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The random-walk behavior of the Euro exchange rate

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ABSTRACT

We use Generalized Andrews–Ploberger (GAP) tests to examine the random-walk behavior of 17 OECD countries' euro exchange rates at daily frequencies. The GAP tests reject the hypothesis of random-walk behavior less often than do traditional tests. Moreover, the random-walk hypothesis cannot be rejected for the euro's exchange rate against most of the major currencies. We also use the generalized Box–Pierce tests to produce evidence that corroborates the above findings. Finally, and in contrast to the traditional tests, the GAP tests produce results that are consistent during the great moderation and the recent global financial crisis periods.

1. Introduction

Two decades after Meese and Rogoff's (1988) findings, views are still divided on whether a random walk (RW) model for exchange rates can be outperformed over short-to-medium term forecast horizons. Evidence on the random-walk behavior of nominal exchange rates can validate alternative theoretical frameworks and investment strategies. Direct implications also exist for policymakers facing a tradeoff between theoretically consistent models with mediocre forecast performance and atheoretical rules of thumb.

We examine whether the euro's nominal exchange rate behavior against 17 OECD currencies is a random walk during the great moderation period and the period covering the recent financial crisis.

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A random walk implies that the first difference of the returns series should be uncorrelated (Choi, 1999). The Andrews and Ploberger (AP) (1996) autocorrelation tests pertain to time series generated by an ARMA(1,1) under the alternative, but they are consistent against all non-white noise alternatives. We use Generalized Andrews and Ploberger (GAP) tests recently proposed by Nankervis and Savin (2010), which allow for the possibility that the time series is uncorrelated but statistically dependent – a typical characteristic of financial returns. Moreover, these tests do not suffer from the cutoff point selection problem as do the generalized Box–Pierce (BP) (Box and Pierce, 1970) tests (Lobato et al., 2002) which we also report for comparison.

2. Background, data, and methodology

The evidence on the random-walk behavior of nominal exchange rates is largely inconclusive. For example, Yang et al. (2008), Belaire-Franch and Opong (2005), and Smoluk et al. (1998), provide evidence of RWs in the euro exchange rates. Yilmaz (2003) finds that coordinated interventions produce deviations from the martingale property while others produce evidence of exchange rate predictability at long horizons (e.g., Mark, 1995; Wu and Hu, 2009).

We consider the daily nominal euro exchange rate against the following OECD currencies: Japanese Yen (JPY), Swiss Franc (CHF), US Dollar (USD), Canadian Dollar (CAD), British Pound (GBP), Australian Dollar (AUD), New Zealand Dollar (NZD), Swedish Krona (SEK), Slovak Koruna (SKK), Polish Zloty (PLN), Norwegian Krone (NOK), Mexican Peso (MXN), Korean Won (KRW), Hungarian Forint (HUF), Czech Koruna (CZK), Danish Krone (DKK) and Icelandic Krona (ISK).[1]

Since returns are serially uncorrelated under a random walk, rejecting the no-serial correlation hypothesis implies rejection of the random-walk hypothesis for the exchange rates. To detect serial correlation in time series Andrews and Ploberger (1996) consider an ARMA(1,1) model of the form,

$$Y_t = (\pi + \beta)Y_{t-1} + \varepsilon_t - \pi\varepsilon_{t-1} \quad \text{for } t = 2, 3 \ldots, \tag{1}$$

where $\{Y_t : t = 1, \ldots T\}$ are observed random variables, $\{\varepsilon_t : t = 1, 2, \ldots\}$ are unobserved innovations and $|\pi + \beta| < 1$. The null/alternative hypothesis is that $\{Y_t : t = 1, \ldots T\}$ is white noise/serially correlated. Under the null, $\beta = 0$ and $Y_t = \varepsilon_t$ with π not present and thus tests are non-standard. Financial returns series are typically uncorrelated but statistically dependent and often exhibit substantial autocorrelation in squared returns. The asymptotic covariance matrix of the sample autocorrelations is not the identity matrix and standard tests can have actual significance levels higher than nominal levels (Nankervis and Savin, 2010).

The GAP tests allow for $\{Y_t : t = 1, \ldots T\}$ being a covariance stationary sequence of statistically dependent but uncorrelated random variables. The ith sample autocorrelation is given by

$$r_i = \sum_{t=i+1}^{T} (Y_t - \bar{Y})(Y_{t-i} - \bar{Y}) \Big/ \sum_{t=1}^{T} (Y_t - \bar{Y})^2 \tag{2}$$

Letting $r^M = (r_1, r_2, \ldots, r_M)'$, we have that under the no-autocorrelation null $\sqrt{T}r^M$ is asymptotically $N(0, V)$, where V is an $M \times M$ matrix.

The AP tests rely on the statistic

$$\mathrm{LM}_M(\pi, V) = (1 - \pi^2)(\rho_M' \sqrt{T} L r^M)^2 \tag{3}$$

where $V^{-1} = L'L$ and $\rho_M = (1, \pi, \pi^2, \ldots, \pi^{M-1})'$.

Andrews and Ploberger (1996) assume that (the unknown) V and L are identity matrices. Nankervis and Savin's (2010) generalization consists in estimating V by a consistent estimator $\hat{V}$. The three AP tests we consider are:

$$\sup \mathrm{LM} = \max_{\pi \in \Pi} (\mathrm{LM}_M(\pi, \hat{V})),$$

[1] The data are from DataStream and their main source is the European Central Bank.

Table 1
Values of the AP and BP test statistics for the euro exchange rates, 1/4/1999–9/16/2009.

$\hat{V}$	I				$\hat{V}^{GP}$				$\hat{V}(SBC)$			
	sup LM	Exp-LM_0	Exp-$LM_{\infty T}$	BP_{12}	sup LM	Exp-LM_0	Exp-LM_∞	BP_{12}	sup LM	Exp-LM_0	Exp-LM_∞	BP_{12}
AUD	4.36	1.16	0.74	22.13**	0.82	0.22	0.11	9.03	2.37	0.63	0.36	22.82**
CAD	134.81***	101.50***	65.31***	139.46***	2.51	1.19	0.69	7.43	3.23	1.52	0.91	9.63
CHF	4.71*	1.87	1.15	37.54***	1.35	0.53	0.29	12.5	4.05	1.14	0.77	13.17
CZK	0.44	0.15	0.08	16.26	0.1	0.04	0.02	5.77	0.13	0.05	0.03	10.44
DKK	19.06***	13.50***	8.34***	28.39***	3.78	2.16	1.25	8.22	3.4	2.47*	1.31	9.36
GBP	11.43***	6.33***	4.60***	31.24***	5.63*	2.48*	1.73*	14.74	5.27*	3.13*	2.02**	20.23*
HUF	8.68**	1.61	1.93*	23.78**	2.44	0.43	0.28	7.86	10.31***	1.43	2.13**	24.45**
ISK	15.93***	8.87***	6.33***	92.45***	0.25	0.17	0.09	7.22	0.94	0.44	0.23	12.47
JPY	1.81	0.34	0.2	28.34***	0.48	0.1	0.05	13.61	1.59	0.22	0.13	13.82
KRW	17.03***	5.90***	6.51***	82.05***	4.15	1.43	1	12.59	7.92**	2.71*	2.46**	23.32**
MXN	2.39	0.89	0.54	10.85	0.66	0.26	0.14	5.42	1.72	0.74	0.41	11.06
NOK	2.6	1.51	0.86	42.91***	0.78	0.44	0.23	18.66*	3.81	1.44	0.88	21.58**
NZD	2.56	1.42	0.81	13.18	1.54	0.69	0.37	9.96	1.64	0.83	0.46	11.36
PLN	6.20**	1.07	1.15	26.29***	1.99	0.34	0.22	11.77	5.21*	0.84	0.82	21.37**
SEK	4.25	1.93	1.26	36.33***	1.85	0.85	0.48	15.38	2.24	1.03	0.6	17.42
SKK	2.12	0.58	0.31	15.92	1.02	0.15	0.08	8.76	1.32	0.18	0.1	10.04
USD	0.94	0.35	0.18	24.13**	0.71	0.22	0.12	15.9	0.58	0.24	0.13	17.03

Note: The test results of the random-walk hypothesis for 17 daily euro exchange rates series. Each series spans the period from January 4, 1999 to September 16, 2009, resulting in a total of 2792 observations. The first four columns show the results of the original AP tests and BP tests when the covariance matrix V is replaced by the identity matrix. The other columns report the generalized tests where the V is substituted by two consistent estimators, $\hat{V}^{GP}$ and $\hat{V}(SBC)$ respectively. The maximum lag length used in VARHAC estimation for $\hat{V}(SBC)$ is 5.

* Rejection of the null hypothesis at 10% significance levels respectively.

** Rejection of the null hypothesis at 5% significance levels respectively.

*** Rejection of the null hypothesis at 1% significance levels respectively.

$$\text{Exp-LM}_0 = \left[\sum_{j=1}^{161}\left(\text{LM}_M(\pi_j, \hat{V})\right)\right] \Big/ 161, \tag{4}$$

$$\text{Exp-LM}_\infty = \ln\left[\left[\sum_{j=1}^{161}(\exp(\text{LM}_{n,M}(\pi_j, \hat{V})/2))\right] \Big/ 161\right],$$

where $\Pi = \{\pi_j\} = \{0, \pm 0.01, \ldots, \pm 0.80\}$ and $M = 20$.[2]

For comparison purposes we also apply a generalization of the BP test proposed by Lobato et al. (2002) for testing

$$\text{H}_0: \ \rho_1 = \cdots = \rho_\text{K} = 0 \qquad \text{against } \text{H}_1: \ \text{At least one } \ \rho_\text{i} \neq 0, \quad i = 1, \ldots, \text{K},$$

with the test statistics given by:

$$\text{BP}_K(\hat{V}) = T(r^K)'\hat{V}^{-1}r^K, \quad \text{where } \hat{V} \text{ is now a } K \times K \text{ matrix.}$$

While the traditional BP test assumes that V is an identity matrix, the generalized BP tests use consistent estimators of V.

We consider two versions of the generalized AP and BP tests: one which uses $\hat{V}^{GP}$, allowing the time series to be a martingale difference sequence (MDS) and one using $\hat{V}(SBC)$, allowing the series to be a MDS or a non-MDS (Lobato et al., 2002).

[2] Nankervis and Savin (2010) find that the value of M does not make any noticeable difference under both the null and alternative as long as $M \geqslant 20$ for $|\pi_j| \leqslant 0.8$.

Table 2
Values of the AP and BP test statistics for the euro exchange rates, 1/4/1999–7/31/2008.

$\hat{V}$	I				$\hat{V}^{GP}$				$\hat{V}(SBC)$			
	sup LM	Exp-LM_0	Exp-LM_∞	BP_{12}	sup LM	Exp-LM_0	Exp-LM_∞	BP_{12}	sup LM	Exp-LM_0	Exp-LM_∞	BP_{12}
AUD	5.14*	2.95*	1.83*	30.26***	3.24	1.76	1.04	26.81***	2.71	1.47	0.85	24.837**
CAD	3.49	1.65	1.01	11.56	3.04	1.35	0.83	11.43	3.44	1.56	0.97	11.47
CHF	3.97	1.04	0.72	14.85	2.38	0.61	0.38	10.09	3.19	0.85	0.55	11.01
CZK	1.17	0.44	0.23	11.19	1.14	0.28	0.15	10.41	0.95	0.31	0.16	10.41
DKK	2.09	1.39	0.73	9.51	0.49	0.24	0.13	5.34	0.37	0.23	0.11	6.29
GBP	2.24	0.53	0.32	25.60**	1.73	0.4	0.23	20.95*	1.79	0.41	0.24	21.05**
HUF	5.58*	1.64	1.31	21.33**	2.09	0.66	0.39	12.92	1.84	0.64	0.36	13.15
ISK	7.16**	4.39**	2.65**	20.52*	2.07	1.2	0.65	8.69	2.02	1.23	0.66	10.51
JPY	3.16	0.91	0.58	10.66	2.44	0.66	0.39	7.73	2.56	0.67	0.4	7.88
KRW	6.10**	3.47**	2.14**	24.50**	3.67	2.05	1.19	16.3	4.24	2.44*	1.42*	17.77
MXN	1.72	1.2	0.62	6.6	1.25	0.92	0.47	5.74	1.25	0.92	0.47	5.74
NOK	4.96*	3.30*	1.88*	18.74*	4.41	2.72*	1.66*	16.26	3.95	2.51*	1.47*	15.46
NZD	4.96*	3.30*	1.88*	18.74*	4.41	2.72*	1.66*	16.26	3.95	2.51*	1.47*	15.46
PLN	7.48**	2.31	2.10**	27.01***	2.33	0.79	0.48	19.16*	6.43**	1.65	1.46*	22.659**
SEK	6.97**	4.01**	2.61**	21.16**	4.82*	2.74*	1.68*	14.95	6.02**	3.54**	2.21**	15.23
SKK	2.13	0.81	0.42	16.51	0.99	0.19	0.1	9.33	1.32	0.22	0.12	10.65
USD	1.51	0.57	0.33	12.5	1.47	0.53	0.3	10.93	1.47	0.53	0.3	10.93

Note: The test results of the random-walk hypothesis for 17 daily euro exchange rates series. Each series spans the period from January 4, 1999 to July 31, 2008, resulting in a total of 2498 observations. The first four columns show the results of the original AP tests and BP tests when the covariance matrix V is replaced by the identity matrix. The other columns report the generalized tests where the V is substituted by two consistent estimators, $\hat{V}^{GP}$ and $\hat{V}(SBC)$ respectively. The maximum lag length used in VARHAC estimation for $\hat{V}(SBC)$ is 5.

* Rejection of the null hypothesis at 10% significance levels respectively.

** Rejection of the null hypothesis at 5% significance levels respectively.

*** Rejection of the null hypothesis at 1% significance levels respectively.

3. Results

Table 1 shows the results from both standard and generalized AP and BP tests for each exchange rate for the full sample (1/4/1999–9/16/2009). The first panel (I) in the tables provides the results from the three AP tests and the BP test while the second ($\hat{V}^{GP}$) and third ($\hat{V}(SBC)$) panels show the corresponding results from the generalized tests.

The traditional AP and/or BP tests reject the random-walk hypothesis for thirteen currencies while the generalized tests reject the random walk only in six cases. Regardless of the test used, the random walk is rejected for the euro against six currencies, namely GBP, PLN, KRW, HUF, AUD, and NOK. Another set of exchange rates (CZK, NZD, SKK, and MXN) show evidence of random-walk behavior across tests. Finally, using the generalized tests overturns the results of the traditional tests for the euro exchange rates against the major currencies USD, JPY, CHF, CAD, as well as against SEK, ISK, and DKK. It is worth mentioning that stronger evidence against the random-walk hypothesis emerges when using the less restrictive $\hat{V}(SBC)$ version of the generalized tests and when using the BP tests as compared to the AP tests.

To check the robustness of our results to the inclusion of the global financial crisis we run the same tests using data up to the end of July 2008. The results reported in Table 2 show that, regardless of the test used, the random-walk hypothesis cannot be rejected for seven exchange rates that include the USD, JPY, CHF, and CAD. The random walk is consistently rejected, however, for eight exchange rates and using the generalized tests reverses the results only for two small countries (ISK and HUF).

Relying on traditional AP and BP tests only, the rejection of the random-walk hypothesis could be deceptively interpreted as a repercussion of the financial crisis shock. The generalized tests, however, provide a different perspective showing that the (random walk or not) behavior of the euro exchange rates has not been dramatically affected by the global financial crisis. This indicates that the generalized tests produce consistent results in the presence of major shocks.

The AP tests have been extended to the case of testing white noise against multiplicative seasonal models (Andrews et al., 1998). A generalized version of these tests has yet to be developed.[3] Such tests could then be applied to intraday exchange rate data (seasonality is unlikely to be an important issue at daily frequencies) and most importantly to unfiltered stock returns.

4. Conclusion

We examine the random-walk behavior for the nominal exchange rates of the euro against 17 OECD currencies and compare the results from conventional AP and BP tests with those from their generalized versions. The generalized tests show that most euro exchange rates follow random walks while the traditional tests tend to over-reject the random-walk hypothesis. Moreover, in contrast to the traditional tests, the generalized tests AP and BP tests produce consistent results across the great moderation and the financial crisis periods.

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[3] Nankervis and Savin (2010) report on the power properties of the generalized (non-seasonal) AP tests in the case of seasonal data.