_t = (d_{1t}, \dots, d_{nt})$ is the vector of *observed* common effects, $\boldsymbol{x}_{it}$ is the vector of observed individual effects, and $\boldsymbol{f}_t$ is a vector of m *unobserved* common factors that affect all individuals at different times and to different degrees allowing for heterogeneity in the slope represented by the vector $\gamma_i = (\gamma_{i1}, \dots, \gamma_{im})'$.

Given this dynamic factor model, we apply our AMG estimator. The AMG procedure is implemented in two steps (Eberhardt, 2012). In Stage (i), a pooled regression model augmented with year dummies is estimated by first difference OLS and the coefficients on the (differenced) year dummies are collected. These represent an estimated cross-group average of the evolution of unobservable factors over time, or "common dynamic process." In Stage (ii), the group-specific regression model is augmented with the common dynamic process: either a) as an explicit variable (in which we impose an additional covariate to make these factors explicit), or b) imposed on each group member with a unit coefficient by subtracting the estimated process from the dependent variable. As in the MG case, each regression model includes an intercept that captures time-invariant fixed effects. As in the CCEMG estimators, the group-specific model parameters are averaged across the panel.

We sum up the two stages for the AMG estimator, a modified version of Eberhardt and Teal (2010),[28] in the following equations (8) and (9):

[26] As reported in Eberhardt (2012), in Monte Carlo simulations (see also Eberhardt and Bond, 2009), the AMG and CCEMG performed similarly well in terms of bias or root mean squared error (RMSE) in panels with non-stationary variables (cointegrated and not) and multifactor error terms (cross-section dependence).
[27] The main hypothesis of the model is that the number of factors cannot be more than the number of individuals.
[28] We included here a vector of observed common effects, separated from the time dummies, to have commodity prices in our setup.

Stage (i) $\Delta y_{it} = \boldsymbol{\delta}'\Delta \boldsymbol{d}_t + \boldsymbol{\beta}'\Delta \boldsymbol{x}_{it} + \sum_{t=2}^{T} c_t \, \Delta D_t + e_{it}$, (8)

where $\boldsymbol{d}_t$ represents the observed common effects, D_t are the (T-1) year dummies and c_t their time-varying coefficients. This is when the common dynamic process is extracted, as year dummy estimated coefficients by first difference OLS ($\hat{\boldsymbol{c}}_t \equiv \hat{\mu}_t^*$) and represents the level-equivalent mean evolution of these unobserved common factors across all the countries.

Next, we apply Stage (ii):

Stage (ii) $y_{it} = \alpha_i + \delta_i' \boldsymbol{d}_t + \boldsymbol{\beta}_i' \boldsymbol{x}_{it} + c_i t + \gamma_i \hat{\mu}_t^* + e_{it}$. (9)

We provide Stage (ii) in levels, the standard for AMG estimates. In the robustness checks, we use the equation in first differences and apply the AMG. This ends up being similar to the Augmented Random Coefficient Model (ARCM), which involves the Swamy (1970) estimator with $\Delta \, \hat{\mu}_t^*$.

We can therefore rewrite our general factor model as in equation (8) replacing $\boldsymbol{f}_t$ with $\hat{\mu}_t^*$ (and it will be $\Delta \, \hat{\mu}_t^*$ in first differences).[29]

$$y_{it} = \alpha_i + \boldsymbol{b}_i' \boldsymbol{x}_{it} + \gamma_i \hat{\mu}_t^* + \delta_i' \boldsymbol{d}_t + e_{it}. \quad (10)$$

The observed common effects across the units ($\boldsymbol{d}_t$) are commodity prices. The idiosyncratic effects ($\boldsymbol{x}_{it}$) are the exchange rates (*vis-à-vis* the USD or a basket of currencies as in the NEER), foreign marginal cost, the gap, and the *de facto* regime.

5 Results

5.1 Baseline estimation results

Our baseline estimation includes the lagged CPI index, the nominal exchange rate as measured by NEER, foreign marginal costs as measured by trade-weighted PPIs, domestic demand conditions proxied by the output gap, and the exchange rate regime. The output gap does not seem to be statistically significant. We replace it with the financial gap, which turns out to be highly significant in many of our specifications. The CPI seems to be more affected by financially-related fluctuations than the regular business cycle. Although slightly puzzling, this result is in

[29] In equation (10), we do not include the linear trend ($c_i t$) in our estimations as in the baseline setup we have other observed common effects, such as commodity prices, that might share and make explicit the same trend. In the robustness checks without commodity prices, this linear trend term is instead included.

line with Comunale (2015b). Hence, our preferred specification includes domestic demand conditions proxied by the financial gap. We also find that commodity prices, and energy prices in particular, are highly significant.

It should be emphasized, however, that the ERPT coefficient is of quite similar magnitude in all of our specifications. Our preferred specification suggests that the ERPT for NEER in the CIS countries is 13 % in the first quarter, while it ranges between 13 % and 17 % in our alternative specifications.

Table 3 ERPT with output gap

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.518***	0.524***	0.500***	0.554***	0.559***	0.544***
	(0.092)	(0.090)	(0.0956)	(0.107)	(0.104)	(0.112)
ln_usd1	**–0.005**	**–0.045**	**–0.046**			
	(0.055)	**(0.055)**	**(0.052)**			
ln_neer1				**–0.134****	**–0.137*****	**–0.131****
				(0.052)	**(0.053)**	**(0.051)**
ln_fmc	–0.010	–0.011	–0.009	–0.021	–0.012	–0.021
	(0.024)	(0.023)	(0.024)	(0.024)	(0.023)	(0.027)
gapy_sa100	**0.041**	**0.045**	**0.040**	**0.045**	**0.052**	**0.041**
	(0.027)	**(0.029)**	**(0.031)**	**(0.035)**	**(0.035)**	**(0.030)**
ln_comm	0.420***			0.348***		
	(0.067)			(0.068)		
ln_en		0.310***			0.258***	
		(0.050)			(0.050)	
ln_non_en			0.018			0.024
			(0.019)			(0.017)
regime	0.006	0.006	0.004	0.011	0.011	0.001
	(0.008)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)
Constant	0.117	0.591**	2.023***	1.263**	1.660***	2.768***
	(0.220)	(0.254)	(0.374)	(0.498)	(0.556)	(0.771)
Common dynamic process	0.571***	0.571***	0.580***	0.531***	0.537***	0.526***
	(0.085)	(0.087)	(0.080)	(0.106)	(0.105)	(0.103)
Observations	419	419	419	419	419	419
Number of co	7	7	7	7	7	7
RMSE	0.014	0.015	0.014	0.015	0.015	0.015

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes. RMSE is the root mean square error.

Table 4 ERPT with financial gap

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.508***	0.514***	0.486***	0.555***	0.560***	0.543***
	(0.092)	(0.092)	(0.096)	(0.104)	(0.102)	(0.108)
ln_usd1	**–0.061**	**–0.061**	**–0.061**			
	(0.047)	**(0.048)**	**(0.045)**			
ln_neer1				**–0.128*** **	**–0.129*** **	**–0.126*** **
				(0.042)	**(0.044)**	**(0.041)**
ln_fmc	–0.003	–0.007	0.000	–0.018	–0.021	–0.016
	(0.025)	(0.0244)	(0.024)	(0.029)	(0.028)	(0.028)
gapfiny_sa100	**0.086*** **	**0.086*** **	**0.078** **	**0.066** **	**0.068*** **	**0.051* **
	(0.029)	**(0.026)**	**(0.036)**	**(0.029)**	**(0.025)**	**(0.030)**
ln_comm	0.425***			0.336***		
	(0.064)			(0.062)		
ln_en		0.313***			0.248***	
		(0.048)			(0.045)	
ln_non_en			0.010			0.020
			(0.019)			(0.019)
Regime	0.004	0.004	0.003	0.006	0.007	0.007
	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)
Constant	0.091	0.587**	2.065***	1.276***	1.666***	2.752***
	(0.213)	(0.257)	(0.382)	(0.436)	(0.495)	(0.644)
Common dynamic process	0.586***	0.584***	0.600***	0.521***	0.524***	0.518***
	(0.080)	(0.083)	(0.076)	(0.092)	(0.093)	(0.089)
Observations	419	419	419	419	419	419
Number of co	7	7	7	7	7	7
RMSE	0.014	0.014	0.014	0.015	0.015	0.015

Standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes. RMSE is the root mean square error.

Spillovers and global factors appear to be important for consumer price trends of CIS countries. Because we are interested in the significance of these common factors, we opt for AMG in our dynamic factor model. Specifically, there is a strong likelihood that unobserved common factors may affect our estimations in the case of consumer prices and can be related to some of our regressors, e.g. to the gaps. In this case, the impact of financial crisis and other shocks in the global economy may be captured by these unobserved common factors (i.e. strong-cross sectional dependence).

Our setup takes into account commodity prices, so we have also some observed common factors. This cannot cover all the possible other global influences related to our setup, and moreover, unobserved common factors include spillovers among the individuals in the panel. Indeed, the close relationships between CIS economies have to be taken into consideration in determining the price development and ERPTs (i.e. weak cross-sectional dependence). It is our view that allowing our specified panel to consider these factors makes the estimations less biased. The coefficients related to these factors are large, positive, and robust across the specification (between 0.5 and 0.7).

When the output gap is included as in Table 3 column 4–6 and it is similar in case of financial gaps (Table 4, column 4–6), our results indicate that the ERPT to consumer prices in CIS countries after two quarters is 28–31 %.[30] We can also compute a simple cumulative ERPT in four quarters, i.e. one year, to have a long-run measure of ERPT (see ECB, 2015).[31] In this case, we obtain a one-year ERPT of 50 %.[32] The main results are summarized in Table B and more specifically analyzed, together with more robustness checks, in the following sub-sections.

[30] This ERPT is computed as in Jimborean (2013). The long-term coefficient of a variable is computed as the sum of its coefficients (of its lags and current values, where applicable) divided by one minus the sum of coefficients of the lags of the dependent variable. In our case, the measure of the long-run pass-through is computes as LR ERPT=$\beta/1-\left[\sum_{j=1}^{\max lag}\phi_j\right]$, where β is the estimated ERPT, the maximum number of lags for the dependent variable, max lag, is 1 and ϕ is the coefficient for the lag value of CPI.

[31] The estimated elasticities of long-run ERPT in ECB (2015) have been computed as cumulated ERPT over four quarters.

[32] In case of the sub-sample 2005–2014, the pass-through is complete (100%) for the cumulative one-year ERPT. Results are available on request.

Table B Short and long-term ERPT to consumer prices in CIS economies using NEER

Specification	Short-run ERPT (one quarter)	2-quarter ERPT (computed as in Jimborean, 2013)	Long-run ERPT (four quarters cumulative)
Baseline: Tables 3 and 4			
Table 3 Column (4) NEER; output gap; commodity prices	13.4%	30.0%	53.6%
Table 4 Column (4) NEER; financial gap; commodity prices	12.8%	28.8%	51.2%
Alternative specifications[33]			
Table 6a Column (4) NEER; financial gap; commodity prices **1999–2008**	15.1%	27.3%	60.4%
Table 6b Column (4) NEER; financial gap; commodity prices **2009–2014**	14.3%	17.6%	57.2%
Table 5a Column (4) NEER; financial gap; **without commodity prices**	17.0%	37.9%	68.0%
Table 13 Column (4) NEER; financial gap; **commodity prices; Russia excluded**	15.6%	28.7%	62.4%

Note: Refers to a 100% change in the CPI.

5.2 Alternative specifications

As a first alternative specification we analyze the ERPT using the bilateral exchange rate w.r.t. the USD as our nominal exchange rate variable. Unlike previous studies, we find no significant pass-through coefficient for the USD. Even the sign for the effect of USD varies in our specifications when all countries of our sample are included.[34]

Also in contradiction to earlier research on other transition and emerging economies, we find no evidence in support of significance of the exchange rate regime in estimating the ERPT in CIS countries. In our estimations, the exchange rate regime variable is not statistically significant – even its coefficient is very small. This could reflect the fact that there is little variation in the exchange rate regime indicator; most countries had some type of fixed arrangement throughout most of our sample period.

We include a time-varying dummy for countries that have adopted inflation targeting in their monetary policy regime. Here, the cases are limited to Armenia, which introduced inflation targeting in 2008, Georgia in 2010, and Russia in 2014.[35] The dummy itself and the interaction

[33] The results with output gaps are very similar in magnitude.
[34] We also add the interaction term between the rate vis-à-vis the USD and the de facto exchange rate regime, but the results are robust, i.e. the ERPT in this case is not significant.
[35] The data on monetary policy regimes are from Dabrovski (2013) up to 2009, and thereafter taken from IMF's AREAER database.

term with the NEER are always very small and only significant at 10 % if we look at the specification with energy prices.[36] Our sample time period for inflation targeting is short and takes place in the wake of the global financial crisis, which may explain the fact that ERPT significance and magnitude are not influenced in these setups.

Leaving out commodity prices does not change dramatically our results on ERPT (Table 5a). The magnitude is slightly greater (17 %), but the main findings are robust and the role of financial gap is confirmed. If we use the specification without commodities, we can disentangle the role of the common trend in prices in CIS economies, which is, as expected, negative and significant and mainly replace the idea of a decline in commodity prices in the last periods.

Table 5a ERPT estimation without commodities

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi
ln_cpi1	0.510***	0.549***	0.508***	0.551***
	(0.084)	(0.092)	(0.084)	(0.089)
ln_usd1	**0.073**		**0.080**	
	(0.058)		**(0.059)**	
ln_neer1		**–0.173*** **		**–0.170*** **
		(0.062)		**(0.056)**
ln_fmc	0.024	0.011	0.008	–0.009
	(0.017)	(0.018)	(0.026)	(0.030)
gapy_sa100	0.022	0.031		
	(0.034)	(0.035)		
gapfiny_sa100			0.061***	0.051*
			(0.019)	(0.028)
regime	0.003	0.010	0.000	0.005
	(0.006)	(0.006)	(0.006)	(0.006)
Constant	1.955***	3.036***	2.008***	3.089***
	(0.417)	(0.723)	(0.407)	(0.641)
Common dynamic process	0.772***	0.692***	0.755***	0.666***
	(0.134)	(0.137)	(0.124)	(0.128)
Linear trend	–0.003**	–0.002*	–0.002**	–0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	419	419	419	419
Number of co	7	7	7	7
RMSE	0.013	0.014	0.013	0.014

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *regime* is the dummy for de facto fixed/intermediate regimes. RMSE is the root mean square error.

[36] Results available on request.

Table 5b ERPT with openness index toward the rest of the world

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.524***	0.531***	0.505***	0.514***	0.521***	0.490***
	(0.081)	(0.080)	(0.085)	(0.082)	(0.081)	(0.086)
ln_usd1	**–0.032**	**–0.031**	**–0.032**	**–0.048**	**–0.046**	**–0.046**
	(0.057)	**(0.058)**	**(0.056)**	**(0.051)**	**(0.051)**	**(0.050)**
ln_fmc	–0.006	–0.006	–0.007	0.003	–0.000	0.003
	(0.023)	(0.022)	(0.022)	(0.022)	(0.021)	(0.020)
gapy_sa100	0.036	0.038	0.033			
	(0.024)	(0.026)	(0.025)			
gapfiny_sa100				0.078***	0.077***	0.070**
				(0.028)	(0.026)	(0.033)
ln_comm	0.421***			0.428***		
	(0.068)			(0.067)		
ln_en		0.184***			0.186***	
		(0.032)			(0.032)	
ln_non_en			0.011			0.005
			(0.019)			(0.019)
Regime	0.008	0.008	0.006	0.006	0.006	0.005
	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
Oi	**0.021**	**0.024**	**0.019**	**0.019**	**0.022**	**0.016**
	(0.020)	**(0.020)**	**(0.020)**	**(0.021)**	**(0.021)**	**(0.021)**
Constant	0.102	0.967***	1.576***	0.069	0.961***	1.597***
	(0.230)	(0.294)	(0.326)	(0.224)	(0.302)	(0.339)
Common dynamic process	0.581***	0.578***	0.589***	0.596***	0.591***	0.610***
	(0.087)	(0.088)	(0.082)	(0.086)	(0.088)	(0.084)
Observations	419	419	419	419	419	419
Number of co	7	7	7	7	7	7

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes; *oi* is the Openness Index as the difference between total trade with the world and intra-CIS trade over GDP.

Table 5c ERPT with openness index within the CIS (rate vis-à-vis the USD)

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.541***	0.547***	0.523***	0.530***	0.536***	0.509***
	(0.078)	(0.077)	(0.083)	(0.080)	(0.079)	(0.085)
ln_usd1	**–0.041**	**–0.040**	**–0.042**	**–0.056**	**–0.055**	**–0.056**
	(0.053)	**(0.054)**	**(0.050)**	**(0.048)**	**(0.048)**	**(0.045)**
ln_fmc	–0.015	–0.017	–0.014	–0.009	–0.013	–0.007
	(0.022)	(0.022)	(0.022)	(0.023)	(0.022)	(0.021)
gapy_sa100	0.039	0.043	0.039			
	(0.029)	(0.032)	(0.032)			
gapfiny_sa100				0.084***	0.083***	0.079***
				(0.025)	(0.024)	(0.028)
ln_comm	0.406***			0.411***		
	(0.064)			(0.063)		
ln_en		0.300***			0.304***	
		(0.048)			(0.048)	
ln_non_en			0.017			0.008
			(0.019)			(0.019)
Regime	0.009	0.009	0.007	0.007	0.008	0.006
	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
oi_cis	**0.089***	**0.092***	**0.082**	**0.081**	**0.084**	**0.070**
	(0.053)	**(0.054)**	**(0.051)**	**(0.052)**	**(0.053)**	**(0.051)**
Constant	0.098	0.560**	1.942***	0.074	0.558**	1.995***
	(0.211)	(0.239)	(0.351)	(0.206)	(0.245)	(0.379)
Common dynamic process	0.550***	0.549***	0.562***	0.566***	0.564***	0.583***
	(0.079)	(0.081)	(0.077)	(0.078)	(0.081)	(0.078)
Observations	419	419	419	419	419	419
Number of co	7	7	7	7	7	7

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes; *oi_cis* is the Openness Index as intra-CIS trade over GDP.

Table 5d ERPT with openness index within the CIS (with the NEER)

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.584***	0.587***	0.571***	0.591***	0.594***	0.576***
	(0.087)	(0.085)	(0.094)	(0.084)	(0.082)	(0.091)
ln_neer	**–0.136*** **	**–0.138*** **	**–0.132*** **	**–0.124*** **	**–0.126*** **	**–0.122*** **
	(0.048)	**(0.048)**	**(0.048)**	**(0.040)**	**(0.041)**	**(0.040)**
ln_fmc	–0.033	–0.033	–0.032	–0.035	–0.039	–0.035
	(0.023)	(0.023)	(0.025)	(0.026)	(0.027)	(0.027)
gapy_sa100	0.051	0.056	0.043			
	(0.042)	(0.043)	(0.041)			
gapfiny_sa100				0.067**	0.068***	0.055*
				(0.028)	(0.026)	(0.028)
ln_comm	0.343***			0.327***		
	(0.059)			(0.053)		
ln_en		0.255***			0.243***	
		(0.044)			(0.039)	
ln_non_en			0.0240			0.0193
			(0.017)			(0.019)
regime	0.014**	0.014**	0.012**	0.009**	0.010**	0.008*
	(0.006)	(0.006)	(0.006)	(0.004)	(0.005)	(0.004)
oi_cis	**0.145** **	**0.146** **	**0.146** **	**0.140** **	**0.141** **	**0.140** **
	(0.070)	**(0.072)**	**(0.065)**	**(0.070)**	**(0.070)**	**(0.059)**
Constant	1.192***	1.587***	2.686***	1.190***	1.579***	2.646***
	(0.353)	(0.400)	(0.549)	(0.316)	(0.361)	(0.480)
Common dynamic process	0.519***	0.523***	0.519***	0.500***	0.504***	0.504***
	(0.086)	(0.086)	(0.087)	(0.075)	(0.076)	(0.076)
Observations	419	419	419	419	419	419
Number of co	7	7	7	7	7	7

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes; *oi_cis* is the Openness Index as intra-CIS trade over GDP.

The Openness Index (OI) is included as a control variable in the specification with USD to study the influence of openness toward trading partners outside the CIS. The results are quite robust and the index itself is not significant (Table 5b). If we instead add trade openness within the CIS, this factor is positive and significant in all the specifications for the setup with NEER, but only true in some cases for the rate *vis-à-vis* the USD (Table 5c and 5d). The results concerning the ERPT coefficients again are quite robust.

For the CIS countries, an increase in trade within the group brings an increase in consumer prices in the home country. Trade among CIS countries has been relatively free, despite the lack of any comprehensive regional agreement. There have been various regional agreements in place during the time period under consideration, as well as several bilateral free trade agreements. On the opposite side, several restrictive measures have been imposed on trade between Russia and Georgia after the war in 2008 and more recently between Russia and Ukraine. In any case, these disputes largely concern bilateral relations.

A decrease in trade flows may have a deflationary effect in the CIS. Hence, the CIS countries seem to be very much interconnected trade-wise.[37] A shock to one can be transmitted to others. Comparing openness within the CIS and with the rest of the world gives an impression on the role of spillovers and global factors related to trade. In any case, these factors are completely captured in the common unobserved factor in our dynamic factor model setup. The trade spillovers among the CIS may be more important than general openness toward other countries.

5.3 Sub-periods

Our results are quite robust with respect to the various sub-periods, with some exceptions for recent years (Tables 6a and 6b). In particular, we check if there is a change after the global financial crisis. The impact of NEER remains statistically significant in most cases, and the ERPT estimate lies in the range of 14–16 % in various specifications for the time periods of 1999–2008, and 2009–2014. In the latter period, the statistical significance of the ERPT estimate becomes weaker or vanishes in some specifications.[38] This could be related to the exceptional nature of the period in the wake of the global financial crisis. The result is in line with the recent study by Jašová et al. (2016), who find that ERPT in emerging economies decreased or was not significant after the financial crisis, while it has remained fairly stable over time in advanced economies.

[37] In this case exports and imports for the openness index refer to final goods.
[38] We have a relatively small number of observations even in our full sample. As a result, small sample size in estimations for sub-periods could cause problems.

Table 6a ERPT time sub-samples — 1999–2008 with financial gap

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.422***	0.426***	0.413***	0.447***	0.450***	0.444***
	(0.088)	(0.086)	(0.088)	(0.094)	(0.093)	(0.092)
ln_usd1	**–0.124****	**–0.123****	**–0.119****			
	(0.053)	**(0.054)**	**(0.051)**			
ln_neer1				**–0.151*****	**–0.152*****	**–0.152*****
				(0.054)	**(0.055)**	**(0.053)**
ln_fmc	0.0157	0.0231	0.005	–0.021	–0.017	–0.011
	(0.055)	(0.055)	(0.055)	(0.048)	(0.044)	(0.054)
gapfiny_sa100	–0.002	0.010	–0.034	–0.016	0.011	–0.085
	(0.089)	(0.085)	(0.105)	(0.120)	(0.113)	(0.142)
ln_comm	0.008			0.018***		
	(0.010)			(0.006)		
ln_en		0.321***			0.228***	
		(0.039)			(0.026)	
ln_non_en			0.020			0.043***
			(0.026)			(0.015)
Regime	–0.002	–0.002	–0.001	0.005	0.004	0.005
	(0.002)	(0.002)	(0.001)	(0.005)	(0.004)	(0.005)
Constant	1.625***	0.627	1.664***	2.934***	2.274***	2.805***
	(0.526)	(0.438)	(0.508)	(0.700)	(0.622)	(0.697)
Common dynamic process	0.718***	0.716***	0.729***	0.645***	0.648***	0.638***
	(0.082)	(0.083)	(0.080)	(0.078)	(0.080)	(0.072)
Observations	254	254	254	254	254	254
Number of co	7	7	7	7	7	7

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes.

Table 6b ERPT time sub-samples — 2009–2014 with financial gap

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.322***	0.331***	0.302***	0.192	0.192	0.195
	(0.109)	(0.111)	(0.112)	(0.150)	(0.153)	(0.150)
ln_usd1	**–0.084**	**–0.109**	**–0.029**			
	(0.063)	**(0.068)**	**(0.071)**			
ln_neer1				**–0.143***	**–0.136**	**–0.144***
				(0.083)	**(0.084)**	**(0.087)**
ln_fmc	0.016	0.028	–0.000	0.024**	0.029*	0.015*
	(0.013)	(0.021)	(0.010)	(0.012)	(0.017)	(0.009)
gapfiny_sa100	–0.023	–0.009	–0.042	–0.027	–0.014	–0.052
	(0.084)	(0.088)	(0.088)	(0.062)	(0.065)	(0.066)
ln_comm	0.009			0.015		
	(0.019)			(0.015)		
ln_en		0.004			0.012	
		(0.016)			(0.014)	
ln_non_en			0.015			0.019
			(0.020)			(0.014)
Regime	–0.002	–0.001	–0.003	0.001	0.003	–0.001
	(0.008)	(0.009)	(0.008)	(0.006)	(0.007)	(0.001)
Constant	2.849***	2.791***	2.970***	4.157***	4.114***	4.172***
	(0.442)	(0.471)	(0.413)	(0.980)	(0.996)	(1.000)
Common dynamic process	0.708***	0.709***	0.723***	0.854***	0.867***	0.837***
	(0.168)	(0.172)	(0.153)	(0.150)	(0.155)	(0.143)
Observations	165	165	165	165	165	165
Number of co	7	7	7	7	7	7

Standard errors in parentheses
*** p<0.01, ** p<0.05, *p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes.

5.4 Asymmetry

Finally, we control for possible asymmetries, i.e. test whether the direction and the size of exchange rate changes affect pass-through. In the spirit of Bussiere (2013) and Pollard and Coughlin (2004), this is computed using interactive dummy variables for appreciation vs. depreciation and small vs. large changes in rates.[39] The setup is as follows:

$$p_{i,t} = \gamma_{1i} p_{i,t-1} + \beta_{1i} s_{i,t-1} D_{1i,t-1} + \beta_{2i} s_{i,t-1} D_{2i,t-1} + \tau_i \, fmc_{i,t} + \eta_{\,i} gap_{i,t} + \psi_i \, X_{i,t} + \omega_i regime_{i,t} + \varepsilon_{i,t} \,, \quad (11)$$

where the variables are the same as in the baseline equation (5) and the dummies are $D_{1i,t-1}$ and $D_{2i,t-1}$. The dummy variables for appreciation vs. depreciation are the following:

$$D_{1i,t-1} = 1 \text{ if } \Delta s_{i,t-1} = s_{i,t-1} - s_{i,t-2} > 0$$
$$D_{2i,t-1} = 1 \text{ if } \Delta s_{i,t-1} = s_{i,t-1} - s_{i,t-2} \leq 0 \,. \quad (12)$$

Concerning the dummy for small vs. large changes (positive or negative) in the rates,[40] the dummies are:

$$D_{1i,t-1} = 1 \text{ if } \| \Delta s_{i,t-1} \| = \| s_{i,t-1} - s_{i,t-2} \| > 2\%$$
$$D_{2i,t-1} = 1 \text{ if } \| \Delta s_{i,t-1} \| = \| s_{i,t-1} - s_{i,t-2} \| < 2\% \text{ or } = 2\% \quad (13)$$

The results using dummy variables for appreciation vs. depreciation interacted with the different exchange rates are quite similar with respect to the preferred setup. The differences in their coefficients are not significantly different from zero.[41]

In case of using dummies for small vs. large changes in the rates, the ERPTs are similar with the NEER while asymmetric if we apply the bilateral USD rate. If the change in absolute value is greater than 2 %, the ERPT is significant and around 13 %, which is similar to the one for the short-run NEER (Table 7). It is only 5 % in case of small changes in the bilateral rate with the USD. If we use output gap instead of the financial gap, asymmetry is confirmed, but the ERPT in case of small changes is not significant.

[39] We use the model here in levels. The cited authors use the model in first differences.
[40] The threshold in Bussiere (2013) and Pollard and Coughlin (2004) is 3%. In our estimations, this 3 % rate is exceeded in very few cases.
[41] Results available on request.

Table 7 Using dummies for small vs. large changes (with financial cycle)

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi	
ln_cpi1	0.561***	0.569***	0.542***	0.550***	0.556***	0.541***	
	(0.087)	(0.085)	(0.093)	(0.105)	(0.102)	(0.108)	
int_1	**–0.136***	**–0.140***	**–0.115***				**usd*D1**
	(0.072)	**(0.075)**	**(0.066)**				
int_2	**–0.055****	**–0.055****	**–0.049***				**usd*D2**
	(0.025)	**(0.024)**	**(0.027)**				
int_3				**–0.132*****	**–0.134*****	**–0.127*****	**neer*D1**
				(0.041)	**(0.043)**	**(0.039)**	
int_4				**–0.131*****	**–0.133*****	**–0.127*****	**neer*D2**
				(0.041)	**(0.042)**	**(0.039)**	
ln_fmc	–0.039	–0.041	–0.044	–0.014	–0.016	–0.013	
	(0.033)	(0.031)	(0.043)	(0.026)	(0.025)	(0.026)	
gapfiny_sa100	0.071*	0.078**	0.063	0.069**	0.072***	0.058*	
	(0.039)	(0.035)	(0.046)	(0.029)	(0.025)	(0.030)	
ln_comm	0.403***			0.339***			
	(0.047)			(0.062)			
ln_en		0.296***			0.251***		
		(0.035)			(0.046)		
ln_non_en			0.024			0.021	
			(0.019)			(0.017)	
Regime	0.0071	0.0072	0.004	0.007	0.008	0.008	
	(0.010)	(0.010)	(0.008)	(0.006)	(0.007)	(0.006)	
Constant	0.212	0.675***	2.065***	1.280***	1.676***	2.375***	
	(0.200)	(0.228)	(0.293)	(0.422)	(0.485)	(0.560)	
Common dynamic process	0.576***	0.575***	0.583***	0.524***	0.529***	0.517***	
	(0.060)	(0.063)	(0.052)	(0.091)	(0.093)	(0.086)	
Observations	353	353	353	419	419	419	
Number of co	7	7	7	7	7	7	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes; oi_cis is the Openness Index as intra-CIS trade over GDP.
For the interaction terms: *int_1* and *int_3* are the exchange rate *vis-à-vis* the USD or NEER multiplied by the dummy D1 in equation 13 (large changes), *int_2* and *int_4* are the exchange rate *vis-à-vis* the USD or NEER multiplied by the dummy D2 in equation 13 (small changes).

5.5 Robustness checks

5.5.1 Estimation in differences

As a first robustness check, we estimate our preferred specification in differences instead of levels (Table 8 and 9), since some of our variables were found to be non-stationary. Moreover, estimation in differences is used almost universally in previous studies, so we can compare our results with outcomes from earlier research.

Our results are of similar magnitude as the ERPT estimates reported in the earlier literature for emerging countries. The short-run ERPT is in the same order of magnitude (12–13%) and the long-run versions are quite similar to those reported in the Table B for the baseline.

Table 8 Estimations in first differences – ERPT with output gap

Variables	(1) dcpi	(2) dcpi	(3) dcpi	(4) dcpi	(5) dcpi	(6) dcpi
dcpi1	–0.079	–0.078	–0.092	–0.062	–0.061	–0.074
	(0.101)	(0.101)	(0.099)	(0.101)	(0.101)	(0.100)
dusd1	**0.059**	**0.059**	**0.057**			
	(0.077)	**(0.076)**	**(0.077)**			
dneer1				**–0.130****	**–0.131****	**–0.129***
				(0.065)	**(0.065)**	**(0.066)**
Dfmc	0.031	0.029	0.019	0.016	0.013	0.008
	(0.024)	(0.023)	(0.014)	(0.021)	(0.019)	(0.015)
gapy_sa100	–0.062	–0.060	–0.065	–0.061*	–0.059	–0.063*
	(0.043)	(0.043)	(0.040)	(0.036)	(0.036)	(0.032)
Dcomm	–0.015**			–0.013**		
	(0.006)			(0.006)		
Den		–0.012**			–0.010**	
		(0.004)			(0.004)	
dnon_en			–0.016			–0.013
			(0.014)			(0.013)
Regime	–0.002	–0.002	–0.001	–0.002	–0.002	–0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.025***	0.025***	0.025***	0.022***	0.022***	0.022***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Common dynamic process	0.977***	0.972***	0.984***	0.967***	0.962***	0.974***
	(0.166)	(0.167)	(0.158)	(0.158)	(0.159)	(0.151)
Observations	417	417	417	417	417	417
Number of co	7	7	7	7	7	7
RMSE	0.012	0.012	0.012	0.012	0.012	0.012

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes. **All variables, except the gaps, are in log first differences.** RMSE is the root mean square error.

With the specification in differences, the ERPTs with NEER and bilateral USD rate remain robust. However, the prices of commodities and energy become negative even if extremely small. Therefore, changes in commodity prices have different impact on inflation than the level of them on price levels. While the impact of their change is small with regard to inflation, their level matters for CPI levels in our countries of interest.

Table 9 Estimations in first differences – ERPT with financial gap

Variables	(1) dcpi	(2) dcpi	(3) dcpi	(4) dcpi	(5) dcpi	(6) dcpi
dcpi1	–0.100	–0.100	–0.113	–0.078	–0.077	–0.091
	(0.102)	(0.101)	(0.099)	(0.100)	(0.100)	(0.100)
dusd1	**0.066**	**0.066**	**0.065**			
	(0.067)	**(0.066)**	**(0.068)**			
dneer1				**–0.123***	**–0.124***	**–0.122***
				(0.066)	**(0.066)**	**(0.066)**
dfmc	0.030	0.027	0.020*	0.016	0.013	0.009
	(0.021)	(0.019)	(0.012)	(0.020)	(0.018)	(0.015)
gapfiny_sa100	–0.052	–0.051	–0.052	–0.054	–0.053	–0.054
	(0.042)	(0.042)	(0.040)	(0.038)	(0.038)	(0.036)
dcomm	–0.014**			–0.012**		
	(0.006)			(0.006)		
den		–0.011***			–0.010**	
		(0.004)			(0.004)	
dnon_en			–0.013			–0.012
			(0.014)			(0.012)
regime	–0.001	–0.001	–0.0009	–0.002	–0.002	–0.001
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
Constant	0.024***	0.024***	0.024***	0.022***	0.022***	0.022***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Common dynamic process	0.973***	0.969***	0.978***	0.970***	0.966***	0.975***
	(0.161)	(0.162)	(0.151)	(0.156)	(0.157)	(0.148)
Observations	417	417	417	417	417	417
Number of co	7	7	7	7	7	7
RMSE	0.012	0.012	0.012	0.012	0.012	0.012

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes. All variables, except the gaps, are in log first differences. RMSE is the root mean square error.

Table 10 Estimations in first differences – ERPT without commodities

Variables	(1) dcpi	(2) dcpi	(3) dcpi	(4) dcpi
dcpi1	–0.131*	–0.113*	–0.151**	–0.132**
	(0.067)	(0.068)	(0.066)	(0.065)
dusd1	**0.061**		**0.068**	
	(0.066)		**(0.055)**	
dneer1		**–0.135***		**–0.124***
		(0.069)		**(0.067)**
dfmc	–0.009	–0.023	–0.008	–0.021
	(0.015)	(0.023)	(0.015)	(0.021)
gapy_sa100	–0.054	–0.053		
	(0.042)	(0.035)		
gapfiny_sa100			–0.052	–0.053
			(0.044)	(0.039)
regime	–0.001	–0.003	0.0003	–0.003
	(0.003)	(0.003)	(0.001)	(0.002)
Constant	0.025***	0.024***	0.023***	0.024***
	(0.004)	(0.005)	(0.002)	(0.004)
Common dynamic process	0.971***	0.969***	0.971***	0.973***
	(0.166)	(0.161)	(0.160)	(0.156)
Linear trend	2.31e–05	6.51e–06	4.93e–05	1.18e–05
	(7.18e–05)	(8.32e–05)	(8.59e–05)	(8.26e–05)
Observations	417	417	417	417
Number of co	7	7	7	7
RMSE	0.012	0.012	0.012	0.011

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *regime* is the dummy for de facto fixed/intermediate regimes. **All variables, except gaps, are in log first differences.** RMSE is the root mean square error.

5.5.2 Estimation with IV-GMM

As a robustness check of the validity of our empirical method, we include in the robustness checks the estimations by using a two-step system IV-GMM. Because the standard errors in two-step estimation tend to be significantly downward biased because of the large number of instruments involved, we follow Jimborean (2011) and we apply Windmeijer (2005) finite-sample correction. To avoid the bias that arises when the number of instruments is relatively too high in small samples, we collapse the instruments as suggested by Roodman (2009a). We assume all the variables in the baseline (Table 3 and 4) are endogenous and we use only the second lag as instruments.[42]

Table 11 IV-GMM estimations

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi
L.ln_cpi	0.466	0.369	0.649***	0.336
	(0.365)	(0.437)	(0.232)	(0.442)
ln_usd1	**–0.076***		**0.003**	
	(0.041)		**(0.017)**	
ln_neer1		**–0.555***		**–0.592***
		(0.322)		**(0.343)**
ln_fmc	–1.621	2.408	–4.772	2.318
	(1.216)	(1.692)	(3.488)	(1.630)
gapy_sa100	–6.821	1.746		
	(4.965)	(1.461)		
gapfiny_sa100			–8.598	1.177
			(6.232)	(0.977)
ln_comm	0.873	–0.338	1.699	–0.299
	(0.641)	(0.256)	(1.237)	(0.227)
regime	–0.812	–0.0970	–0.703	–0.248***
	(0.529)	(0.117)	(0.451)	(0.090)
Constant	6.699	–3.805	15.98	–3.129
	(4.747)	(3.537)	(11.46)	(3.043)
Observations	419	419	419	419
Number of co	7	7	7	7

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Two-step System GMM with Windmeijer (2005) finite-sample correction. Instruments for first differences equation: GMM-type (missing=0, separate instruments for each period unless collapsed). L2.(L.ln_cpi ln_neer1 ln_fmc gapfiny_sa100 ln_comm) collapsed. Instruments for levels equation with constant GMM-type (missing=0, separate instruments for each period unless collapsed). DL.(L.ln_cpi ln_neer1 ln_fmc gapfiny_sa100 ln_comm) collapsed.

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *regime* is the dummy for de facto fixed/intermediate regimes.

The results with the two-step system IV-GMM estimator confirm the main findings of our analysis with the AMG estimator (Table 3 and 4) if we include the commodity prices measure.[43] The ERPT based on the NEER is again significant, but much higher (55 % for short-run with output gap and 60 % with financial gap). The ERPT with the bilateral exchange rate *vis-à-vis* the USD

[42] We apply only the second lag of the endogenous variables as instruments. The small number of countries in our sample and the large number of instruments weakens the Sargan test results. Thus, we make a rule of thumb to keep the number of instruments less or equal to the number of groups.
[43] Results with energy prices and non-energy prices are available upon request.

is significant only if we include output gap and in any case it is much smaller (7.6 % in the short run) than the ERPT with NEER (Table 11). In case of estimation with energy prices, the ERPT with NEER is the only one significant and around 33 %, which is three times as big as the coefficient we found with the AMG estimator. In all the specifications the commodity prices and the gaps are not significant. The regime dummy becomes negative and significant in the specification with NEER and financial gap; meaning that in case it is equal to one, i.e. when the regime is fixed or intermediate (managed arrangements included), the consumer price index decreases.

Summing up the outcome for the ERPT, if you do not take into account the heterogeneity across individuals and the presence of cross-sectional dependence (which can hide some key common global factors or spillovers effects); the ERPT with NEER is much higher than the preferred setup and also not comparable with the average estimates from the literature (Table 1 in the text).

5.5.3 Dynamic factor model

We include a dynamic version of the factor model setup to account for possible endogeneity between variables such as exchange rate and commodity prices.[44] We applying the dynamic CCE (MG)-GMM estimator of Neal (2015) to fully correct for both endogeneity and cross-sectional dependence while maintaining heterogeneity in the coefficients. The cross-section averages of the variables (together with the averages with one and two lags) are included to deal with cross-sectional dependence. All variables (except the exogenous regime dummy) are instrumented using one and two lags. The GMM estimator is applied. The ERPT with NEER in most specifications is significant, and the magnitude of the coefficient is larger in these cases than in the preferred setup (in a range between 17 % and 30 %). The significance of adding the regime dummy is seen in just two cases: in the setup with energy prices and output gap and non-energy prices and financial gap. The ERPT with the USD rate is significant and around 30% only if we consider general commodity prices and financial gap.

5.5.4 Other robustness checks

We also perform additional robustness checks leaving Russia out of the sample (as it is a notably larger economy compared to the others), controlling for oil-exporting v. oil-importing countries with a dummy variable and controlling for exchange rate volatility. The magnitude of the ERPT

[44] All results available on request.

estimates for NEER remains at 15 % and statistical tests show that the additional control variables should be omitted from the model.

Moreover, leaving Russia out of the sample, the ERPT with USD becomes significant and just slightly smaller than the NEER case (Tables 12 and 13). This result is somewhat puzzling. Firstly, it might reflect the fact that the role of domestic currency as well as the euro as an invoicing currency is higher in Russia than in the other countries of the sample. In 2013–14, the share of both RUB and EUR was about 30 % in the invoicing currencies of Russian imports. Secondly, it might be related to the close relationship between Russia's exchange rate and oil price. Exchange rate tends to appreciate when oil price increases dampening inflation pressures. For oil exporters, this has been referred to as one of the possible reasons for finding non-significant or quantitatively very small results for ERPT. At least our oil-exporter dummy, however, is not providing support for this explanation because it is not significant in any of our specifications. On the opposite side, the consumer prices of oil importers may be influenced more by the price of oil, literally importing inflation (deflation) in case of an increase (decrease) in oil prices. Hence we checked for a possible asymmetry between oil importers and exporters in that regards, adding an interaction term between energy prices and a dummy for importers. This term is again not significant and the ERPT coefficient very robust with respect to the preferred baseline setup. Hence, we do not find any evidence of the abovementioned behavior[45].

[45] Results available on request.

Table 12 ERPT excluding Russia – with output gap

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.421***	0.427***	0.411***	0.452***	0.457***	0.447***
	(0.087)	(0.087)	(0.085)	(0.106)	(0.105)	(0.107)
ln_usd1	**–0.102****	**–0.103****	**–0.100***			
	(0.0520)	**(0.0515)**	**(0.0537)**			
ln_neer1				**–0.157****	**–0.159****	**–0.157****
				(0.068)	**(0.069)**	**(0.069)**
ln_fmc	0.023	0.022	0.030	0.013	0.015	0.016
	(0.027)	(0.027)	(0.028)	(0.026)	(0.025)	(0.027)
gapy_sa100	0.005	0.012	0.0061	0.026	0.033	0.027
	(0.052)	(0.053)	(0.051)	(0.049)	(0.048)	(0.043)
ln_comm	0.466***			0.406***		
	(0.061)			(0.067)		
ln_en		0.346***			0.301***	
		(0.046)			(0.050)	
ln_non_en			0.021			0.020
			(0.023)			(0.022)
Regime	0.008	0.008	0.006	0.010	0.010	0.0090
	(0.009)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)
Constant	0.0651	0.596**	1.585***	1.437**	1.894***	2.765***
	(0.262)	(0.284)	(0.317)	(0.566)	(0.620)	(0.785)
Common dynamic process	0.635***	0.635***	0.639***	0.635***	0.638***	0.629***
	(0.086)	(0.087)	(0.081)	(0.110)	(0.111)	(0.107)
Observations	356	356	356	356	356	356
Number of co	6	6	6	6	6	6

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes.

Table 13 ERPT excluding Russia – with financial gap

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.426***	0.432***	0.407***	0.456***	0.462***	0.446***
	(0.093)	(0.093)	(0.090)	(0.108)	(0.107)	(0.108)
ln_usd1	**–0.118*** **	**–0.118*** **	**–0.118*** **			
	(0.0427)	**(0.0424)**	**(0.0443)**			
ln_neer1				**–0.156** **	**–0.155** **	**–0.157** **
				(0.065)	**(0.066)**	**(0.063)**
ln_fmc	0.019	0.015	0.032	–0.001	–0.002	0.006
	(0.028)	(0.029)	(0.028)	(0.034)	(0.034)	(0.033)
gapfiny_sa100	0.075***	0.077***	0.073**	0.084**	0.085***	0.074**
	(0.024)	(0.021)	(0.033)	(0.034)	(0.029)	(0.032)
ln_comm	0.457***			0.393***		
	(0.058)			(0.063)		
ln_en		0.338***			0.290***	
		(0.043)			(0.047)	
ln_non_en			0.005			0.007
			(0.024)			(0.023)
Regime	0.006	0.006	0.006	0.005	0.006	0.006
	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)
Constant	0.101	0.634**	1.652***	1.540***	1.977***	2.873***
	(0.242)	(0.273)	(0.339)	(0.545)	(0.603)	(0.741)
Common dynamic process	0.638***	0.636***	0.650***	0.632***	0.632***	0.629***
	(0.084)	(0.085)	(0.081)	(0.108)	(0.109)	(0.103)
Observations	356	356	356	356	356	356
Number of co	6	6	6	6	6	6

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *regime* is the dummy for de facto fixed/intermediate regimes.

We also add volatilities of the rate *vis-à-vis* the USD and the NEER into our preferred setup.[46] The ERPT to USD is still not significant (Table 14a) and all the coefficients very robust w.r.t. the baseline (Tables 3 and 4). The ERPT to NEER is also robust w.r.t. the baseline (Table 14b with financial gap)[47]. However, non-energy prices become significant in the case of the output gap. Moreover, in the case of non-energy prices, the financial cycle is no longer be significant in some specifications. The volatilities of rates are never significant.

[46] The volatilities are computed as in section 4.1.
[47] The results are robust if output gap is added.

Table 14a USD volatility

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.517***	0.523***	0.498***	0.507***	0.514***	0.484***
	(0.092)	(0.090)	(0.097)	(0.094)	(0.092)	(0.095)
ln_usd1	**–0.043**	**–0.042**	**–0.045**	**–0.058**	**–0.057**	**–0.058**
	(0.056)	**(0.056)**	**(0.053)**	**(0.048)**	**(0.049)**	**(0.046)**
ln_fmc	–0.008	–0.008	–0.009	–0.001	–0.004	0.0005
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.024)
gapy_sa100	0.035	0.038	0.035			
	(0.028)	(0.031)	(0.029)			
gapfiny_sa100				0.078***	0.079***	0.072**
				(0.029)	(0.026)	(0.035)
ln_comm	0.421***			0.427***		
	(0.067)			(0.065)		
ln_en		0.311***			0.314***	
		(0.050)			(0.049)	
ln_non_en			0.019			0.011
			(0.019)			(0.020)
vol_usd	**–0.012**	**–0.015**	**–0.0084**	**–0.008**	**–0.012**	**–0.008**
	(0.023)	**(0.024)**	**(0.022)**	**(0.015)**	**(0.017)**	**(0.015)**
Regime	0.006	0.006	0.004	0.004	0.004	0.003
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Constant	0.108	0.583**	2.024***	0.0839	0.582**	2.065***
	(0.225)	(0.261)	(0.388)	(0.217)	(0.261)	(0.390)
Common dynamic process	0.574***	0.573***	0.582***	0.588***	0.586***	0.602***
	(0.086)	(0.088)	(0.081)	(0.081)	(0.084)	(0.077)
Observations	419	419	419	419	419	419
Number of co	7	7	7	7	7	7

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *vol_usd* is the quarterly volatility of the bilateral rate *vis-à-vis*t he USD; *regime* is the dummy for de facto fixed/intermediate regimes.

Table 14b NEER volatility (with financial gap)

Variables	(1) ln_cpi	(2) ln_cpi	(3) ln_cpi	(4) ln_cpi	(5) ln_cpi	(6) ln_cpi
ln_cpi1	0.549***	0.548***	0.555***	0.554***	0.537***	0.537***
	(0.106)	(0.106)	(0.104)	(0.104)	(0.110)	(0.110)
ln_neer1	**–0.133*** **	**–0.136*** **	**–0.133*** **	**–0.137*** **	**–0.133*** **	**–0.136*** **
	(0.043)	**(0.043)**	**(0.044)**	**(0.044)**	**(0.042)**	**(0.042)**
ln_fmc	–0.018	–0.016	–0.022	–0.020	–0.017	–0.014
	(0.029)	(0.029)	(0.028)	(0.028)	(0.028)	(0.028)
gapfiny_sa100	0.063**	0.064**	0.066**	0.067***	0.049	0.049
	(0.030)	(0.030)	(0.026)	(0.026)	(0.030)	(0.030)
ln_comm	0.338***	0.338***				
	(0.063)	(0.03)				
ln_en			0.250***	0.250***		
			(0.046)	(0.046)		
ln_non_en					0.023	0.024
					(0.019)	(0.019)
vol_neer138	**–0.008**		**–0.009**		**0.005**	
	(0.040)		**(0.038)**		**(0.042)**	
vol_neer41		**0.006**		**0.005**		**0.022**
		(0.038)		**(0.036)**		**(0.040)**
Regime	0.006	0.006	0.007	0.006	0.006	0.006
	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
Constant	1.318***	1.328***	1.707***	1.720***	2.802***	2.798***
	(0.449)	(0.447)	(0.510)	(0.508)	(0.648)	(0.643)
Common dynamic process	0.524***	0.525***	0.527***	0.528***	0.522***	0.520***
	(0.091)	(0.091)	(0.093)	(0.093)	(0.089)	(0.088)
Observations	419	419	419	419	419	419
Number of co	7	7	7	7	7	7

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The exchange rates used are *usd* and *neer*; *fmc* is the foreign marginal cost; *gapy_sa100* is the output gap multiplied by 100; *gapfiny_sa100* is the financial gap multiplied by 100; *comm* is commodities price; *en* is energy price and *non_en* is non-energy price; *vol_neer138* and *vol_neer41*are the quarterly volatility of the NEER with respectively138 and 41 partners; *regime* is the dummy for de facto fixed/intermediate regimes.

For the sake of completeness, we should also check the robustness of the results for dependent variables other than the plain-vanilla CPI (e.g. core inflation and CPI excluding administered prices). Unfortunately, this is not possible due to lack of data for some countries in our sample. To some extent, however, this deficiency can be overcome in some estimations by controlling for energy-price development.

As a final robustness check we apply a simple homogeneous panel VAR setup,[48] with dependent variables (in Cholesky order): financial gap, foreign marginal cost, commodity prices, NEER, and CPI. We use the setup as in Abrigo and Love (2015), who apply GMM-type estimators to this setup. The results are similar to our preferred specification, with the coefficients for the lagged value of the NEER significant and equal to 18 %. Looking at the IRFs (Figure 1) on a horizon of eight periods (two years), the pass-through is complete in less than two years. The ERPT after four quarters is also well in line with our estimates.

6 Conclusions and implications

We find that after one quarter ERPT is still relatively high and rapid in the CIS countries (12–13 %), and for NEER climbs to over 50 % after four quarters. These results for ERPT are broadly in line with earlier studies of emerging economies. They are quite robust with respect to different sub-periods, weakening only in the last quarters, in line with the recent literature. Common factors are found to be important for ERPT estimation in the CIS countries and commodity prices in particular are also explicitly significant. We find that especially financial gaps need to be accounted for in the estimation of ERPT for CIS countries. On the other hand, we could not establish a statistically significant impact from the exchange rate regime, volatility of the exchange rate, or the fact that a particular country was a commodity exporter.

We also examined the possibility of asymmetry in ERPT for the first time in a cross-country setting for the CIS countries. We found little support for asymmetric effects of appreciation and depreciation. For NEER, our results point to symmetric effects from large and small changes in the exchange rate. For the USD, there was some evidence of a higher ERPT coefficient in the event of large exchange rate changes. The fact that we cannot find much evidence for asymmetric effects is a bit surprising. On the other hand, there are only a few instances of very large changes in our sample period.

From the policy point of view, our results confirm that ERPT is still an important factor for price development in the CIS countries and should be taken into account when evaluating the inflation outlook. Our results suggest that there are several factors influencing ERPT in CIS countries that need to be accounted for when estimating the effects. Recent significant changes in the monetary policy regimes in some CIS countries may also affect ERPT although we did not find much evidence of that. Currently too little time has yet passed to evaluate the full effects of these changes, but they will undoubtedly be an important topic in future studies.

[48] Results available on request.

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