MPRA

A new approach to estimation of actively managed component of foreign exchange reserves

Dąbrowski, Marek A.

22 July 2019

A new approach to estimation of actively managed component of foreign exchange reserves

Marek A. Dąbrowski

Cracow University of Economics, Faculty of Economics and International Relations, Department of Macroeconomics, Rakowicka 27, 31-510 Cracow, Poland, +48 12 293 56 68, marek.dabrowski@uek.krakow.pl

Abstract

Changes in foreign exchange (FX) reserves are difficult to measure in an economically meaningful way because central banks do not decompose reported data into passive and active components. Only the latter should be used when the usefulness of FX reserves in crisis management is assessed or symptoms of currency manipulations are looked for. The applicability of the existing approach to identification of active component of FX reserves is highly limited as it relies on data that are available for a relatively short timespan. To overcome these problems the new approach to estimation of active component of FX reserves is laid out. It makes use of a time-varying coefficient model estimated with Bayesian techniques. The empirical results are obtained for 20 countries over 1995-2017 period. The main finding is that the estimates from the new approach are highly correlated with those from the existing approach, but the timespan of the former is substantially larger than that of the latter. The estimates based on the new approach are cross-checked against the data on FX market interventions of the Czech National Bank. It is demonstrated that the estimates are in general superior to plain changes in FX reserves as a measure of FX interventions and are not worse than those from the existing approach.

JEL classification: F31, F41, E58, C32

Key words: foreign exchange reserves, foreign exchange interventions, open economy macroeconomics, Czech National Bank, state space models

Acknowledgements

1. Introduction

In the 1990s, after a series of financial crises in Asia, Europe and Latin America, monetary authorities of many emerging market economies started to accumulate foreign exchange (FX) reserves on a large scale (see, e.g., ECB, 2006, Aizenman et. al, 2015; Gopalakrishnan and Mohapatra, 2018). Their behaviour was driven by a precautionary or self-insurance motive (Feldstein, 1999). Some commentators, however, argued that it was a mercantilist motive that was behind reserve accumulation. That phenomenon was simply a side effect of having undervalued currency that was in turn an important element of the export-led growth strategy.[1] Blanchard and Milesi-Ferretti (2012) point out that the steady accumulation of reserves 'beyond any reasonable precautionary level' is not necessarily a telltale sign of intentional undervaluation: if outflow of capital is controlled and current account is in surplus, foreign assets will be accumulated by the central bank. Their point is valid. It can be made even stronger if one takes into account that changes in FX reserves can be decomposed into active and passive. Only some changes driven by an active component may be related to intent of monetary authorities.

In this paper a new approach to estimation of active component of FX reserves is offered. That component needs to be estimated because central banks in a vast majority of countries do not publish data on active and passive reserves changes. Our approach is new because it is based on a completely different methodology than the approach developed in the early 2010s by Dominguez, Hashimoto and Ito (hereafter DHI). In a nutshell, the DHI approach draws information from various sets of data, whereas the new approach is less data demanding and employs econometric techniques instead (differences are discussed in more detail below).

The reason that motivates the research on an active component of FX reserves given in the introductory paragraph is important but not the only one. FX reserves can be used in macroeconomic crisis management. For example, Dąbrowski et al. (2015) find that reserves depletion accompanied by depreciation was effective in mitigating the impact of the global financial crisis on emerging market economies (EMEs) (see also Bussière et al., 2015). Aizenman and Sun (2012) present evidence that only about half of the EMEs investigated depleted their reserves as part of the adjustment mechanism to the global liquidity crisis. Dominguez (2012) argues that the 'non-role of reserves during the crisis' identified in some

---

[1] See, e.g., Dooley et al. (2004 and 2009). They claim that a kind of the Bretton Woods system was revived. For more on both motives see, e.g., Choi and Taylor (2017), Aizenman and Lee (2007).

studies – Aizenman and Sun (2012) coined even a new term 'fear of losing reserves' for it – can be misleading. She demonstrates that if the passive component of FX reserves is stripped out, then it becomes clear that many EMEs actively depleted reserves during the crisis.

Another motivation to identify the active component of FX reserves can be found in the literature on *de facto* exchange rate regime classifications. Levy-Yeyati et al. (2013) claim that the use of reserve changes distinguishes their classification from other attempts at classifying exchange rate regimes that rely solely on exchange rate volatility. Even though they realise that '[r]eserves are notoriously difficult to measure and there is usually a large difference between changes in reserves and interventions', they do not attempt to identify an active component of FX reserves (Levy-Yeyati and Sturzenegger, 2005, p. 1607).[2] Thus, although their approach is well-founded from a theoretical point of view, it is plagued with the lack of relevant data on reserves on empirical ground. The motivation that stems from the literature on exchange rate regime classifications seems to gain in importance recently, since a renew interest in the topic can be observed (see, e.g., Bleaney and Tian, 2017; Dąbrowski et al., 2019; Ilzetzki et al., 2019; Levy-Yeyati and Sturzenegger, 2016).[3]

The contribution of the paper is fourfold. First, it offers new, more up-to-date estimates of actively managed component of FX reserves for 20 countries. More importantly, the timespan of estimates is not constrained by the limited SDDS data availability, so it is possible to identify the active component of FX reserves for large reserve holders like China and for the pre-2000 period.[4] Second, the paper lays out the empirical methodology that can be applied to other countries and the main results can be replicated. Third, in order to demonstrate the usefulness of the approach offered in the paper and to lend more support to it a comparative analysis is carried out. The DHI approach is used to obtain estimates of actively managed component of FX reserves for longer and more recent period than that in DHI (2012). Then the estimates from the new approach are compared with those from the DHI approach. Finally, data on FX market interventions provided by the Czech National Bank are used in a case study that demonstrates the differences between the use of data on plain changes in FX reserves (a naïve

---

[2] Instead the central bank's net foreign assets minus government deposits at the central bank are used.

[3] We do not intend to make the list of arguments that motivate research on active component of FX complete. It can definitely include other reasons, for example assessment of the crowding out effect induced by FX reserve accumulation (Reinhart et al., 2016) or the importance of reserves in the saving glut hypothesis (Bernanke, 2005; Obstfeld and Rogoff, 2009).

[4] The SDDS data are available for the period starting in 2000 and only for some countries.

approach), the DHI approach and the new approach laid out in the paper.

The rest of the paper is structured as follows. The next section briefly discusses the existing methodology of identification of active component of FX reserve developed in an important contribution by Dominguez et al. (2012). In Section 3 theoretical framework is laid out. The three-step empirical strategy and data are presented in Section 4. Empirical results covering a comparative analysis of estimates obtained under the new and DHI approaches as well as a case study on the FX interventions in the Czech Republic are discussed in Section 5. The last section presents conclusions.

2. The DHI approach to active component of reserves

The actively managed component of FX reserves is identified for a group of more than sixty countries by Dominguez, Hashimoto and Ito in their 2012 paper (Dominguez et al., 2012).[5] They proceed in three steps. First, they identify valuation changes in reserves, VE_t, as a difference between changes in official reserve assets obtained from the data reported under the Special Data Dissemination Standard (SDDS) and reserves and related items obtained from the Balance of Payments Statistics (BOPS). Second, using data on foreign currency reserves (securities and total currency and deposits) from the SDDS dataset, SFX_t, the currency denomination of reserves from the IMF Currency Composition of Official Foreign Exchange Reserves dataset, 10-year government bond yields and three-month inter-bank yields they estimate interest income on reserves, II_t. Third, the actively managed component AC_t is calculated as a residual

$$AC_t = \Delta SFX_t - II_t - VE_t. \tag{1}$$

They argue that changes in reserves would be 'a particularly poor proxy for interventions when interest income or valuation changes are large' (DHI, 2012, p. 393).

The DHI methodology is neat and well-founded. It suffers, however, from two problems. First, its use is heavily constrained by data availability. The SDDS data are available starting 2000, but for some – mainly high-income – countries only. Many emerging market economies only recently have started to report data in accordance with the SDDS Reserve Template. For example, data for China and India are available starting June 2015 and October

---

[5] See also the on-line appendix to Dominguez et al. (2011) and Dominguez (2012).

2007, respectively. Moreover, the (publicly available) BOPS data are on quarterly basis and cover only recent years for many countries. For instance data for China and Poland start in 2005 and 2000, respectively. Thus, the DHI estimates of actively managed component of reserves can be obtained for a limited timespan in general, and substantially limited timespan in the case of many emerging market economies.

Second, the DHI approach is focused on foreign currency reserves. DHI (2012, p. 393) argue that non-currency reserves do 'not change frequently'. According to the SDDS Reserve Template official reserve assets (foreign exchange reserves) can be divided into foreign currency reserves and non-currency reserves that include: IMF reserve position, SDRs, gold and other reserve assets. As far as the first three items are concerned DHI's argument is acceptable, but it seems to be an oversimplification with respect to the last item. Other reserve assets are a component of FX reserves that *can* be actively managed and indeed in some countries they change substantially.[6] In order to illustrate their importance in Argentina and Poland foreign currency reserves and foreign currency reserves plus other reserve assets are depicted in Figure 1 (data for some other countries are illustrated in Figure A1 in the Appendix A). In both countries the distance between two time series has changed over time. Thus, the point is that the omission of changes in other reserve assets – as it is done by DHI who implicitly include these changes in a valuation effect – can result in misleading estimates of an active component of reserves.
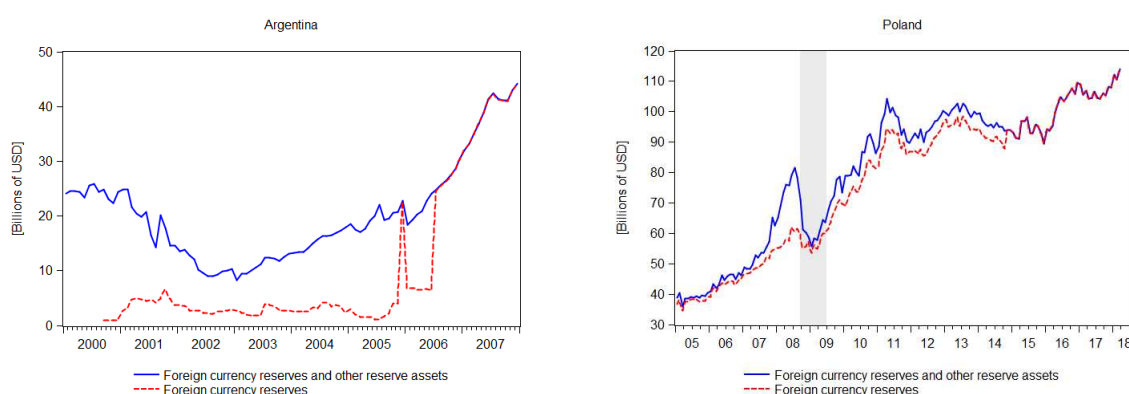

Figure 1. Foreign currency reserves and other currency reserves in Argentina and Poland

---

[6] They include the following items: financial derivatives, loans to nonbank nonresidents and other. For example, the last item 'other' is important in reporting some of reverse repos. For details see IMF (2013, p. 16-17).

The approach offered in this paper overcomes both problems. In a nutshell, it relies on much longer time series on FX reserves that include both currency and non-currency reserves except for gold. The underlying idea is to estimate the actively managed component of reserves within the state space model.

3. Theoretical framework

FX reserves can be divided into active and passive components. The former is driven by changes due to actions of monetary authorities, e.g. foreign exchange market interventions, granting loans to nonbank nonresidents. The latter reflects changes in interest income and valuation effect and as such is driven by interest rates and exchange rates. The reserves are held in a form of safe assets, so interest income is not too volatile. The opposite holds for valuation effect: since assets are in various currencies and exchange rates between major currencies are far from being fixed, exchange rate volatility transmits into changes in the overall reserves, no matter which currency is chosen to report data.

The *level* of total foreign exchange reserves reported in U.S. dollars in (the end of) period t, R_t, can be defined as

$$R_t = \sum_{i=1}^{N} S_{it} R_{it} \tag{2}$$

where S_{it} is an exchange rate of currency i in (the end of) period t, defined as a price of that currency in U.S. dollars, and R_{it} stands for reserves in currency i in (the end of) period t. Thus, $S_{it} R_{it}$ is a U.S. dollar equivalent of reserves in currency i in (the end of) period t.[7] N is the number of currencies in which reserves are denominated and it is not necessarily large since usually only international currencies are considered appropriate for FX reserves.[8]

As is clear from equation (2), even if the reserves in individual currencies are kept fixed, the total reserves can fluctuate due to the changes in the exchange rates. The additional source of changes are interest earnings. The *change* in total reserves can be decomposed into a change in amount of reserves due to actions of monetary authorities AC_t, an interest income II_t and

---

[7] The choice of the U.S. dollar as a unit is just a matter of convention – data on FX reserves are usually reported in that currency. The point is that numbers have to be expressed in the same unit.

[8] For example, the IMF COFER database covers eight currencies and has a residual category 'other currencies'.

valuation effect VE_t that includes changes due to exchange rate fluctuations:

$$\Delta R_t = AC_t + II_t + VE_t = g_t^{AC} R_{t-1} + i_t R_{t-1} + VE_t \tag{3}$$

where g_t^{AC} is the rate of growth of active component and i_t is the weighted average interest rate on international assets held by the central bank.

In order to identify the active component of FX reserves equation (2) is transformed into the analogue for the *rates of change*

$$f_t = \sum_{i=1}^{N} u_{it-1} g_{it} + \sum_{i=1}^{N} u_{it-1} h_{it} + \sum_{i=1}^{N} u_{it-1} g_{it} h_{it} \tag{4}$$

where f_t, g_{it} are the rates of growth of total reserves and reserves in currency i, respectively, h_{it} is the rate of change of the U.S. dollar price of currency i and u_{it-1} is a share of assets in currency i in total assets at the end of period $t-1$. The first sum on the right-hand side of equation (4) comprises changes in active component of FX reserves and changes in interest income, the second sum includes changes in exchange rates and the third sum is a mixture of all changes. If, for example, exchange rates do not change ($h_{it} = 0$ for $i = 1, \dots, N$), then the second and third sums are zero and reserves change because of interest income and changes in amounts of assets in individual currencies. If in turn these are zero, i.e. a central bank is passive in its actions on reserves and receives no interest income, then the first and third sums are zero but reserves can change due to exchange rate fluctuations.

The identification of an actively managed component of FX reserves proceeds in two steps. First, using observation that for each currency i

$$g_{it} = g_{it}^{AC} + i_{it} \tag{5}$$

and equation (4) it is possible to demonstrate that

$$g_t^{AC} = \sum_{i=1}^{N} u_{it-1}(g_{it} - i_{it}) \equiv g_t - i_t. \tag{6}$$

Second, given the rate of change of the actively managed component of FX reserves, the component itself is obtained from its definition used in equation (3) as

$$AC_t = g_t^{AC} R_{t-1} \tag{7}$$

Thus, AC_t is that part of a change in FX reserves that can be attributed to changes in amounts of assets in individual currencies and not to exchange rate fluctuations or interest income.

4. Empirical methodology and data

Empirical methodology consist of three steps. First, the state space model for the rate of change in FX reserves on rates of change in exchange rates is estimated. Second, the interest income is identified using interest rates and currency composition of official FX reserves. Third, the actively managed component of FX reserves is disentangled from interest earnings. These steps are described below.

The state space model

In order to make our strategy of uncovering an active component of FX reserves operational equation (4) needs to be estimated. For the purposes of estimation the number of international currencies concerned N is limited to four: the U.S. dollar, the euro, the Japanese yen and the British pound sterling. These are currencies with the greatest shares in international reserves in the COFER database – their total average share in 2015-2017 in the allocated reserves was 93.1%.[9] Moreover, equation (4) can be written in a more convenient form, i.e.

$$f_t = \sum_{i=1}^{4} u_{it-1} g_{it} + \sum_{i=1}^{4} u_{it-1}(1 + g_{it}) h_{it} + oth_t \tag{8}$$

where oth_t includes terms in other currencies. This, in turn, can be written in a more general form as

$$y_t = Z_t \alpha_t + \varepsilon_t \tag{9}$$

where $y_t = f_t$, a vector of explanatory variables $Z_t = [1 \quad h_{1t} \quad ... \quad h_{4t}]$, five time-varying coefficients $\alpha_t = [\sum_{i=1}^{4} u_{it-1} g_{it} \quad u_{1t-1}(1 + g_{1t}) \quad ... \quad u_{4t-1}(1 + g_{4t})]'$, and the error term $\varepsilon_t \sim i.i.d.N(0, h^{-1})$.

The state space model used in the first step includes one observation (or measurement) equation and a set of five state equations. Its general form is as follows:

$$y_t = Z_t \alpha_t + \varepsilon_t, \quad \varepsilon_t \sim i.i.d.N(0, h^{-1}) \tag{10a}$$

$$\alpha_{t+1} = \alpha_t + \eta_t, \quad \eta_t \sim i.i.d.N(0, H^{-1}) \tag{10b}$$

where y_t is an observed dependent variable at time t, Z_t is a $1 \times p$ vector of explanatory

---

[9] The average shares of these four currencies were 64.8%, 19.7%, 4.1%, 4.4%, respectively. All numbers based on data from the COFER database.

variables (assumed to be exogenous) and a known constant at time t and α_t is a $p \times 1$ vector of states (time-varying coefficients) at time t. Error term ε_t is serially independent and normally distributed with the error precision $h = \sigma_\varepsilon^{-2}$, where σ_ε^2 is a constant variance of ε_t. Analogous assumptions are adopted with respect to a $p \times 1$ vector of error terms η_t in state equations: they are serially independent and normally distributed and a $p \times p$ precision matrix H is diagonal with $h\lambda_i^{-1}$ on the main diagonal ($i = 0, \dots, p - 1$). Finally, it is assumed that ε_t and η_t are independent of each other at all time points.[10]

The model is estimated under the Bayesian approach. Therefore, first the priors for all coefficients are defined and then – using Bayes' rule – their posteriors need to be derived. The detailed description of the Bayesian approach to state space modelling, which this section draws on, can be found in Koop (2006).[11]

Gamma prior is chosen for precision parameters h and H. The latter is a diagonal matrix, so it is enough to adopt gamma priors for λ_i^{-1} instead of a more general Wishart prior for H. Thus

$$h \sim G\left(\underline{s}^{-2}, \underline{v}\right) \tag{11}$$

$$\lambda_i^{-1} \sim G\left(\underline{\lambda}_i^{-1}, \underline{v}_i\right) \quad \text{for} \quad i = 0, \dots, p - 1 \tag{12}$$

where hyperparameters $\underline{s}^2 = 0.01, \underline{v} = 1, \underline{\lambda}_i = 1, \underline{v}_i = 1$. Priors are relatively noninformative: degrees of freedom $\underline{v}$ and $\underline{v}_i$ are set to one, so priors contain the same information as one data point. Moreover, since data are rates of change, $\underline{s}^2 = 0.01$ implies that 95% of the errors are less than 20%.

The state equations (10b) provide a hierarchical prior for states α which can formally be written as

$$p(\alpha|H) = \prod_{t=1}^{T} p(\alpha_t|\alpha_{t-1}, H) \tag{13}$$

where for $t = 1, \dots, T - 1$

$$\alpha_{t+1}|\alpha_t, H \sim N(\alpha_t, H) \tag{14}$$

and $\alpha_0 = 0$, so $\alpha_1|H \sim N(0, H)$.

---

[10] For a detailed description of state space models see Durbin and Koopman (2003).

[11] See also Koop and Korobilis (2010) for the treatment of a multivariate case.

The posterior conditional distributions are derived in Koop (2006). The conditional posterior for h takes the form

$$h|y, \alpha_1, \dots, \alpha_T \sim G\left(\overline{s}^{-2}, \overline{\nu}\right) \tag{15}$$

where

$$\overline{\nu} = T + \underline{\nu} \tag{16}$$

$$\overline{s}^2 = \frac{1}{\overline{\nu}}\left[\sum_{t=1}^{T}(y_t - Z_t\alpha_t)^2 + \underline{\nu}\underline{s}^2\right] \tag{17}$$

Conditional posterior for H simplifies to

$$\lambda_i^{-1}|y, h, \alpha_1, \dots, \alpha_T \sim G\left(\overline{\lambda}_i^{-1}, \overline{\nu}_i\right) \tag{18}$$

for $i = 0, \dots, p-1$ where

$$\overline{\nu}_i = T + \underline{\nu}_i \tag{19}$$

$$\overline{\lambda}_i = \frac{1}{\overline{\nu}_i}\left[h\sum_{t=0}^{T-1}(\alpha_{i,t+1} - \alpha_{i,t})(\alpha_{i,t+1} - \alpha_{i,t})' + \underline{\nu}_i\underline{\lambda}_i\right] \tag{20}$$

Conditional posterior of states $p(\alpha_1, \dots, \alpha_T|y, h, H)$ is a multivariate normal distribution. As explained by Koop (2006, p. 197) it can be, however, hard to draw from such a distribution in practice as it is T-dimensional and its elements can be highly correlated with one another. Thus, following Koop's recommendation an algorithm developed by de Jong and Shephard (1995) is applied to obtain draws from the posterior of states α conditional on y, h and H.

The Gibbs sampler with data augmentation is used in Bayesian computation It sequentially draws from conditionals defined in (15), (18) and de Jong and Shephard's algorithm provides draws from the errors in state equations which are transformed into draws of α using equation (10b) and initial condition $\alpha_0 = 0$. The number of draws is set at 22,000 with 2,000 burn-in draws. Computation is carried out with a Matlab code developed by Koop (2006).[12] Some minor modifications have been introduced into the code to adjust it to the data used.

---

[12] The code is available at Gary Koop's website (https://sites.google.com/site/garykoop/).

Identification of interest income

The actively managed component of FX reserves needs to be recovered from the estimates of $\alpha_{0,t} = \sum_{i=1}^{4} u_{it-1} g_{it}$ obtained in the first step. The rate of change of active component from equation (6) is

$$\hat{g}_t^{AC} = \hat{\alpha}_{0,t} - \hat{\imath}_t \tag{21}$$

where $\hat{\imath}_t$ is the estimate of yield on foreign assets held by monetary authority. Ideally, the interest income should be calculated as a sum of interests accruals from all assets held in FX reserves. Unfortunately, such data are not available.

At this point one is faced with a trade-off between precision of estimates of active component of FX reserves and their time coverage. DHI (2012) prefer precision: they decide to use two sets of information: (i) the shares of reserves held in securities and in currency and deposits (the SDDS Reserve Template data) and (ii) the aggregate data on currency denomination of these assets (the COFER data). Our choice is time coverage of estimates. Thus, due to limited data availability, it is not possible to rely on the SDDS Reserve Template data. The simplifying assumption is adopted that interest earnings on FX reserves are equal to 10-year government bond yields

$$\hat{\imath}_t = \sum_{i=1}^{4} \hat{u}_{it-1} i_{it} \tag{22}$$

where $\hat{u}_{it-1}$ are calculated from the COFER data as shares of claims in U.S. dollars, euros, Japanese yen and pounds sterling in allocated FX reserves.

Admittedly, in this step we neglect – unlike DHI (2012) – the distinction between securities and currency and deposits. We do not, however, consider this a serious disadvantage in comparison with the DHI approach. The point is that the currency composition of FX reserves, no matter whether they are held in securities or currency and deposits, is approximated with aggregate information from the COFER dataset under both approaches. Thus, the precision gained under the DHI approach from the decomposition of reserves into securities and currency and deposits can be illusory: it can be more than offset by coarse information on the currency denomination of assets.[13] Less importantly, the share of currency and deposits in FX reserves

---

[13] For example, it can be demonstrated that if the interest income is underestimated under both approaches, the estimate obtained under our approach will be closer to the true income. The opposite holds for the case in which the interest income is overestimated under both approaches.

is usually much smaller than the share of securities. For example, the average share of currency and deposits in four large emerging market economies Brazil, China, India and Russia in 2000-2017 was 18.5%, 0.6%, 43.2%, 22.4%, respectively.

Identification of actively managed component of FX reserves

The third step is trivial. The estimated interest income is stripped out of the rate of change obtained in the first step (see equation (21)). The resulting rate of change of active component of FX reserves $\hat{g}_t^{AC}$ is then used in equation (7) along with the FX reserves at the end of period $t-1$. In this way the active component of FX reserves is obtained.

Following DHI (2012) the accumulated change in actively managed component of FX reserves is also reported. Such a change, being the effects of intentional actions of monetary authorities, can be used as a measure of willingness of monetary authorities to accumulate reserves.

Data

Empirical analysis is carried out for 20 countries: Argentina, Bulgaria, Chile, Brazil, China, Croatia, the Czech Republic, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Mexico, the Philippines, Poland, Romania, Russia, South Africa, Turkey. In general, the sample spans January 1994 to March 2018.

Data are retrieved from five main sources: International Financial Statistics (IFS) dataset, Eurostat database, Currency Composition of Official Foreign Exchange Reserves (COFER) database, Special Data Dissemination Standard (SDDS) Reserve Template data, Balance of Payments and International Investment Position Statistics (BOP/IIPS) database. A detailed list of variables and data sources is in Table 1.

Table 1. List of variables and data sources

Variable	Description	Source
FX reserves	International liquidity, total reserves excluding gold, foreign exchange, U.S. dollars, monthly data	IFS
exchange rate	Exchange rate, U.S. dollar per domestic currency, end of period, monthly data	IFS
currency shares in FX reserves	COFER data on shares of claims in U.S. dollars, euros, Japanese yens and British pounds sterling in foreign exchange reserves, quarterly data 1999-2018 and annual data 1995-1998	COFER
long-term interest rate	Government bond yields, 10 years' maturity, monthly data	Eurostat
short-term interest rate	Money market interest rates, monthly data	Eurostat
foreign currency reserves	Foreign currency reserves (in convertible foreign currency), monthly data	SDDS Reserve Template
securities	Foreign currency reserves held as securities, monthly data	SDDS Reserve Template
currency and deposits	Foreign currency reserves held as total currency and deposits, monthly data	SDDS Reserve Template
total reserves	Total reserves, U.S. dollars (gold at market price), quarterly data	IFS
reserve assets from BOP	Balance of Payments, supplementary items, reserves and related items, U.S. dollars, quarterly data	BOP/IIPS
FX market interventions	Sales or purchases of foreign currency against CZK effected by the CNB, monthly data	Czech National Bank's website

5. Empirical results

The actively managed component of FX reserves is by definition different from actual changes in FX reserves unless changes in the passive component are all the time zero which is unlikely. Therefore, the actual changes in FX reserves cannot be used to assess the goodness of estimates of the active component of FX reserves. We use two benchmarks to assess whether our estimates are reasonable approximation of actions taken by monetary authorities with respect to FX reserves. First, it is possible to use the estimates from the DHI approach as a benchmark. This is because their approach is based on high quality data, albeit their availability is limited. Thus, the estimates obtained under both approaches are compared. Second, the data on FX market interventions of the Czech National Bank are used as a benchmark to assess the

goodness of estimates of the active component of FX reserves in the Czech Republic under both the DHI and new approaches.

Comparative analysis

The estimates of the active component of FX reserves are depicted on the left-had side panels in Figure 2. These are estimates just for three large emerging market economies, Brazil, China and India.[14] The active component is illustrated with bars and the accumulated changes in that component with a broken line. All estimates are in billions of U.S. dollars. The interpretation is straightforward. For example, an active component of FX reserves in Brazil, the first country in Figure 2, was close to zero till the end of 2005, substantially positive in 2006-2011 except for the global financial crisis in 2008-2009 and again close to zero in post-2011 period. The assumption that the accumulated changes start from the zero level in the end of 1994 is a normalizing assumption.

On the right-hand side panels in Figure 2 the estimates obtained under the DHI approach are presented. The general pattern of both series of estimates is quite similar to those on the left-hand side panels. So, for instance, the same period of fast reserves accumulation in Brazil is observed in 2006-2011 with an interruption in autumn 2008 and spring 2009. At first sight, it may appear that the evolution of an active component of reserves under two approaches is dissimilar in India and especially in China. This, however, is not the case. The differences are only apparent and are the outcome of differences in the timespan for which the estimates are available. To put it differently, they are related to the normalizing assumption. Estimates for India under the DHI approach are available starting in 2008q1, whereas the estimates obtained under new approach start in 1995q1. Accordingly, the normalizing assumption under the former approach is that accumulated changes in active component of FX reserves is zero at the end of 2007 whereas under the latter approach they are set to zero at the end of 1994. Thus, if the relevant segments of these estimates are compared the similarities can easily be observed. The same line of reasoning is a bit more difficult to follow for China, because due to a limited availability of data required under the DHI approach it can hardly be applied to that country. Nevertheless, the sharp decrease in the accumulated changes of an active component of FX reserves in 2016 and its levelling-off in 2017 can be observed irrespective of the approach

---

[14] The estimates obtained under the new approach for the whole sample of 20 countries are reported in the Appendix B.

employed.
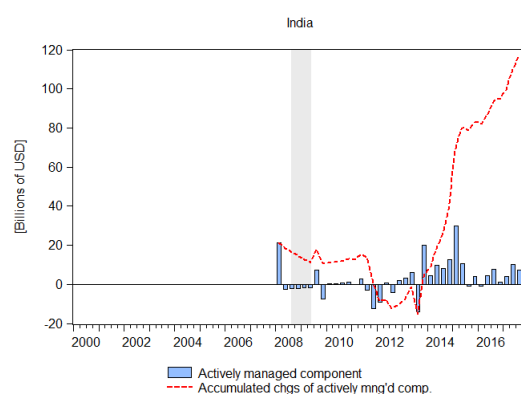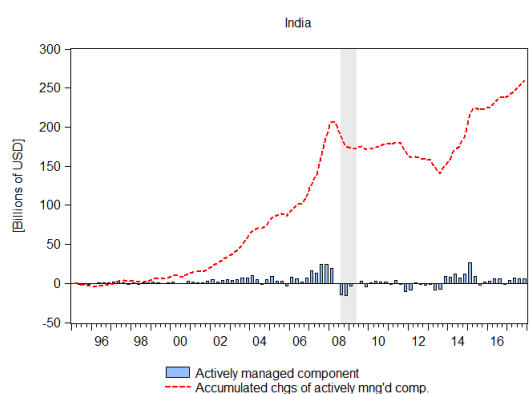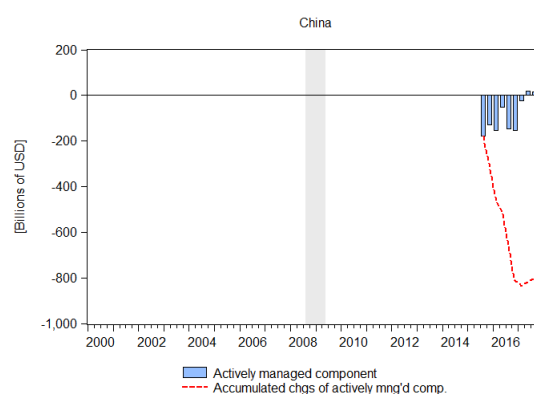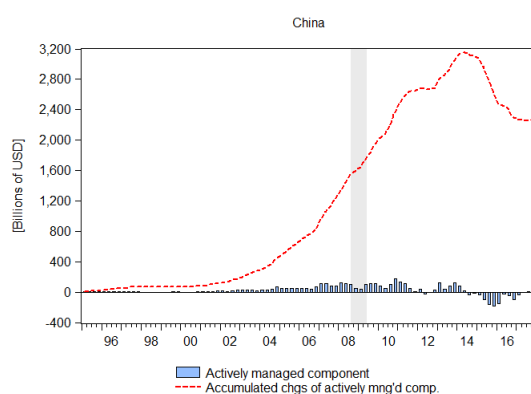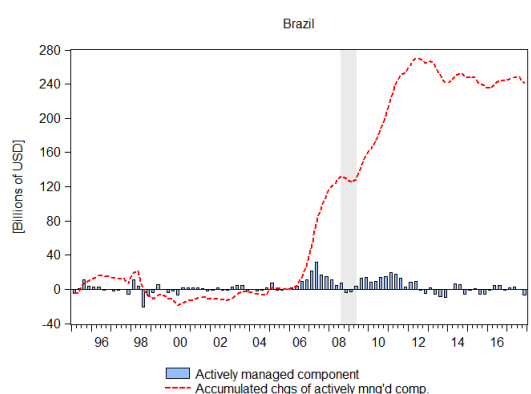
(a) New approach   (b) DHI approach

Figure 2. Estimates of active component of FX reserves in Brazil, and India under new and DHI approaches, 1995-2017

In order to make comparisons easier the estimates of the actively managed component of FX reserves in Brazil, China and India obtained under both approaches are depicted in Figure 3.[15] The direct comparison reveals that there are some differences between estimates, but they are quite small. Not only do the turning points in the estimates coincide to a great extent, but also the magnitudes of the active component of FX reserves identified with both approaches are almost the same.
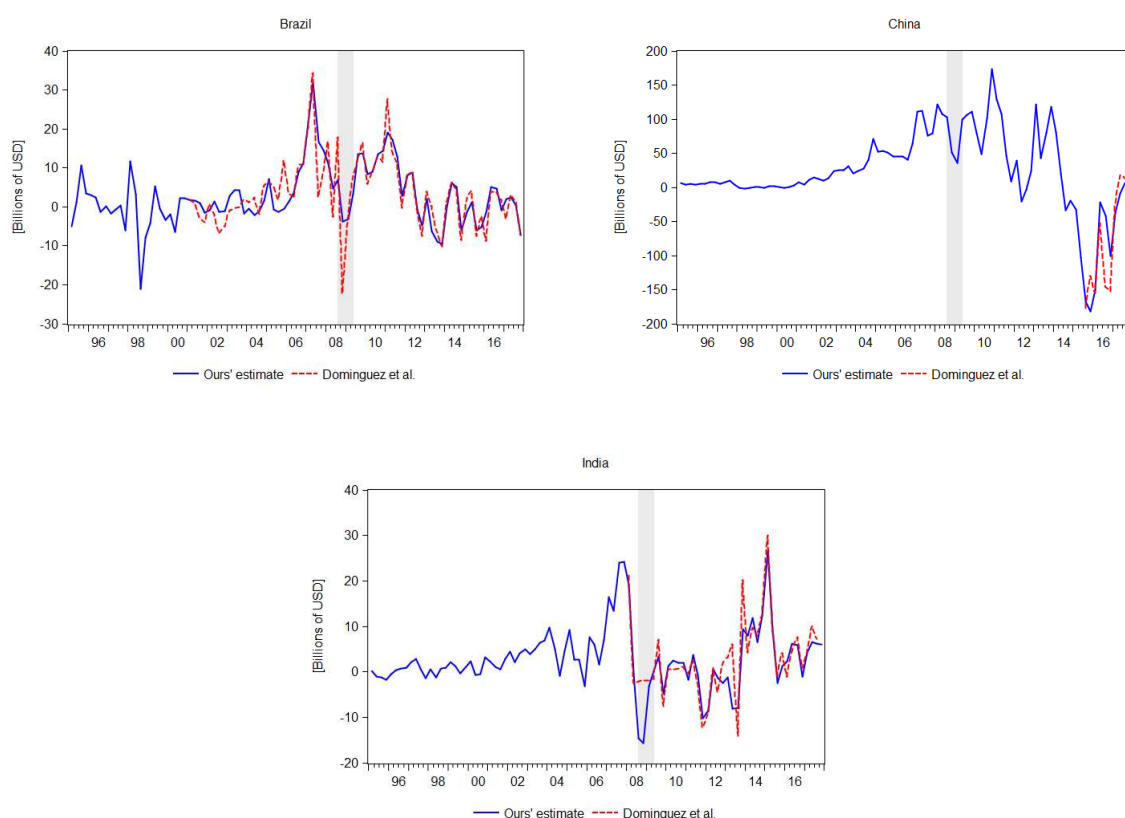
Figure 3. Actively managed component of FX in Brazil, China and India under the new and DHI approaches

The correlation coefficients between the estimates obtained under both approacheds are depicted in Table 2. All of them are positive and highly statistically significant. Correlation coefficients for Argentina, Croatia, Hong Kong, Malaysia, Poland and Russia are a bit smaller, i.e. not greater than 0.8, than for the remaining countries. A weaker correlation for these six

---

[15] The results for the whole sample of 20 countries are reported in the Appendix B.

countries is not, in fact, puzzling. The likely reason behind this observation is that DHI (2012) focus exclusively on foreign currency reserves, whereas the new approach includes also data on non-currency reserves (except for gold), especially other reserve assets that can be managed. The difference between two series has already been discussed in Section 2 (see also Figure 1 and Figure A1 in the Appendix A).

Table 2. Correlations between actively managed components of FX reserves identified with the DHI and new approaches

Country	Correlation	Country	Correlation
Argentina	0.60***	Japan	0.94***
Brazil	0.85***	Korea	0.90***
Bulgaria	0.87***	Malaysia	0.80***
Chile	0.88***	Mexico	0.91***
China	0.84***	The Philippines	0.89***
Croatia	0.48***	Poland	0.72***
The Czech Republic	0.94***	Romania	0.47***
Hong Kong	0.72***	Russia	0.70***
India	0.85***	South Africa	0.81***
Indonesia	0.91***	Turkey	0.85***

*** significant at 1% level.

The findings on correlations together with the results of graphical exposition of the estimates lend strong support to the claim that the new approach provides estimates that are very close to those obtained under the DHI approach. At the same time the main drawback of the DHI approach is mitigated: the timespan of new estimates is not constrained by limited data availability.

Case study: FX market interventions of the Czech National Bank

The arguments in support of the new approach to estimation of the active component of FX reserves that are derived from the comparative analysis can be brought into question by a claim that both approaches are wrong. In other words, the counterargument could be that the use of

estimates obtained under the DHI approach as a benchmark is ill-founded. As such it is the argument against the DHI approach rather than the new approach. Obviously, given the lack of official data on active component of FX reserves, it is not possible to run an appropriate empirical test. Fortunately, it is possible to use data published by few central banks on their FX market interventions. Such data are published by the Czech National Bank (CNB) on a monthly basis. These can be used as a benchmark for the assessment of the goodness of estimates of an active component of FX reserves in the Czech Republic.

The focus on the Czech Republic is useful because of an additional reason: the explicit use of the exchange rate in monetary policy. In November 2013 the CNB decided to 'start to use the exchange rate of the koruna as an instrument for easing monetary policy' and to 'prevent excessive appreciation of the koruna below CZK 27/EUR' (CNB, 2014, p. 51). The decision was motivated by the fact that key interest rates were at their lower bound on the one hand and by the threat of deflation and a need to facilitate a faster economic recovery and a faster return of inflation to the target on the other hand (CNB, 2014, p. 7). The commitment quickly became credible and after initial FX market interventions in November 2013 the CNB did not have to intervene till summer 2015. Since that time the CNB intervened to suppress tendency to appreciation of the koruna that was related to 'quantitative easing by the ECB and continued favourable developments in the domestic economy' (CNB, 2017, p. 10). The period of the one-sided exchange rate commitment ended in April 2017, i.e. after 42 months. The direct reason to exit the commitment was that 'the conditions for sustainable fulfilment of the 2% inflation target in the future had been met' so 'continuation of the exchange rate commitment was no longer needed to fulfil the CNB's primary objective of price stability' (CNB, 2017, p. 12).[16]

Following actual changes in the way monetary policy was run in the Czech Republic two 42-month periods are distinguished: (1) the period without traditional FX market interventions, May 2010 – October 2013, and (2) the exchange rate commitment period with a floor of 27 korunas per euro, November 2013 – April 2017. Changes in FX reserves along with the data on FX market interventions are illustrated in Figure 4. It can be observed that data on plain changes in FX reserves (black bars) are a very poor proxy of FX interventions (green bars) in period (1) and very good in period (2) (see left- and right-hand side panel in Figure 4,

---

[16] See, for example, Caselli (2017) and Alichi et al. (2015) for a more thorough discussion of changes in monetary policy in the Czech Republic. The CNB's pre-2013 experience with FX market interventions is described in, i.a., Lízal and Schwarz (2013) and Geršl and Holub (2006).

respectively). This is hardly surprising: in period (1) changes in FX reserves are mainly driven by the passive component, whereas in period (2) by the active component.

(a) May 2010 – October 2013   (b) November 2013 – April 2017
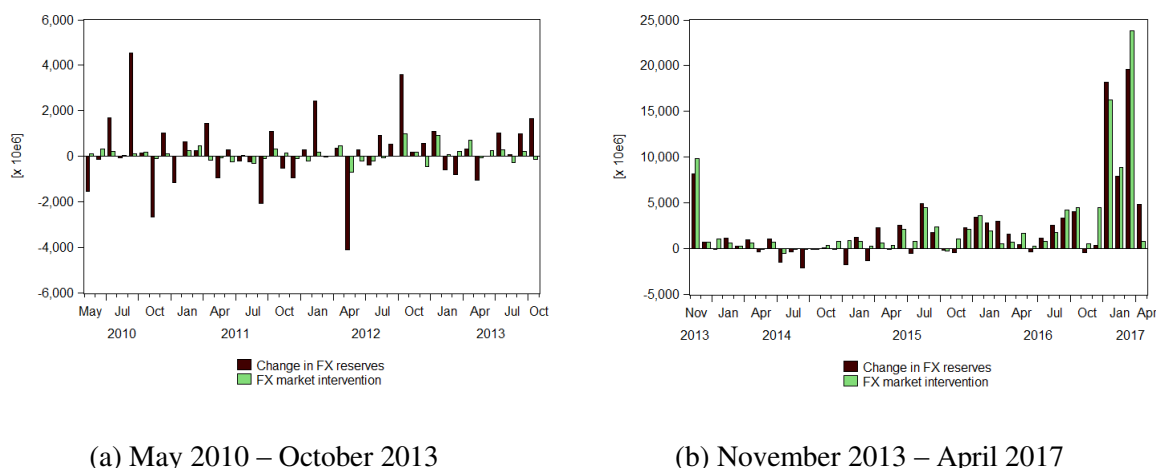
Figure 4. Foreign exchange reserves and interventions in the Czech Republic, 2010-2017
Source: own calculations based on data from the IMF and CNB.

The natural question is whether the estimates of actively managed component of FX reserves do better than plain changes in FX reserves. To answer this question deviations of changes in FX reserves and actively managed component of FX reserves from FX market interventions are depicted in Figure 5 with black and blue bars, respectively. Undoubtedly, the estimates of the active component of FX reserves are much closer to FX interventions than changes in the FX reserves in period (1). In period (2), however, the picture is less clear-cut.

In order to cast more light on the usefulness of the estimates of active component of FX reserves the basic statistics of deviations from the FX market interventions are reported in Table 3. The conclusion drawn from Figure 5 with respect to period (1) is confirmed by statistics presented in the upper part of Table 3: mean, standard deviation and root mean square error (RMSE) are all smaller for the active component of FX reserves than for changes in FX reserves. The same finding holds for period (2) if mean measures are used, but the opposite is true if variability measures are used instead (the middle part of Table 3). One should not, however, draw a premature conclusion that the active component of FX reserves is an inferior measure of FX interventions in period (2).
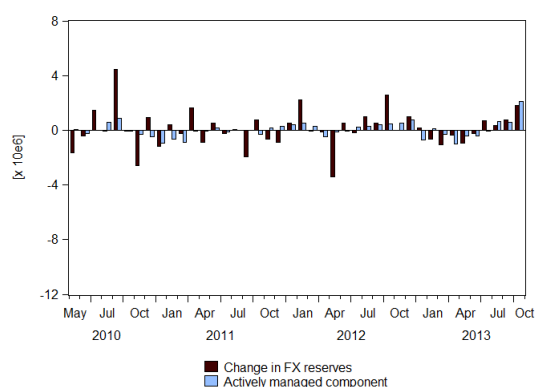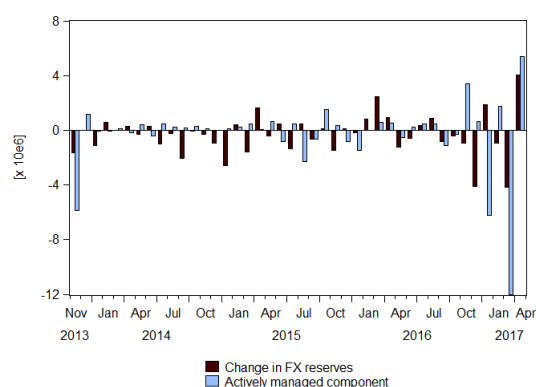
(a) May 2010 – October 2013　　　　　　　　(b) November 2013 – April 2017

Figure 5. Deviations of total FX reserves and estimates of active component of FX reserves from FX interventions in the Czech Republic, 2010-2017 (monthly)

Source: own calculations based on data from the IMF and CNB.

A closer look at FX market interventions makes it possible to identify four data-points that can be considered (far) outliers. These are FX interventions in November 2013 and the first three months of 2017. Interventions in these months totalled 9.8, 16.2, 8.9 and 23.8 billion of U.S. dollars, respectively, which is much greater than either the average (USD 2.5 bn) or the median (USD 0.8 bn) for the whole period (for a boxplot and empirical quantiles of FX market intervention see Figure A2 in the Appendix A). If these four outlying data-points are removed from the sample then the active component of FX reserves is at least as good proxy for FX market interventions as the plain changes in FX reserves (the lower part of Table 3).

In the previous subsection estimates obtained under the new approach are compared with those from the DHI approach. It seems worthwhile to extend such a comparison on the case of FX market interventions in the Czech Republic. The easiest way to do it would be to include in Table 3 the relevant statistics for the estimates obtained under the DHI approach. Unfortunately, this is not possible since estimates from the DHI approach are on quarterly basis only. It is, however, perfectly possible to use quarterly frequency for all the data. The basic statistics for deviations of FX reserves and estimates of active component of FX reserves identified with the DHI and new approaches from the FX market interventions are reported in Table 4.

Table 3. Deviations from the FX market interventions in the Czech Republic – basic statistics
(monthly data)

Variable	Mean	Median	St. deviation	RMSE
May 2010 – October 2013				
Change in FX reserves	107.1	-19.3	1,363.6	1,351.5
Our estimate	38.7	-24.9	564.0	558.6
November 2013 – April 2017				
Change in FX reserves	-323.0	-259.2	1,489.5	1,506.6
Our estimate	-304.8	147.3	2,595.7	2,582.6
December 2013 – December 2016 and April 2017				
Change in FX reserves	-226.6	-211.0	1,360.4	1,361.4
Our estimate	253.7	186.5	1,226.8	1,236.9

Note: RMSE is a root mean square error calculated as $\sqrt{\frac{1}{T}\sum_{t=1}^{T}(x_t - FXI_t)^2}$, where FXI_t stands for the FX market interventions and x_t is either a change in FX reserves or an active component of FX reserves.

The main findings are similar to those drawn from statistics reported in Table 3. In period (1) estimates of active component of FX reserves, irrespective of the approach employed, are much better than plain changes in FX reserves (the upper part of Table 4 and the left-hand side panel in Figure A3 in the Appendix A). Moreover, one can argue that the new approach is marginally better than the DHI approach. The ranking is reversed in period (2), at least if the variability measures are used (the middle part of Table 4 and the right-hand side panel in Figure A3 in the Appendix A). None of the two estimates of active component of FX reserves is better than plain changes in FX reserves. If, however, outlying observations are removed, then the estimates from the new approach are the best approximation of the FX market interventions (the lower part of Table 4).

Table 4. Deviations from the FX market interventions in the Czech Republic – basic statistics
  (quarterly data)

Variable	Mean	Median	St. deviation	RMSE
2010q2 – 2013q3				
Change in FX reserves	154.9	-880.6	2,638.5	2,547.2
DHI's estimate	-258.1	-335.5	1,245.8	1,227.9
Our estimate	-45.6	-36.0	1,258.1	1,213.2
2013q4 – 2017q1				
Change in FX reserves	-1,127.9	-1,080.8	2,270.6	2,461.6
DHI's estimate	-997.7	-486.7	3,359.9	3,387.9
Our estimate	-1,148.6	-77.8	4,694.6	4,667.4
2014q1 – 2016q4				
Change in FX reserves	-1,051.2	-1,080.8	2,351.0	2,484.3
DHI's estimate	-26.5	-14.5	1,911.9	1,830.7
Our estimate	261.1	94.0	1,439.4	1,402.6

Note: RMSE is a root mean square error calculated as $\sqrt{\frac{1}{T}\sum_{t=1}^{T}(x_t - FXI_t)^2}$, where FXI_t stands for the FX market interventions and x_t is either a change in FX reserves or an active component of FX reserves (under the DHI approach or new approach).

Overall, the Czech case lends support to the conclusion that the estimates of active component of FX reserves obtained under the new approach are superior to plain changes in FX reserves as a measure of intentional actions undertaken by monetary authority in periods when this activity is normal. The estimates become less informative when the central bank undertakes isolated actions that are highly abnormal, i.e. deviate substantially and abruptly from the central bank's previous behaviour. Importantly, the new approach provides no worse estimates of active component of FX reserves as the DHI approach.

6. Conclusions

Interpretation of data on FX reserves is not an easy task because of various sources of reserve changes. Better understanding of factors behind changes in FX reserves can be useful in

alleviating tensions in international trade that are related to accusations of currency manipulation. As explained by Blanchard and Milesi-Ferretti (2012) finding out that a country runs a deliberate strategy designed to gain competitive advantage requires '[p]roving intent […which] is likely to be difficult' and '[i]gnoring intent may be politically unacceptable.' Estimates of active component of FX reserves can be used to build more complete picture of strategies adopted by trading partners. Moreover, such data are much more relevant in other contexts as well, for instance if the role of FX reserves in crisis management is to be assessed or the *de facto* exchange rate regimes are to be identified.

The new approach to estimation of active component of FX reserves is developed in this paper. Estimates are obtained from a three-step procedure: (1) the time-varying coefficient model of FX reserves is estimated (with Bayesian techniques); (2) interest earnings on FX reserves are identified; and (3) actively managed component of FX reserves is disentangled from interest income.

It is demonstrated that the new approach has three important advantages over the existing approach that was developed by DHI (2012). First, the DHI approach is heavily constrained by limited data availability, especially those reported under the SDDS. For this reason it can hardly be applied to such reserve holders as China or India. The new approach is less data-demanding as it employs econometric techniques to recover actively managed component of reserves from the aggregate data on FX reserves and exchange rate changes. Thus, the estimates are obtained for the period starting as early as in 1995, irrespective of the date of meeting the SDDS requirements. Interestingly, in spite of substantial methodological differences between the new and DHI approaches, the estimates of active component of FX reserves obtained under both approaches are quite similar and strongly correlated. Second, the new approach uses information on all actively managed components of FX reserves (including other reserve assets), whereas the DHI approach is focused on currency reserves only. This difference is a likely reason behind a relatively weaker correlation of estimates obtained under both approaches for some countries, e.g. Argentina or Croatia. Third, the new approach can be employed to obtain estimates of active component of FX on both monthly and quarterly basis, whereas the DHI approach provides estimates on quarterly basis only.

A case study of the FX market interventions of the Czech National Bank indicates that plain changes in FX reserves are poor approximation of active component of reserves unless monetary authority undertakes abnormal actions in which raw data on reserves are simply dominated by their active component. It is demonstrated that in periods of normal activity of

monetary authority estimates of active component of FX reserves obtained under the new approach are superior to both plain changes in reserves and are definitely not worse than analogous estimates from the DHI approach.

Overall, the new approach laid out in the paper can be useful in better understanding of changes in FX reserves and their importance to macroeconomic policy, especially at the times of crisis. With the set of new estimates of active component of FX reserves the role they play in crisis management can be re-examined. Such estimates can shed more light on this and other issues, like currency wars, exchange rate regime classifications. These are the promising topics for future research.

References

Aizenman, J., Cheung, Y.-W., & Ito, H. (2015). International reserves before and after the global crisis: Is there no end to hoarding?. *Journal of International Money and Finance*, 52, 102-126.

Aizenman, J., & Lee, J. (2007). International reserves: Precautionary versus mercantilist views, theory and evidence. *Open Economies Review*, 18, 191-214.

Aizenman, J., & Sun, Y. (2012). The financial crisis and sizable international reserves depletion: From 'fear of floating' to the 'fear of losing international reserves'?. *International Review of Economics and Finance*, 24, 250-269.

Alichi, A., Benes, J., Felman, J., Feng, I., Freedman, C., Laxton, D., Tanner, E., Vavra, D., & Wang, H. (2015). Adding the exchange rate as a tool to combat deflationary risks in the Czech Republic. IMF Working Paper, No. WP/15/74.

Bernanke, B. S. (2005). The Global Saving Glut and the U.S. Current Account Deficit. Speech from Board of Governors of the Federal Reserve System (U.S.), https://www.federalreserve.gov/boarddocs/speeches/2005/200503102/, access 14.02.2019.

Blanchard, O., & Milesi-Ferretti. G. M. (2012). (Why) Should current account balances be reduced?. *IMF Economic Review*, 60 (1), 139-150.

Bleaney, M. F., & Tian, M. (2017) Measuring exchange rate flexibility by regression methods, *Oxford Economic Papers*, 69 (1), 301-319.

Bussière, M., Cheng, G., Chinn, M. D., & Lisack, N. (2015). For a few dollars more: Reserves and growth in times of crises. *Journal of International Money and Finance*, 52, 127-145.

Calvo, G. A., & Reinhart, C. M. (2002), Fear of floating. *The Quarterly Journal of Economics*, 117 (2), 379-408.

Caselli, F. (2017). Did the exchange rate floor prevent deflation in the Czech Republic?. IMF Working Paper, No. WP/17/206.

Choi, W. J., & Taylor, A. M. (2017). Precaution versus mercantilism: Reserve accumulation, capital controls, and the real exchange rate. NBER Working Paper 23341.

CNB (2014). *Inflation Report I/2014*. Czech National Bank.

CNB (2017). *Inflation Report II/2017*. Czech National Bank.

Dąbrowski, M. A., Papież, M., & Śmiech, S. (2019). Classifying de facto exchange rate regimes of financially open and closed economies: A statistical approach. MPRA Paper No. 91348, https://mpra.ub.uni-muenchen.de/91348/1/MPRA_paper_91348.pdf, access 11.02.2019.

Dąbrowski, M. A., Śmiech, S., & Papież, M. (2015). Monetary policy options for mitigating the impact of the global financial crisis on emerging market economies. *Journal of*

International Money and Finance, 51, 409-431.

de Jong, P., & Shephard, N. (1995). The simulation smoother for time series models. *Biometrika*, 82 (2), 339-350.

Dominguez, K. M. E. (2012). Foreign reserve management during the global financial crisis. *Journal of International Money and Finance*, 31, 2017–2037.

Dominguez, K. M. E., Hashimoto, Y. & Ito, T. (2012). International reserves and the global financial crisis. *Journal of International Economics*, 88, 388-406.

Dominguez, K. M. E., Hashimoto, Y. & Ito, T. (2011). International reserves and the global financial crisis. NBER Working Paper, No. 17362.

Dooley, M., Folkerts-Landau, D., & Garber, P. (2004). The revived Bretton Woods system. *International Journal of Finance and Economics*, 9, 307-313.

Dooley, M., Folkerts-Landau, D., & Garber, P. (2009). Bretton Woods II still defines the international monetary system. *Pacific Economic Review*, 14(3), 297-311.

Durbin, J., & Koopman, S. J. (2003). *Time series analysis by state space methods*. Oxford, U.K.: Oxford University Press.

ECB (2006). The accumulation of foreign reserves. European Central Bank Occasional Paper Series, No. 43 (February).

Geršl, A., & Holub, T. (2006). Foreign exchange interventions under inflation targeting: the Czech experience. *Contemporary Economic Policy*, 24 (4), 475-491.

Gopalakrishnan, B., & Mohapatra, S. (2018). Turning over a golden leaf? Global liquidity and emerging market central banks' demand for gold after the financial crisis. *Journal of International Financial Markets, Institutions and Money*, 57, 94-109.

Feldstein, M. (1999). Self-protection for emerging market economies. NBER Working Paper, No. 6907.

Ilzetzki , E., Reinhart, C. M, & Rogoff, K. S. (2019). Exchange Arrangements Entering the 21ST Century: Which Anchor Will Hold?. *The Quarterly Journal of Economics*, 134(2), 599-646.

IMF (2013). *International reserves and foreign currency liquidity: guidelines for a data template*. Washington, D.C.: International Monetary Fund.

Koop, G. (2006). *Bayesian econometrics*. Chichester: Wiley.

Koop, G., & Korobilis, D. (2010). Bayesian multivariate time series methods for empirical macroeconomics. *Foundations and Trends in Econometrics*, 3 (4), 267-358.

Levy-Yeyati, E., & Sturzenegger, F. (2016). Classifying Exchange Rate Regimes: 15 Years

Later. CID Working Paper No. 319.

Levy-Yeyati, E., & Sturzenegger, F. (2005). Classifying exchange rate regimes: Deeds vs. words. *European Economic Review*, 49, 1603-635.

Levy-Yeyati, E., Sturzenegger, F., & Gluzmann, P. A. (2013). Fear of appreciation. *Journal of Development Economics*, 101, 233-247.

Lízal, L., & Schwarz, J. (2013). Foreign exchange interventions as an (un)conventional monetary policy tool: mid-term evaluation. BIS Working Papers, No. 73, 127-143.

Obstfeld, M. & Rogoff, K. (2009). Global imbalances and the financial crisis: products of common causes. In *Asia and the global financial crisis*. Conference Proceedings, Federal Reserve Bank of San Francisco, p. 131-172.

Reinhart, C. M., Reinhart, V., & Tashiro, T. (2016). Does reserve accumulation crowd out investment?. *Journal of International Money and Finance*, 63, 89-111.

Appendix A

Supplementary material
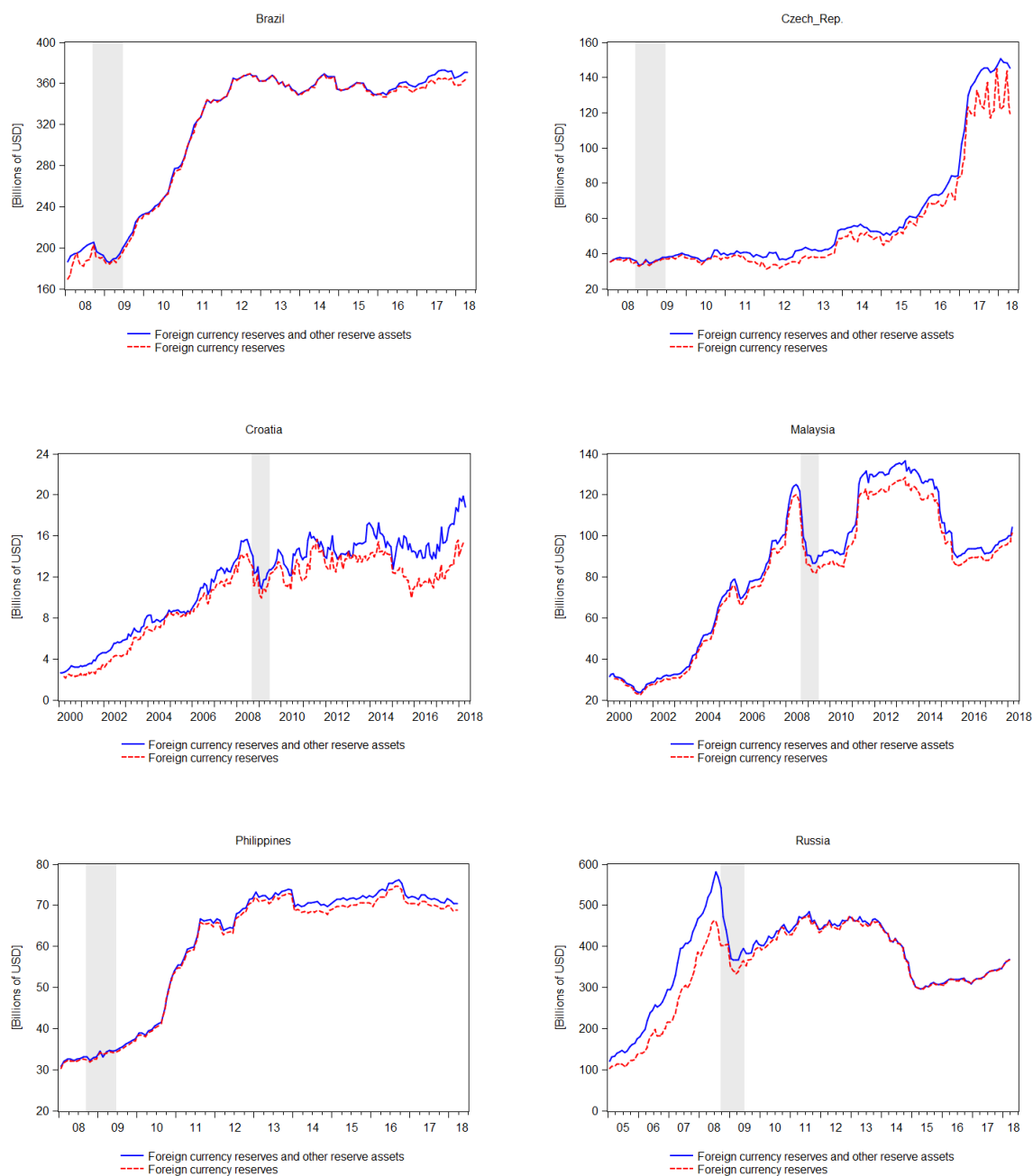
Figure A1. Foreign currency reserves and other currency reserves in Brazil, the Czech Republic, Croatia, Malaysia, the Philippines and Russia

(a) Boxplot

(b) Empirical quantiles
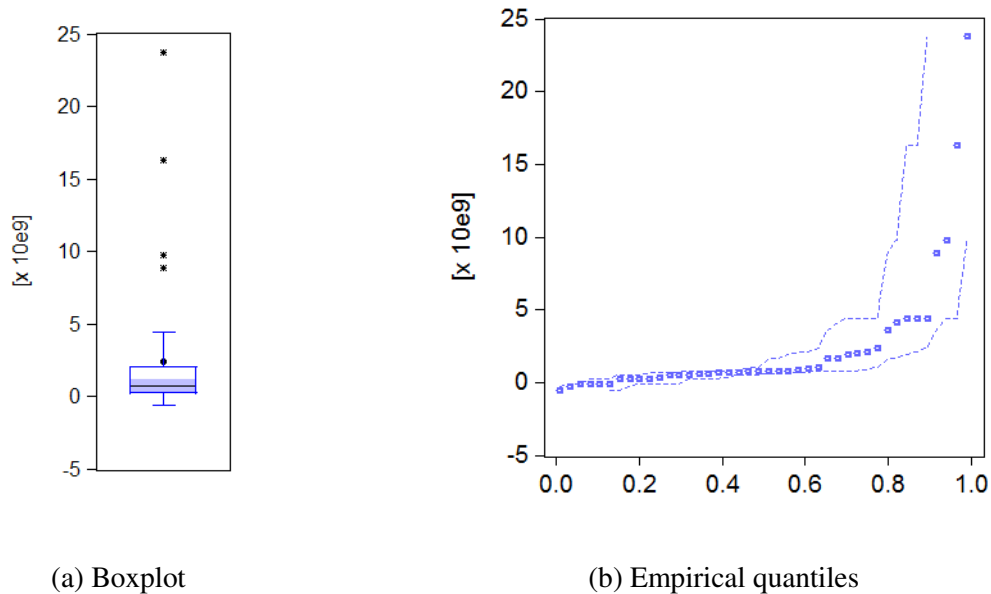
Figure A2. FX market interventions in November 2013 – April 2017

Note: An asterisk in panel (a) denotes a far outlier. It is an observation that is above the third quartile plus three times the difference between the third and first quartiles, i.e. above $QR_3 + 3(QR_3 - QR_1)$.

(a) May 2010 – October 2013

(b) November 2013 – April 2017
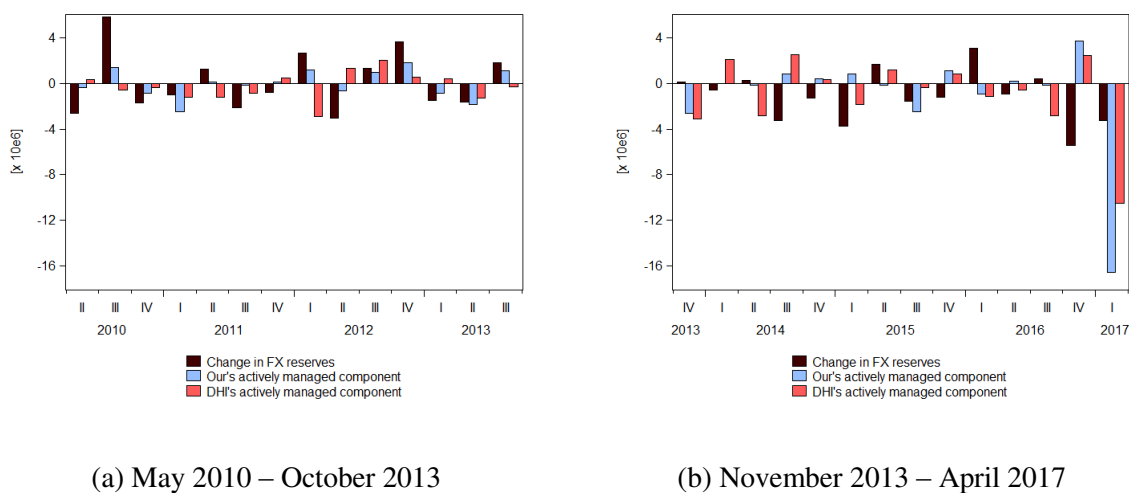
Figure A3. Foreign exchange reserves and interventions in the Czech Republic, 2010-2017 (quarterly)

Source: own calculations based on data from the IMF and CNB.

Appendix B

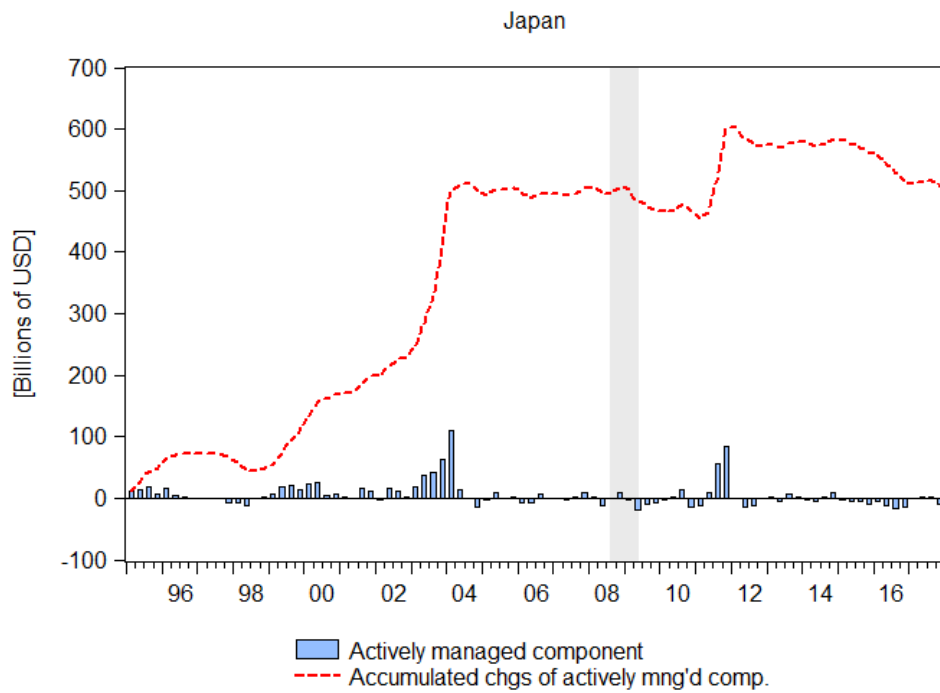**Detailed results on individual countries**
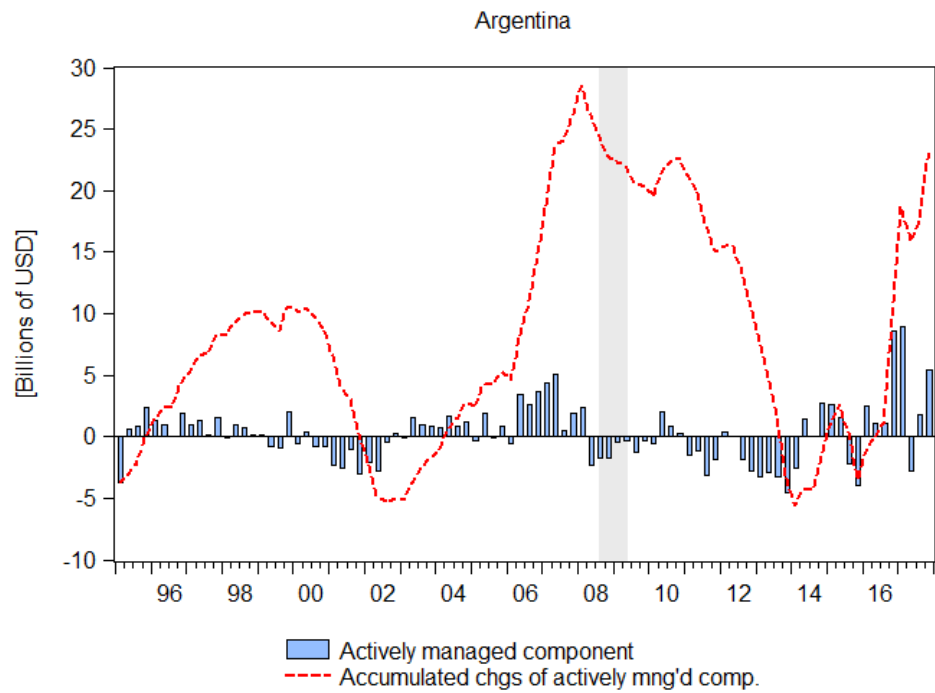
(a) Active component of FX reserves and its accumulated changes under new approach
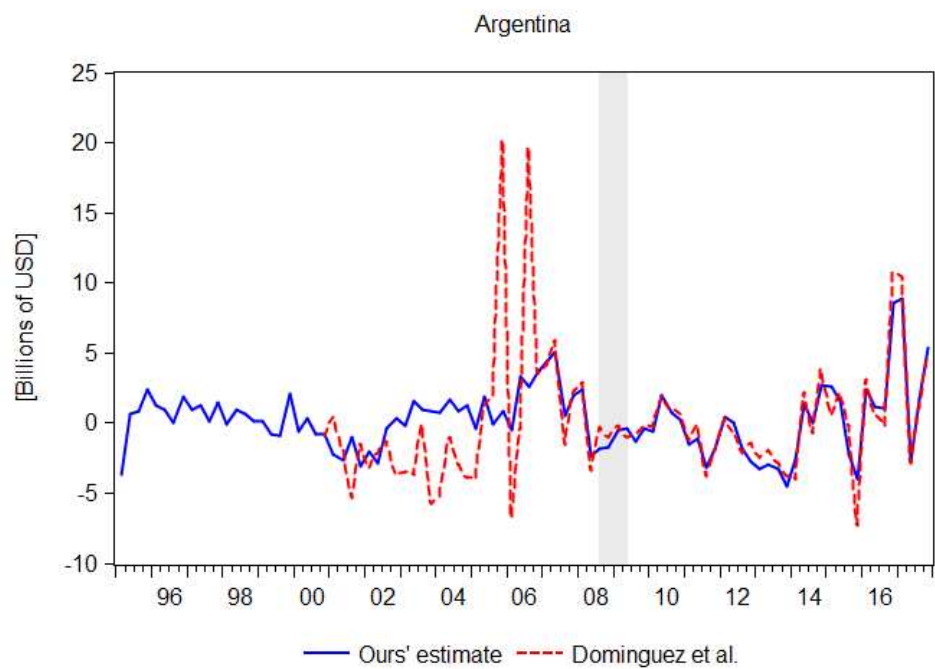
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B1. Estimates of active component of FX reserves in Argentina
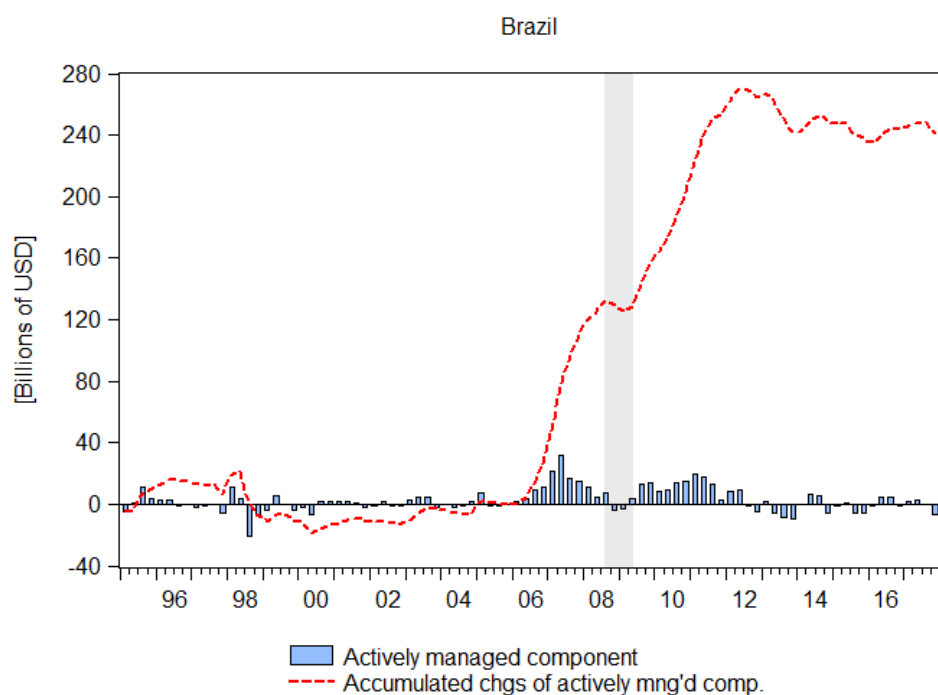
(a) Active component of FX reserves and its accumulated changes under new approach
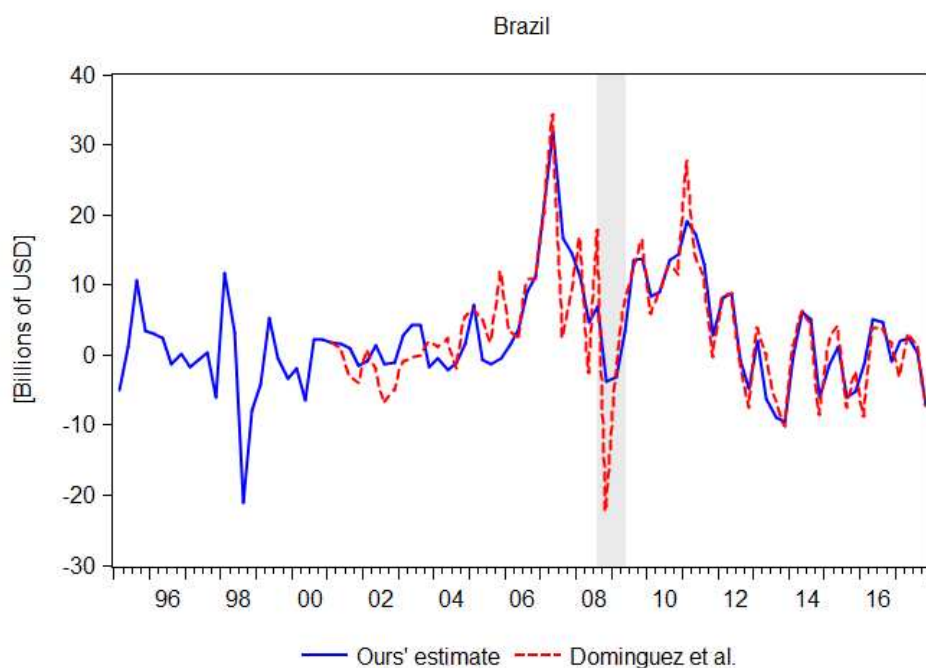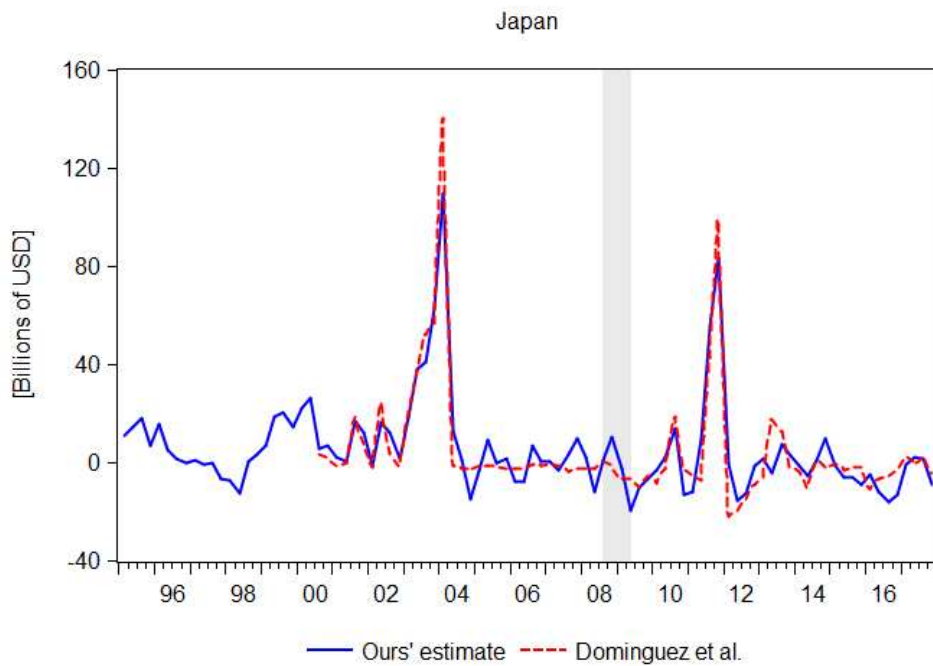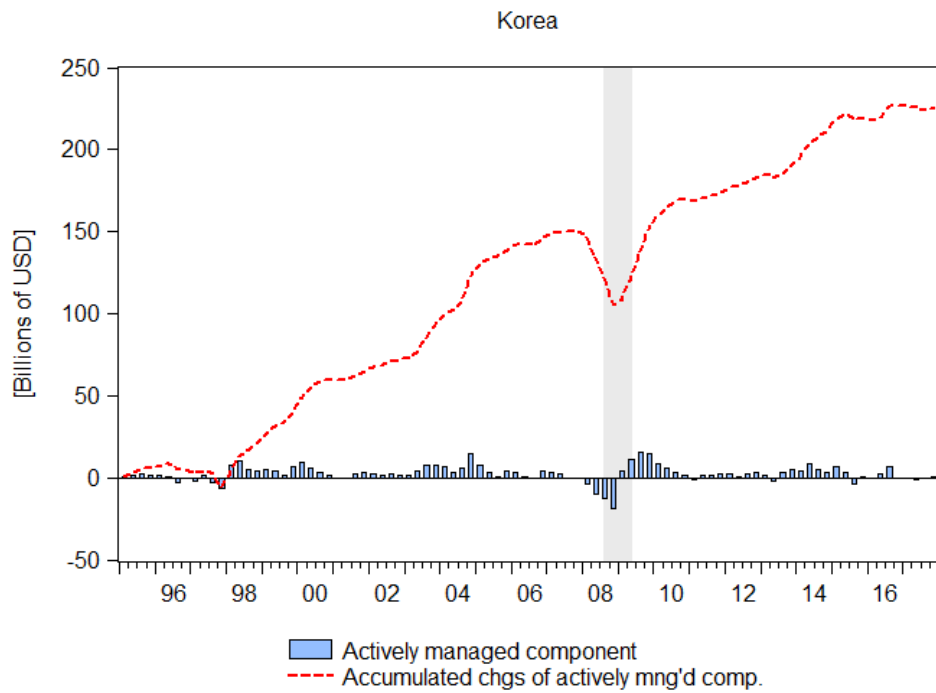

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B2. Estimates of active component of FX reserves in Brazil
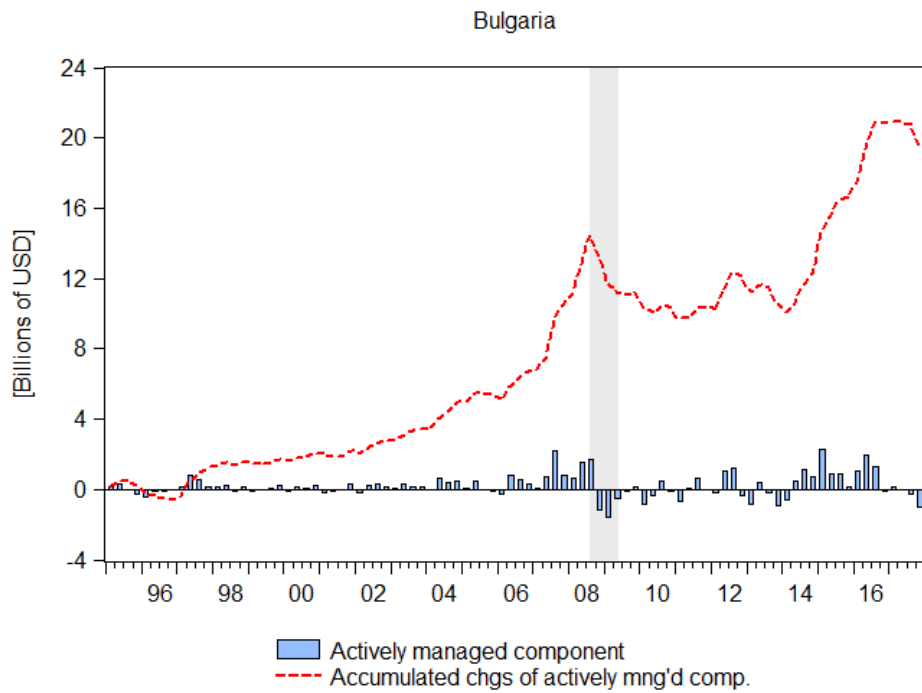
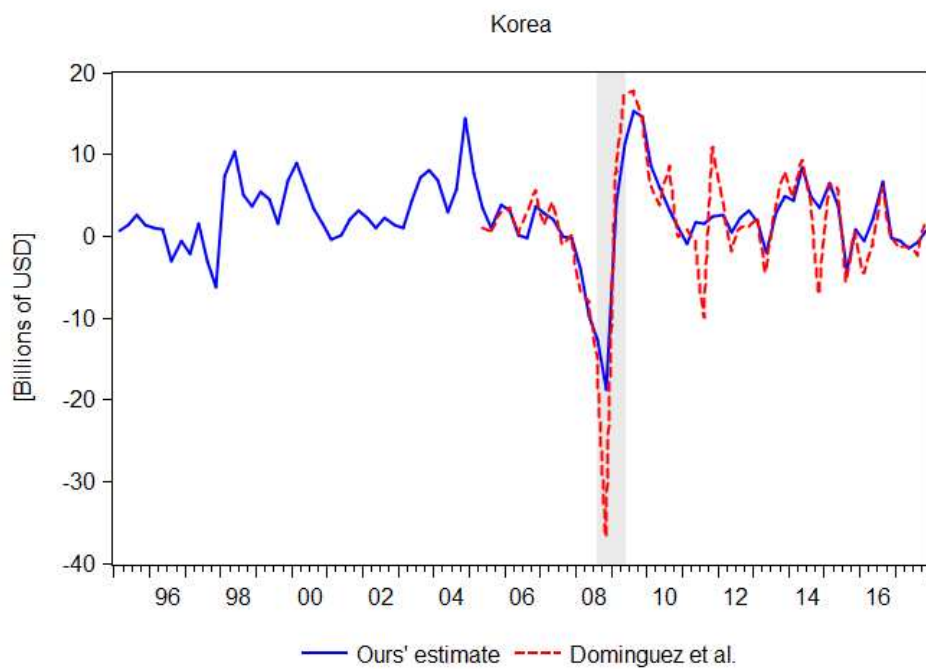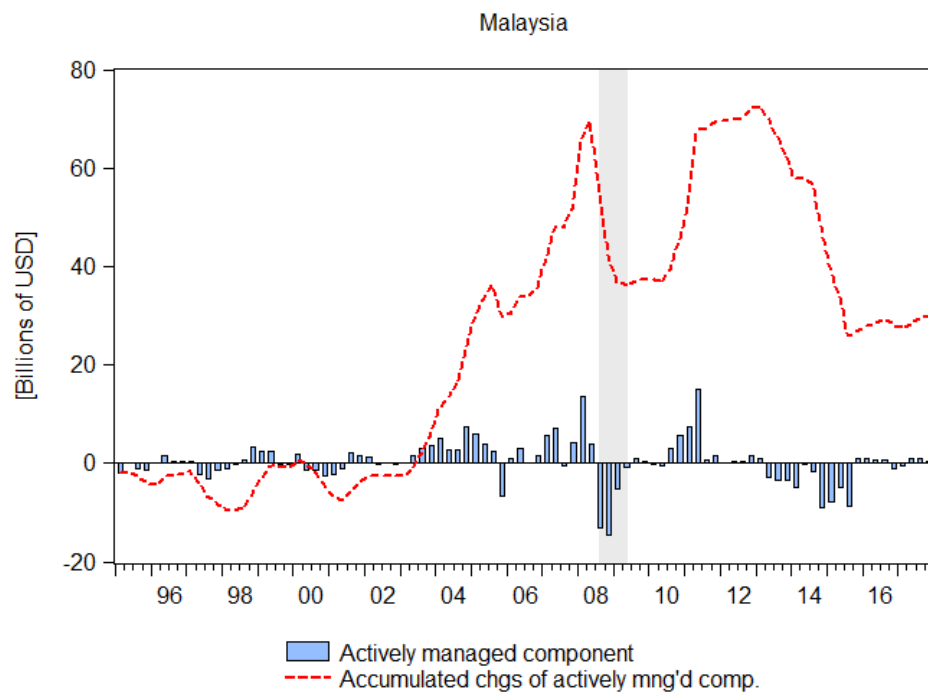(a) Active component of FX reserves and its accumulated changes under new approach
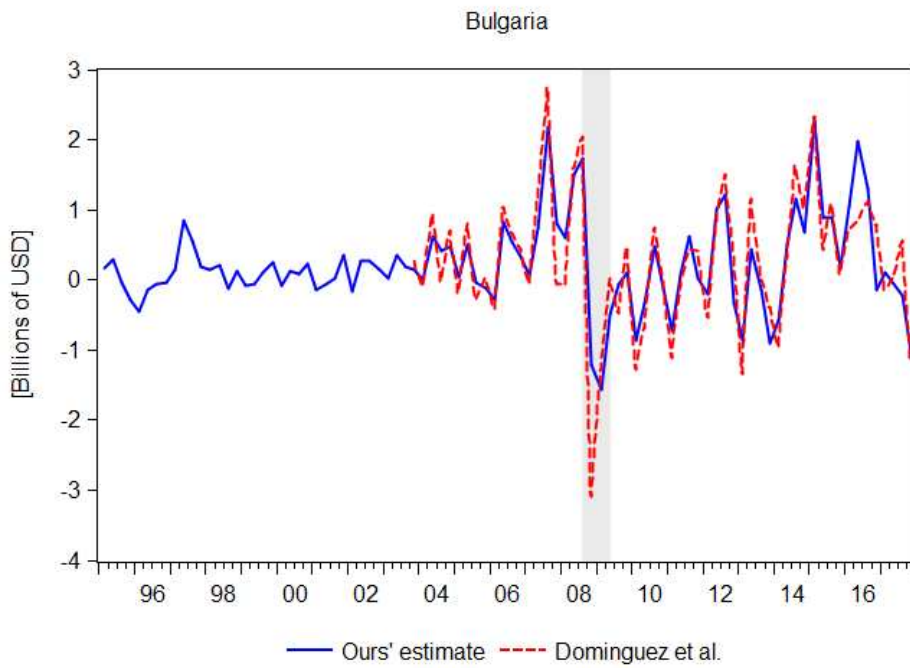
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B3. Estimates of active component of FX reserves in Bulgaria
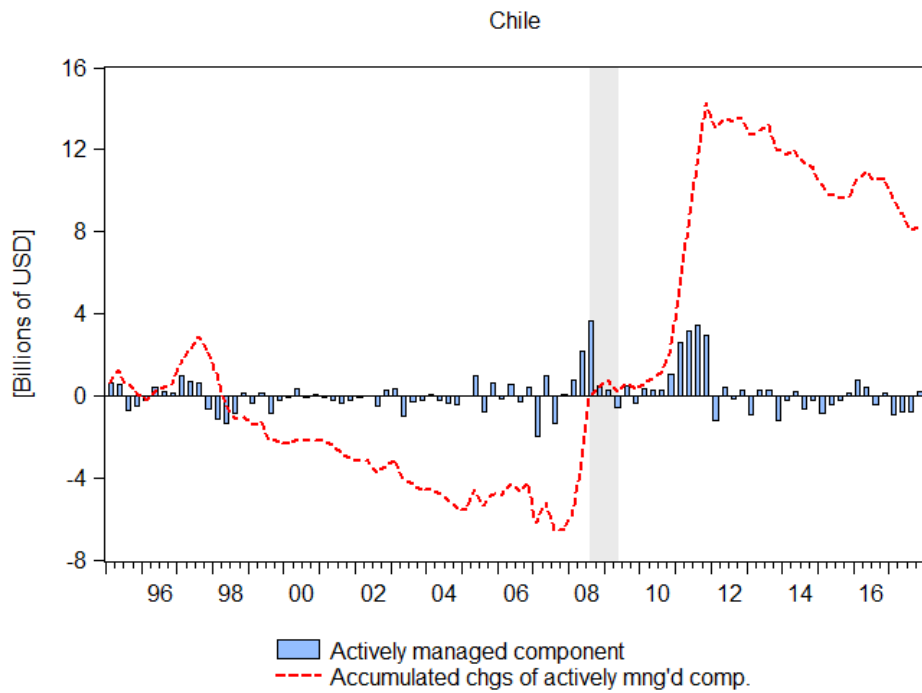
(a) Active component of FX reserves and its accumulated changes under new approach
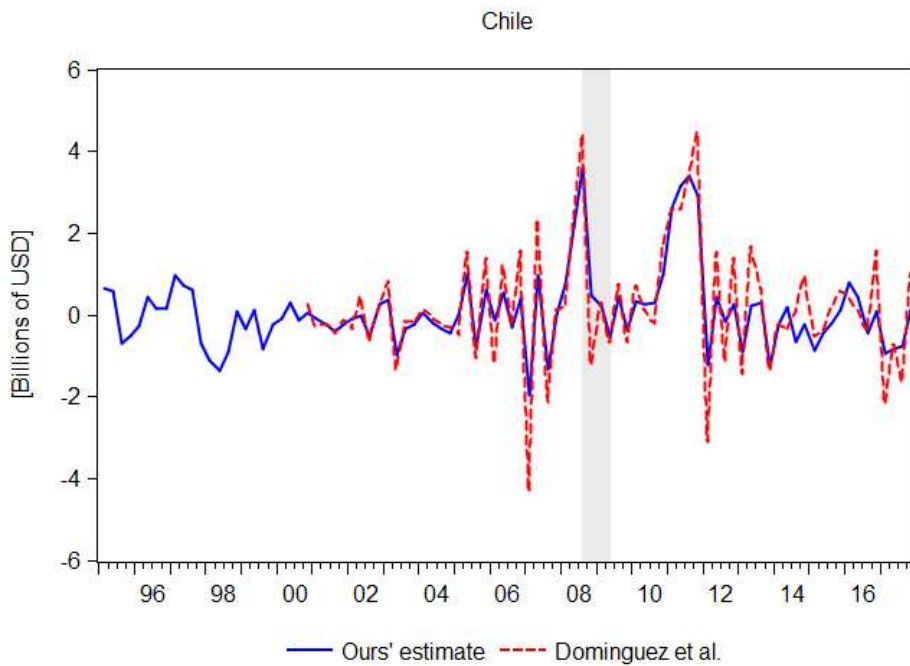
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B4. Estimates of active component of FX reserves in Chile
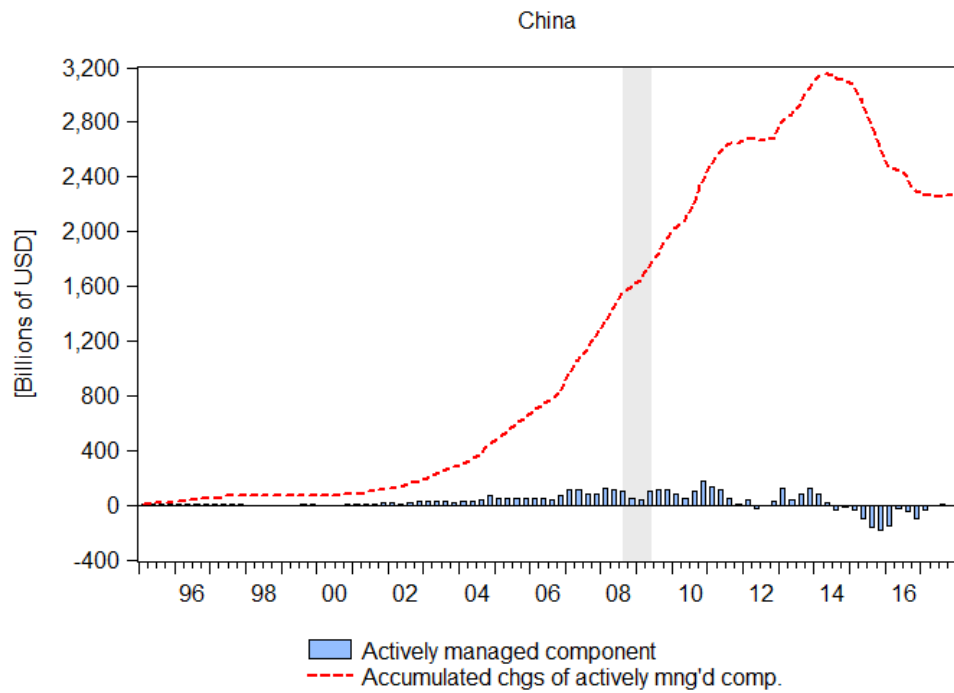
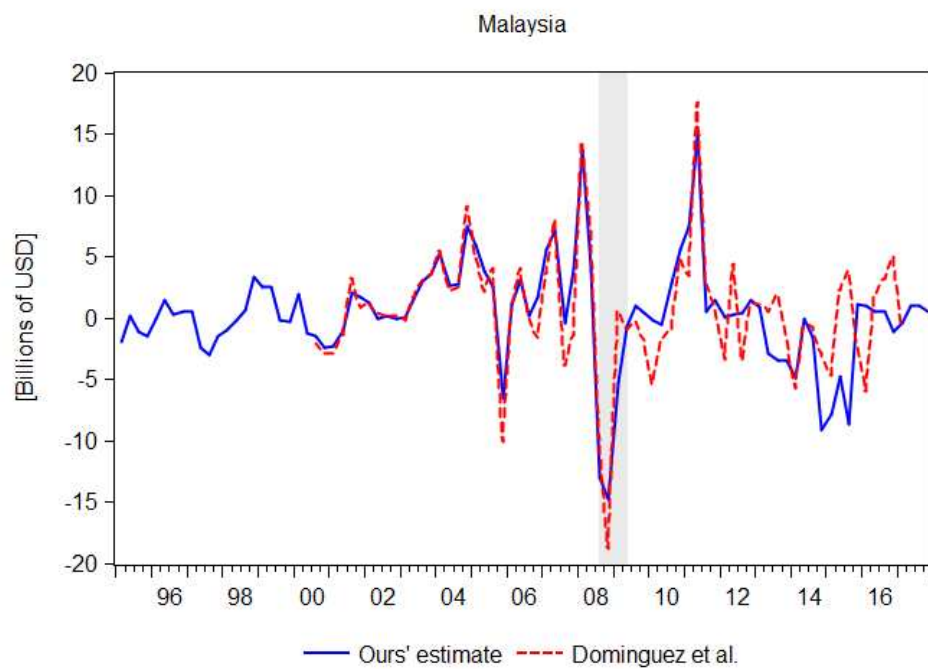(a) Active component of FX reserves and its accumulated changes under new approach
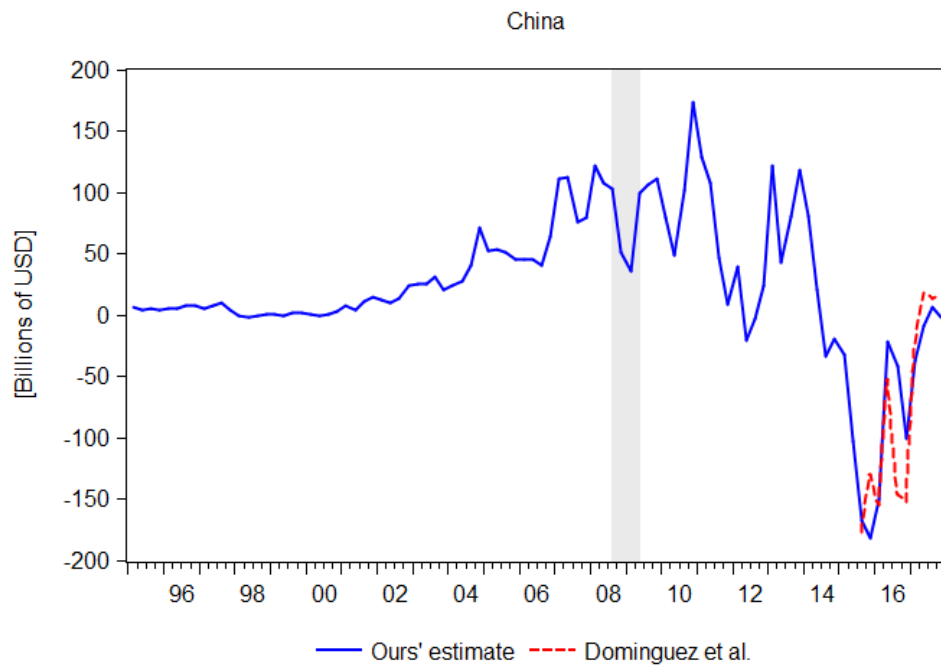
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B5. Estimates of active component of FX reserves in China
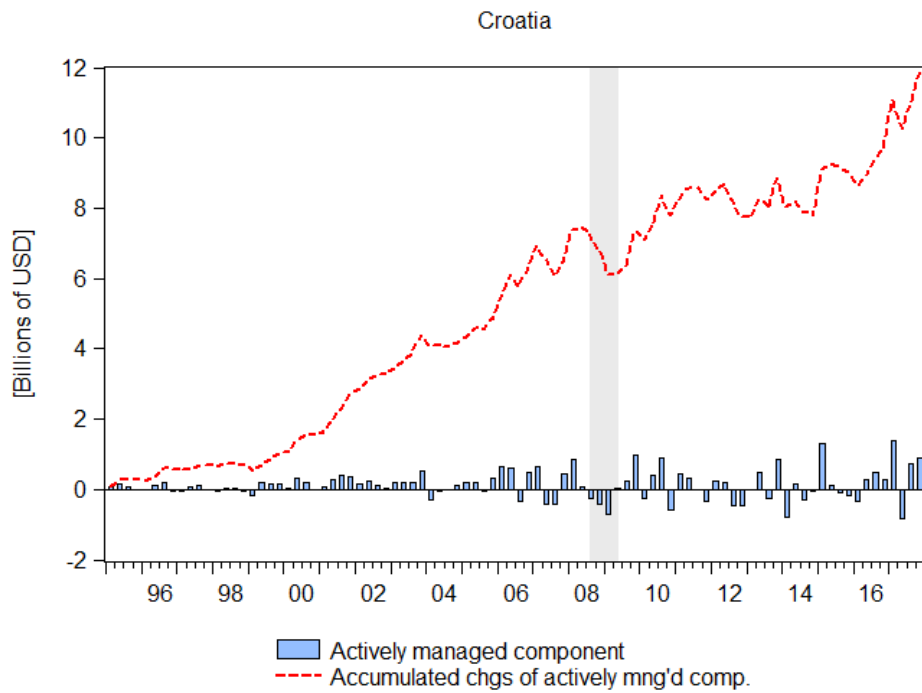
35

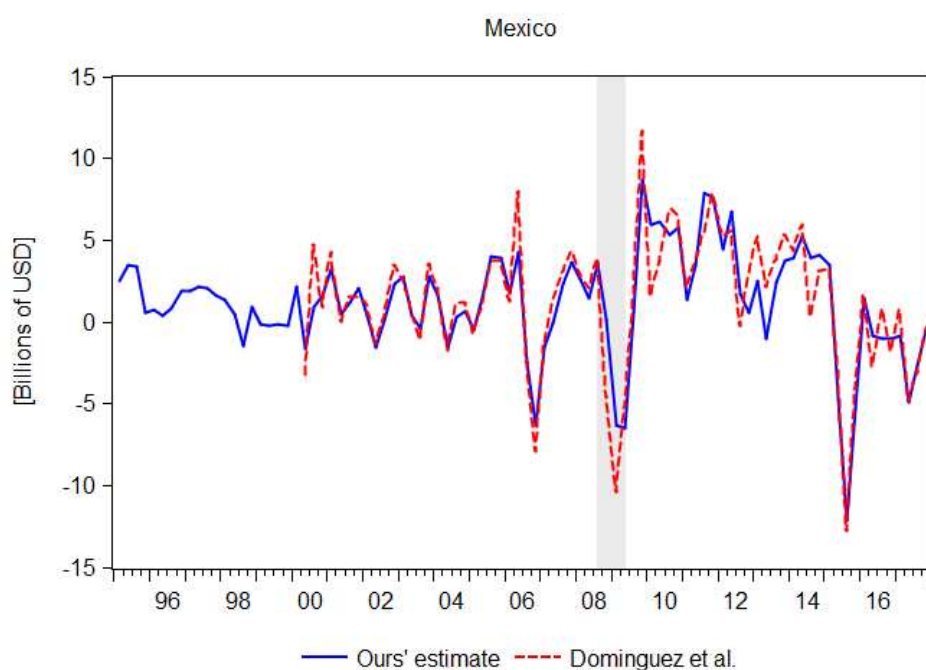(a) Active component of FX reserves and its accumulated changes under new approach
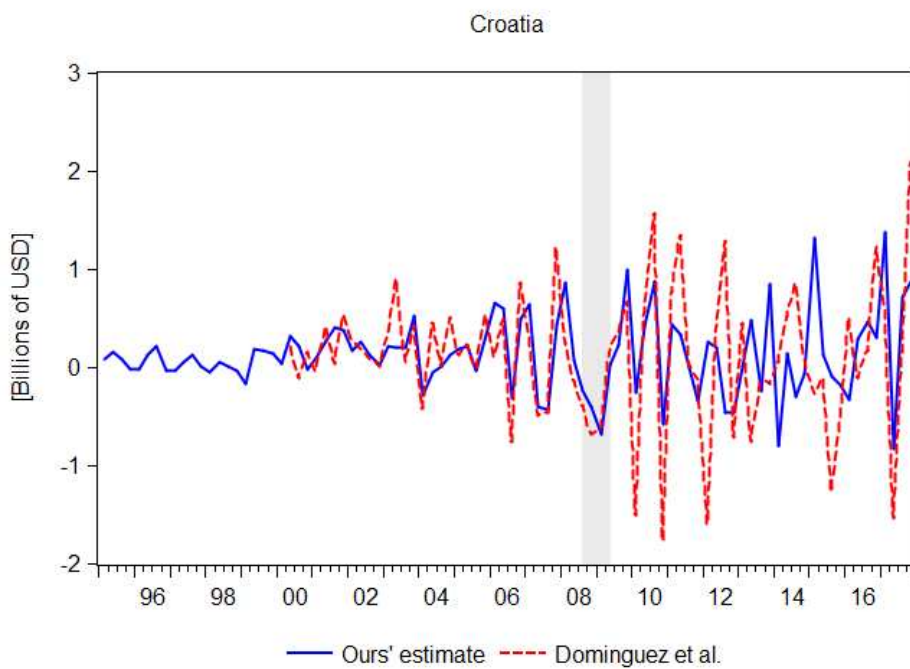
(b) Active component of FX reserves: new approach vs. DHI approach

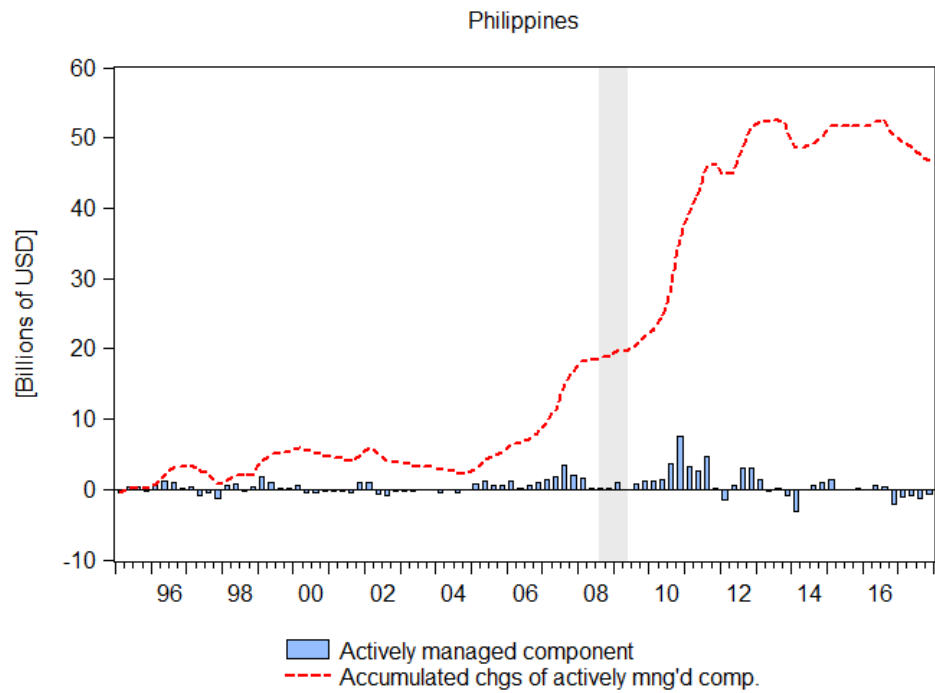**Figure B6.** Estimates of active component of FX reserves in Croatia
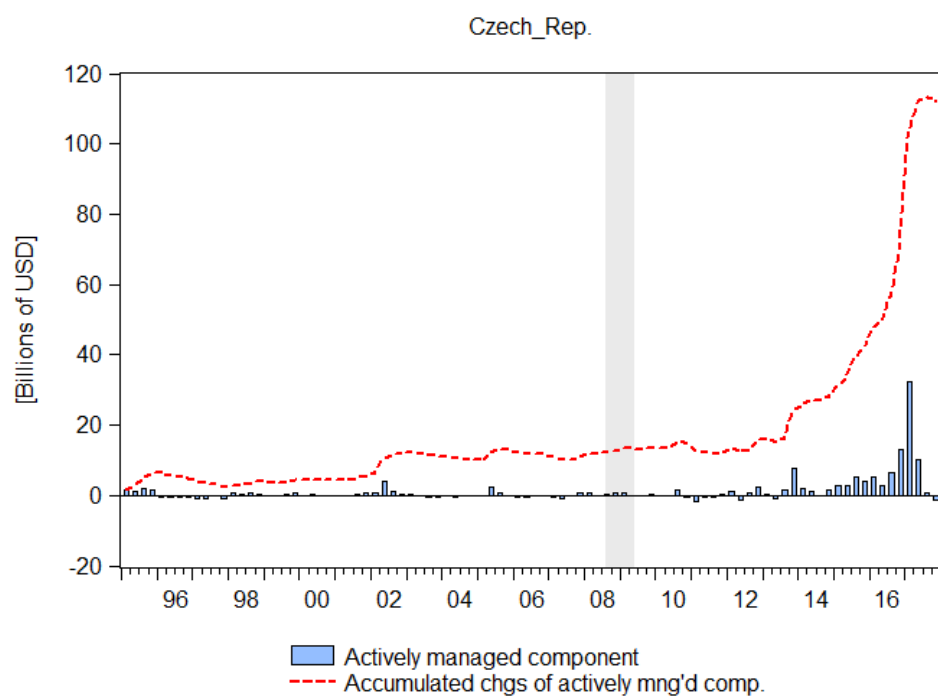
(a) Active component of FX reserves and its accumulated changes under new approach
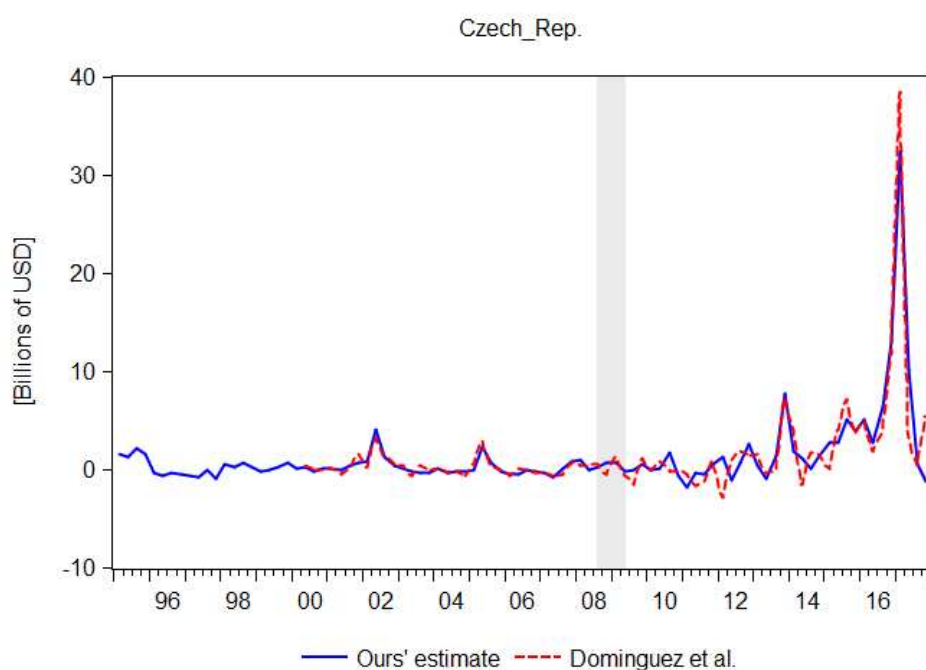
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B7. Estimates of active component of FX reserves in the Czech Republic
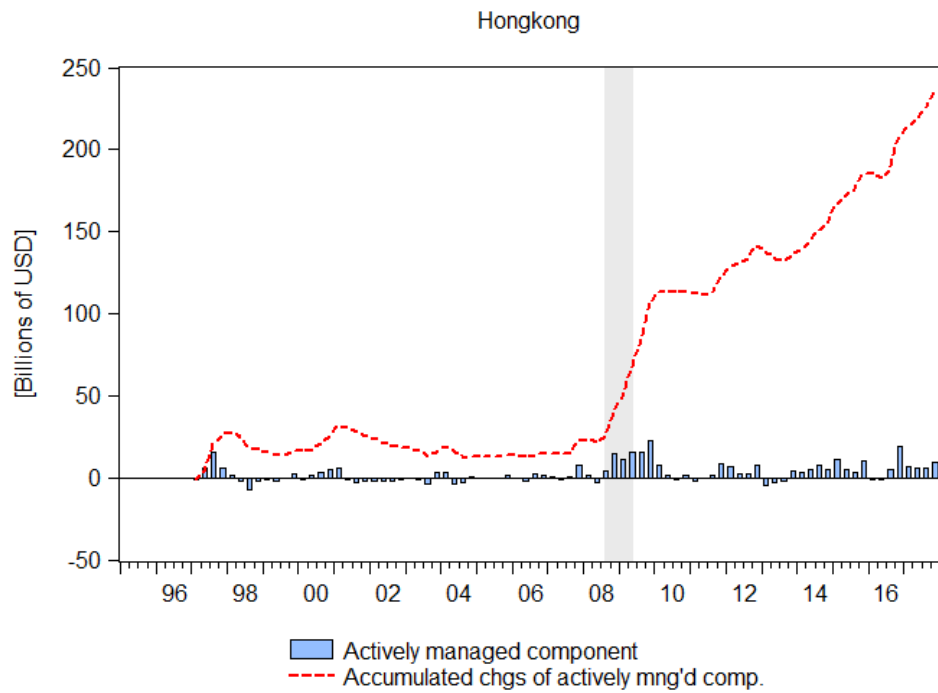
(a) Active component of FX reserves and its accumulated changes under new approach
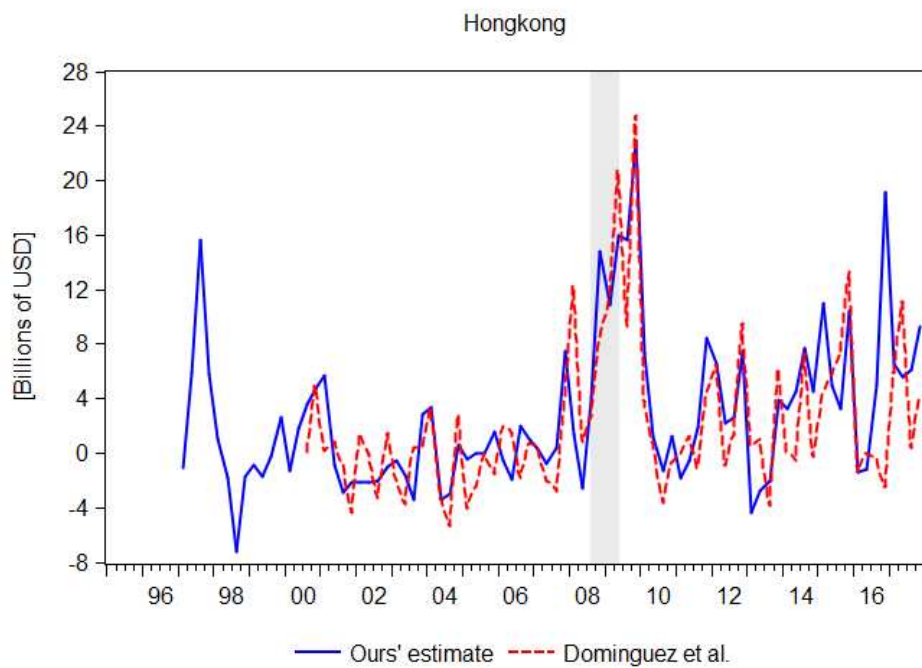
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B8. Estimates of active component of FX reserves in Hong Kong
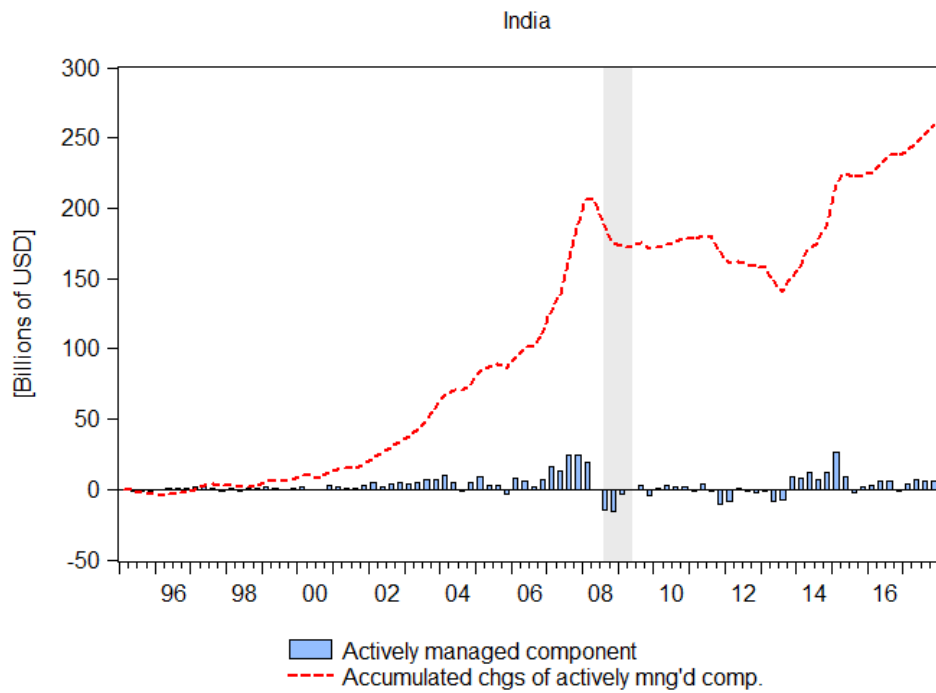
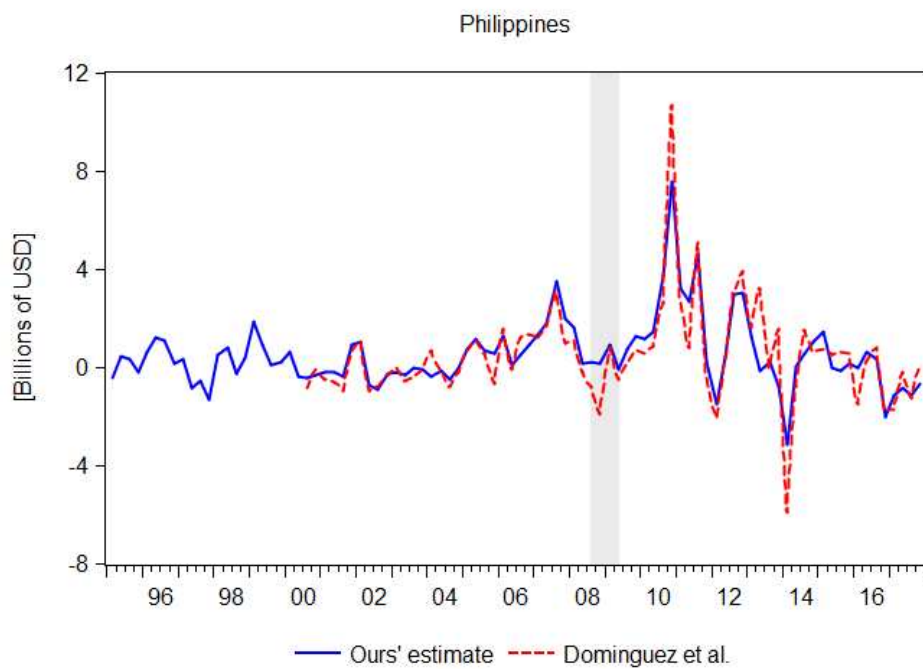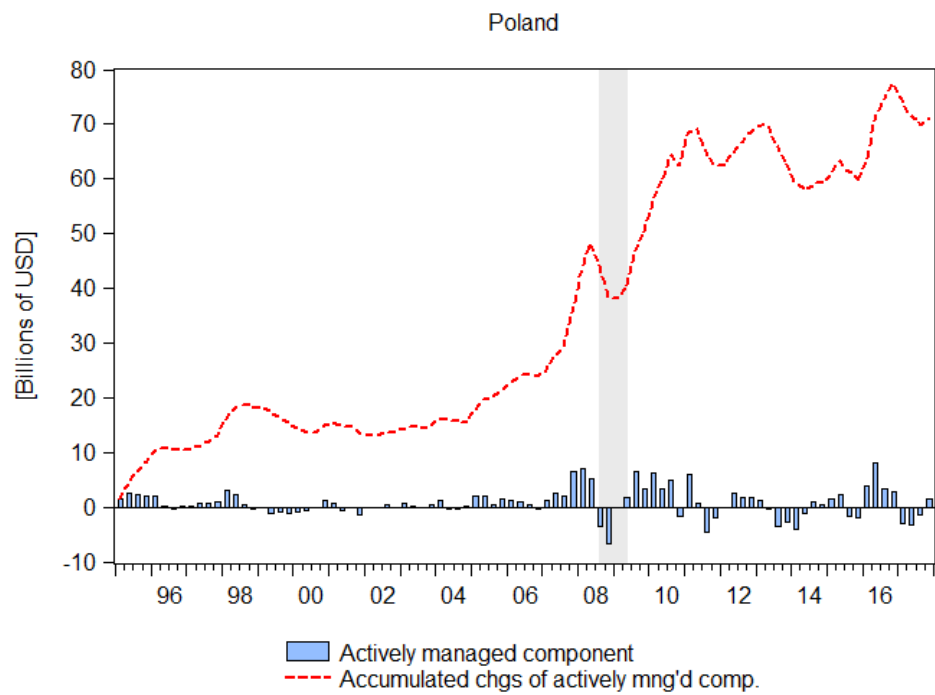(a) Active component of FX reserves and its accumulated changes under new approach
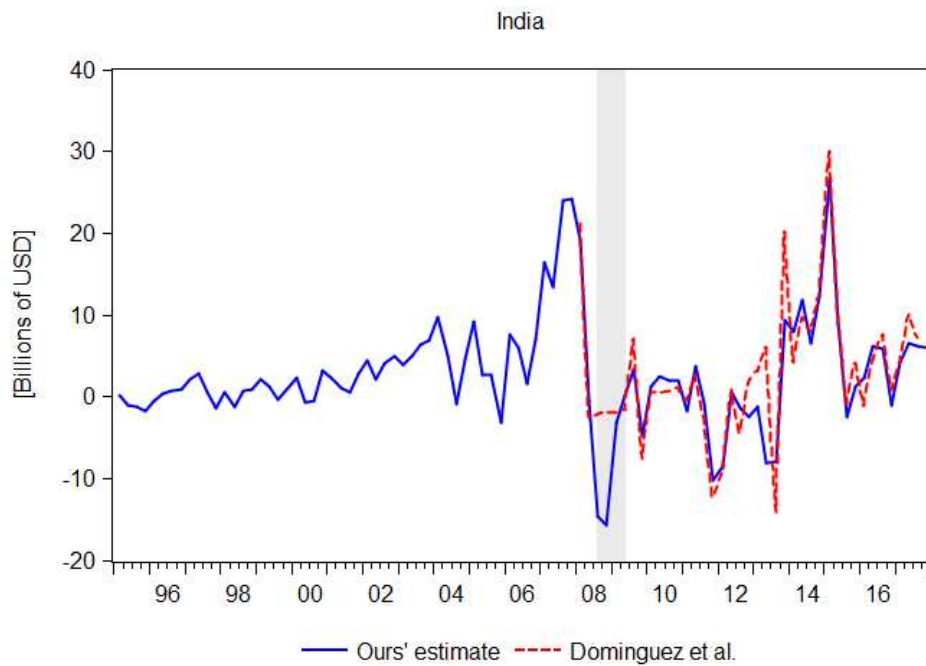
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B9. Estimates of active component of FX reserves in India
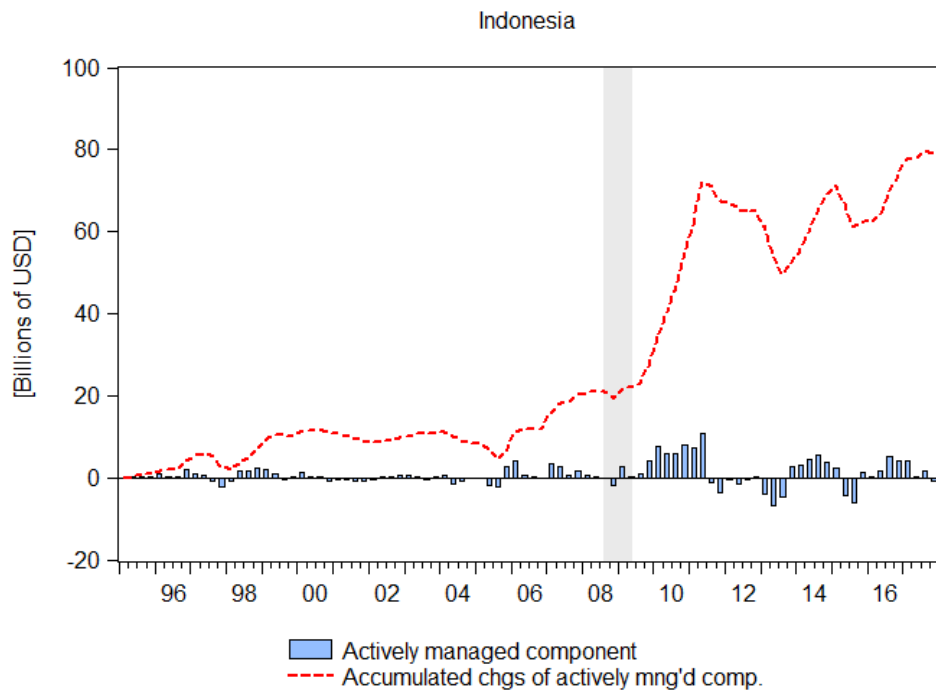
(a) Active component of FX reserves and its accumulated changes under new approach
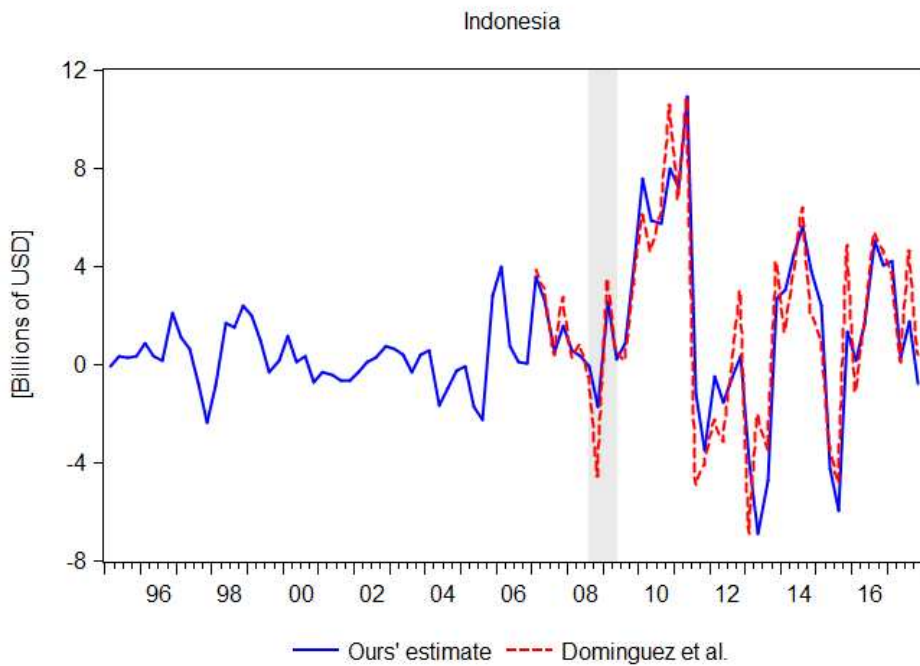
(b) Active component of FX reserves: new approach vs. DHI approach

Figure B10. Estimates of active component of FX reserves in Indonesia

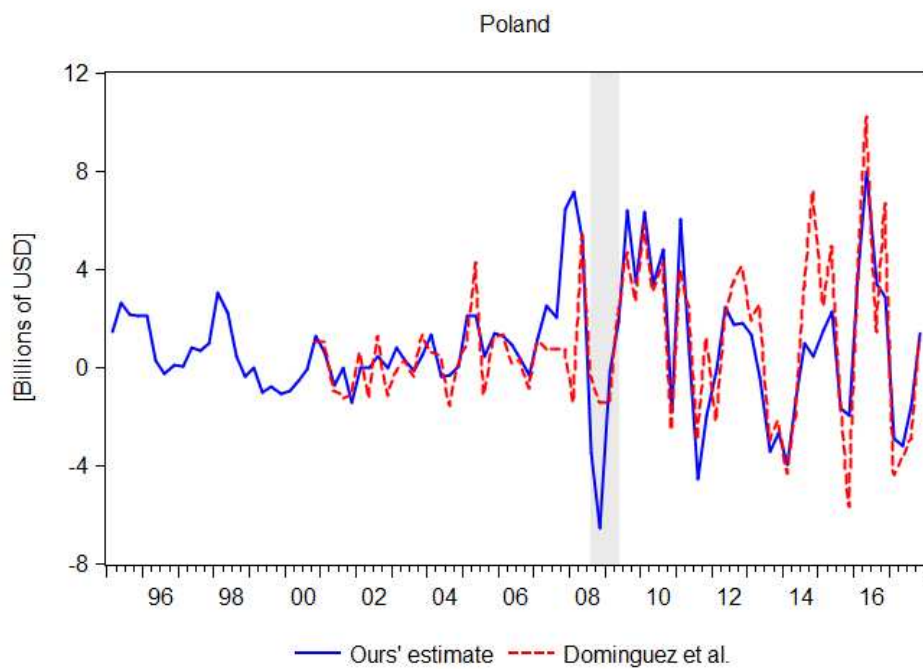(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

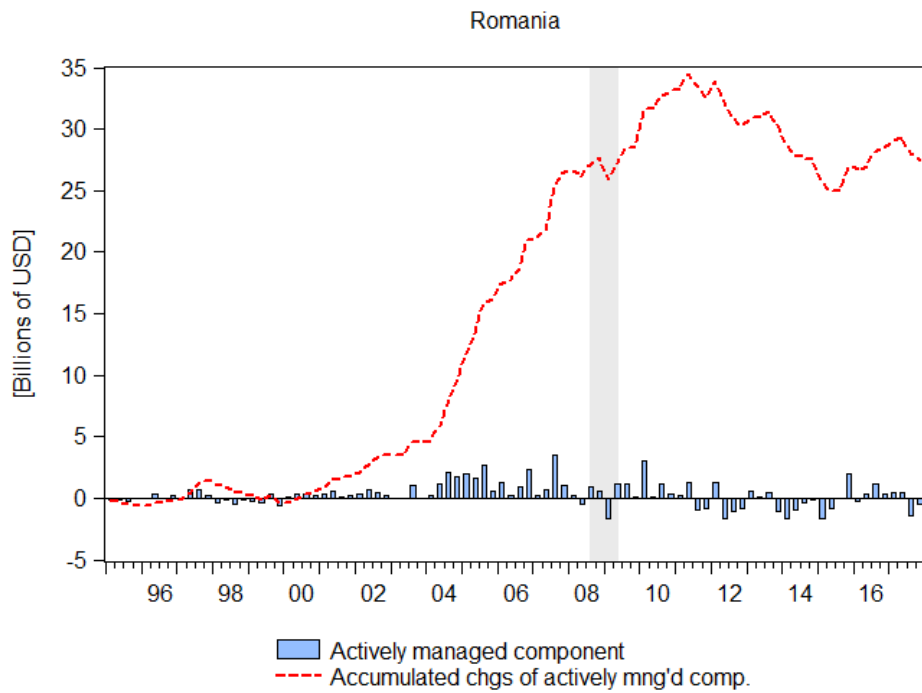**Figure B11.** Estimates of active component of FX reserves in Japan

(a) Active component of FX reserves and its accumulated changes under new approach
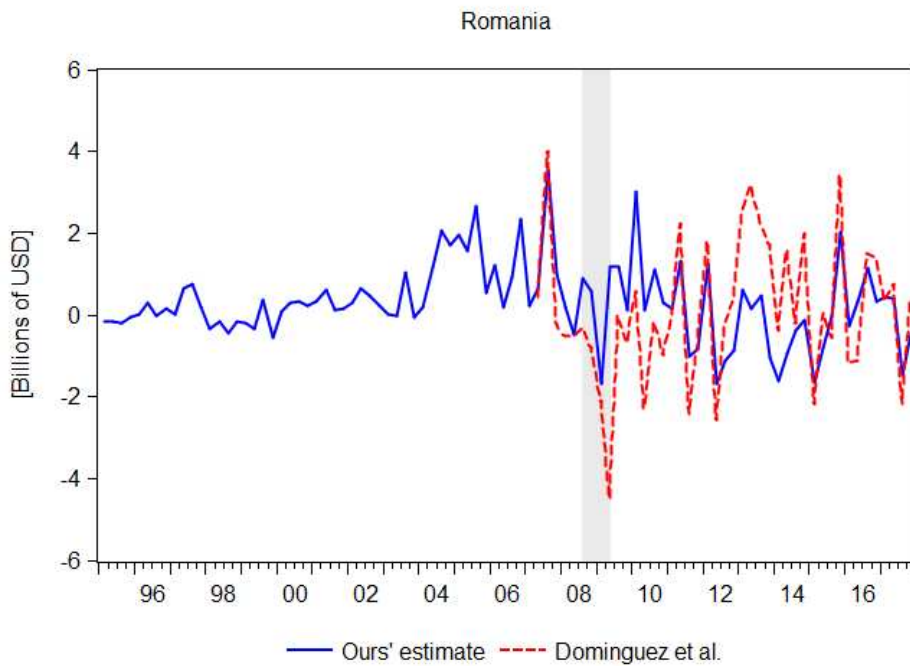

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B12. Estimates of active component of FX reserves in Korea

(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B13. Estimates of active component of FX reserves in Malaysia
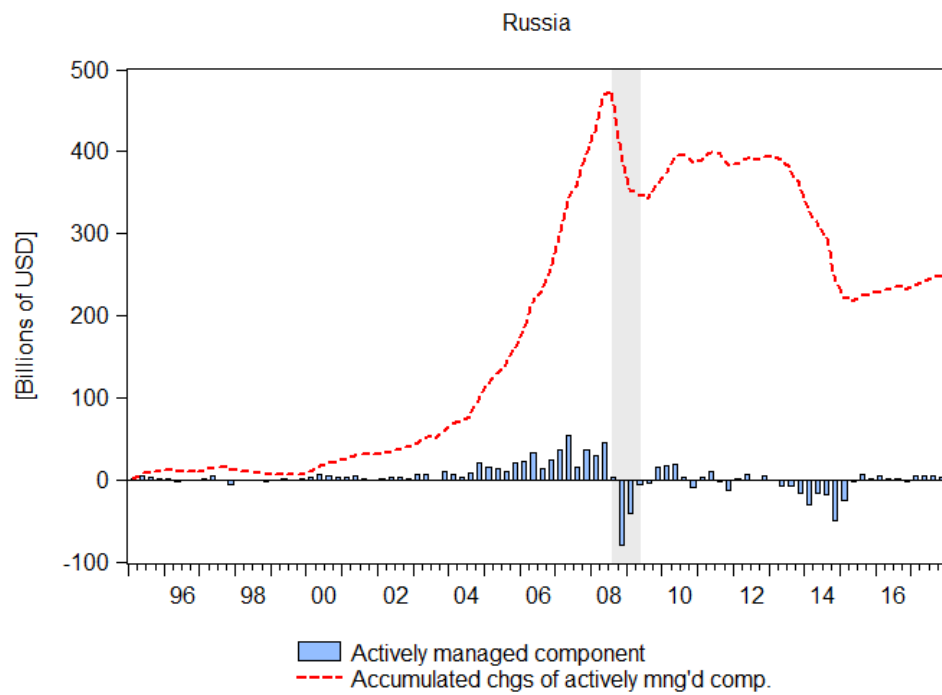
43

(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B14. Estimates of active component of FX reserves in Mexico

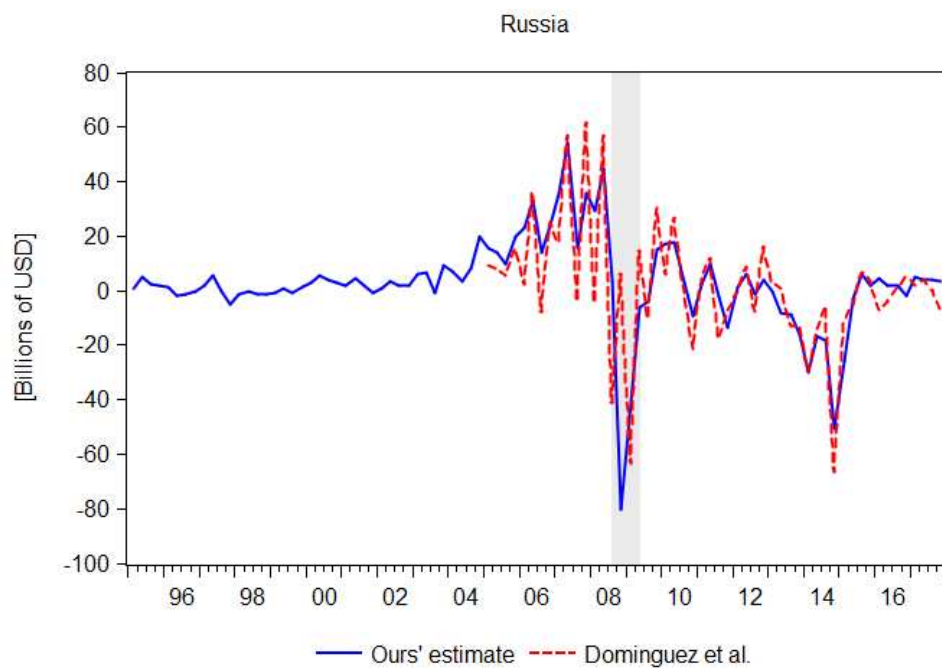(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B15. Estimates of active component of FX reserves in the Philippines
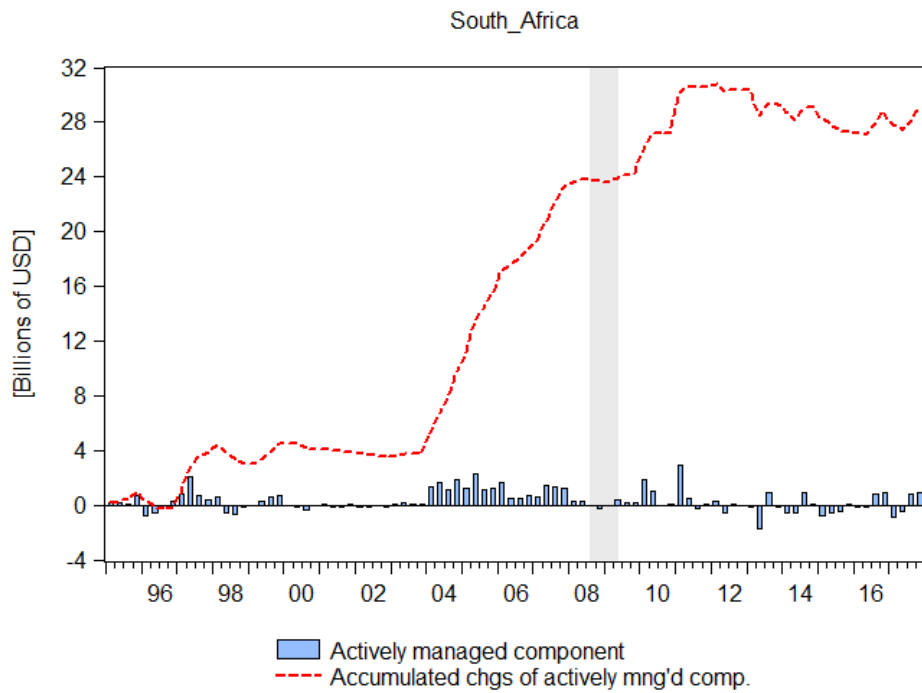
(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B16. Estimates of active component of FX reserves in Poland

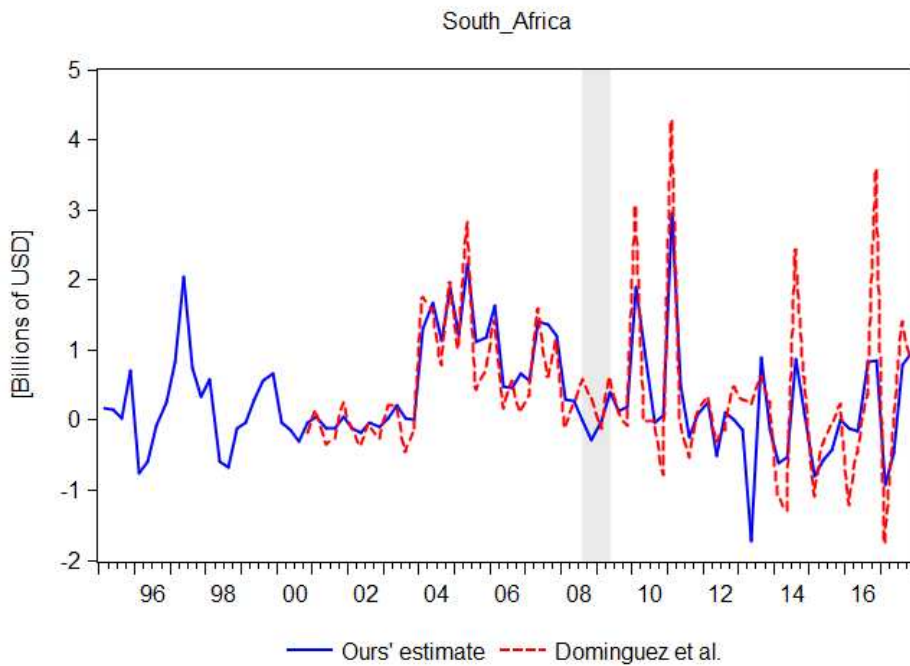(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B17. Estimates of active component of FX reserves in Romania
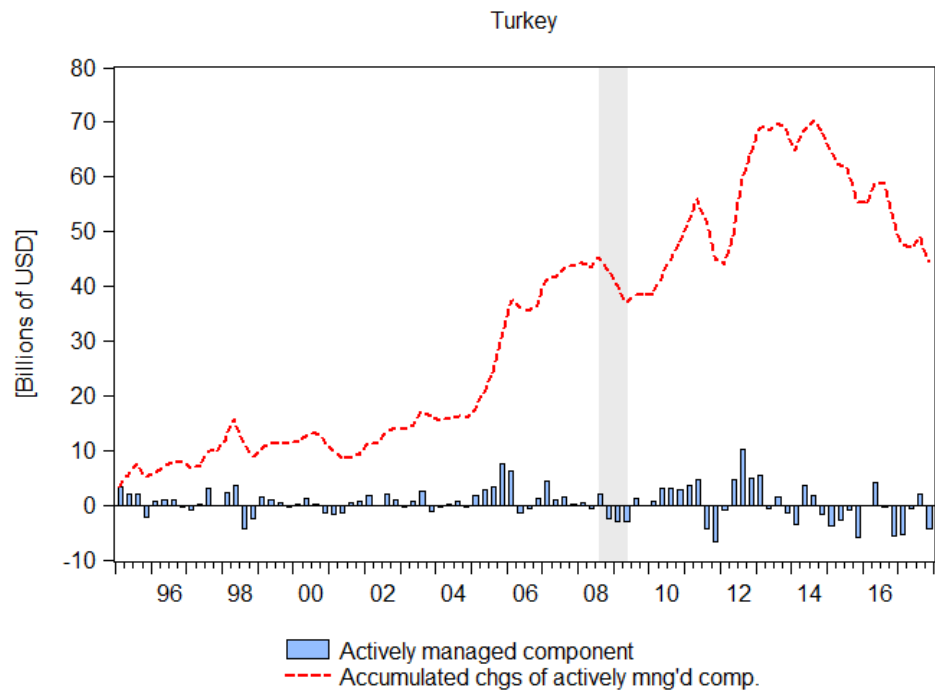
47

(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B18. Estimates of active component of FX reserves in Russia

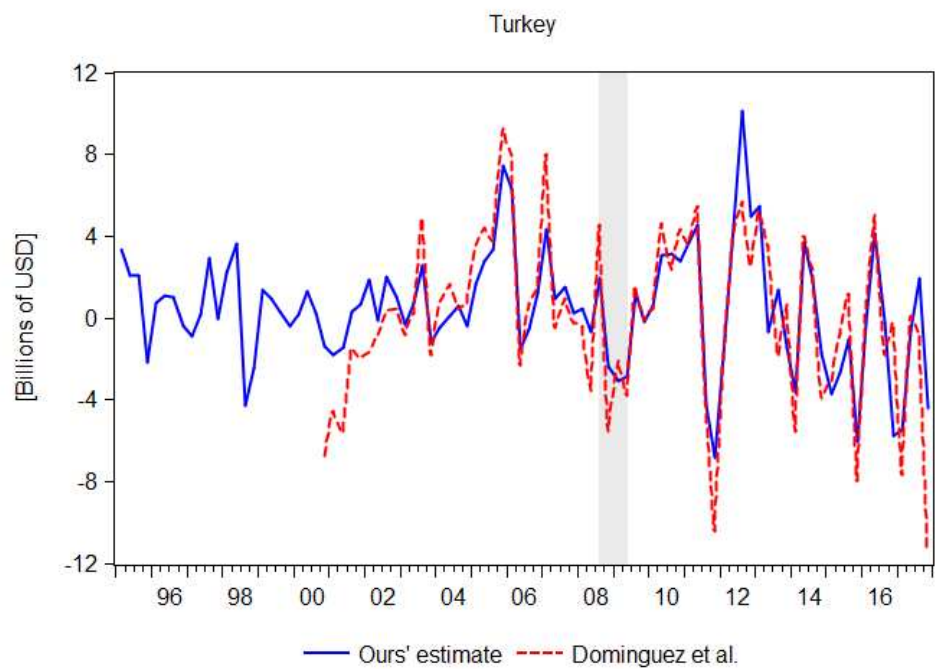(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B19. Estimates of active component of FX reserves in South Africa

(a) Active component of FX reserves and its accumulated changes under new approach

(b) Active component of FX reserves: new approach vs. DHI approach

Figure B20. Estimates of active component of FX reserves in Turkey