# Output volatility and exchange rates: New evidence from the updated de facto exchange rate regime classifications

Dąbrowski, Marek A. and Papież, Monika and Śmiech, Sławomir

Cracow University of Economics

11 April 2021

# Output volatility and exchange rates: New evidence from the updated *de facto* exchange rate regime classifications

Marek A. Dąbrowski*, Monika Papież†, Sławomir Śmiech‡

**Abstract**

This paper raises the question of whether the exchange rate regime matters for output volatility. Using the two *de facto* exchange rate regime classifications, it is demonstrated that the answer to this question is conditional 'yes'. The key finding is that the exchange rate regime modifies the importance of determinants of output volatility rather than impacts it directly. This point is explained within a macroeconomic model of an open economy and is corroborated with empirical evidence for 48 advanced and emerging market economies. It is found that under the pegged regime the trade openness contributes to a reduction in output volatility, whereas the financial development has an opposite effect. Moreover, bigger economies experience lower output volatility irrespective of the exchange rate regime, albeit the beneficial size effect is stronger under floating regimes. The results do not depend on the classification employed to identify *de facto* pegs and floats.

***Keywords:*** *exchange rate regime; output volatility; open economy macroeconomics; panel regressions*

***JEL Classification:*** F33, F41, C23

**Acknowledgements**

The authors gratefully acknowledge financial support from the National Science Centre in Poland (grant No. 2015/17/B/HS4/02681).

* Corresponding author: Cracow University of Economics, Faculty of Economics, Finance and Law, Department of Macroeconomics, ul. Rakowicka 27, 31-510 Kraków, Poland, e-mail: marek.dabrowski@uek.krakow.pl.

† Cracow University of Economics, Faculty of Economics, Finance and Law, Department of Statistics, e-mail: monika.papiez@uek.krakow.pl.

‡ Cracow University of Economics, Faculty of Economics, Finance and Law, Department of Statistics, e-mail: slawomir.smiech@uek.krakow.pl.

## 1. Introduction

The relations between nominal and real variables have been lying at the centre of macroeconomic controversies at least since the debate between John Maynard Keynes and the 'classics' (see, e.g., Johnson et al., 2001). The consequences of exchange rate regimes for output volatility are one of the instalments of this debate. Michael Mussa's study reveals that countries that let their currencies float experience greater both nominal and real exchange rate volatility (Mussa, 1986). Other authors find no systematic relation between the exchange rate regime and macroeconomic volatility. For example, in their oft-cited paper, Baxter and Stockman (1989, p. 399) report that 'the behavior of real aggregates such as industrial production and trade flows do not appear to change in any systematic way as a result of a change in the exchange-rate system' (see also Flood and Rose, 1995; Jeanne and Rose, 2002). These findings constitute the hypothesis of neutrality of exchange rate regime[1]. The hypothesis itself can be considered a part of a wider concept of classical dichotomy (see, e.g., Klein and Shambaugh, 2010).

This paper contributes to the debate on the consequences of the exchange rate regimes. We re-examine the relations between the exchange rate regime and output volatility using panel data on both advanced and emerging market economies that span over two decades. The focus is on output volatility and not on the long-term economic growth, since there is little controversy as to whether the classical dichotomy prevails in the long run (Galí, 2015). Moreover, the influence of the exchange rate regime on the short-term behaviour of output can be reconciled with price stickiness. Thus, our research question is whether the choice of an exchange rate regime matters for output volatility.

The paper contributes to the literature by providing new evidence on the importance of exchange rate regimes for output volatility in 48 advanced and emerging market economies. Three aspects of this contribution merit attention. First, building on Rodrik's argument that it is manufacturing industries rather than the entire economies that operate under the competitive threat from abroad, we argue that the consequences of exchange rate regimes should be looked for in the performance of such industries, and, accordingly, we use output volatility in manufacturing and not GDP volatility. Moreover, the cyclical component of output used to construct the volatility measure is obtained with the method proposed by Hamilton (2018), and, as such, it is free of deficiencies related to the Hodrick-Prescott filter (see, e.g., Hamilton, 2018; Schüler, 2020). Second, the countries that fix or float their currencies are identified with the

[1] Obstfeld and Rogoff (2001) use the term puzzle rather than hypothesis to stress that the exchange rates are disconnected from fundamentals.

two recent *de facto* exchange rate classifications developed by Ilzetzki et al. (2019) and Dąbrowski et al. (2020). It is demonstrated that the results are robust to the choice of classification, although the results obtained under the latter classification lend more support to the importance of the exchange rate regime for output volatility. Third, a distinguishing feature of our approach is that it captures more than just the direct effect of the exchange rate regime on output volatility. It is demonstrated both theoretically and empirically that the exchange rate regime modifies the importance of other determinants of output volatility. If the corresponding interaction effects are neglected, the results become ambiguous.

The paper consists of six sections. In the next section the literature on the link between the exchange rate regime and output volatility is reviewed. Section 3 presents the theoretical framework that is used to derive hypotheses on the relation between output volatility and the exchange rate regime. Econometric methodology is briefly discussed in Section 4. Section 5 provides the details on output volatility measure and exchange rate classifications used as well as other data. Empirical results are discussed in Section 6. The last section summarises the main findings and concludes.

## 2. Literature review

The literature on the causes, choices, and consequences of exchange rate regimes is voluminous. Our study is related to that strand of the literature which considers the issue of consequences of exchange rate regime and the nominal exchange rate volatility for a real economy and in particular for an output. The pre-late 1990s empirical literature on the consequences of exchange rate regimes focuses on comparing volatility of nominal and real exchange rates and other macroeconomic variables across regimes. It provides empirical evidence lending support to the hypothesis of neutrality of exchange rate regime (e.g., Baxter and Stockman, 1989; Flood and Rose, 1995). According to Tavlas et al. (2008), 'a major conundrum' is that 'the volatility of many key macroeconomic variables is invariant to the exchange-rate system while that of the key relative price – the real-exchange rate – is not invariant'.

The works published in the last two decades do not provide an explanation of this conundrum. The exchange-rate-regime-neutrality hypothesis has not been unambiguously corroborated in the literature: empirical findings seem to depend on the group of countries and the time range considered as well as on the exchange rate regime classification employed. The mixed results are obtained, for example, by Bleaney and Fielding (2002) and Ghosh et al. (2003). In the former study, the relation between volatility of output growth rate and the exchange rate regime is examined in a sample of 80 developing economies in the period between 1980 and 1989. No significant difference in output volatility across the exchange rate regimes is found. The only exception is the Communauté Financière Africaine (African Financial Community, CFA) zone countries which has higher output volatility than both the other pegging countries and the floating ones. In the latter study, the sample covering 147 countries over the period 1970-1999 is used. It is found that, on the one hand, the pegged exchange rates are associated with greater output volatility, but on the other hand, when the *de facto* exchange rate regime classification is employed instead of the *de jure* one, pegged regimes are found to be associated with significantly lower volatility.

Different findings are obtained by Rogoff et al. (2004) for the sample of 158 countries in the period between 1970 and 1999. The volatility of the real GDP growth does not appear to vary systematically across regimes when the Reinhart and Rogoff's natural exchange rate regime classification is used, but there is some evidence of lower output volatility for pegged regimes when the de jure classification is employed. In a related study Husain et al. (2005, p. 60) argue that their results for emerging market economies are 'in line with the earlier Baxter-Stockman finding of the absence of any robust relation between economic performance and exchange rate regime'. They find that in developing and advanced economies the pegged and floating regimes respectively may contribute to a better performance in terms of growth and inflation.

Levy-Yeyati and Sturzenegger (2003) develop an alternative *de facto* exchange rate regime classification and employ it to investigate economic performance of 183 countries in the post-Bretton Woods period (1974-2000). They find that in non-industrial countries less flexible exchange rate regimes are associated with slower growth as well as with greater output volatility. In industrial countries regimes does not appear to have any significant impact on growth, but less flexible regimes are characterised by lower output volatility. They point out that 'the evidence on the relationship between output volatility and exchange rate regimes is in fact rather mixed' (Levy-Yeyati and Sturzenegger, 2003, p. 1180).

In his discussion of important lessons on exchange rate policies in emerging markets Edwards (2011) analyses, inter alia, the relationship between exchange rate regimes and macroeconomic stability. Using a sample of 157 countries in the period between 1970 and 2006, he demonstrates that the flexible exchange regimes allow countries to accommodate external shocks to a greater extent than the pegged regimes. Similar conclusion is drawn by Erdem and Özmen (2015). They find that the impact of external shocks on economic activity is less pronounced in economies under flexible exchange rate regimes. In a more recent study Terrones

(2020) examines the link between both long- and short-term growth and an exchange rate regime on a sample of 114 countries between 1973 and 2016. He finds no robust relationship between exchange rate regimes and long-term growth. As far as the short-term growth is concerned, economies with fixed exchange rates experience a weaker growth performance during global recoveries than those with non-fixed regimes. The importance of exchange rate regimes for growth performance during episodes of global recessions is found less pronounced.

There are at least two related strands in the literature. The first strand is focused on the relationship between economic growth and the exchange rate regime. The results of this line of research are as ambiguous as those that concern the link between output volatility and the exchange rate regime as acknowledged by Ghosh et al. (2003, p. 98): '[o]verall, and in line with the theoretical literature, the results do not suggest a strong link between the exchange rate regime and real GDP growth'. A similar conclusion is repeated by Klein and Shambaugh (2010, p. 200), who do not find 'any compelling evidence that the exchange rate regime affects the long-run level of output' and explain that '[t]his lack of finding is consistent with the general theory of long-run monetary neutrality'. In spite of a lack of plausible theoretical foundations, empirical research on the links between exchange rate regimes and economic growth is continued. Some recent studies within this area include: Baycan (2016), Jibrin et al. (2017), Ashour and Chen Yong (2018), Mohammed et al. (2018), Erdal and Pınar (2019), Schmidt-Hebbel (2019), Seraj et al. (2020).

The second related strand of the literature is devoted to the insulation properties of the exchange rate regime against shocks that hit an economy. This line of research draws on influential papers by Fleming (1962) and Mundell (1963) who demonstrate that the choice of an exchange rate regime affects macroeconomic policy effectiveness unless capital flows are controlled. The key insight that floating rate regimes provide better insulation of output against real shocks whereas fixed regimes are better at absorbing nominal shocks is investigated in many studies.[2] The shock absorption and shock propagation properties of exchange rate regimes is investigated by Arratibel and Michaelis (2014), Shevchuk (2014), Audzei and Brázdik (2018), Dąbrowski and Wróblewska (2016), Dąbrowski and Wróblewska (2020), De and Sun (2020), Deskar-Škrbić et al. (2020), Wong (2020).

[2] This point can be indeed linked to papers by Fleming and Mundell since, as explained by Ghosh et al. (2003, p. 23), macroeconomic policies can be reinterpreted as real and nominal shocks.

## 3. Theoretical framework

*Model setup*

Ghosh et al. (2003) observe that the literature on macroeconomic performance under alternative exchange rate regimes is too voluminous to be captured by a single framework. Thus, we illustrate the key elements in a stylized small open economy model that is similar to the one developed by Engel and West (2006) and Galí and Monacelli (2005). In its structural form, the model has three equations for aggregate supply, aggregate demand and uncovered interest rate parity. All shocks, i.e. productivity, demand, monetary and financial shocks, are assumed to be (uncorrelated) white noise processes.[3]

The aggregate supply is borrowed from Ghosh et al. (2003). It links output with the difference between actual and expected inflation, $\pi_t - \pi_t^e$, under a simplifying assumption that the natural output is zero

$$y_t = \theta(\pi_t - \pi_t^e) + u_t^s \quad (1)$$

where $y_t$ is (the log of) the output, $u_t^s$ is a productivity (supply) shock and $\theta$ is a positive parameter. Equation (1) is a Lucas-type supply function (see Ghosh et al., 2003). Inflation expectations are assumed to be rational.

The aggregate demand equation is taken from the Engel and West's model although we introduce financial shock as an additional source of variability

$$y_t = -\gamma_s(s_t - \bar{s}_t) + u_t^d - \gamma_f u_t^f \quad (2)$$

where $s_t$ is (the log of) the nominal exchange rate defined as a price of domestic currency in terms of a foreign currency, so its increase is an appreciation of domestic currency, $u_t^d$ and $u_t^f$ are demand and financial shocks, respectively, and $\gamma$'s are positive parameters. The exchange rate implied by the purchasing power parity theory is used as (the log of) an equilibrium exchange rate, so $\bar{s}_t = p_t^* - p_t$ equals the difference between (the logs of) foreign and domestic price levels. The former is assumed to be exogenous. Engel and West (2006) explain that equation (1) can be interpreted in terms of a dynamic IS relation in an open economy.

The relation between interest rates and the exchange rate is captured by the uncovered interest rate parity

$$i_t - i_t^* = -(s_{t+1}^e - s_t) + u_t^f \quad (3)$$

where $s_{t+1}^e$ is the exchange rate expected in period $t$ to prevail in period $t+1$. Thus, the interest rate differential is accounted for by the expected depreciation of domestic currency and a

[3] It is a simplifying assumption. There is no need to impose the AR(1) dynamics on shocks since the model is stylized.

financial shock. The latter can be thought of as a time-varying risk premium. The foreign interest rate is considered an exogenous variable.

In order to close the model, it needs to be supplemented by information on the way monetary policy is conducted. Under the peg exchange rate regime, monetary policy is used to stabilise both the actual and expected exchange rates, so $s_t = s_{t+1}^e = s^{PEG}$. It is convenient to rewrite the equilibrium exchange rate as $\bar{s}_t = -(\pi_t - \pi_t^*) - q_{t-1} + s_{t-1}$, where $q_{t-1}$ is (the log of) the real exchange rate and $s_{t-1} = s^{PEG}$, as the exchange rate is fixed.[4] Then, it is straightforward to demonstrate that

$$y_t = \Xi^{PEG'} u_t \tag{4}$$

where $\Xi^{PEG} = \left[\frac{\gamma_s}{\gamma_s+\theta}, \frac{\theta}{\gamma_s+\theta}, -\frac{\gamma_f\theta}{\gamma_s+\theta}, 0\right]'$ is a vector of coefficients and $u_t = \left[u_t^s, u_t^d, u_t^f, u_t^m\right]$ is a vector of shocks.[5]

Monetary authorities are assumed to follow the conventional interest rate rule under the floating exchange rate regime. Therefore, normalising the inflation target and natural output to zero, the interest rate is set according to

$$i_t = \phi_\pi \pi_t + \phi_y y_t + u_t^m \tag{5}$$

where $u_t^m$ is a monetary shock and $\phi$'s are positive.[6] It is assumed that the exchange rate is expected to gradually adjust to its equilibrium level

$$s_{t+1}^e = s_t - \sigma(s_t - \bar{s}_t) \tag{6}$$

where $0 < \sigma \leq 1$. Using equations (1), (2), (3), (5) and (6), one can obtain the solution for the output under the floating rate regime[7]

$$y_t = \Xi^{FLT'} u_t \tag{7}$$

with coefficients $\Xi^{FLT} = \left[\frac{\gamma_s\phi_\pi}{\psi}, \frac{\theta\sigma}{\psi}, \frac{\theta(\gamma_s - \gamma_f\sigma)}{\psi}, -\frac{\gamma_s\theta}{\psi}\right]'$ where $\psi = \theta\left(\sigma + \gamma_s\phi_y\right) + \gamma_s\phi_\pi$ is positive.

*Output volatility and exchange rate regime*

Having found the relation between the *level* of output and shocks in equations (4) and (7) and using the fact that shocks are mutually uncorrelated, we can derive the formula for output *volatility*

$$\text{var}(y_t) = \Xi^{REG'} \Sigma_u \Xi^{REG} \tag{8}$$

[4] We use 'peg' and 'fix' interchangeably.
[5] In order to save space, our solutions for inflation and interest rate are not presented but are available upon request.
[6] Likewise in Engel and West (2006), all constants and trend terms are omitted.
[7] The details are omitted to save space.

where $\mathrm{var}(\cdot)$ is an operator of variance, $\Sigma_u$ is a (diagonal) covariance matrix of shocks, $\Xi^{REG}$ is a vector of a regime-specific output sensitivity to shocks, and $REG \in \{PEG, FLT\}$. To put it simply, output volatility is a weighted sum of variances of shocks.[8]

The direct comparison of regimes using equation (8) enables us to draw three conclusions concerning the importance of shocks as sources of output volatility under both exchange rate regimes. First, monetary shocks do not contribute to output volatility under the fixed rate regime. Second, if hit by demand shocks output is more volatile under the fixed rate than under the floating rate, especially if the Taylor principle holds, i.e. $\phi_\pi > 1$.[9] Third, if in turn the only source of disturbance is either supply or financial shocks, then no exchange rate regime dominates the other: regimes' 'contributions' to output volatility depend on the characteristics of an economy reflected in relations between parameters.[10] The bottom line is that the importance of the relative frequency of shocks in shaping output volatility does depend on the exchange rate regime.

Interestingly, our theoretical framework has two further important implications regarding the significance of the exchange rate regime for output volatility. The exchange rate regime can matter for the strength of a relationship between output volatility and its determinants, such as trade openness and financial development. Intuitively, in a closed economy with no foreign trade, the choice of an exchange rate regime is irrelevant. Similarly, in an economy at the infant stage of financial development, foreign trade is likely to be dominated by barter-type transactions that are not intermediated via the shallow foreign exchange market. As the economy gets more involved in international trade and advances on a ladder of financial development, the potential importance of an exchange rate regime increases.[11]

Within our theoretical framework, trade openness and financial development can be proxied with parameters $\gamma_s$ and $\gamma_f$, respectively. The rationale behind the former is that in a more open economy, the aggregate demand can be expected to be more sensitive to the exchange rate fluctuations (around the equilibrium path). The latter captures the overall sensitivity of aggregate demand to financial disturbances and as such is likely to increase with the rising importance of the financial system.

[8] For a similar finding, although in a different theoretical framework, see, e.g., Grydaki and Fountas (2009).

[9] In fact, this is a sufficient condition. A necessary condition is that $\phi_\pi > \sigma - \theta\phi_y$.

[10] The output is less volatile under the floating rate regime than under the peg rate regime in the face of supply shocks if a weight on price stability in the monetary rule is relatively small, $\phi_\pi < \gamma_s\phi_y + \sigma$, and in the face of financial shocks if their impact on aggregate demand is sufficiently strong, $\gamma_f > \gamma_s(\gamma_s + \sigma)[\psi + \sigma(\gamma_s + \theta)]^{-1}$.

[11] The relations between trade openness and financial development has recently been investigated by, e.g., Wajda-Lichy et al. (2020).

Equation (8) can be used to establish how trade openness and financial development affect output volatility. This is done in two steps. First, the coefficients measuring the impact of shocks volatility on output volatility are obtained from equation (8), and then the sensitivity of these coefficients to both trade openness and financial development, proxied with $\gamma_s$ and $\gamma_f$, respectively, is examined. Formally, $\frac{\partial^2}{\partial\gamma'\partial(\text{diag}(\Sigma_u))}\left(\Xi^{REG'}\Sigma_u\Xi^{REG}\right)$ are calculated under each exchange rate regime.[12] The signs of these derivatives are depicted in Table 1. Thus, an increase in trade openness results in a higher sensitivity of output volatility to supply shocks volatility, but a lower sensitivity to demand shocks volatility, irrespective of the exchange rate regime. The importance of the exchange rate regime can be noticed when financial and monetary shocks are considered. The rise in trade openness under the floating exchange rate regime amplifies the sensitivity of output volatility to volatility in financial and monetary shocks. The opposite (or nil) effect is found when the exchange rate is pegged. The results for changes in financial development are even easier to interpret because they interact with financial shocks volatility only: the rise in financial development decreases the sensitivity of output volatility if the exchange rate is allowed to float and increases that sensitivity under the fixed rate regime.

Two testable hypotheses can be inferred from results reported in Table 1. First, a high trade openness tends to lower output volatility if the exchange rate is fixed unless the only source of disturbance in an economy is supply shocks. Under the floating rate regime, the high trade openness amplifies output volatility unless shocks other than demand shocks are assumed to be non-existent.[13] Second, a higher level of financial development feeds into an increased output volatility under the fixed exchange rate regime and a decreased volatility if the exchange rate can float.

Summing up, given that output volatility depends on the type of shocks hitting an economy, we do not expect to uncover empirically a direct relationship between output volatility and the exchange rate regimes. It can, however, be argued that (1) the high trade openness contributes to lower output volatility under the fixed rate regime, and (2) the high level of financial development tempers output volatility when the exchange rate floats.

---

[12] The derivatives can be obtained in two steps. First the relevant coefficients are obtained as the derivatives of $\Xi^{REG'}\Sigma_u\Xi^{REG}$ with respect to (the diagonal elements of) $\Sigma_u$. These coefficients are diag($\Xi^{REG}\Xi^{REG'}$). Then their derivatives with respect to $\gamma' = \left[\gamma_s, \gamma_f\right]'$ are calculated. The results can be compactly written as $2\Lambda^{REG}\frac{\partial\Xi^{REG}}{\partial\gamma'}$ where $\Lambda^{REG}$ is a diagonal matrix with $\Xi^{REG}$ on its main diagonal. The detailed results are available upon request.

[13] Under an unrealistic assumption that an economy is relatively closed but financially developed, high incidence of financial shocks would make the impact of rising trade openness negative.

## 4. Empirical strategy

To analyse the impact of different factors on output volatility, this paper applies the dynamic Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991). This method gains popularity in estimating dynamic panel models i.e. panel regression models in which a dependent variable is a function of its own past realizations.

$$y_{it} = \sum_{j=1}^{p} \beta_j y_{i,t-j} + \gamma' x_{it} + u_i + \varepsilon_{it} \tag{9}$$

where, $i \in \{1, .. N\}$ is the number of cross-sections and $t \in \{1, .. T\}$ number of periods; $y_{it}$ – dependent variable, $x_{it}$ – regressors, $u_i$ represents fixed effects, $\beta_j$ and $\gamma$ are model parameters, finally $p$ is the number of lags. The Arellano and Bond estimator is dedicated for situations with small time dimension ($T$) and large cross-sectional dimension ($N$) (see Roodman, 2009). This method allows for potential endogeneity in data, which means that explanatory variables are correlated with the past or current errors. What is more, it permits of fixed individual effects, heteroskedasticity and autocorrelation within individual objects. The estimation begins with the differencing of variables and the application of the GMM. The number of instruments available increases in subsequent time periods and is related with the number of lags that can be applied. For example, when $t = 5$, four available instruments can be applied. In consequence, in later time periods, additional orthogonality condition improves the efficiency of Arellano-Bond estimator. The GMM estimator weights the vector of sample-average moment conditions by the inverse of the covariance matrix of the moment conditions. As the distributions of disturbance are not identical, we use a two-step GMM estimator. To avoid the spurious regression, unit root tests are applied in each series. In the case of the global variables, the Augmented Dickey-Fuller (ADF) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests are applied. In panel variables the Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS) as well as Fisher type Phillips-Perron (PP) unit root tests are used (Levin et al., 2002, Im et al., 2003). Finally, the non-stationary series, are transformed by taking first differences, and estimated models consist of stationary series. Since the GMM requires no autocorrelations in the errors, the autocorrelation of order two tests are used. To test the validity of the overidentifying restrictions, when the number of moment conditions is larger than the number of models parameters, the Sargan test is used Sargan (1958). The null hypothesis assumes that the overidentifying restrictions are valid.

## 5. Data

The dataset includes three types of data: the output volatility measure, variables that describe the exchange rate regime classification, and output volatility determinants.

Monthly data on industrial production are used to construct a measure of output volatility. To a certain extent, this choice is motivated by data availability: monthly data on GDP are available for few countries. The key point, however, is that the exchange rate regime can be expected to exert an important influence on the manufacturing industries rather than the entire economies. Producing tradeable goods and being exposed to foreign competition, these industries are susceptible to exchange rate fluctuations and misalignments. Our point is similar to the one raised by Rodrik (2013) with respect to unconditional convergence within the manufacturing industries. Rodrik (2013, p. 201-2) claims that

> these industries produce tradable goods and can be rapidly integrated into global production networks, facilitating technology transfer and absorption. Even when they produce just for the home market, they operate under competitive threat from efficient suppliers from abroad, requiring that they upgrade their operations and remain efficient. Traditional agriculture, many nontradable services, and especially informal economic activities do not share these characteristics.

Thus, we use monthly data on manufacturing in 48 countries in the period between 1990 and 2019. The list of countries, data description and sources are detailed in Tables A1 and A2 in Appendix A, respectively.

The output volatility measure is constructed in two steps. First, the cyclical component of (the log of) the index of manufacturing is obtained with the Hamilton method. Hamilton (2018) argues that the cyclical component of a possibly nonstationary series can be obtained by answering the question: How different is the value of a series at date $t+h$ from the value that we would have expected to see based on its behaviour through date $t$? Hamilton demonstrates that the cyclical component can be obtained from the linear projection of $y_{t+h}$ on a constant and a vector of the twelve most recent values of $y$ as of date $t$. Thus, we run the following regression

$$y_{t+h} = \beta_0 + \beta_1 y_t + \beta_2 y_{t-1} + \cdots + \beta_p y_{t-p+1} + \nu_{t+h} \quad (10)$$

where $y_t$ is (the log of) the manufacturing index and, given monthly data, $h$ and $p$ are set to 24 and 12, respectively. The residual $\hat{\nu}_{t+h}$ is an estimate of a cyclical component at date $t+h$.

Second, the output volatility in country $i$ in year $t$, $ovol_{it}$ is constructed as a root mean squared cyclical component

$$ovol_{it} = \sqrt{\frac{1}{11}\sum_{m=1}^{12} \hat{\nu}_{it,m}^2} \quad (11)$$

where $m$ is an index for months. If the number of observations in a given year is less than six, the volatility measure is set as not available. Intuitively, the output volatility measure can be interpreted as a standard deviation of a cyclical component calculated under the assumption that the mean is zero.

Following our theoretical framework, we divide countries into peggers and floaters. We do it by alternatively employing two *de facto* exchange rate regime classifications. The first is the updated Reinhart and Rogoff classification available for 194 countries in the period between 1946 and 2016 Ilzetzki et al. (2019). They use six (coarse) categories that can be roughly described as: (1) fixed, (2) narrow bands, (3) broad bands and managed floating, (4) freely floating, (5) (dysfunctional) freely falling, and (6) multiple, dual or parallel markets with limited or no data the structure of exchange rates. Their groups are mapped into two main categories: the least flexible arrangements, i.e. groups 1 and 2 are merged into 'pegs', the more flexible arrangements, i.e. groups 3 and 4, are labelled as 'floats', and the remaining two groups are placed in a residual category 'others'.[14] The detailed mapping is reported in Table A3 in Appendix A.

The second *de facto* exchange rate regime classification we employ has recently been developed by Dąbrowski et al. (2020). The (updated) classification is available for 180 countries in the period between 1995 and 2019. Five categories of exchange rate arrangements are used: fix, float, inconclusive, under pressure, and outlier. We generally retain the original classification, and the only modification is that three last categories are combined into a single residual category 'others' (see Table A3 in Appendix A).

In the third group of variables, output volatility determinants other than exchange rate regimes are collected. The group can be divided into global and country-specific explanatory variables. The former include such variables as implied volatility index (VIX), economic policy uncertainty index, oil price index, and non-energy price index. The latter include trade openness measured with the sum of exports and imports to GDP ratio, financial development proxied with private credit by deposit money banks and other financial institutions to GDP ratio or, alternatively, with the GDP *per capita* relative to the world level, a size of an economy measured with the GDP relative to the world aggregate or a share in the world population, and the index of political stability and absence of violence/terrorism. Moreover, a dummy for the advanced economy status according to the classification by the IMF and a euro area

[14] In fact, Ilzetzki et al. (2019) already use such broad groups in their paper.

membership dummy are used. The detailed data description is provided in Table A2 in Appendix A.

## 6. Results and discussion

*Preliminary analysis*

It is worth starting the analysis of the importance of the exchange rate regime for output volatility with a simple exposition of data. Boxplots of output volatility across the exchange rate arrangements are depicted in two panels of Figure 1. Boxplots for pegs and floats illustrated in panel (a) are obtained under the updated Reinhart and Rogoff (RRI) classification. Three observations can be made. First, the distribution of output volatility for floats is located to the left from the distribution for pegs. Both mean and median are smaller in the group of floats than in the group of pegs. Second, output volatility among pegs is more dispersed than that of floats. Third, both distributions are right-skewed, which can be expected as output volatility is positive.

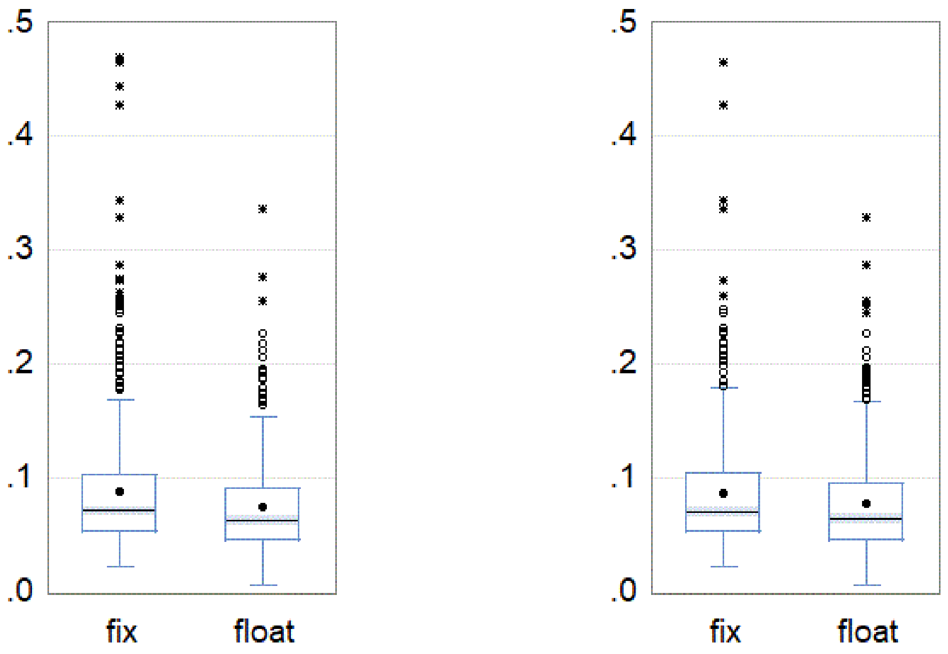
These visual impressions are confirmed by formal tests: hypotheses of equality of means, medians, and variances are rejected at the conventional significance level of 5% (or lower), and skewness is positive. The statistical details are provided in Table A4 in Appendix A. The same three observations can be made when the Dąbrowski-Papież-Śmiech (DPS) exchange rate classification is used to derive distributions of pegs and floats. These boxplots are depicted in panel (b) in Figure 1.[15]

Irrespective of the exchange rate classification adopted, output volatility seems to be smaller in countries that let their currencies float. Even though the difference between pegs and floats is on average statistically significant, the customary reservations apply here. So far, no control variables have been taken into account in our analysis, so the apparent relationship can be an outcome of the omitted variable problem. Boxplots and tests should be simply considered descriptive tools that provide an initial outlook of the data.

An additional issue that should be considered is the stationarity of panel data used. The set of panel unit root tests carried out includes the LLC, IPS, ADF and PP tests. We find that the output volatility and its country-specific determinants are stationary except for the relative size of an economy. The global determinants are in turn non-stationary except for the VIX index. The detailed results are reported in Table A5 in Appendix A. In line with these findings,

[15] The same time range as for the RRI classification is used to make descriptions comparable. The picture based on the extended sample, 1995-2019, is almost the same.

stationary variables enter empirical analysis in levels, and non-stationary variables are transformed into first differences.




(a) RRI classification (b) DPS classification

Figure 1. Output volatility across exchange rate arrangements obtained from alternative classifications, 1995-2016

*Notes:* RRI stands for the classification from Ilzetzki et al. (2019); DPS stands for the classification from Dąbrowski et al. (2020). The boxplot for the latter in the period between 1995 and 2019 is similar. The box portion of a boxplot represents the first and third quartiles, and the difference between them is an interquartile range (IQR). Whiskers and staples are set at the first quartile minus 1.5*IQR and the third quartile plus 1.5*IQR.

*Main results*

In order to be able to compare the results regarding the importance of the exchange rate regime for output volatility obtained under two alternative classifications, the sample is set in such a way that the time range is limited to the period covered by both classifications, i.e. 1995-2016. Moreover, since the focus is on the differences between pegs and floats, only the countries classified as such under both classifications are included in the sample. In other words, the intersection of the sets of pegs and floats under two classifications is considered. In Table 2, the data on the incidence of exchange rate regimes under both classifications are reported. More than 92% of country-years are classified as either fix or float. Thus, the restriction imposed is not too costly in terms of degrees of freedom since only 75 observations out of 998 are not in the intersection and need to be left outside the sample. At the same time, the restriction makes the comparison meaningful: the same observations are included in the sample irrespective of the classification used.

The natural starting point is a benchmark specification that captures the potential determinants of output volatility other than the exchange rate regime. To account for the persistence of output volatility and to eliminate the serial correlation in the error terms, the lags of the dependent variable are included

$$ovol_{it} = \sum_{j=1}^{p} \beta_j ovol_{i,t-j} + \gamma' x_{it} + u_i + \varepsilon_{it} \quad (12)$$

where $x_{it}$ is a vector of output volatility determinants, and $\gamma$ is a vector of coefficients. Two lags of the dependent variable work well in almost all specifications, so we set $p = 2$ and report the Arellano–Bond test for first- and second-order autocorrelation in the first-differenced errors.

Estimation results of equation (12) are reported in Table 3. In the first specification, the set of explanatory variables includes only country-specific determinants: the trade openness, the financial development, the (first difference in the) relative size of an economy and the political stability and absence of violence/terrorism index (hereafter the political stability index). Even though the exchange rate regime is omitted in this specification, it is worthwhile to briefly discuss the results. It is because in other specifications the signs of coefficients remain basically the same. Thus, the more open an economy, the less volatile its output. This can be a bit surprising since foreign trade constitutes an additional source of shocks. There are, however, well-known mechanisms that work in the opposite direction. In an open economy, firms are less vulnerable to country-specific shocks as their production and sales can be geographically diversified. Moreover, both the textbook macroeconomic model and empirical literature indicate that the expenditure multiplier decreases in the marginal propensity to import.[16] Financial development contributes positively to output volatility. This can be related to a higher susceptibility of a real economy to adverse financial disturbances and breaks in financial intermediation. For example, using a narrower concept of financial depth, Acedański and Pietrucha (2019) find that it is positively associated with volatility of GDP. A rise in the relative size of an economy is found to mitigate output volatility which is in line with the literature (see, e.g., Karras, 2006). An intuitive explanation could be that, as an economy expands, its markets become more absorbent and production can be diversified to a greater extent. Not surprisingly,

[16] For example, Haddad et al. (2012) find the negative effect of openness on output volatility. A positive link is found for developing countries by Alimi and Aflouk (2017).

output volatility is on average smaller in more politically stable environment. Even though in this simple specification the coefficient is not statistically significant, the political stability index is retained as an informative explanatory variable because in extended specifications it is significant. We experimented with the (log difference in the) relative GDP *per capita* and the relative population, but found that they are insignificant when used with the private credit-to-GDP ratio and the relative GDP, respectively.[17]

The set of explanatory variables is extended by global determinants in the second specification. The increased financial uncertainty, measured with the VIX index, results in an increased output volatility, whereas changes in prices of oil and non-energy commodities are associated with decreases in output volatility. The importance of country-specific determinants is almost unchanged, and the only exceptions are that the private credit-to-GDP ratio is insignificant and the political stability index is significant.

The country status dummies are introduced into the three other specifications. The euro area member states as well as the advanced economies are found to have their outputs less volatile. The inclusion of dummies makes trade openness and changes in oil price insignificant. Interestingly, examining five Central and Eastern European euro area member states, Hegerty (2020) finds that global determinants of output volatility seem to be more important than regional shocks, trade openness or euro area accession. Given these results, we retain the country status dummies as they can provide an important check for the robustness of the results obtained in specifications that capture the importance of the exchange rate arrangements.

Having identified the set of key determinants of output volatility, we are ready to examine whether the data on the exchange rate regimes convey additional information. Equation (12) is, therefore, extended

$$ovol_{it} = \sum_{j=1}^{p} \beta_j ovol_{i,t-j} + \gamma' x_{it} + \delta\, peg_{it}^{c} + u_i + \varepsilon_{it} \qquad (13)$$

where the exchange rate regime dummy $peg_{it}^{c}$ equals 1 if the $i$-th country has the fixed exchange rate regime in year $t$ and 0 if the floating regime is adopted. The superscript $c \in \{RRI, DPS\}$ stands for the exchange rate regime classification.

The regression results are reported in Table 4. The sign of coefficient on exchange rate regime dummy is found to be negative in both classifications and all specifications. This implies that output volatility is smaller when the exchange rate is fixed than under the floating rate regime. Importantly, both country-specific and global determinants of output volatility remain important although trade openness and oil price are no longer significant. This is a similar

[17] Results available upon request.

finding to the one observed in the benchmark specification of equation (12) when the euro area and/or advanced economy dummies are introduced.

The beneficial influence of pegging the exchange rate does not seem to be robust. It is because the effect ceases to be significant when we control for the euro area membership and/or the status of an advanced economy (columns 3-8). Thus, one can claim, using dispiriting words of Rose (2011), that the exchange rate regimes are 'flaky' in a sense that they do not seem to have visible consequences.[18] This finding, however, is not surprising: the key implication from the theoretical framework is that the exchange rate regime affects the response of output to various shocks rather than directly determines output volatility.

Given that our theoretical framework implies that the exchange rate regime can change the importance of trade openness and financial development to output volatility, we extend equation (13) to allow for interaction terms between country-specific determinants and the exchange rate regime

$$ovol_{it} = \sum_{j=1}^{p} \beta_j ovol_{i,t-j} + \gamma' x_{it} + \delta\, peg_{it}^{c} + \theta' x_{it}^{sp}\, peg_{it}^{c} + u_i + \varepsilon_{it} \qquad (14)$$

where $x_{it}^{sp}$ is a vector of country-specific determinants of output volatility and is a subset of the vector $x_{it}$. $\theta$ is a vector of coefficients of interactive variables. The exchange rate dummy is defined as previously.

The results of the regressions with interaction terms are reported in Table 5. Both country-specific and global determinants of output volatility remain important, although, like in regressions without interaction terms, trade openness, private credit-to-GDP ratio and oil price are not significant. The direct effect of the exchange rate regime is negative under both classifications and in all specifications, albeit it is significant only when the DPS classification is used.

According to our theoretical framework, output volatility depends on the type of shocks rather than on the exchange rate regime. The latter, however, can moderate or amplify the importance of other output volatility determinants. The coefficients on interaction terms reported in Table 5 capture these influences. It can be observed that trade openness reduces output volatility when the exchange rate is fixed and remains unimportant when the exchange rate is floating. This can explain why trade openness is found to be insignificant in regression results reported in Table 4 in which no interaction terms are allowed. Moreover, this finding is

[18] Rose (2011, p. 671) is much more sceptical as he argues that the exchange rate regimes 'seem to have neither discernible causes nor visible consequences'.

in line with the hypothesis derived in Section 3 that the increase in trade openness reduces output volatility under the fixed rate regime.

The interaction term in the credit-to-GDP ratio is insignificant under the RRI classification and significantly positive under the DPS classification. Interestingly, the overall effect of financial development under the fixed exchange rate regime is positive (except for the specification in column (1) where it is close to zero) irrespective of the classification employed. Given that some second-order autocorrelation in the errors is left in the regressions with the RRI classification and that the relevant coefficients are insignificant in these regressions, it is reasonable to put more weight on the results obtained in regressions with the DPS classification. It can, therefore, be argued that the impact of credit-to-GDP ratio on output volatility is amplified by having the fixed rate regime. This finding lends support to the hypothesis on the relevance of financial development derived from the theoretical framework in Section 3.

The coefficients of interaction terms of two other country-specific determinants, i.e. the relative size of an economy and political stability, are positive, so both determinants enhance output volatility under the fixed exchange rate regime. Interestingly, the effects stemming from interactions are more than offset by direct effects, so the overall influence of the relative size of an economy and political stability remains negative. Given that the interaction term in the political stability index is not significant, it can be claimed that the impact of this determinant on output volatility is the same under both exchange rate regimes. This is not the case when the relative size of an economy is considered: its overall effect on output volatility is weaker, i.e. less negative, under the fixed rate than under the floating rate regime.

The dummies on the euro area membership and the advanced economy status are used in specifications from (3) to (8) in Table 5. Similar to the baseline case, we find that output volatility is lower both in the euro area member states and advanced economies. The key finding, however, is that the results reported in columns (1) and (2) are robust to the inclusion of these dummies. The importance of the exchange rate regime goes beyond having or not the common European currency in circulation or being an advanced economy.

The sample used so far is the intersection of the sets of pegs and floats under two exchange rate regime classifications. This implies that it is enough to have a given country-year classified as ‘other’ under any classification to exclude such a data point from the sample. Moreover, the DPS classification provides information on exchange rate regimes till 2019 that is not used in our main analysis because the same time range has been adopted for both classifications in order to keep the results comparable across classifications. It is worthwhile to check whether the results are similar when the single-classification perspective is adopted.

All the regressions with the interaction terms are rerun on the ‘pegs’ and ‘floats’ obtained from either the RRI classification or the DPS classification. For the latter, the time range is extended till 2019. The results are reported in Table 6. The parameter point estimates are almost unchanged in comparison to those reported in Table 5. This is especially the case when the determinants of output volatility, the interaction terms and the exchange rate regime dummies are analysed. Thus, the results remain robust to using the single-classification perspective and longer time range.

## 7. Conclusions

This paper analyses the importance of the exchange rate regime for output volatility. The choice of the exchange rate regime is a decision regarding a nominal variable, whereas output is a real variable. Given that the classical dichotomy holds in the long run, the research focus is on the output volatility rather than on the long-term economic growth. Thus, we raise the research question whether the exchange rate regime matters for output volatility. Using two alternative *de facto* exchange rate regime classifications, we demonstrate that the answer to this question is conditional ‘yes’. The results can be summarised as follows.

Neither the naïve approach based on simple correlations between output volatility and exchange rate regimes nor the more elaborated regression-based approach with control variables provide compelling evidence on the importance of the exchange rate regimes. Even though the former suggests a trade-off between the exchange rate and output volatilities, it is subject to the omitted variable problem. The latter neglects the different sources of shocks hitting economies, some of which are easier to absorb under the fixed exchange rate and some under the floating rate. Indeed, empirical evidence on the direct contribution of the exchange rate regime to output volatility is at best wonky: having the fixed rate regime decreases output volatility, but this beneficial effect seems to proxy for the euro area membership and/or being an advanced economy.

Building on a simple model of an open economy, it is demonstrated that the exchange rate regime can modify the importance of some determinants of output volatility. This is because output sensitivity to shocks depends on the same set of determinants, but the relation is different under fixed and floating exchange rate regimes. In line with the theoretical framework, it is found that the trade openness contributes to the reduction in output volatility if the exchange rate is fixed, whereas it importance is insignificant under the floating rate regime. Similarly, the financial development feeds into increased output volatility when the exchange rate is fixed, but its effect is negligible if the exchange rate floats. Out of two other determinants of output volatility only the relative size of an economy is found to interact with the exchange rate regime. The bigger the economy, the smaller the output volatility under both exchange rate regimes, but the beneficial size effect is stronger when the exchange rate is let to float. Politically stable economies are found to undergo smaller output volatility irrespective of the exchange rate regime. Among the global determinants considered, both uncertainty in international financial markets, measured with the VIX index, and changes in prices of non-energy commodities affect output volatility. Somewhat surprisingly, changes in oil prices are found to be unimportant, albeit this finding is in line with economic literature (see, e.g., Blanchard and Riggi, 2013; Kilian, 2009).

Finally, the results do not depend on the exchange rate regime classification employed to identify *de facto* pegs and floats. This finding is important because the agreement between the RRI and DPS classifications is less than perfect (about 80%). The differences between classifications find their way into the point estimates of some coefficients but almost do not change either the signs of relations or their statistical significance. It can be argued that the results obtained with the DPS classification lend more support to our findings.

It should be acknowledged that our approach and findings are subject to several limitations. First, we do not attempt to empirically identify shocks and do not directly compare the responses of real variables to them under fixed and floating exchange rates. That would provide a more detailed perspective on the importance of the exchange rate regime but would entail the focus on several economies only and the use of different techniques that are not well-suited to the panel data. Second, we claim that the exchange rate regime matters for manufacturing industries as they produce tradeables. Some services, however, are also tradeables, and it would be desirable to encompass the production and provision of these services in our measure of output volatility. The problem is that the relevant data are hardly available for a large set of countries. Third, the analysis could be extended to include additional explanatory variables in order to mitigate the problem of omitted variables. Such an extension could be carried out within the framework of Bayesian model averaging that seems to be an adequate method of dealing with large sets of explanatory variables also in the panel data context (see, e.g., Moral-Benito and Roehn, 2016). The limitations listed make our results less general than we wish, but at the same time they provide us with ideas for further research.

## References


Acedański, J., and Pietrucha, J. (2019). Level and dynamics of financial depth: consequences for volatility of GDP. *Applied Economics*, 51(31), 3389–3400. https://doi.org/10.1080/00036846.2019.1578857

Ahir, H., Bloom, N., and Furceri, D. (2018). The World Uncertainty Index. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3275033

Alimi, N., and Aflouk, N. (2017). Terms-of-trade shocks and macroeconomic volatility in developing countries: Panel smooth transition regression models. *The Journal of International Trade & Economic Development*, 26(5), 534-551. ttps://doi.org/10.1080/09638199.2016.1278029.

Arellano, M., and Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, 58(2), 277–297. https://doi.org/10.2307/2297968

Arratibel, O., and Michaelis, H. (2014). The impact of monetary policy and exchange rate shocks in Poland. Evidence from a time-varying VAR. *European Central Bank, Working Paper Series*, 1636(16), 1–37.

Ashour, M., and Chen Yong, C. (2018). The impact of exchange rate regimes on economic growth: Empirical study of a set of developing countries during the period 1974–2006. *Journal of International Trade and Economic Development*, 27(1), 74–90. https://doi.org/10.1080/09638199.2017.1339117

Audzei, V., and Brázdik, F. (2018). Exchange rate dynamics and their effect on macroeconomic volatility in selected CEE countries. *Economic Systems*, 42(4), 584–596. https://doi.org/10.1016/j.ecosys.2018.02.003

Baxter, M., and Stockman, A. C. (1989). Business cycles and the exchange-rate regime. Some international evidence. *Journal of Monetary Economics*, 23(3), 377–400. https://doi.org/10.1016/0304-3932(89)90039-1

Baycan, I. O. (2016). The effects of exchange rate regimes on economic growth: evidence from propensity score matching estimates. *Journal of Applied Statistics*, 43(5), 914–924. https://doi.org/10.1080/02664763.2015.1080669

Blanchard, O. J., and Riggi, M. (2013). Why are the 2000s so different from the 1970s? A structural interpretation of changes in the macroeconomic effects of oil prices. *Journal of the European Economic Association*, 11(5), 1032–1052. https://doi.org/10.1111/jeea.12029

Bleaney, M., and Fielding, D. (2002). Exchange rate regimes, inflation and output volatility in developing countries. *Journal of Development Economics*, 68(1), 233–245. https://doi.org/10.1016/S0304-3878(02)00002-0

Dąbrowski, M. A., Papież, M., and Śmiech, S. (2020). Classifying de facto exchange rate regimes of financially open and closed economies: A statistical approach. *Journal of International Trade and Economic Development*, 29(7), 821–849. https://doi.org/10.1080/09638199.2020.1748692

Dąbrowski, M. A., and Wróblewska, J. (2016). Exchange rate as a shock absorber in Poland and Slovakia: Evidence from Bayesian SVAR models with common serial correlation. *Economic Modelling*, 58, 249–262. https://doi.org/10.1016/j.econmod.2016.05.013

Dąbrowski, M. A., and Wróblewska, J. (2020). Insulating property of the flexible exchange rate regime: A case of Central and Eastern European countries. *International Economics*, 162, 34–49. https://doi.org/10.1016/j.inteco.2020.03.002

De, K., and Sun, W. (2020). Is the exchange rate a shock absorber or a source of shocks? Evidence from the U.S. *Economic Modelling*, 89, 1–9. https://doi.org/10.1016/j.econmod.2019.10.015

Deskar-Škrbić, M., Kotarac, K., and Kunovac, D. (2020). The third round of euro area enlargement: Are the candidates ready? *Journal of International Money and Finance*, 107, 102205. https://doi.org/10.1016/j.jimonfin.2020.102205

Edwards, S. (2011). Exchange-Rate Policies in Emerging Countries: Eleven Empirical Regularities From Latin America and East Asia. *Open Economies Review*, 22(4), 533–563. https://doi.org/10.1007/s11079-011-9206-4

Engel, C., and West, K. D. (2006). Taylor Rules and the Deutschmark-Dollar Real Exchange Rate. *Journal of Money, Credit, and Banking*, 38(5), 1175–1194. https://doi.org/10.1353/mcb.2006.0070

Erdal, B., and Pınar, A. (2019). Major Determinants of Economic Growth under Intermediate and Flexible Exchange Rate Regimes: Empirical Evidence from Turkey. *Advances in Management & Applied Economics*, 9(1), 1–20.

Erdem, F. P., and Özmen, E. (2015). Exchange Rate Regimes and Business Cycles: An Empirical Investigation. *Open Economies Review*, 26(5), 1041–1058. https://doi.org/10.1007/s11079-015-9361-0

Fleming, J. M. (1962). Domestic Financial Policies under Fixed and under Floating Exchange Rates. *Staff Papers - International Monetary Fund*, 9(3), 369–380. https://doi.org/10.2307/3866091

Flood, R. P., and Rose, A. K. (1995). Fixing exchange rates A virtual quest for fundamentals. *Journal of Monetary Economics*, 36(1), 3–37. https://doi.org/10.1016/0304-3932(95)01210-4

Galí, J. (2015). *Monetary policy, inflation, and the business cycle: An introduction to the new Keynesian framework and its applications*: *Second edition*. Princeton University Press.

Galí, J., and Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *Review of Economic Studies*, 72(3), 707–734. https://doi.org/10.1111/j.1467-937X.2005.00349.x

Ghosh, A. R., Gulde, A. M., and Wolf, H. C. (2003). *Exchange rate regimes: choices and consequences*. MIT Press, Cambridge.

Grydaki, M., and Fountas, S. (2009). Exchange rate volatility and output volatility: A theoretical approach. *Review of International Economics*, 17(3), 552–569. https://doi.org/10.1111/j.1467-9396.2009.00833.x

Haddad, M., Lim, J. J., Pancaro, C., and Saborowski, C., (2012). Trade openness reduces growth volatility when countries are well diversified. ECB Working Paper Series No. 1491.

Hamilton, J. D. (2018). Why you should never use the Hodrick-Prescott filter. *Review of Economics and Statistics*, 100(5), 831–843. https://doi.org/10.1162/rest_a_00706

Hegerty, S. W., (2020). Macroeconomic volatility, monetary union, and external exposure: evidence from five Eurozone members. *Baltic Journal of Economics*, 20(2), 117–138. https://doi.org/10.1080/1406099X.2020.1780694.

Husain, A. M., Mody, A., and Rogoff, K. S. (2005). Exchange rate regime durability and performance in developing versus advanced economies. *Journal of Monetary Economics*, 52(1), 35–64. https://doi.org/10.1016/j.jmoneco.2004.07.001

Ilzetzki, E., Reinhart, C. M., and Rogoff, K. S. (2019). Exchange Arrangements Entering the Twenty-First Century: Which Anchor will Hold? *The Quarterly Journal of Economics*, 134(2), 599–646. https://doi.org/10.1093/qje/qjy033

Im, K. S., Pesaran, M. H., and Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

Jeanne, O., and Rose, A. K. (2002). Noise trading and exchange rate regimes. *Quarterly Journal of Economics*, 117(2), 537–569. https://doi.org/10.1162/003355302753650328

Jibrin, A. A., Jelilov, G., and Gayypov, Y. (2017). Exchange rate and economic growth in economic Community of West African States (ECOWAS). *The Empirical Economics Letters*, 16(15), 519–526.

Johnson, L. E., Ley, R., and Cate, T. (2001). Keynes' theory of money and his attack on the classical model. *International Advances in Economic Research*, 7(4), 409–418. https://doi.org/10.1007/BF02295770.

Karras, G., (2006). Trade openness, economic size, and macroeconomic volatility: Theory and empirical evidence. *Journal of Economic Integration*, 21(2), 254–272. https://doi.org/10.11130/jei.2006.21.2.254.

Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review*, 99(3), 1053–1069. https://doi.org/10.1257/aer.99.3.1053.

Klein, M. W., and Shambaugh, J. C. (2010). *Exchange Rate Regimes in the Modern Era*. In *MIT Press Books* (Vol. 1). The MIT Press.

Levin, A., Lin, C. F., and Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, 108(1), 1–24. https://doi.org/10.1016/S0304-4076(01)00098-7

Levy-Yeyati, E., and Sturzenegger, F. (2003). To float or to fix: Evidence on the impact of exchange rate regimes on growth. *American Economic Review*, 93(4), 1173–1193. https://doi.org/10.1257/000282803769206250

Mohammed, T., Retia, M., Gaidi, K., and Boudeghdegh, A. (2018). The Impact of Exchange Rate Regimes on Economic Growth. In N. Tsounis and A. Vlachvei (Eds.), *Advances in Panel Data Analysis in Applied Economic Research. ICOAE 2017. Springer Proceedings in Business and Economics*. Springer, Cham. https://doi.org/10.1007/978-3-319-70055-7_33

Moral-Benito, E., and Roehn, O. (2016). The impact of financial regulation on current account balances. *European Economic Review*, 81, 148–166. https://doi.org/10.1016/j.euroecorev.2015.07.005

Mundell, R. A. (1963). Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates. *The Canadian Journal of Economics and Political Science*, 29(4), 475–485. https://doi.org/10.2307/139336

Mussa, M. (1986). Nominal exchange rate regimes and the behavior of real exchange rates: Evidence and implications. *Carnegie-Rochester Confer. Series on Public Policy*, 25(C), 117–214. https://doi.org/10.1016/0167-2231(86)90039-4

Obstfeld, M., and Rogoff, K. (2001). The Six Major Puzzles in International Macroeconomics: Is There a Common Cause? *NBER Macroeconomics Annual*, 15, 339–390. https://doi.org/10.1086/654423

Rodrik, D. (2013). Unconditional convergence in manufacturing. *Quarterly Journal of Economics*, 128(1), 165–204. https://doi.org/10.1093/qje/qjs047

Rogoff, K. S., Husain, A. M., Mody, A., Brooks, R., and Oomes, N. (2004). Evolution and performance of exchange rate regimes. IMF Occasional Papers, 229, 1–55. https://doi.org/10.5089/9781451875843.001

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal*, 9(1), 86–136. https://doi.org/10.1177/1536867x0900900106

Rose, A. K. (2011). Exchange rate regimes in the modern era: Fixed, floating, and flaky. *Journal of Economic Literature*, 49(3), 652–672. https://doi.org/10.1257/jel.49.3.652

Sargan, J. D. (1958). The Estimation of Economic Relationships using Instrumental Variables. *Econometrica*, 26(3), 393–415. https://doi.org/10.2307/1907619

Schmidt-Hebbel, K. (2019). Macroeconomic Institutions: Lessons from World Experience for MENA Countries. In *Economic Research Forum Working Papers* (No. 1311).

Schüler, Y. S. (2020). On the Cyclical Properties of Hamilton's Regression Filter. SSRN 3559776 *Electronic Journal*, 03. https://doi.org/10.2139/ssrn.3559776

Seraj, M., Bahramian, P., Alhassan, A., and Shahabad, R. D. (2020). The validity of Rodrik's conclusion on real exchange rate and economic growth: factor priority evidence from feature selection approach. *Palgrave Communications*, 6(1), 1–6. https://doi.org/10.1057/s41599-020-0465-9

Shevchuk, V. (2014). Shock-absorbing properties of the exchange rates in transformation economies: SVAR estimates. In M. Papież and S. Śmiech (Eds.), *Proceedings of the 8th Professor Aleksander Zelias International Conference on Modelling and Forecasting of Socio-Economic Phenomena* (pp. 155–164). Foundation of the Cracow University of Economics, Cracow.

Tavlas, G., Dellas, H., and Stockman, A. C. (2008). The classification and performance of alternative exchange-rate systems. *European Economic Review*, 52(6), 941–963. https://doi.org/10.1016/j.euroecorev.2008.02.003

Terrones, M. E. (2020). Do fixers perform worse than non-fixers during global recessions and recoveries? *Journal of International Money and Finance*, 104, 102160. https://doi.org/10.1016/j.jimonfin.2020.102160

Wajda-Lichy, M., Kawa, P., Fijorek, K., and Denkowska, S. (2020). Trade Openness and Financial Development in the New EU Member States: Evidence from a Granger Panel Bootstrap Causality Test. *Eastern European Economics*, 58(3), 242–263. https://doi.org/10.1080/00128775.2019.1701498

Wong, D. K. T. (2020). A re-examination of the impacts of macroeconomic and financial shocks on real exchange rate fluctuation: evidence from G7 and Asian countries. *Applied Economics*, 52(50), 5491–5515. https://doi.org/10.1080/00036846.2020.1765962

Table 1. Impact of changes in trade openness and financial development on sensitivity of output volatility to volatility in shocks[*]

| | Sensitivity to volatility in: | | | |
|---|---|---|---|---|
| | supply shocks | demand shocks | financial shocks | monetary shocks |
| *Response to trade openness under* | | | | |
| Fixed rate | + | – | – | 0 |
| Floating rate | + | – | +[**] | + |
| *Response to financial development under* | | | | |
| Fixed rate | 0 | 0 | + | 0 |
| Floating rate | 0 | 0 | –[**] | 0 |

Notes: [*] A sign of the derivative of a coefficient that captures the impact of a given shock's volatility on output volatility; derivatives with respect to $\gamma_s$ (the first two rows) and $\gamma_f$ (the last two rows). [**] For a relatively open economy, that is if $\gamma_s > \gamma_f/\sigma$.

Table 2. Exchange rate regime incidence under the RRI and DPS classifications

| DPS \ RRI | Fix | Float | Other | Total |
|---|---|---|---|---|
| Fix | 469 (47.0) | 29 (2.9) | 4 (0.4) | 502 (50.3) |
| Float | 106 (10.6) | 319 (32.0) | 12 (1.2) | 437 (43.8) |
| Other | 33 (3.3) | 19 (1.9) | 7 (0.7) | 59 (5.9) |
| Total | 608 (60.9) | 367 (36.8) | 23 (2.3) | 998 (100.0) |

*Note:* Percentage of total (998) in parentheses. A simple measure of agreement between classifications is 79.7% (a sum of numbers on a main diagonal to the total).

Table 3. Regressions with country-specific and global fundamentals, 1995-2016

| VARIABLES | Country-specific fundamentals (1) | All fundamentals (2) | with the euro area dummy (3) | with the advanced economy dummy (4) | with both dummies (5) |
|---|---|---|---|---|---|
| *ovol*, lag(1) | 0.4178*** | 0.3797*** | 0.3750*** | 0.3643*** | 0.3660*** |
| | (0.0195) | (0.0263) | (0.0255) | (0.0224) | (0.0227) |
| *ovol,* lag(2) | -0.1321*** | -0.1466*** | -0.1482*** | -0.1348*** | -0.1354*** |
| | (0.0173) | (0.0189) | (0.0167) | (0.0234) | (0.0271) |
| log *open* | -0.0861*** | -0.0201** | -0.0112 | -0.0136 | -0.0091 |
| | (0.0074) | (0.0092) | (0.0116) | (0.0083) | (0.0095) |
| log *pct* | 0.0096*** | -0.0044 | -0.0024 | -0.0013 | -0.0007 |
| | (0.0017) | (0.0038) | (0.0036) | (0.0033) | (0.0036) |
| diff log *yppp* | -0.4023*** | -0.3548*** | -0.3556*** | -0.3716*** | -0.3544*** |
| | (0.0290) | (0.0515) | (0.0553) | (0.0444) | (0.0601) |
| *pos* | -0.0063 | -0.0200*** | -0.0223*** | -0.0214*** | -0.0185*** |
| | (0.0046) | (0.0051) | (0.0049) | (0.0060) | (0.0054) |
| log *vix* | | 0.0336*** | 0.0347*** | 0.0365*** | 0.0346*** |
| | | (0.0022) | (0.0023) | (0.0016) | (0.0024) |
| diff log *poil*, | | -0.0064** | -0.0028 | -0.0048 | -0.0045 |
| | | (0.0027) | (0.0036) | (0.0036) | (0.0036) |
| diff log *pnen* | | -0.0192** | -0.0272*** | -0.0261*** | -0.0259*** |
| | | (0.0095) | (0.0075) | (0.0087) | (0.0066) |
| *ead* | | | -0.0138*** | | -0.0044 |
| | | | (0.0048) | | (0.0046) |
| *aed* | | | | -0.0365*** | -0.0303* |
| | | | | (0.0107) | (0.0156) |
| Observations | 763 | 763 | 763 | 763 | 763 |
| Countries | 48 | 48 | 48 | 48 | 48 |
| AR(1) | -4.3771*** | -4.5271*** | -4.5262*** | -4.4919*** | -4.5100*** |
| AR(2) | -1.1331 | -1.5181 | -1.4983 | -1.7506* | -1.7159* |
| Sargan | 45.2907 | 44.5298 | 44.2125 | 45.8084 | 44.1829 |

*Notes:* results obtained with xtabond command in Stata 16.0. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table 4. Regressions with exchange rate regime dummies, 1995-2016

| VARIABLES | RRI (1) | DPS (2) | RRI with the euro area dummy (3) | DPS with the euro area dummy (4) | RRI with the advanced economy dummy (5) | DPS with the advanced economy dummy (6) | RRI with both dummies (7) | DPS with both dummies (8) |
|---|---|---|---|---|---|---|---|---|
| *ovol*, lag(1) | 0.3989*** | 0.3714*** | 0.3812*** | 0.3761*** | 0.3746*** | 0.3561*** | 0.3687*** | 0.3589*** |
| | (0.0204) | (0.0213) | (0.0234) | (0.0267) | (0.0228) | (0.0231) | (0.0315) | (0.0257) |
| *ovol,* lag(2) | -0.1533*** | -0.1685*** | -0.1487*** | -0.1479*** | -0.1581*** | -0.1478*** | -0.1349*** | -0.1452*** |
| | (0.0147) | (0.0196) | (0.0180) | (0.0204) | (0.0214) | (0.0149) | (0.0240) | (0.0236) |
| log *open* | -0.0167 | -0.0150 | -0.0160* | -0.0118 | -0.0086 | -0.0161 | -0.0035 | -0.0003 |
| | (0.0105) | (0.0126) | (0.0085) | (0.0122) | (0.0109) | (0.0145) | (0.0119) | (0.0117) |
| log *pct* | -0.0007 | -0.0032 | 0.0016 | -0.0020 | -0.0008 | -0.0014 | -0.0012 | -0.0027 |
| | (0.0033) | (0.0038) | (0.0029) | (0.0037) | (0.0035) | (0.0036) | (0.0036) | (0.0038) |
| diff log *yppp* | -0.3409*** | -0.3877*** | -0.3655*** | -0.3817*** | -0.4176*** | -0.3688*** | -0.3635*** | -0.3960*** |
| | (0.0480) | (0.0410) | (0.0502) | (0.0572) | (0.0423) | (0.0588) | (0.0592) | (0.0665) |
| *pos* | -0.0205*** | -0.0192*** | -0.0175*** | -0.0223*** | -0.0158*** | -0.0170*** | -0.0210*** | -0.0178*** |
| | (0.0042) | (0.0045) | (0.0053) | (0.0054) | (0.0044) | (0.0062) | (0.0061) | (0.0067) |
| log *vix* | 0.0329*** | 0.0365*** | 0.0350*** | 0.0352*** | 0.0324*** | 0.0344*** | 0.0350*** | 0.0345*** |
| | (0.0027) | (0.0021) | (0.0020) | (0.0023) | (0.0027) | (0.0023) | (0.0021) | (0.0025) |
| diff log *poil*, | -0.0048 | -0.0050 | -0.0027 | -0.0023 | -0.0011 | -0.0046 | -0.0035 | -0.0035 |
| | (0.0032) | (0.0031) | (0.0036) | (0.0036) | (0.0035) | (0.0034) | (0.0039) | (0.0038) |
| diff log *pnen* | -0.0288*** | -0.0168** | -0.0272*** | -0.0270*** | -0.0284*** | -0.0253** | -0.0272** | -0.0215* |
| | (0.0097) | (0.0085) | (0.0098) | (0.0076) | (0.0087) | (0.0107) | (0.0113) | (0.0113) |
| *ead* | | | -0.0120*** | -0.0138** | | | -0.0035 | -0.0038 |
| | | | (0.0045) | (0.0054) | | | (0.0047) | (0.0035) |
| *aed* | | | | | -0.0307** | -0.0368*** | -0.0328*** | -0.0284* |
| | | | | | (0.0124) | (0.0116) | (0.0126) | (0.0168) |
| $peg^{RRI}$ | -0.0223*** | | -0.0182* | | -0.0136 | | -0.0153* | |
| | (0.0082) | | (0.0100) | | (0.0090) | | (0.0086) | |
| $peg^{DPS}$ | | -0.0068*** | | -0.0014 | | -0.0030 | | -0.0027 |
| | | (0.0024) | | (0.0026) | | (0.0025) | | (0.0025) |
| Observations | 763 | 763 | 763 | 763 | 763 | 763 | 763 | 763 |
| Countries | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| AR(1) | -4.6740*** | -4.6067*** | -4.5203*** | -4.5308*** | -4.5023*** | -4.4983*** | -4.5221*** | -4.4993*** |
| AR(2) | -1.2832 | -1.1098 | -1.4237 | -1.4997 | -1.0565 | -1.5077 | -1.7889* | -1.5742 |
| Sargan | 44.1027 | 45.7418 | 44.1633 | 44.8684 | 42.9898 | 42.1816 | 44.3387 | 43.8347 |

*Notes:* results obtained with xtabond command in Stata 16.0. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table 5. Regressions with exchange rate regime dummies and interaction terms, 1995-2016

| VARIABLES | RRI & interact's (1) | DPS & interact's (2) | RRI & interact's with the euro area dummy (3) | DPS & interact's with the euro area dummy (4) | RRI & interact's with the advanced economy dummy (5) | DPS & interact's with the advanced economy dummy (6) | RRI & interact's with both dummies (7) | DPS & interact's with both dummies (8) |
|---|---|---|---|---|---|---|---|---|
| *ovol*, lag(1) | 0.4244*** | 0.3698*** | 0.3826*** | 0.3538*** | 0.3896*** | 0.3789*** | 0.3629*** | 0.3663*** |
| | (0.0388) | (0.0258) | (0.0276) | (0.0299) | (0.0294) | (0.0367) | (0.0302) | (0.0418) |
| *ovol,* lag(2) | -0.1356*** | -0.1611*** | -0.1212*** | -0.1639*** | -0.1233*** | -0.1593*** | -0.0998*** | -0.1820*** |
| | (0.0174) | (0.0207) | (0.0251) | (0.0266) | (0.0207) | (0.0261) | (0.0241) | (0.0340) |
| log *open* | 0.0308 | 0.0017 | 0.0531*** | 0.0098 | 0.0547* | 0.0045 | 0.0559** | 0.0001 |
| | (0.0232) | (0.0189) | (0.0205) | (0.0143) | (0.0300) | (0.0164) | (0.0226) | (0.0167) |
| log *pct* | 0.0059 | -0.0052 | 0.0011 | -0.0032 | 0.0113 | -0.0044 | 0.0001 | -0.0032 |
| | (0.0086) | (0.0043) | (0.0088) | (0.0048) | (0.0094) | (0.0032) | (0.0086) | (0.0040) |
| diff log *yppp* | -0.7728*** | -0.5555*** | -0.7548*** | -0.5487** | -0.7310*** | -0.5646*** | -0.7803*** | -0.5582*** |
| | (0.0442) | (0.0361) | (0.0559) | (0.2270) | (0.0675) | (0.0418) | (0.0474) | (0.0395) |
| *pos* | -0.0231*** | -0.0247*** | -0.0278*** | -0.0239*** | -0.0189*** | -0.0254*** | -0.0214** | -0.0255*** |
| | (0.0084) | (0.0074) | (0.0065) | (0.0084) | (0.0060) | (0.0075) | (0.0090) | (0.0094) |
| log *vix* | 0.0293*** | 0.0324*** | 0.0303*** | 0.0329*** | 0.0286*** | 0.0327*** | 0.0309*** | 0.0357*** |
| | (0.0035) | (0.0022) | (0.0032) | (0.0028) | (0.0033) | (0.0025) | (0.0035) | (0.0029) |
| diff log *poil*, | -0.0021 | -0.0062* | -0.0023 | -0.0034 | -0.0015 | -0.0055 | -0.0018 | -0.0080** |
| | (0.0031) | (0.0034) | (0.0037) | (0.0047) | (0.0031) | (0.0038) | (0.0043) | (0.0033) |
| diff log *pnen* | -0.0328*** | -0.0168** | -0.0246** | -0.0201** | -0.0276*** | -0.0301*** | -0.0229** | -0.0229** |
| | (0.0103) | (0.0072) | (0.0101) | (0.0089) | (0.0084) | (0.0115) | (0.0102) | (0.0116) |
| *ead* | | | -0.0113** | -0.0155** | | | -0.0045 | -0.0049 |
| | | | (0.0045) | (0.0069) | | | (0.0036) | (0.0068) |
| *aed* | | | | | -0.0279** | -0.0110 | -0.0314*** | -0.0164 |
| | | | | | (0.0122) | (0.0152) | (0.0118) | (0.0194) |
| $peg^{RRI}$ | -0.0040 | | -0.0409 | | 0.0049 | | -0.0339 | |
| | (0.0408) | | (0.0382) | | (0.0455) | | (0.0386) | |
| $peg^{RRI}$ log *open* | -0.0873*** | | -0.1141*** | | -0.1363*** | | -0.1254*** | |
| | (0.0313) | | (0.0277) | | (0.0386) | | (0.0317) | |
| $peg^{RRI}$ log *pct* | -0.0073 | | -0.0011 | | -0.0114 | | 0.0015 | |
| | (0.0102) | | (0.0096) | | (0.0106) | | (0.0096) | |
| $peg^{RRI}$ diff log *yppp* | 0.6565*** | | 0.6587*** | | 0.4824*** | | 0.5809*** | |
| | (0.0967) | | (0.0973) | | (0.1140) | | (0.1042) | |
| $peg^{RRI}$ *pos* | 0.0107 | | 0.0113 | | 0.0097 | | 0.0063 | |
| | (0.0087) | | (0.0082) | | (0.0064) | | (0.0088) | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $peg^{DPS}$ | | -0.1116*** | | -0.1114*** | | -0.0895*** | | -0.0934*** |
| | | (0.0270) | | (0.0365) | | (0.0282) | | (0.0319) |
| $peg^{DPS}$ log *open* | | -0.0628*** | | -0.0566*** | | -0.0531*** | | -0.0517*** |
| | | (0.0158) | | (0.0155) | | (0.0164) | | (0.0163) |
| $peg^{DPS}$ log *pct* | | 0.0221*** | | 0.0237*** | | 0.0194*** | | 0.0192** |
| | | (0.0067) | | (0.0091) | | (0.0072) | | (0.0080) |
| $peg^{DPS}$ diff log *yppp* | | 0.3288*** | | 0.3129 | | 0.3589*** | | 0.4133*** |
| | | (0.0954) | | (0.2265) | | (0.1181) | | (0.1293) |
| $peg^{DPS}$ *pos* | | 0.0117 | | 0.0102 | | 0.0064 | | 0.0122 |
| | | (0.0074) | | (0.0080) | | (0.0072) | | (0.0083) |
| Observations | 763 | 763 | 763 | 763 | 763 | 763 | 763 | 763 |
| Number of id_ob | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| AR(1) | -4.8045*** | -4.6905*** | -4.5935*** | -4.6413*** | -4.4961*** | -4.6693*** | -4.4469*** | -4.6734*** |
| AR(2) | -1.9297* | -1.4644 | -2.1432** | -1.2918 | -1.8045* | -1.4133 | -2.4859** | -1.0167 |
| Sargan | 41.8822 | 42.0161 | 40.7332 | 40.6484 | 45.4423 | 39.3326 | 41.3309 | 40.3093 |

*Notes:* results obtained with xtabond command in Stata 16.0. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table 6. Regressions with exchange rate regime dummies and interaction terms, classification specific samples†

| VARIABLES | RRI & interact's (1) | RRI & interact's with the euro area dummy (2) | RRI & interact's with the advanced economy dummy (3) | RRI & interact's with both dummies (4) | DPS & interact's (5) | DPS & interact's with the euro area dummy (6) | DPS & interact's with the advanced economy dummy (7) | DPS & interact's with both dummies (8) |
|---|---|---|---|---|---|---|---|---|
| *ovol*, lag(1) | 0.3811*** | 0.3876*** | 0.3629*** | 0.3768*** | 0.3754*** | 0.3880*** | 0.3616*** | 0.3796*** |
| | (0.0242) | (0.0288) | (0.0201) | (0.0213) | (0.0315) | (0.0291) | (0.0384) | (0.0444) |
| *ovol,* lag(2) | -0.1467*** | -0.1553*** | -0.1318*** | -0.1507*** | -0.1864*** | -0.1699*** | -0.1575*** | -0.1787*** |
| | (0.0200) | (0.0223) | (0.0323) | (0.0279) | (0.0232) | (0.0221) | (0.0277) | (0.0362) |
| log *open* | 0.0371 | 0.0649*** | 0.0525* | 0.0341 | -0.0105 | -0.0056 | -0.0039 | 0.0044 |
| | (0.0257) | (0.0235) | (0.0308) | (0.0362) | (0.0165) | (0.0175) | (0.0167) | (0.0167) |
| log *pct* | 0.0079 | 0.0091 | 0.0072 | 0.0128 | -0.0078** | -0.0050 | -0.0028 | -0.0058 |
| | (0.0077) | (0.0077) | (0.0074) | (0.0104) | (0.0035) | (0.0039) | (0.0035) | (0.0043) |
| diff log *yppp* | -0.7071*** | -0.6746*** | -0.6730*** | -0.6454*** | -0.5920*** | -0.5591*** | -0.5638*** | -0.5687*** |
| | (0.0646) | (0.0694) | (0.0731) | (0.0729) | (0.0429) | (0.0571) | (0.0561) | (0.0468) |
| *pos* | -0.0246*** | -0.0244*** | -0.0239*** | -0.0257*** | -0.0211*** | -0.0154* | -0.0164*** | -0.0183** |
| | (0.0068) | (0.0078) | (0.0074) | (0.0080) | (0.0056) | (0.0084) | (0.0063) | (0.0086) |
| log *vix* | 0.0353*** | 0.0364*** | 0.0348*** | 0.0363*** | 0.0307*** | 0.0288*** | 0.0307*** | 0.0285*** |
| | (0.0031) | (0.0033) | (0.0029) | (0.0024) | (0.0021) | (0.0027) | (0.0030) | (0.0033) |
| diff log *poil*, | -0.0004 | 0.0018 | -0.0018 | -0.0009 | -0.0008 | -0.0013 | -0.0018 | 0.0006 |
| | (0.0034) | (0.0033) | (0.0034) | (0.0038) | (0.0028) | (0.0025) | (0.0031) | (0.0033) |
| diff log *pnen* | -0.0244*** | -0.0317*** | -0.0281*** | -0.0314*** | -0.0244** | -0.0271*** | -0.0291** | -0.0269** |
| | (0.0081) | (0.0099) | (0.0087) | (0.0088) | (0.0096) | (0.0097) | (0.0131) | (0.0109) |
| *ead* | | -0.0122** | | -0.0016 | | -0.0156** | | -0.0043 |
| | | (0.0054) | | (0.0059) | | (0.0065) | | (0.0067) |
| *aed* | | | -0.0433*** | -0.0461*** | | | -0.0278* | -0.0028 |
| | | | (0.0090) | (0.0139) | | | (0.0146) | (0.0182) |
| $peg^{RRS}$ | -0.0365 | -0.0381 | -0.0365 | -0.0178 | | | | |
| | (0.0394) | (0.0355) | (0.0298) | (0.0419) | | | | |
| $peg^{RRI}$ log *open* | -0.1144*** | -0.1344*** | -0.1160*** | -0.0960** | | | | |
| | (0.0304) | (0.0326) | (0.0344) | (0.0447) | | | | |
| $peg^{RRI}$ log *pct* | -0.0010 | -0.0004 | 0.0024 | -0.0029 | | | | |
| | (0.0096) | (0.0086) | (0.0078) | (0.0105) | | | | |
| $peg^{RRI}$ diff log *yppp* | 0.4931*** | 0.4483*** | 0.4648*** | 0.3513*** | | | | |
| | (0.1034) | (0.1257) | (0.1154) | (0.1180) | | | | |
| $peg^{RRI}$ *pos* | 0.0061 | 0.0074 | 0.0057 | 0.0135* | | | | |
| | (0.0061) | (0.0064) | (0.0077) | (0.0074) | | | | |

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| *peg*$^{DPS}$ | | | | | -0.1094*** | -0.1157*** | -0.0906*** | -0.1017*** |
| | | | | | (0.0256) | (0.0302) | (0.0284) | (0.0309) |
| *peg*$^{DPS}$ log *open* | | | | | -0.0549*** | -0.0518*** | -0.0475*** | -0.0423*** |
| | | | | | (0.0139) | (0.0137) | (0.0135) | (0.0150) |
| *peg*$^{DPS}$ log *pct* | | | | | 0.0258*** | 0.0267*** | 0.0211*** | 0.0240*** |
| | | | | | (0.0068) | (0.0074) | (0.0073) | (0.0078) |
| *peg*$^{DPS}$ diff log *yppp* | | | | | 0.5124*** | 0.3567*** | 0.3882*** | 0.3308*** |
| | | | | | (0.1130) | (0.1024) | (0.1204) | (0.0982) |
| *peg*$^{DPS}$ *pos* | | | | | 0.0026 | 0.0049 | 0.0030 | 0.0011 |
| | | | | | (0.0050) | (0.0071) | (0.0068) | (0.0072) |
| Observations | 814 | 814 | 814 | 814 | 904 | 904 | 904 | 904 |
| Number of id_ob | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| AR(1) | -4.6325*** | -4.8014*** | -4.6670*** | -4.7092*** | -4.8094*** | -4.8052*** | -4.8004*** | -4.6054*** |
| AR(2) | -1.7912* | -1.5640 | -1.8354* | -1.5852 | -1.0155 | -1.0590 | -1.3806 | -0.7257 |
| Sargan | 43.5282 | 44.4298 | 40.7865 | 42.4675 | 37.3509 | 40.9915 | 41.0771 | 39.8741 |

*Notes:* † The time range is 1995-2016 and 1995-2019 for the RRI and DPS classifications, respectively. Pegs and floats identified with the use of a single classification: the RRI for columns (1)-(4) and DPS for columns (5)-(8). Results obtained with xtabond command in Stata 16.0. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

# Supplementary material

## Appendix A

Table A1. Country coverage

| | | | |
|---|---|---|---|
| Austria | Estonia* (2011) | Japan | Romania* |
| Belgium | Finland | Korea* (1997) | Russia* |
| Bosnia and Herzegovina* | France | Latvia* (2014) | Serbia * |
| Brazil* | Germany | Lithuania* (2015) | Slovak Republic* (2009) |
| Bulgaria* | Greece | Luxembourg | Slovenia* (2007) |
| Canada | Hungary* | Malta* (2008) | South Africa* |
| Chile* | Iceland | Mexico* | Spain |
| Colombia | India* | Montenegro* | Sweden |
| Croatia* | Indonesia* | Netherlands | North Macedonia* (prev. Macedonia, the FYR) |
| Cyprus* (2001) | Ireland | Norway | Turkey* |
| Czech Republic* (2009) | Israel* (1997) | Poland* | United Kingdom |
| Denmark | Italy | Portugal | United States |

*Notes:* Emerging market economies denoted with an asterisk. In parentheses, the year since when the country has been re-classified as an advanced economy.

Source: based on the IMF *World Economic Outlook* classification.

Table A2. Data description and sources

| Name | Symbol | Description | Source |
|---|---|---|---|
| Output volatility | *ovol* | A root mean squared cyclical component of manufacturing, annual data. The cyclical component derived with the Hamilton method from monthly data on manufacturing (the log of the index 2015 = 100, not seasonally adjusted data) | Authors' calculations based on data from OECD Main economic indicators online database. For Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Malta, Montenegro, North Macedonia, Romania, and Serbia the Eurostat data used |
| Financial uncertainty | *vix* | CBOE implied volatility index, annual data (average) | Federal Reserve Economic Data |
| Economic policy uncertainty | *epu* | Global (simple average) economic policy uncertainty index, annual data (quarterly average) | Ahir et al. (2018). |
| Oil price | *poil* | Crude oil Brent price (nominal), index (2010 = 100), annual data (monthly average) | World Bank Commodity Price Data (The Pink Sheet) |
| Non-energy price | *pnen* | Non-energy price (nominal) index (2010 = 100), annual data (monthly average) | World Bank Commodity Price Data (The Pink Sheet) |
| Trade openness | *open* | The sum of exports and imports of goods and services to GDP ratio, annual data | World Development Indicators |
| Private credit to GDP | *pct* | Private credit by deposit money banks and other financial institutions to GDP ratio, annual data. Data in 2018 and 2019 obtained using the rate of change of domestic credit to private sector (% of GDP). The same method used to obtain missing data for Cyprus and Serbia in 2016 and 2017. Missing data in 1998 and 1999 for Austria, Belgium, France, Luxembourg, the Netherlands, and in 2009 for Lithuania and Latvia interpolated (Eviews 11) | Global Financial Dataset (Private credit by deposit money banks and other financial institutions to GDP ratio ) and World Development indicators (domestic credit to private sector) |
| GDP per capita | *ypc* | The GDP per capita relative to the world GDP per capita, PPP (constant 2017 international $) | World Development Indicators |
| Economy size | *yppp* | The GDP relative to the world aggregate, PPP (constant 2017 international $) | World Development Indicators |
| Population share | *pop* | The share in the world population | World Development Indicators |

| | | | |
|---|---|---|---|
| Political stability | *pos* | The index of political stability and absence of violence/terrorism. The missing data in 1997, 1999, and 2001 are the averages of two adjacent years | World Bank, Worldwide Governance Indicators |
| Advanced economy dummy | *aed* | A dummy for an advanced economy status according to the classification by the IMF | World Economic Outlook database |
| Euro area dummy | *ead* | A euro area membership dummy | ECB website |

Table A3. Exchange rate classifications and mapping into pegs and floats

| Category used | Categories in the RRI classification | Categories in the DPS classification |
|---|---|---|
| Peg | Fixed (1)<br>Narrow bands (2) | Fix |
| Float | Broad bands and managed floating (3)<br>Freely floating (4) | Float |
| Other | Freely falling (5)<br>Multiple, dual or parallel markets with limited or no data the structure of exchange rates (6) | Inconclusive<br>Under pressure<br>Outlier |

*Notes:* 'RRI' denotes the classification developed by Ilzetzki et al. (2019). Numbers in parentheses correspond to the coarse classification categories. 'DPS' denotes the classification developed by Dąbrowski et al. (2020).

Table A4. Output volatility distribution across exchange rate regimes under RRI and DPS classifications

| Descriptive statistic / test statistic | RRI classification Fix | RRI classification Float | DPS classification Fix | DPS classification Float |
|---|---|---|---|---|
| Mean | 0.0883 | 0.0750 | 0.0865 | 0.0774 |
| equality test statistic | 15.2944 (0.0001) | | 7.1794 (0.0075) | |
| Median | 0.0717 | 0.0633 | 0.0706 | 0.0651 |
| equality test statistic | 4.1231 (0.000) | | 3.0476 (0.0023) | |
| Variance | 0.0033 | 0.0020 | 0.0029 | 0.0021 |
| equality test statistic | 1.6605 (0.0000) | | 1.3463 (0.0021) | |
| Skewness | 2.8067 | 1.8628 | 2.6789 | 1.7927 |
| Kurtosis | 14.6494 | 8.1289 | 14.3505 | 7.4390 |
| No. of observations | 581 | 353 | 446 | 420 |

*Notes:* Equality test statistics are from the Welch F-test, Wilcoxon/Mann-Whitney (tie-adjusted) test, and F-test. They are used to test the equality of means, medians, and variances, respectively. In parenthesis, p-values are reported.

Table A5. Unit root tests, 1995-2016

| Variable | Test a) LLC | IPS | ADF b) | PP |
|---|---|---|---|---|
| $ovol$ | -9.674 *** | -7.735 *** | 208.935 *** | 204.417 *** |
| $\log open$ | -10.277 *** | -3.857 *** | 132.347 *** | 229.488 *** |
| $\log pct$ | -8.476 *** | -1.977 ** | 136.147 *** | 71.473 |
| $\log yppp$ | 1.022 | 3.620 | 98.903 | 74.199 |
| $pos$ | -3.069 *** | -2.069 ** | 129.346 *** | 106.970 |
| $\log vix$ | . | . | -3.304 ** | . |
| $\log poil$ | . | . | -1.429 | . |
| $\log pnen$ | . | . | -0.920 | . |

*Notes:* a) LLC is Levin, Lin and Chu test ($t^*$ statistic), IPS is Im, Pesaran and Shin test (W statistic), ADF is augmented Dickey Fuller test (Fisher Chi-square statistic), PP is Phillips and Perron test (Fisher Chi-square statistic). In all tests individual intercepts are included. Tests employ a null hypothesis of a unit root. b) For $\log vix$, $\log poil$, $\log pnen$ univariate ADF test (t statistic). Eviews 11.0 is used to obtain the results.