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IS THE POLONIA RATE PREDICTABLE ON WIBOR O/N?

Abstract: The paper reports on whether the Polonia rate showing the price of one-day money in Poland is predictable on WIBOR O/N, its banking industry mid-morning forecast. In what follows the analysis is nested within the ARDL approach to a cointegration framework. Having the error correction model estimated on the daily sampled data from the period 24 Jan 2005 to31 Dec 2019, the paper simulated 100 sequences of the one-day dynamic Polonia rate forecasts up to 30 April 2020, the trading day preceding a significant modification of the WIBOR's setting mechanism resulting in the late afternoon disclosure of the overnight rate estimates. The author also computed 95% confidence bands for those forecasts. The analysis shows that the error correction model specified on the Akaike information criterion performs well both in and out of the sample. Nevertheless, it slightly overestimated the actual Polonia rate at times when the monetary authority cuts the reference rate or shortly after that. In such circumstances the actual rate incidentally goes beyond the lower confidence band.

Keywords: Polonia rate, ARDL approach to cointegration, dynamic forecasts.

1. Introduction

Polonia and WIBOR (Warsaw Interbank Offered Rate) O/N are two important indicators dedicated to exhibit the price of one day money in Poland. Polonia is a transaction volume weighted average of the overnight rates at which major banks conclude their unsecured lending in the interbank market every working day by 16.30 CET (see: Regulamin, 2017a). It is influenced by the National Bank of Poland (NBP)

which conducts open-market operations in order to keep it close to the bank's reference rates. WIBOR O/N is a trimmed average of major banks overnight offered rates declared the same working day at 11.00 CET so that it represents the rate at which banks perceive they can raise unsecured funds (see: Regulamin, 2017b). The purpose of the paper is to check whether the information revealed on WIBOR O/N helps predict the Polonia rate. To the best of the author's knowledge its predictability on WIBOR has not been addressed so far. The existing but limited literature on the issue focuses on the dynamics of the Polonia spread (the difference between the Polonia rate and the reference rate) and aims at assessing the efficiency of the monetary policy conducted by the NBP. It includes Kliber and Płuciennik (2011) and Kliber et al. (2016), who investigated the ability of the central bank to have control over the Polonia rate before, in times of, and after the global financial crisis, and Lu (2012) and Kliber (2017) who searched for factors driving the spread, as well as Fiszeder and Pietryka (2018) who compared the efficiency of monetary policies conducted by the European Central Bank and that of the NBP.

In what follows the author assumed that the bank industry's conjectures about the price of one-day money in Poland exhibited in WIBOR O/N are not perfect, so that the conjectured price and the Polonia rate, i.e. the actual price, may diverge at times. Since both are believed to be at most integrated of order one variables, the analysis was nested within the ARDL framework to test for whether they are bound together and cointegrate. In case they are, the author built his analysis on the corresponding error correction model. Having estimated it on the daily sampled data from the period 24 January 2005 to-31 December 2019, the study simulated 100 sequences of one-day dynamic Polonia rate forecasts up to 30 April 2020, the trading day preceding a significant modification of the WIBOR's setting mechanism, which resulted in the late afternoon disclosure of the overnight rate estimates. The author also computed 95% confidence bands for those forecasts, using the 'forecast solve' procedure of Stata followed by the 'simulate' command. The analysis shows that the error correction model specified on the Akaike information criterion performs well both in and out of the sample. Nevertheless, it also slightly overestimates the actual Polonia rate at times when the monetary authority cuts the reference rates or shortly after that. In such circumstances the actual rate incidentally goes beyond the lower confidence band.

The remainder of the paper proceeds as follows. Section 1 outlines an error correction model for the Polonia rate based on the ARDL approach to cointegration and shows the way it is used to obtain its one-day dynamic forecasts with 95% confidence bands. Section 2 presents the empirical results, while the final section briefly concludes.

2. Model

The ARDL(k, q) model for Polonia rate (p_t) and WIBOR O/N (w_t) reads

$$\phi(L, k)p_t = \beta(L, q)w_t + \delta' z_t + \epsilon_t,$$

where $\phi(L, k) = 1 - \phi_1 L - \cdots - \phi_k L^k$, $\beta(L, q) = \beta_0 + \beta_1 L + \cdots + \beta_q L^q$, L is a lag operator such that $Lp_t = p_{t-1}$, z_t is a $r \times 1$ vector of deterministic variables such as intercept term, time trend or exogenous variables with fixed lags, ϵ_t is an error term, and $t = max(k, q), \ldots, T$. The exogenous variables should be $I(0)$ variables that affect only the short-run dynamics.

The corresponding conditional error correction model (ECM) yields

$$\Delta p_t = \Sigma_{i=1}^{k-1} \phi_i^* \Delta p_{t-i} + \beta_0 \Delta w_t + \Sigma_{j=1}^{q-1} \beta_j^* \Delta w_{t-j} + \delta^{*\prime} z_t + \phi(1, k) \times EC_{t-1} + \epsilon_t,$$

where $EC_t = p_t - \theta w_t$ is an error correction term and $\phi(1, k)$ measures its quantitative importance. θ is a long-run coefficient for the response of p_t to a unit change in w_t. The remaining coefficients ϕ_i^*, β_j^* and δ^* exhibit the short-run dynamics of the model's convergence to equilibrium. For details see: Pesaran and Shin (1999), Pesaran and Pesaran (2009, pp. 463-465), and Kripfganz and Schneider (2018).

In testing for the existence of a long-run relationship between p_t and w_t, the author followed Pesaran et al. (2001). First, the author decided about the inclusion of deterministic model components and fixed the lag orders k and q based on the Akaike information criterion. Next, the chosen ARDL($\hat{k}, \hat{q}$) model was estimated by the ordinary least squares (OLS) and the bounds test was performed to test for the existence of a long-run (cointegrating) relationship using the critical values and approximate p-values obtained from the response surface regressions (see: Kripfganz and Schneider (2020)). Since the validity of bounds test relies on normally distributed error terms ϵ_t that are serially uncorrelated and homoscedastic, as well as on the stability of model coefficients over time, a bundle of validation tests was performed including the skewness/kurtosis tests for normality, the Breusch-Godfrey LM test for autocorrelation, the Breusch-Pagan test for heteroscedasticity, and the cumulative sum test for parameter stability. To ensure that the Polonia rate and WIBOR O/N cointegrate, the study additionally performed the ADF unit root test on the error correction term of the corresponding restricted ECM, taking critical values from MacKinnon (2010).

Next, based on the estimated ECM the author checked the ability of WIBOR O/N to predict Polonia rate. Since the ultimate interest is in forecasting p_t, before starting the author appended the ECM with identity $p_t \equiv p_{t-1} + \Delta p_t$ to reverse the first-differencing. Then, the study computed the out-of-sample one-step-ahead forecasts of Δp_t and p_t up to date $T + h$ as $\Delta \hat{p}_{T+s} = \Sigma_{i=1}^{k-1} \hat{\phi}_i^* \Delta p_{T+s-i} + \hat{\beta}_0 \Delta w_{T+s} + \Sigma_{j=1}^{q-1} \hat{\beta}_j^* \Delta w_{T+s-j} + \hat{\phi}(1, \hat{k}) EC_{T+s-1}$, and $\hat{p}_{T+s} = \hat{p}_{T+s-1} + \Delta \hat{p}_{t+s}$ $(s = 1, 2, \ldots, h)$, as well as sample residuals, i.e. the forecast values minus the actual values for each variable and all observations. To assess forecast accuracy, the author performed a simulation accounting for both parameter and random error uncertainty, in doing so replicating 100 sequences of dynamic forecasts. At each replication and for each period

in the forecast horizon the study computed dynamic forecasts of Δp_t and p_t as $\Delta \tilde{p}_{T+s} = \Sigma_{i=1}^{k-1} \tilde{\phi}_i^* \Delta \tilde{p}_{T+s-i} + \tilde{\beta}_0 \Delta w_{T+s} + \Sigma_{j=1}^{q-1} \tilde{\beta}_j^* \Delta w_{T+s-j} + \tilde{\phi}(1, \hat{k}) \times \widehat{EC}_{T+s-1} + u_{T+s}$, and $\tilde{p}_{T+s} = \tilde{p}_{T+s-1} + \Delta \tilde{p}_{t+s}$, where $\tilde{\phi}_i^*$, $\tilde{\beta}_0$, $\tilde{\beta}_j^*$ and $\tilde{\phi}(1, \hat{k})$ were drawn from the multivariate normal distribution with mean $(\hat{\phi}_1^*, \dots, \hat{\phi}_{k-1}^*, \hat{\beta}_0, \hat{\beta}_1^*, \dots, \hat{\beta}_{q-1}^*, \hat{\phi}(1 - \hat{k}))$ and whose variance is the covariance matrix obtained by the OLS, and u_{T+s} is a randomly selected element from the pool of residuals for Δp_t. Finally, the standard deviations across replications were used to obtain 95% confidence bands for $\Delta \tilde{p}_{T+s}$ and $\tilde{p}_{T+s}$.

3. Empirical results

The empirical analysis began by investigating the stochastic nature of the Polonia rate and WIBOR O/N. To this end they were plotted first against time (see Figure 1). The visual inspection of both series suggests that they are nonstationary as they rarely pass through their mean levels. The results of the conventional unit root (ADF) and stationarity (KPSS) tests indicate that Polonia and WIBOR O/N are $I(1)$ variables so that they may be included in the ARDL model.[1] More interestingly, p_t and w_t happen to wander across time close to the reference rate and within the bands of lombard and deposit rates that are set by the NBP to control for the Polonia level. Since they are kept fixed for longer periods of time, they are stationary and may serve as $I(0)$ exogenous variables.

Next, the study estimated the number of the ARDL models for the Polonia rate and WIBOR O/N and the corresponding ECMs, allowing for a mix of deterministic components being included therein as well as one out of the reference rates. The most promising ECM specified on the AIC occurs to be that with $k = 20$ and $p = 19$ with unrestricted constant, restricted trend and lombard rate (l_t), that reads[2]

$$\Delta p_t = \cdots - 0.47386 \times ec_{t-1} - 0.03557 l_t + 0.03872 + u_t$$
$$(0.05767) \quad (0.00999) \quad (0.02371)$$

and

$$ec_t = p_t - 1.05397 w_t + 0.00005 t,$$
$$(0.01726) \quad (9.41 \times 10^{-6})$$

where u_t stands for a residual. Since the estimates of F and t test statistics in bounds test for this model equalled 24.420 and -8.217, i.e. they are more extreme than 5% critical values for $I(1)$ variables, the author rejected the null hypothesis of no existence

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[1] The results of the tests are available to interested readers upon request.
[2] The lags of Δp_t and Δw_t are omitted to save space. The figures in the parentheses under the parameter estimates exhibit their standard errors.

of a level relationship between the Polonia and WIBOR O/N.[3] However, this statement is partially undermined by the results of the validation tests for the ECM (see Table 1). While its specification is free from structural break and the error terms are uncorrelated, the latter are heteroscedastic and not normally distributed. In such circumstances, the cointegration relationship between the Polonia rate and WIBOR O/N is ascertained by testing for (non)stationarity of the error correction term with the use of the ADF test. The estimate of the test statistic for the constant case equalled -3.64 and is below the 5% critical value ($t_c(\infty) = -3.34$; see: MacKinnon (2010), Table 2).

The ECM specifications chosen on the AIC criterion including other combinations of deterministic components and one out of the reference rates, suffer from either the structural brake or an autocorrelation of error terms problem, or both, thus they are excluded from further analysis.
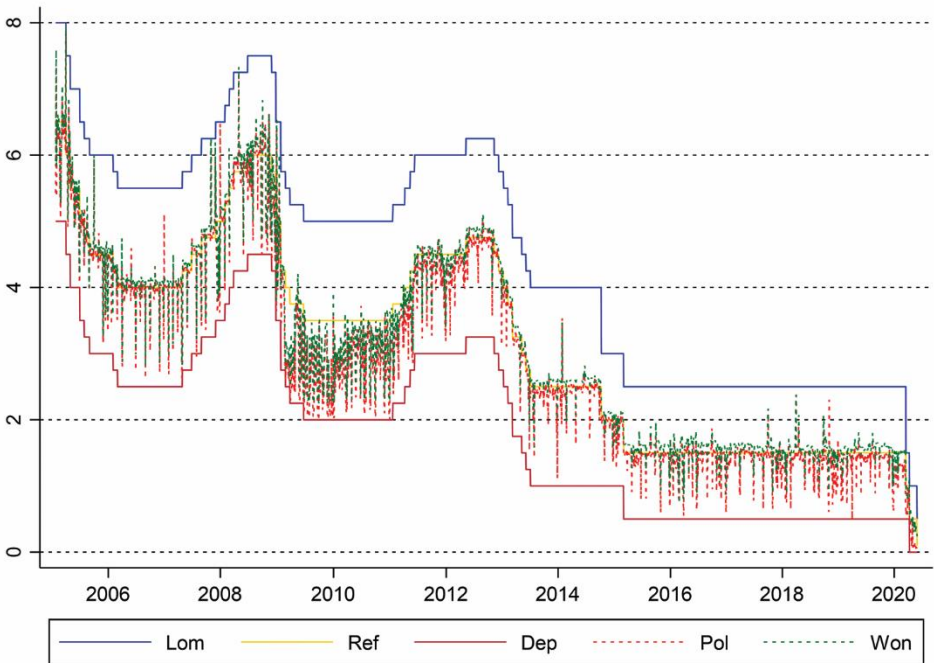
Fig. 1. Polonia (Pol), WIBOR O/N (Won), and the NBP's reference rates – lombard rate (Lom), reference rate (Ref) and deposit rate (Dep)
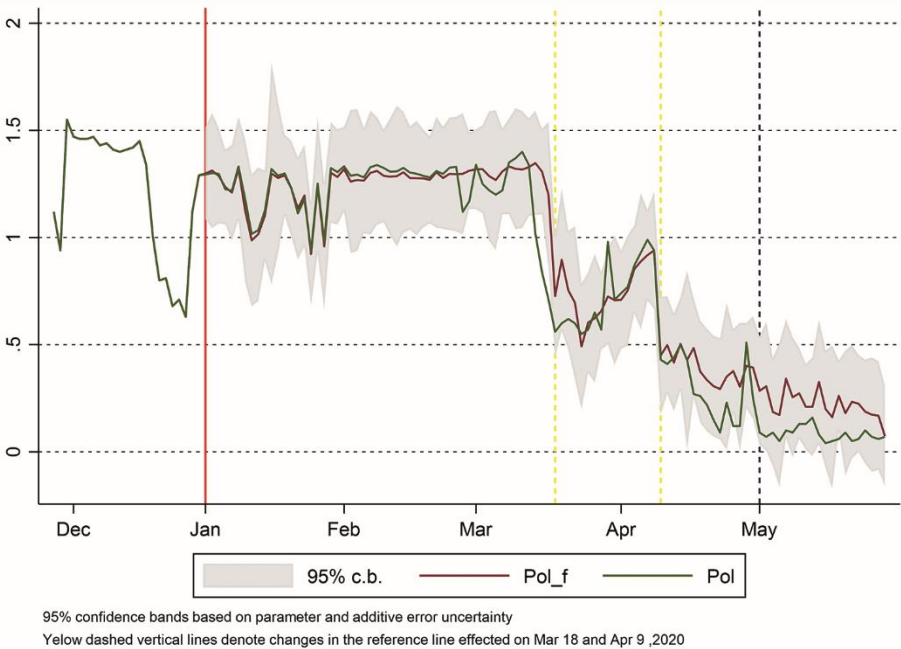
Source: own study.

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[3] The critical values for $T = 3747$, one independent variable and 41 short-run coefficients are $F_{0.05} = 5.195$ and $t_{0.05} = -3.685$, respectively (see: Kripfganz and Schneider (2020), Appendix D, Table C4).

Table 1. The results of validation tests for the ARDL/ECM

Test	Test statistic	5% c.v.
Normality*	961.60	5.991
Autocorrelation**	24.739	31.4
Heteroskedasticity***	539.45	3.841
Structural break****	0.727	0.948

* Skewness/kurtosis test for normality of D'Agostino, Belanger, and D'Agostino Jr. (1990) with the empirical correction by Royston (1991) under the null of normality distributed approximately as $\chi^2(2)$; ** Breusch-Godfrey LM test for autocorrelation of order up to 20 under the null of no autocorrelation distributed as $\chi^2(20)$; *** Breusch-Pagan (1979) test for heteroskedasticity under the null of constant variance distributed as $\chi^2(1)$; **** Cumulative sum on recursive residuals test for parameter stability of Brown, Durbin, and Evans (1975).

Source: own computations.

95% confidence bands based on parameter and additive error uncertainty
Yelow dashed vertical lines denote changes in the reference line effected on Mar 18 and Apr 9 ,2020

Fig. 2. Polonia rate (Pol) and its one day forecast (Pol_f) with 95% confidence bands, Dec 2019-May 2020

Source: own study.

Having computed a series of one-day-ahead forecasts of the Polonia rate and appropriate 95% confidence bands on the restricted ECM. I visualize both in Figure 2, where the red solid vertical line separates the estimation period (24 Jan 2005 to-31 Dec

2019) from the forecasting period (2 Jan 2020 to-30 April 2020). The yellow dashed vertical lines show the trading days when changes in the reference rates were effected (18 March 2020 and 9 April 2020),[4] while the dark navy dashed vertical line shows the day of the change in the setting mechanism for WIBORs (4 May 2020).

The inspection of Figure 2 leads to several conclusions.

First, the restricted ECM seems to perform reasonably well out of the sample. In the forecasting period the series of the one-day-ahead Polonia forecasts (Pol_f) and the Polonia rate (Pol) comove across time close to each other. The distance between the two seems to increase as time goes by.

Second, the forecasts based on the ECM slightly overestimate the actual Polonia rate at times when the monetary authority cuts the reference rates or shortly after that.

Third, at such times the actual Polonia rate incidentally goes beyond the lower confidence band.

Table 2. Accuracy measures for the ECM and forecasts made on this model

Period	$\Delta Polonia$		$Polonia$		$RW*$	
	RSME	ME	RMSE	ME	RMSE	ME
Estimation period						
22 Jan 2005-31 Dec 2019	0.1372	0.0000	×	×	×	×
Forecasting period						
2 Jan 2020-17 Mar 2020	0.1027	0.0094	0.1139	0.0274	0.2723	–0.0411
18 Mar 2020-8 Apr 2020	0.1402	–0.0302	0.1238	0.0411	0.3056	0.0131
9 Apr 2020-30 Apr 2020	0.1239	0.0096	0.1528	0.1194	0.2361	–0.0262
2 Jan 2020-30 Apr 2020	0.1147	0.0019	0.1236	0.0465	0.2730	–0.0331
4 May 2020-29 May 2020	0.0841	–0.0055	0.1637	0.1517	0.2967	–0.0023

* The Polonia rate one-step-ahead forecast based on the random walk with independent and identically distributed (normal) innovations with mean and variance equal to those estimated for Δp_t (22 Jan 2005 to-31 Dec 2019).

Source: own computations.

The estimates of accuracy measures for the ECM and the predictions made on this model (root mean square error, $RMSE$, and mean error, ME) are showed in Table 2. They indicate that the model in first differences performs considerably well both in the sample ($RMSE = 0.1372$) and out of the sample ($RMSE = 0.1147$). The estimates of $RMSE$ increase in the subsequent forecasting periods, but not by much. The same applies to the model in levels. The forecasts made for the Polonia rate on average slightly overestimate the actual rate ($ME = 0.0465$) contrary to those naïve ones

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[4] On 18 Mar 2020, the reference rate and the lombard rate were cut by 0.5% and 1%, respectively, from 1.5% to 1.0% and from 2.5% to 1.5%, while the deposit rate remained unchanged at 0.5%. The next cut accounting of 0.5% concerned all 3 reference rates and was effected on 9 April 2020.

based on a random walk ($ME = -0.0331$). The accuracy of latter is much worse ($RMSE = 0.2730$), however. The forecast mean error for the Polonia rate for the period after the second reference rates cut ($ME = 0.1194$) is almost three times bigger than that for the preceding period ($ME = 0.0411$). Had the simulations and forecasting on the restricted ECM been extended beyond the day at which the change in the setting mechanism for WIBORs was effected (4 May 2020), the forecasting accuracy for the Polonia rate would further deteriorate ($RMSE = 0.1637$ and $ME = 0.1517$). That is why its use for the prediction of the Polonia rate is recommended only for short forecasting horizons, no longer than four months.

4. Conclusion

The purpose of the paper was to check whether the Polonia rate exhibiting the price of one-day money in Poland could be predictable on WIBOR O/N, its banking industry mid-morning forecast. Since they are both believed to be $I(1)$ variables, the author built upon the ARDL approach to the cointegration framework. Having an appropriate ARDL model chosen using the AIC criterion and the corresponding restricted ECM estimated, the author performed simulations to obtain a series of one-day-ahead Polonia rate forecasts and its 95% confidence bands. The analysis showed that the restricted ECM performed well both in and out of the sample. It slightly overestimated the actual Polonia rate at times when the monetary authority cut the reference rate or shortly after that. In such circumstances the actual rate incidentally went beyond the lower confidence band. Had the simulations and forecasting been extended beyond the day at which the change in the setting mechanism for WIBORs was effected, the forecasting accuracy would deteriorate. That is why the author recommends its use for the prediction of the Polonia rate only for short forecasting horizons up to four months.

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CZY STAWKĘ POLONIA MOŻNA PROGNOZOWAĆ, WYKORZYSTUJĄC WIBOR O/N?

Streszczenie: W artykule pokazano, że stawkę Polonia odzwierciedlającą cenę pieniądza jednodniowego w Polsce można prognozować na podstawie stopy WIBOR O/N, jej przybliżenia z późnego poranka. W tym celu wykorzystano model korekty błędem wywodzący się z modelu ARDL. Po oszacowaniu tego modelu na danych o częstotliwości dziennej z okresu 24.01.2005-31.12.2019 dokonano symulacji 100 sekwencji jednodniowych dynamicznych prognoz stawki Polonia do 30.04.2020 roku, tj. do ostatniego dnia roboczego poprzedzającego znaczącą zmianę systemu stanowienia stawek WIBOR, która skutkowała przesunięciem obliczania i ogłaszania stawki jednodniowej do późnych godzin popołudniowych. Wyznaczono także 95-procentowe przedziały ufności dla tych prognoz. Analiza wyników symulacji prowadzi do wniosku, że model korekty błędem wyspecyfikowany na podstawie kryterium informacyjnego Akaike charakteryzuje się dobrymi własnościami prognostycznymi w próbie oraz poza próbą. Niemniej w chwilach obniżek stóp referencyjnych przez władze monetarne lub bezpośrednio po obniżkach model ten nieznacznie przeszacowuje bieżącą stawkę Polonia. W takich wypadkach stawka ta okazjonalnie wykracza poza dolną granicę przedziału ufności.

Słowa kluczowe: stawka Polonia, podejście ARDL do kointegracji, prognozy dynamiczne.