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Identifying Algeria's de facto exchange rate regime: a wavelet-based approach

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Abstract

The Central Bank of Algeria has announced a managed float of the Algerian dinar since 1994. Yet, there are some substantial differences between various de facto classifications of Algeria's exchange rate regime. This study looks into the exchange rate regime of Algeria, aiming to identify de facto regime. To identify the implicit basket weights for the Algerian dinar, first the OLS rolling window methodology is used to estimate the celebrated Frankel-Wei regression. Then, the wavelet-based methods are applied to study the co-movement patterns of the exchange rates of the Algerian dinar, US dollar, and Euro. In the main, the OLS rolling window results show that the US dollar and the Euro are the currencies with the most influence over the Algerian dinar. Further, from the Wavelet Multiple Correlation (WMC) results, the US dollar is identified as the potential leader in the implicit basket for the Algerian dinar. Additionally, from the Wavelet Local Multiple Correlation (WLMC) results, it is found that the Algerian DZD, US dollar, and Euro are highly correlated, with a correlation value around 0.90 for most of the time scales. Based on the results obtained, we suggest that Algeria's exchange rate regime could be a crawling peg and band around the US dollar and Euro.

Keywords: Exchange rate regimes, Fear of floating, Frankel-Wei regression, Rolling windows, Wavelet analysis, Algeria

1 Introduction

Until 1998, the International Monetary Fund (IMF) classified exchange rate regimes according to official government notifications to the IMF (de jure classification). Since the 2000s numerous studies have emphasized the gap between what countries say about their exchange regime and what they actually do. This has led to the development of alternative classification methods based on statistical data, termed de facto classifications. Since 1999, even the IMF has used its staff judgements in classifying its member countries' regimes rather than relying exclusively on what countries claim it to be. It is important, however, to investigate not only de facto exchange rate regimes, but also to identify the degree of de facto exchange rate flexibility.

The present paper is based on the approach developed by Frankel and Wei (2008) designed to estimate the basket of currencies to which a currency is pegged, as well as de facto degree of exchange rate flexibility. Officially, since 1994, the Bank of Algeria has implemented a managed float exchange rate policy with the objective of maintaining the

real effective exchange rate (REER) close to its equilibrium level. In this paper, we are interested in examining a number of questions by empirically investigating the actual behaviour of Algeria's exchange rate:

i) Has Algeria adopted a managed float regime as officially claimed, or a crawling peg and band around the US dollar and Euro?
ii) Has there been a change in the degree of de facto exchange rate flexibility for the dinar over time?

The central focus of this work in hand is twofold: the first is to assess whether Algeria is among fear of floating countries, and the second is to provide a de facto classification for Algeria's exchange regime. To these ends, this paper applies ordinary least square (OLS) to estimate Frankel and Wei (2008) regression. The OLS rolling window methodology is also used to estimate this regression in order to obtain a better estimation of the changes in the currency regime. Wavelet methods such as Wavelet Multiple Correlation and Wavelet Local Multiple Correlation proposed by Fernández-Macho (2012, 2018) are also applied to examine the co-movement between the Algerian dinar, US dollar and Euro in the time scale domain.

The remainder of this paper is organized as follows: Section two briefly discusses the literature that deals with identifying exchange regimes. Section three reviews a brief history of the exchange regime in Algeria and discusses the results of testing the fear of floating hypothesis in that country. Section four details the methodology employed. Section five presents the model specification and data. Section six presents the empirical findings, and the last section proposes some conclusions and recommendations for decision-makers.

2 A brief overview of the literature

The de jure exchange rate classifications are published in the IMF Annual Report on Exchange Rate Arrangements and Exchange Rate Restrictions. Before 1999, the IMF considered three exchange rate regime categories: pegged regimes, regimes with limited flexibility (intermediate regimes) and floating arrangements (Bubula and Ötker, 2002). This approach of classifying exchange regimes offers numerous advantages in terms of country coverage, frequent updating (on a quarterly basis), and a long history (extending back to 1970) (Bubula and Ötker, 2002). However, the de jure classification system had serious shortcomings, particularly its failure to capture differences between the official classification, based on countries' formally announced regimes, and the facto exchange rate arrangements followed by countries (Johnston and Swinburne 1999). According to the Johnston and Swinburne (1999), almost 60 percent of members classified with managed or independently floating exchange rate arrangements followed de facto peg regimes. In an attempt to overcome the deficiencies of the de jure classification, in 1999, the IMF adopted a new classification scheme based on information from IMF staff as well as the movements in nominal exchange rates and official reserves. It distinguishes among eight forms of exchange rate arrangements as follows: Exchange Arrangements with No Separate Legal Tender, Currency Board Arrangements, Other Conventional Fixed Peg Arrangements, Pegged Exchange Rates within Band, Crawling Pegs, Exchange

Rates within Crawling Bands, Managed Floating with No Preannounced Path For the Exchange Rate, and Independent Floating (see Johnston and Swinburne 1999).

In addition to the IMF de facto classification scheme, many studies have been conducted on exchange rate regime identification using different methodologies. Some of the more prominent studies identified the de facto exchange rate regimes on the basis of factual data such as exchange rate volatility, changes in foreign reserves, interest rate differentials, and parallel-market exchange rates. Examples of such classifications include: Ghosh et al. 2002; Calvo and reinhart, 2002; Shambaugh, 2004; Reinhart and Rogoff, 2004; Levy-Yeyati and Sturzenegger, 2005.

Nevertheless—as noted in Bleaney and Francisco, 2007; Frankel and Wei, 2008—most of these classification schemes failed to develop a consensus in classifying exchange rate regimes, since the results of these classifications showed a high level of disagreement between each other and the de jure classification (Bleaney and Tian, 2016). Frankel and Wei (2008) argued that the important reason behind these disagreements between different classification schemes is that, apart from a relatively small number of countries that peg firmly and a few countries that float freely, the majority of countries follow an intermediate regime that is not easily identified.

To deal with the issue, Frankel (1993) and Frankel and Wei (1994, 1995) developed an approach to identify the de facto classification for countries that have managed their exchange rate against a basket of foreign currencies. The Frankel and Wei (1994) approach, commonly known as Frankel–Wei regressions, is based on a linear regression method to estimate the implicit basket weights of the major currencies in the domestic currency. This methodology was then applied by Bénassy-Quéré (1999), Ohno (1999), Frankel et al. (2000), Frankel et al. (2001) and Bénassy-Quéré et al. (2006). It has also gained attention recently, as it has been extensively used in empirical literature to estimate the basket weights in the exchange rate of some Asian countries, particularly China, India, Taiwan and Singapore (Eichengreen, 2006; Shah et al., 2005; Ogawa and Yoshimi, 2008; Cavoli and Rajan, 2005).

More recently, Frankel and Wei (2008) have developed a new approach to estimate de facto exchange rate regimes. Frankel and Wei (2008) have introduced the exchange market pressure variable (EMP) in the technique that estimates the implicit currency weights in the basket that anchors the home currency. The estimated parameter of the EMP captures the de facto degree of flexibility in the exchange rate. The authors have tried this new technique on 20 currencies that officially use baskets as anchors.

As far as Algeria is concerned, two studies have been adopted to investigate de facto exchange rate regime. In this respect, Si Mohammed and Larbaoui (2015) used Levy-Yeyati and Sturzenegger (2005) methodology to identify the de facto classification of the Algerian exchange rate regime and concluded that Algeria had a fixed exchange rate regime between 2006 and 2015. Another study by Azzi and Messoudi (2018) analysed the de facto classifications of Algeria's exchange rate regime. The authors have supported the recent classification of ILzetzki, Reinhart and Rogoff (2017) of Algeria's exchange rate regime as a crawling band regime since 1995.

Many studies use the rolling OLS regression. Nonetheless, this method cannot provide reliable time varying coefficients estimates (Zanin and Marra, 2012). Hence, we rely on the wavelet methods to cope with this failure. Our study, thus contributes

to the literature by applying Wavelet methods such as Wavelet Multiple Correlation (WMC) and Wavelet Local Multiple Correlation (WLMC) proposed by Fernández-Macho (2012, 2018) to explore the issue of the de facto exchange regime.

3 Overview of Algeria's exchange rate regime

3.1 The history of exchange rate regime in Algeria

After the Algerian independence, which took place in 1962, Algeria established its own Central Bank (Banque Centrale d'Algerie) to replace the former Bank of Algeria (Banque d'Algerie). In 1964, the Algerian replaced the Algerian Franc at per value. Algeria maintained a fixed peg of its national currency "the Dinar" to the French franc for over 10 years, from 1964 to 1974.

Since 1974, Algeria's exchange rate regime has been transformed from a peg to a basket of currencies to a managed float. From January 1974 to October 1994, the exchange rate of the Algerian dinar was determined on the basis of a fixed relationship with a basket of 16 currencies. The US Dollar made up a large weight of the basket of currencies due to its importance in hydrocarbon export revenues and external debt services payments (Koranchelian, 2005).

In 1994, as part of economic reform programmes backed by the IMF, the Algerian authority adopted a managed float exchange rate regime, with the objective of stabilizing the real effective exchange rate. Since October 1994, the Bank of Algeria has implemented a managed float exchange rate through daily fixing sessions that include six commercial banks. In 1996, an interbank foreign exchange market was set up to determine the value of the Algerian dinar.

According to the Bank of Algeria, the de jure exchange arrangement has been the managed float since 1994. Nonetheless, between 1994 and 2017, the IMF classified Algeria's de facto exchange regime as "other managed arrangement with no predetermined path for exchange rate", with the exception of 2002–2008, when it was considered a managed floating. For Habermeier et al. (2009), this category (other managed arrangement) captures countries in which the de facto and the de jure arrangements differ, which manage their exchange rates but are not floating, and which exhibit frequent or irregular changes in policies.

An alternative classification scheme provided by Ilzetzki, Reinhart and Rogoff (2017) identified Algeria as a de facto crawling band around the French Franc (1995–1999) and the dollar (1999–2016). Bénassy-Quéré et al. (2006) identified Algeria as de facto basket peg regime on US Dollar and Euro during 1999–2004. According to the classification of Levy-Yeyati and Sturzenegger (2016), Algeria's de facto exchange regime ranged from a floating to an intermediate exchange regime.

As a matter of fact, there are some substantial differences between various de facto exchange rate arrangements of Algeria. The exchange rate regime in Algeria is de jure managed float, but the facto fluctuates between managed float with no predetermined path for the exchange rate (IMF classifications), float and intermediate (Levy-Yeyati and Sturzenegger's classifications), and a crawling band around a basket of currencies dominated by the Dollar (Ilzetzki, Reinhart and Rogoff's classifications).

3.2 Fear of floating in Algeria

This section consists of determining whether Algeria is among fear of floating countries. The so-called "fear of floating" term was introduced by Calvo and Reinhart (2002). Calvo and Reinhart (2002) define fear of floating as the jure floating regime while the central bank intervenes heavily in foreign exchange market to avoid a sudden or large depreciation in the nominal exchange rate. The authors find that lots of countries that say they float do not really do so. Fear of floating practices seems to be common in most emerging and developing countries due to several reasons. For example, lack of credibility limits central banks' ability to act as an effective lender of last resort which feeds the fear of large exchange rate variations (Calvo and Reinhart, 2002). The existence of a large debt in foreign currency gives reason for a country to confine exchange rate movements to narrow bands (Calvo and Reinhart, 2002). Countries that have a large share of exports and imports libelled US $ and an important level of foreign reserves have a tendency to intervene in exchange markets to cap exchange swings (Hausmann and Panizza, 2003). High exchange rate pass-through and its effects on domestic prices explain why central banks in emerging countries show less tolerability toward large variations of exchange rate (Reinhart et al. 2003).

Following Calvo and Reinhart (2002), monthly percentage change in the exchange rate and foreign reserves are used to test the fear of floating hypothesis in Algeria. The data used for this analysis range from January 2000 to November 2019, obtained from the IMF International Financial Statistics. We divide our dataset into two sub-periods, period of financial ease resulting from the increase in oil prices (2000.01–2013.12), and after oil prices collapse period (2014.01–2019.11). Table 1 reports the probability that each variable changes fall within the plus /minus 1% and 2.5% bands.

The results indicate that there was limited variability of the exchange rate, translated by more than 90 percent probability that the monthly exchange rate would move within the ± 2% range, which is a high probability and suggests some control on the exchange rate by the central bank. The limited variability of the exchange rate was reflected in reserves as the probability that the monthly percent change in reserves falls within the ± 2% range is 63.86 percent, implying an active use of foreign reserves to reduce the variability of the exchange rate. Considering the entire period, the results in Table 2 show a high probability of low monthly changes of exchange rate, and low probability of stability of reserves. This is equivalent to saying that the Algerian economy experienced some sort of fear of floating as the exchange rate variability

Table 1 Probability of monthly percent change in exchange rates and foreign exchange reserves

Periods	Probability that the monthly percent change in the nominal exchange rate falls within:		Probability that the monthly percent change in foreign exchange reserves falls within:		Correlation between changes in the exchange rate and changes in reserves
	± 1% band	± 2.5% band	± 1% band	± 2.5% band	
2000.01–2019.11	68.84	92.43	29.41	63.86	−0.097**
2000.01–2013.12	65.26	92.81	28.14	58.08	−0.065*
2014.01–2019.11	74.64	91.54	11.26	77.46	−0.29**

* denotes significant at 10% and ** denotes significant at 5% level. Source: based on International Financial Statistics Data

was less than 10 percent over the study period. The final column of Table 1 summarizes the correlation coefficients between exchange rate changes and reserves. The results indicate a negative and significant correlation between the two variables, suggesting that reserves were used to prevent the exchange rate from depreciating and some fear of floating may also be present. This negative association is confirmed in the scatterplot of the exchange rate changes against reserves in Fig. 1. Overall, the probability of changes in exchange rate for Algeria over the period study is greater than 90 percent. This seems to be consistent with the results of Calvo and Reinhart (2002) on dirty floaters countries.

Some authors, however, remain sceptical about the classification proposed by Calvo and Reinhart (2002) of fear of floating. Ball and Reyes (2004a, 2004b) argued that using Calvo and Reinhart's (2002) classification can misclassify countries that target inflation as fear of floaters.

4 Econometric methodology

In this study, we use three econometric techniques to estimate Eq. 9 and examine the co-movement between the exchange rate of the Dinar and both US Dollar and Euro. In the first stage, we use ordinary least squares (OLS) method to estimate Frankel–Wei regression. In the second stage, we estimate this regression using rolling windows. In the final stage, we study the time varying co-movement patterns of exchange rates (Algerian dinar, US dollar and Euro) with the help of wavelet-based methods.

4.1 Rolling window regression

Rolling regression (also known as recursive regression) is often used in time series analysis to assess the stability of the regression coefficients over time. The rolling window regression is based on changing sub-samples of fixed size that sequentially roll over the

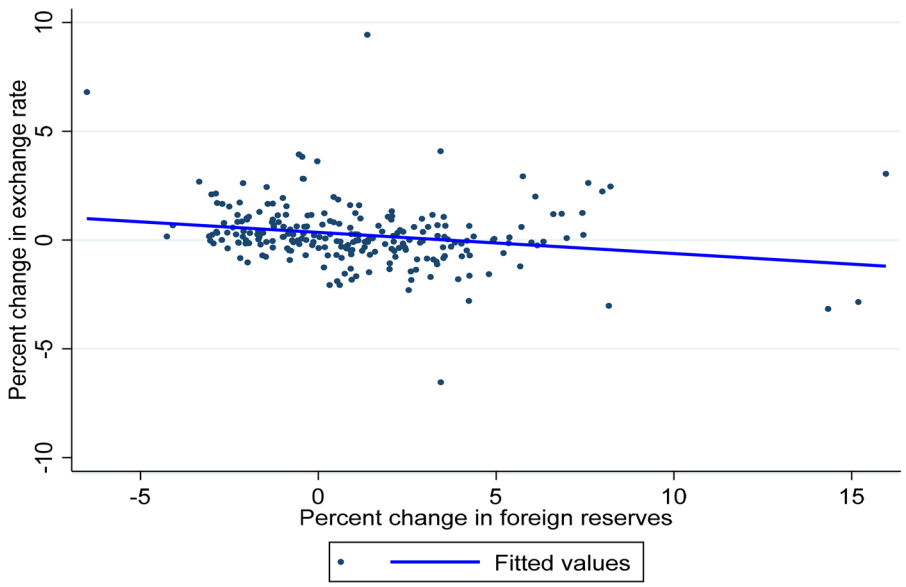

Fig. 1 Exchange rate versus foreign reserves (partial relation)

sample period by adding observations to the end of the sample and dropping them from the start one, that is, computing the parameters estimates over a rolling window with a fixed sample size through the entire sample. The size of the rolling window determines the number of observations used for each rolling regression.

The advantage of using rolling OLS regression is basically to track over time the evolution of the coefficients of the regression. Although the rolling regression is typically applied to produce time varying coefficients, the window size choice is one of the main drawbacks of this technique, because it often affects significantly the value of the estimated coefficients over time. This means that this method cannot produce reliable time varying coefficients estimates (Zanin and Marra, 2012). The above-mentioned shortcoming can be addressed by using the Wavelet Multiple Correlation (WMC) and Wavelet Local Multiple Correlation (WLMC) measures proposed by Fernández-Macho (2012, 2018).

4.2 Wavelet analysis

This section describes in detail the wavelet functions we later implement to study the relationship between exchange rates. First, we provide an overview of the Wavelet Multiple Correlation (WMC). Second, we describe the Wavelet Local Multiple Correlation Method proposed by Fernández-Macho (2018).

The Wavelet Multiple Correlation (WMC) proposed by Fernández-Macho (2012) measures the overall correlation among a multivariate time series at different time scales; so, one can distinguish between the short run, medium run and long run. The Maximum Overlap Discrete Wavelet Transformation (MODWT) method is adopted to calculate the Wavelet Multiple Correlation. The Maxima Overlap Discrete Wavelet Transformation (MODWT) represents a technique that is used to decompose signal into multilevel wavelet and scaling coefficients. The MODWT is similar to the Discrete Wavelet Transform (DWT). Nevertheless, the MODWT offers some favourable properties over the DWT (See Chen 2015; Aguiar-Conraria and Soares 2014; Dar and Shah 2014; Fernández-Macho 2012, Andrieş et al. 2016). For example, the MODWT can handle any sample size data and translation-invariant, since a shift in the original time series results in a corresponding shift in the transformed coefficients (Andrieş et al. 2016). Thence, these properties make the MODWT perfect to time series analysis. The MODWT wavelet and scaling coefficients w_j and v_j are defined as:

$$W_{j,t} = \sum_{l=0}^{n-1} \tilde{h}_{j,l} X_{t-1} \mod N, \tag{1}$$

$$j = 1, 2, ..., L,$$

$$V_{j,t} = \sum_{l=0}^{n-1} \tilde{g}_{j,l} X_{t-1} \mod N, \tag{2}$$

where $\tilde{h}_{j,t}$ is the MODWT wavelet filters ($\tilde{h}_{j,l} = h_j/2^{j/2}$), $\tilde{g}_{j,l}$ the scaling filters ($\tilde{g}_{j,l} = g_j/2^{j/2}$),$L$ the length of the filter, and j the level of decomposition.

The MODWT allows to perform a multi-resolution analysis (MRA) to decompose the time series into a sum of sampler time series, named, Smooths S_j that captures the low-frequency dynamics, and Details D_j that captures the higher frequency characteristics. Hence, the original time series can be expressed as:

$$X = \sum_{j=1}^{J-1} D_j + S_j, \tag{3}$$

where J is the number of multi-resolution levels.

Fernández-Macho (2012) defines the Wavelet Multiple Correlation (WMC) measure as follows:

$$\phi_x(\lambda_j) = Corr(w_{ijt}, \hat{w}_{ijt}) = \frac{Cov(w_{ijt}, \hat{w}_{ijt})}{\sqrt{Var(w_{ijt})\ Var(\hat{w}_{ijt})}}, j = 1, 2, ..., J, \tag{4}$$

where $\phi_x(\lambda_j)$ represents the Wavelet Multiple Correlation at scale λ_j based on a set of multivariate stochastic process $X_t = (x_{1t}, x_{2t}, ..., x_{nt})$ and their respective wavelet coefficients $W_{jt} = (w_{1jt}, w_{2jt}, ..., w_{njt})$ calculated using the MODWT.

In Eq. (4), the wavelet variances and covariance are defined as:

$$Var(w_{ijt}) = \frac{1}{T_j} \sum_{t=j-1}^{T-1} w_{ijt}^2, \tag{5}$$

$$Var(\hat{w}_{ijt}) = \frac{1}{T_j} \sum_{t=j-1}^{T-1} \hat{w}_{ijt}^2, \tag{6}$$

$$Cov(w_{ijt}, \hat{w}_{ijt}) = \frac{1}{T_j} \sum_{t=j-1}^{T-1} w_{ijt}, \hat{w}_{ijt}. \tag{7}$$

More recently, Fernández-Macho (2018) introduced Wavelet Local Multiple Correlation (WLMC) as an extension of the WMC. The WLMC is a useful statistical tool in the analysis of co-movement dynamics within a set of time series (Fernández-Macho, 2018).

Fernández-Macho (2018) defines the estimated WLMC based on the MODWT as:

$$\begin{aligned} \tilde{\phi}_{x,s}(\lambda_j) &= Corr(\theta(t-s)^{1/2}\tilde{w}_{ijt}, \theta(t-s)^{1/2}\tilde{\hat{w}}_{ijt}) \\ &= \frac{Cov(\theta(t-s)^{1/2}\tilde{w}, \theta(t-s)^{1/2}\tilde{\hat{w}}_{ijt})}{\sqrt{Var(\theta(t-s)^{1/2}\tilde{w}_{ijt})\ Var(\theta(t-s)^{1/2}\tilde{\hat{w}}_{ijt})}}, s = 1...T, \end{aligned} \tag{8}$$

where $s = 1...T$, and $\theta(\bullet)$ is a given moving average weight function.

5 Model specification and data

This section provides an attempt to classify Algeria's de facto exchange rate regime using the well-known Frankel–Wei methodology (see Frankel and Wei, 1994, 2008). In the case of Algeria, this methodology is preferred because it was developed for basket pegging where exchange rates fluctuate around the anchor.

In this approach, the currencies composing the basket should be identified. As the European Union and the United States are Algeria's largest trading partners and absorb the major part of Algerian international trade (51%); therefore, it is realistic to suppose that their currencies (the dollar and the Euro) are included in the country's basket. Our regression includes also the Japanese Yen despite its low weight in Algeria's foreign trade. Following Frankel and Wei (2008) the Special Drawing Rights (SDR) was used as a *numeraire* to measure the variability of the exchange rate of the dinar against the currencies composing the basket.

Following Frankel and Wei (2008), the analysis uses this regression model:

$$d\log(DZD/SDR)_t = \alpha_0 + \alpha_1 d\log(USD/SDR)_t + \alpha_2 d\log(EUR/SDR)_t + \alpha_3 d\log(JPY/SDR)_t + \gamma(EMP)_t + \varepsilon_t\,. \tag{9}$$

In the above equation, $d\log$ is log first difference operator, $(DZD/SDR)_t$ is the exchange rate of the dinar against the special drawing rights, $(USD/SDR)_t$, $(EUR/SDR)_t$ and $(JPY/SDR)_t$ are, respectively, the exchange rate of the Dollar, the Euro and the Yen against the special drawing rights. $(EMP)_t$ is an Exchange Market Pressure variable that has been used by Frankel and Wei (2008) to measure the exchange rate regime flexibility. EMP is calculated as the sum of percentage changes in the exchange rate (E_t) and in reserves (R_t) (Klyoev and Dao, 2016). Considering the following:

$$EMP_t = \Delta E_t/E_{t-1} + \Delta R_t/R_{t-1}. \tag{10}$$

The constant term α_0 captures the average rate of appreciation and depreciation of the domestic currency over time. Coefficients β_1, β_2 and β_3 are potential weights of the three

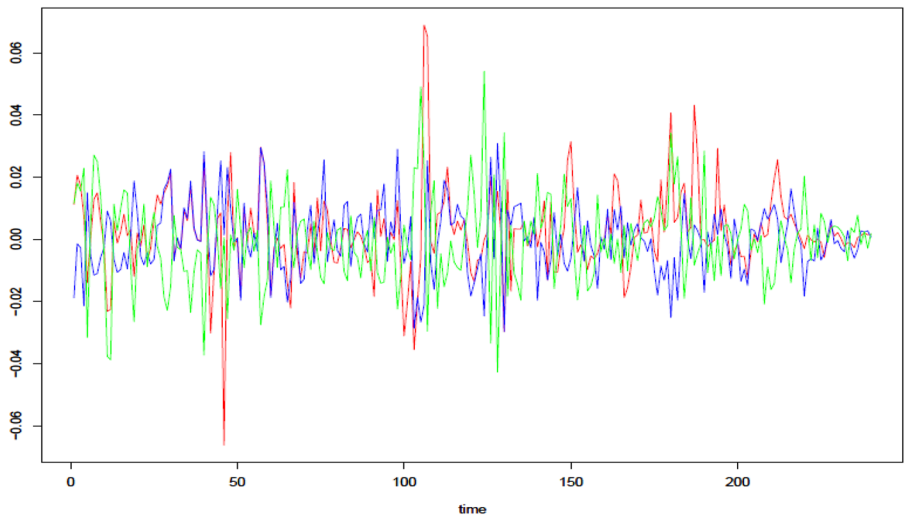

Fig. 2 Log first difference of the dinar DZD (red line), dollar USD (blue line) and EURO (green line) against the special drawing rights (Source: Own work using data from IFS)

anchor currencies (US Dollar, Euro and Japanese Yen) in the basket. The coefficient γ on the EMP variable captures the degree of currency flexibility. An estimated coefficient close to zero for the EMP variable signifies a more fixed exchange rate regime, whereas a coefficient close to one signifies a more flexible regime. In the intermediate regime such as a managed float or adjustable peg γ lies between zero and one, and the R-squared tends to be below one.

This study employs monthly data from January 2000 to November 2019. The data source for all variables is the IMF's International Financial Statistics (IFS) database. As we can see from Fig. 2, the exchange rates considered show somewhat similar patterns.

6 Results and discussion

6.1 Frankel–Wei OLS estimates results

In order to identify the implicit basket weights for the Algerian dinar, the Frankel–Wei regression model is first estimated using OLS. The results from the estimation are presented in Table 2.

The results show that the estimated coefficients on the US Dollar and the Euro are highly statistically significant with a weight of 0.89 and 0.41, respectively. The coefficient on the Japanese Yen is negative and statistically insignificant. It is clear from these results that the US Dollar and the Euro are the currencies with the most influence over the Algerian dinar. From Table 2, it can also be seen that the estimated coefficient on the flexibility index (EMP) is highly statistically significant, with a coefficient value of 0.28, appears enough to categorically suggest a managed float exchange rate regime. This further supports the notion that Algeria has adopted a basket peg arrangement with the USD and the Euro as a nominal anchor. The constant term is statistically significant, which indicates a tendency for the dinar to depreciate over time by about 0.16 percent per month.

To check whether national currency follows a currency basket, we test the null hypothesis that the currencies on the right-hand side of Eq. (9) sum to unity, following Cavoli and Rajan (2007). Table 2 reports the Wald test results. The results indicate that the null

Table 2 Frankel–Wei OLS estimates

Independent variables	Coefficient	Std-error	Prob
US dollar	0.89***	0.139	0.000
Euro	0.41***	0.116	0.000
Yen	−0.04	0.034	0.224
EMP	0.28***	0.038	0.000
Constant	0.0016**	0.00073	0.028
R-square	0.35		
Adjusted R-squared	0.34		
RMSE	0.011		
Durbin–Watson	2.027		
Wald test	1.04 (0.3095)		
Observation	238		

Dependent variable: DZD per SDR. ***and ** represent significance at the 1% and 5% level, respectively. Wald test (*F*-test) for coefficient restriction where null hypothesis is that all currencies on the right-hand side = 1

hypothesis of the unity sum is not rejected. This finding suggests that most of the currencies tested might form the basket.

6.2 Frankel–Wei rolling window estimates results

The Frankel–Wei regression results based on the standard time invariant OLS estimate show the average behaviour of the coefficients over the entire period, and may mask substantial changes of the currency exchange rate regime. Thus, we go on to the rolling or recursive OLS estimates. Rolling OLS regression allows us to track over time the evolution of the coefficients obtained from the Frankel–Wei model. As Cavoli and Rajan (2007) point out, a high and stable coefficient for a major currency is a sign of sustained intervention by the central bank to manage the exchange rate. While a large variation in an estimated coefficient might reflect market driven influences. Results of the rolling regression coefficients and R-squared are presented in Figs. 3, 4.

Figure 3 shows the instability in the US dollar and European currency rolling coefficients. We also find out that the dollar and Euro followed a very similar path during the

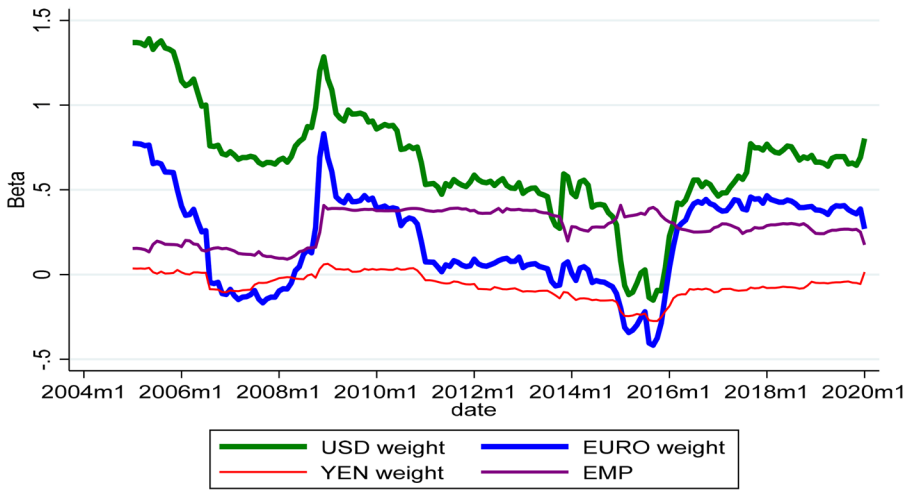

Fig. 3 Rolling window Frankel–Wei regressions (coefficients)

Fig. 4 Rolling window Frankel–Wei regressions (R-squared)

whole period, an indication that the dinar is managed against those currencies. Moreover, it can be seen that after the collapse of oil prices in 2014, the dollar has lost some influence over the dinar, while the Euro has gained influence slightly. From the recursive estimates for the flexibility index, we reveal that the index has steadily increased, especially since the 2008 financial crisis. The Yen's influence has been insignificant over the thorough sample period. Rolling regression R-squared started up between 0.35 and 0.55 and has declined since 2014 oil price drop following the bank of Algeria decision to allow Algerian dinar to decline in response to the foreign reserves drop (Fig. 4).

Combining the recursive series of the US dollar, Euro and the flexibility index, we can see that the Algerian currency regime appears to have become more flexible (free float) during the 2014–2016 oil price shock, where the weights of the US dollar and Euro declined sharply to approximately zero, while the flexibility index increased to around 0.5. Besides that, the R-squared declined during that same period. Since late 2016, with the slight improvement in oil prices, the weights for the US dollar and Euro have increased and remained relatively stable at approximately 0.5. The EMP index has stabilized around 0.48. In sum, recursive OLS estimations suggest that Algeria's exchange regime appears to be crawling peg and band around the US dollar and the European currency, with the exception of the 2014–2016 period when the Algerian dinar exhibited a trend toward free floating.

6.3 Wavelet analysis results

In this section, we utilize the Wavelet Multiple Correlation (WMC) and Wavelet Local Multiple Correlation (WLMC) to investigate the co-movement and the potential leader among the group of exchange rates that include the Algerian dinar, US dollar and Euro against the SDR. The Japanese Yen exchange rate against the SDR will not be included in this analysis, as the previous OLS and Rolling Regression results indicated that the Yen's influence over the dinar exchange rate was not statistically significant.

Figure 5 and Table 3 show the Wavelet Correlation (WMC) for the Algerian dinar, US dollar and Euro against SDR at different time scales (levels 1–5). In Fig. 5, we can see the graph of the estimated WMC, the 95 percent confidence intervals and the exchange rate that the correlation value at each scale. It is clear from Fig. 5 that the Wavelet Multiple Correlations are very high and significantly positive at all scales. As it can be seen from Table 3, the WMC ranges between 0.86 at the shorter time scale ($J=1$) and 0.90 and 0.93 at the longer time scales ($J=4$ and $J=5$), suggesting that the Algerian dinar, US dollar and Euro against the SDR are more correlated for longer time horizons. Figure 5 also suggests that US dollar maximizes WMC against other exchange rates at time scales of 2–4, 4–8, 8–16 and 16–32 months ($J=1$, $J=2$, $J=3$ and $J=4$). These results identify US dollar as potential exchange rate leader at time scales ($J=1$ to $J=4$), while the Euro leads ahead other exchange rates at time scale of 36–64 months ($J=5$).

More specifically, the evidence of the WMC results reveals that the US dollar tends to lead statistically the implicit basket for the Algerian dinar in short, medium and long run. These findings, in fact, corroborate the results from our OLS estimate in Table 2, and rolling OLS estimation in Fig. 3, which suggest the US dollar as the currency with the most influence over the Algerian dinar.

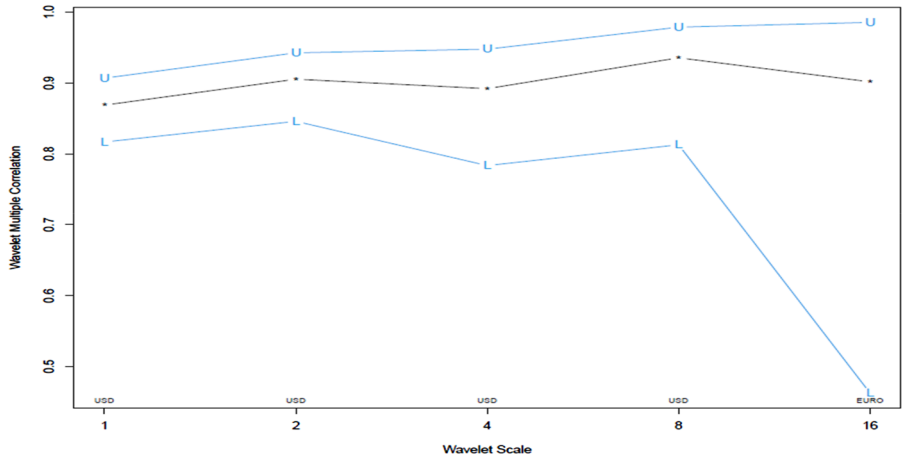

Fig. 5 Wavelet Multiple Correlation for log first difference of the dinar (DZD/SDR), dollar (USD/SDR) and Euro (EURO/SDR) against the special drawing rights. The blue lines correspond to the upper and lower bounds of the 95% confidence interval

Table 3 Wavelet multiple correlation

Level	WMC	Lower bound	Upper bound
$J=1$	0.868	0.816	0.906
$J=2$	0.905	0.845	0.942
$J=3$	0.891	0.783	0.947
$J=4$	0.935	0.812	0.978
$J=5$	0.901	0.462	0.985

In the next step, we apply the Wavelet Local Multiple Correlation (WLMC) (Fernández-Macho, 2018) to handle co-movement dynamic relationships between our three exchange rate variables. Toward this, we present the WLMC results of estimation: a heat map where the wavelet local multiple correlations are visualized (Fig. 6a), and a five multiscale line plots together with the 95% confidence intervals at different time scales (Fig. 6b).

Figure 6a provides the heat map of WLMC values for the exchange rate of the Algerian dinar, US dollar and Euro against SDR for the overall period (2000–2019). The results show that, in general, the correlation between all the variables is strong (with values from 0.75 to 0.95), particularly, for time scales of 16–32 and 32–64 months around 2000–2010 and 2012–2019. Thence, these results indicate high long run correlation levels.

Our WLMC analysis (Fig. 6b) shows that the wavelet correlations within the exchange rates (DZD, US Dollar and Euro) are strong and significantly positive across all the time scales. For the time scales of 2–4, 4–8 and 8–16 months ($J=1$, $J=2$ and $J=3$) the correlations between the exchange rates of the Algerian dinar, US dollar and Euro were around 95 percent at the end of 2000 and the beginning of 2001. After that, it decreased to around 85 percent. After which it rose slightly to the levels of close to 0.90 around 2002, then it remained relatively stable until 2010. Later, the WLMC decreased again, particularly at the time scale of 8–16 months to around 0.65 percent.

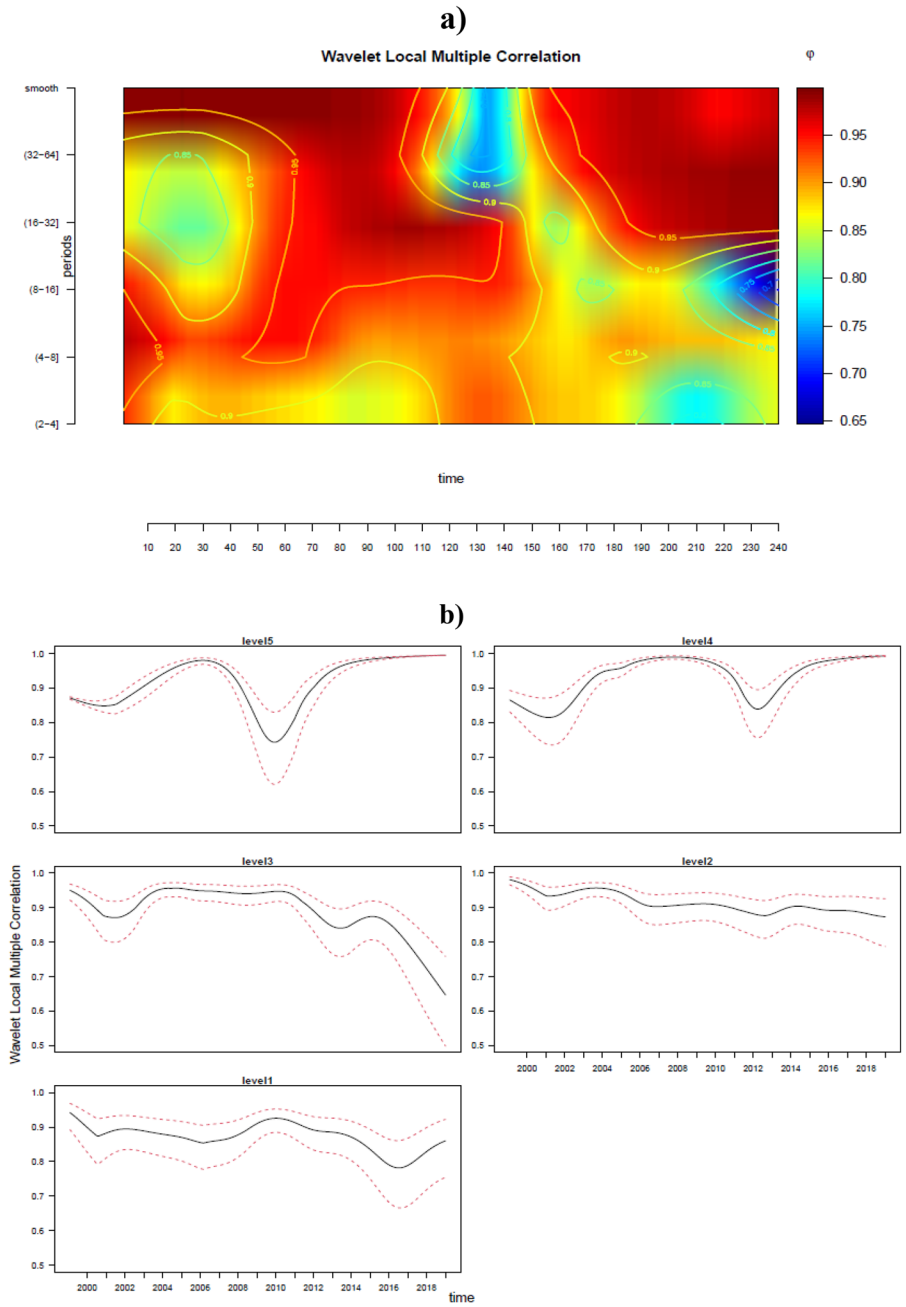

Fig. 6 Wavelet Local Multiple Correlation for log first difference of the dinar (DZD/SDR), dollar (USD/SDR) and Euro (EURO/SDR) against the special drawing rights. "Level 1", "Level 2", "Level 3", "Level 4" and "Level 5" represent five different wavelet scales that capture dynamics with five different periods in the range of 2–4, 4–8, 8–16, 16–32 and 32–64 months, respectively. The red lines correspond to the upper and lower bounds of the 95% confidence interval

Therefore, it is clear that the WLMC values show a decreasing trend in the short and medium run cycles. At the time scale of 16–32 and 32–64 months (J = 4 and J = 5), WLMC decreased sharply around 2010 and 2014 and then rose to the levels close to 1 and remained relatively unchanged for the rest of the time period. In general, we

can see that the WLMC is more stable at the short run (2–4 and 4–8 months) and more dynamic and stronger at the medium and long run (16–32 and 32–64 months). In addition, we can see a clear increase in the WLMC after 2016 at all time scales, except for the time scale of 8–16 months. Figure 6a (heat map) also reveals that for time scales 16–32 and 32–64 months, WLMC between exchange rates shows a clear downwards trend of 0.70 since 2014. In fact, since June 2014 the Algerian dinar has depreciated by about 30 percent against the US dollar. This can be explained by the large fall in oil prices from mid-2014 to 2016 and the downward trajectory of Algeria's foreign currency reserves. From the WMC results, the US dollar is identified as the currency leader for the other currencies (dinar and Euro). From the WLMC results, it is seen that the Algerian DZD, US dollar and Euro are highly correlated. With a correlation value around 0.90 for most of the time scales, it can be said that the value of Algeria's currency follows the fluctuations in the US dollar and the European currency. This result is consistent with the results we obtained previously via the recursive regression estimates (see Fig. 3).

7 Conclusion

Determining the de facto exchange rate regime is important to identify the impact of the exchange rate policy on macro-economic performance. This study, thus, seeks to determine Algeria's de facto exchange rate regime. First, we have analysed the fear of floating in Algeria. The results indicated that there was limited variability of the exchange rate hence reflecting continuous central bank intervention using foreign reserves.

The Frankel–Wei method was used to determine Algeria's de facto exchange rate regime. The results of the estimation based on the standard OLS suggested that Algeria has adopted a basket peg arrangement with the US dollar and Euro as nominal anchor. Likewise, the coefficients of the rolling OLS results of Frankel and Wei (2008) regression indicated that Algeria's exchange regime could be a crawling peg and band around the US dollar and Euro. The estimated rolling coefficient on the flexibility index (EMP) is supportive for this result.

Additionally, we have employed the novel WMC and WLMC to assess the time–frequency co-movement patterns of the Algerian dinar, US dollar and Euro. The results from Wavelet multiple correlation revealed that the US dollar leads statistically to the implicit basket for the Algerian dinar in short, medium and long run. Next, the results from the wavelet local multiple correlation (WLMC) revealed a high level of co-movement within Algeria's currency, US dollar and Euro across all time scales. These findings are consistent with the results we obtained previously via the recursive regression estimates.

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Author contributions
All the authors have equally contributed for scheming the research, studying concepts or design, processing data collection, and calculation so as to write the manuscript. All authors read and approved the final manuscript.

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Declarations

Competing interests
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