



## Are exchange rates serially correlated? New evidence from the Euro FX markets

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### ABSTRACT

This paper examines the serial uncorrelatedness hypothesis in the Euro FX markets by testing for autocorrelation in daily FX returns of 82 countries over the period of 1999–2010. We use three newly developed tests that are robust to conditional heteroskedasticity of unknown forms and that do not choose a lag parameter arbitrarily. They are Escanciano & Lobato (2009)'s automatic Box–Pierce  $Q_b$  test, Nankervis & Savin (2010)'s generalized Andrews–Ploberger test and Deo (2000)'s robust Durlauf test. We find no significant autocorrelation in the FX returns of around 58 to 62 countries, suggesting that majority of the Euro FX markets are weak-form efficient.

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### 1. Introduction

The efficiency of financial markets has been a long standing debateable issue in the finance literature. This idea implies that (changes in) asset prices are serially uncorrelated, i.e., the serial uncorrelatedness hypothesis. Testing for autocorrelation therefore has held a central role in the empirical finance literature on the issue. However, Robinson (1991) notes that traditional tests for autocorrelation are limited in the sense that they ignore the possibility that a time series can be statistically uncorrelated but still not independent over time. In particular, they may not be robust to nonlinear dependency (such as conditional heteroskedasticity). Since then, there has been a growing interest in developing new tests for autocorrelation that allow for nonlinear dependence of unknown forms. See Francq, Roy, and Zakoian (2005) for a review of this literature.

The presence of nonlinear dependence is well known in the foreign exchange markets. Famous examples include Hsieh (1989) and Panayotis and Apergis (1996). Hsieh (1989) first reported evidence of nonlinear dependence in daily foreign exchange rates. Panayotis and Apergis (1996) show that traditional tests provide mixed results on the efficient market hypothesis in the foreign exchange market. However, once the ARCH effect (a form of conditional

heteroskedasticity) is properly accounted for, there is conclusive evidence supporting the efficient market hypothesis.

The advent of the Euro is one of the important developments in the recent history of international finance. Since its introduction in 1999, the Euro has quickly established itself as the second most widely held international currency after the US dollar. Its importance suggests that a better understanding of the behaviour of Euro-based exchange rates is needed because the majority of previous studies examined FX rates against the US dollars only. This paper aims to re-examine the serial uncorrelatedness hypothesis in the Euro foreign currency markets with three newly developed tests that allow for conditional heteroskedasticity of unknown form. These tests have the additional advantage that we do not need to determine the lag length arbitrarily as it is data-driven. A comprehensive dataset that covers Euro-based FX rates of 82 countries over the period 1999 to 2010 is used.

The results show that out of the 82 foreign currencies examined, we can reject the serial uncorrelatedness hypothesis in only 20 to 24 of them. These foreign currencies are typically currencies of small countries with undeveloped financial markets. Further analysis on sub-period rolling results confirms the main result.

The rest of this paper is organized as follows. We first provide a selected literature review in Section 2 where the motivation for our study is given. Section 3 outlines the methodology and dataset, followed by Section 4 where the empirical results and sensitivity analyses are reported and discussed. Section 5 concludes this paper.

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**Table 1**  
Empirical results of the AQ, GAP and DD test statistics for 82 Euro exchange rates, 4/1/1999–31/12/2010.

Currency		Panel A: p-values			Panel B: Percentage of rejection over rolling subsamples (i.e. p-value<10%)			Panel C: Three country classification lists		
No.	Name	AQ	GAP	DD	AQ	GAP	DD	ED List*	GL List*	FX List*
1	ALBANIAN LEK	0.816	0.589	0.634	0.000	0.029	0.000	EDC	E	FGR
2	ALGERIAN DINAR	0.126	0.024	0.071	0.000	0.076	0.000	EDC	AF	MF
3	ARGENTINE PESO	0.442	0.331	0.449	0.000	0.010	0.000	EDC	A	FGR
4	BAHRAINI DINAR	0.586	0.489	0.548	0.000	0.219	0.000	EDC	AS	FR
5	AUSTRALIAN \$	0.492	0.382	0.435	0.010	0.000	0.019	DC	O	FGR
6	BANGLADESH TAKA	0.688	0.727	0.652	0.086	0.038	0.086	EDC	AS	FGR
7	BERMUDA \$	0.910	0.452	0.671	0.000	0.086	0.000	DC	A	FR
8	BOLIVIAN BOLIVIANO	0.849	0.829	0.915	0.000	0.000	0.000	EDC	A	FGR
9	BOTSWANAN PULA	0.024	0.061	0.017	0.067	0.000	0.114	EDC	AF	FGR
10	BRAZILIAN REAL	0.206	0.073	0.090	0.010	0.229	0.000	EDC	A	FGR
11	BRUNEI \$	0.068	0.027	0.035	0.524	0.524	0.524	DC	AS	FGR
12	BULGARIAN LEV	0.659	0.240	0.477	0.000	0.076	0.000	EDC	E	FR
13	BURUNDI FRANC	0.530	0.155	0.263	0.038	0.000	0.000	EDC	AF	MF
14	CANADIAN \$	0.172	0.118	0.175	0.219	0.305	0.210	DC	A	FGR
15	CHILEAN PESO	0.111	0.164	0.133	0.076	0.057	0.057	EDC	A	FGR
16	CHINESE YUAN	0.011	0.014	0.012	0.210	0.200	0.133	EDC	AS	FGR
17	COLOMBIAN PESO	0.858	0.637	0.558	0.000	0.000	0.000	EDC	A	MF
18	CROATIAN KUNA	0.598	0.156	0.383	0.000	0.067	0.000	EDC	E	FGR
19	CZECH KORUNA	0.000	0.001	0.000	0.714	0.676	0.676	DC	E	FGR
20	DANISH KRONE	0.031	0.040	0.029	0.314	0.295	0.324	DC	E	FR
21	ECUADOR SUCRE	0.200	0.067	0.186	0.019	0.143	0.010	EDC	A	FGR
22	EGYPTIAN £	0.492	0.630	0.668	0.143	0.143	0.410	EDC	AF	MF
23	FIJIAN \$	0.651	0.672	0.686	0.181	0.229	0.162	EDC	O	FGR
24	GAMBIAN DALASI	0.845	0.464	0.377	0.000	0.000	0.000	EDC	AF	MF
25	GHANAIAI CEDI	0.153	0.028	0.114	0.010	0.067	0.000	EDC	AF	MF
26	GUINEA FRANC	0.163	0.217	0.201	0.190	0.086	0.124	EDC	AF	MF
27	HONG KONG \$	0.592	0.624	0.623	0.010	0.000	0.000	DC	AS	FR
28	HUNGARIAN FORINT	0.222	0.290	0.272	0.000	0.095	0.000	EDC	E	FGR
29	INDIAN RUPEE	0.002	0.347	0.105	0.029	0.010	0.029	EDC	AS	MF
30	ICELANDIC KRONA	0.766	0.293	0.518	0.000	0.057	0.000	DC	E	FGR
31	INDONESIAN RUPIAH	0.191	0.255	0.245	0.010	0.029	0.010	EDC	AS	MF
32	ISRAELI SHEKEL	0.004	0.005	0.004	0.362	0.352	0.333	DC	AS	FGR
33	JAPANESE YEN	0.542	0.676	0.648	0.000	0.000	0.000	DC	AS	FGR
34	JORDANIAN DINAR	0.696	0.450	0.502	0.000	0.057	0.000	EDC	AS	FR
35	KAZAKHSTAN TENGE	0.224	0.122	0.119	0.181	0.238	0.190	EDC	E	FGR
36	KENYAN SHILLING	0.306	0.209	0.306	0.038	0.019	0.019	EDC	AF	MF
37	SOUTH KOREAN WON	0.002	0.001	0.002	0.552	0.524	0.495	DC	AS	FGR
38	KUWAITI DINAR	0.002	0.002	0.002	0.524	0.514	0.514	EDC	AS	FR
39	LATVIAN LAT	0.816	0.304	0.533	0.000	0.057	0.000	EDC	E	FR
40	LEBANESE £	0.386	0.517	0.519	0.057	0.029	0.038	EDC	AS	FR
41	LITHUANIAN LITA	0.820	0.309	0.538	0.000	0.057	0.000	EDC	E	FR
42	MALAWIAN KWACHA	0.862	0.610	0.718	0.000	0.038	0.000	EDC	AF	FGR
43	MALAYSIAN RINGGIT	0.074	0.018	0.052	0.324	0.476	0.333	EDC	AS	MF
44	MAURITANIAN OUGULYA	0.433	0.411	0.504	0.000	0.010	0.000	EDC	AF	MF
45	MAURITIUS RUPEE	0.528	0.470	0.499	0.000	0.219	0.000	EDC	AF	MF
46	MEXICAN PESO	0.379	0.326	0.421	0.010	0.000	0.019	EDC	A	FGR
47	MOROCCAN DIRHAM	0.756	0.820	0.734	0.152	0.095	0.171	EDC	AF	FGR
48	NEW MOZAMBIQ METICAL	0.840	0.309	0.594	0.000	0.076	0.000	EDC	AF	FGR
49	NEW ZEALAND	0.806	0.940	0.931	0.000	0.000	0.000	DC	O	FGR
50	NIGERIAN NAIRA	0.019	0.050	0.013	0.505	0.076	0.543	EDC	AF	MF
51	NORWEGIAN KRONE	0.083	0.024	0.033	0.038	0.238	0.086	DC	E	FGR
52	OMAN RIAL	0.000	0.000	0.000	0.952	0.962	1.000	EDC	AS	FR
53	PAKISTAN RUPEE	0.746	0.304	0.542	0.000	0.076	0.000	EDC	AS	MF
54	NEW GUINEA KINA	0.524	0.156	0.274	0.000	0.000	0.000	EDC	O	MF
55	PARAGUAY GUARANI	0.134	0.067	0.119	0.105	0.210	0.105	EDC	A	MF
56	PERUVIAN NUEVO SOL	0.121	0.177	0.139	0.057	0.048	0.038	EDC	A	MF
57	PHILIPPINE PESO	0.011	0.014	0.012	0.505	0.505	0.429	EDC	AS	FGR
58	POLISH ZLOTY	0.683	0.308	0.413	0.010	0.352	0.010	EDC	E	FGR
59	NEW ROMANIAN LEU	0.708	0.226	0.457	0.000	0.057	0.000	EDC	E	FGR
60	QATARI RIAL TO	0.000	0.000	0.000	0.781	0.686	0.695	EDC	AS	FR
61	SAUDI RIYAL	0.035	0.046	0.033	0.171	0.181	0.181	EDC	AS	FR
62	RUSSIAN ROUBLE	0.229	0.098	0.221	0.000	0.095	0.000	EDC	E	FGR
63	SINGAPORE \$	0.696	0.908	0.879	0.162	0.152	0.410	DC	AS	MF
64	SOUTH AFRICA	0.250	0.171	0.264	0.171	0.238	0.171	EDC	AF	FGR
65	SRI LANKAN RUPEE	0.890	0.271	0.221	0.000	0.000	0.000	EDC	AS	FGR
66	SWEDISH KRONA	0.128	0.025	0.096	0.029	0.238	0.029	DC	E	FGR
67	SWISS FRANC	0.143	0.168	0.171	0.038	0.114	0.105	DC	E	FGR
68	TAIWAN NEW \$	0.266	0.326	0.318	0.000	0.019	0.000	DC	AS	FGR
69	TANZANIAN SHILLING	0.545	0.750	0.684	0.000	0.105	0.000	EDC	AF	MF
70	THAI BAHT	0.002	0.341	0.105	0.095	0.086	0.105	EDC	AS	MF
71	TUNISIAN DINAR	0.866	0.348	0.576	0.000	0.057	0.000	EDC	AF	FGR

(continued on next page)

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