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Mean Reversion and Momentum in Central and Eastern European Countries – A Case Study on Poland and Romania

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Abstract

There is considerable evidence showing that both mean reversion and momentum exist in stock prices, especially in financially-developed countries. We analyze these phenomena for two Central and Eastern European countries with very different transitions from centrally-planned to market economies: Poland and Romania. Although Poland's stock market cannot be considered well-developed, its capitalization increased from 3 percent of GDP in 1995 to about 30 percent in 2017, while Romania's stayed under 6 percent of GDP in the 1990s and early 2000s, and only recently has increased to about 21 percent. Examining how mean reversion and momentum affect stock prices, we find very similar results for the two countries. The speed at which stocks converge back to their fundamentals (i.e., mean reversion) is much faster than that of the developed markets, with half-lives of just over 9 months for both countries (similar to the results obtained in the literature for the Chinese market, but much shorter than the 3-4 years for the well-developed markets). We also find that the momentum effect lasts less than in the developed countries. Therefore, in most cases, strategies combining mean reversion and momentum generate abnormal excess returns only for holding periods of less than 12 months.

Keywords: mean reversion, momentum, financial markets, international finance, Central and Eastern European countries

1. Introduction

An extensive literature is dedicated to investors' reaction to news. Part of the literature suggests that investors initially overreact to extraordinary news. Eventually, however, stock market prices move back to their fundamental values. DeBondt and Thaler (1985, 1987) propose an investing strategy of buying past losers and selling past winners (i.e., a contrarian or mean reversion strategy). As Jegadeesh and Titman (1993, 2001) notice, this strategy only works for very short (one week or one month) or very long (three to five years) holding periods. They propose a different strategy resulting from the investors' underreaction (usually to ordinary or unwanted news – "bad news travels slowly") which consists of buying past winners and selling past losers (i.e., momentum strategy). This strategy works best for a holding period of three to twelve months. Poterba and Summers (1988) propose a model in which stock returns are positively (negatively) serially correlated over short (long) periods of time and show that stock prices do not follow a random walk. They assume that stock prices have a temporary component which might influence the investor to buy an equity which has recently declined in value. Balvers and Wu (2006) suggest a mixed model that allows the investor to combine momentum and mean reversion in one strategy.

Using the same approach, we attempt to examine stock price mean reversion and momentum in two Central and Eastern Europe (CEE) countries: Poland and Romania. A lot of research has been done on the emerging financial markets that started their liberalization process in the 1980s (e.g., China), but very little literature focuses on the ex-communist countries in CEE, mainly due to the restricted data availability. Rouwenhorst (1999) finds that returns in emerging markets are mostly explained by local factors, while global factors are much less significant. Regarding momentum, it is present in some markets (e.g., Nigeria) and absent in others (e.g., Argentina). Foster and Kharazi (2008) analyze contrarian and momentum strategies in Iran and find evidence of momentum only. Dhouib and Abaoub (2007) present evidence of momentum and mean reversion in Tunisia. Wu (2011) examines the Chinese market and finds that a pure momentum strategy does not generate positive returns, while mean reversion is much stronger than in the developed markets. According to Buckberg (1995), all these differences

between the developed and developing financial markets arise from fewer updates received by investors, fewer trades, more noise and informational imperfections (such as information about firms), uncertainty about the financial conditions (leading to higher variance in stock returns), less stable policies (leading to a further reduction in liquidity for fear of devaluation, closing of the stock market, or additional capital controls).

Most of the literature focuses on the largest CEE markets (Czech Republic, Hungary, Poland, and Russia). However, as Baele et al. (2015) notice, the financial markets in CEE are very heterogeneous in terms of development. We select two countries, Poland and Romania, at opposing ends in terms of successful transition to market economies. Poland was among the first CEE countries to open a stock market (in the spring of 1991) and currently it has one of the highest stock market capitalizations in the region (see Figure 1 and Baele et al., 2015), one of the highest market turnover ratios (see, for instance, Pajuste, 2002; and Baele et al., 2015), and one of the least concentrated markets (see, for instance, Baele et al., 2015) (Note 1). On the other side of the spectrum, Romania has one of the lowest stock market capitalizations (see Figure 1 and Baele et al., 2015), one of the lowest market turnover ratios (see, for instance, Pajuste, 2002; and Baele et al., 2015), and one of the most concentrated markets (see, for instance, Baele et al., 2015). Baele et al. (2015) compute an index of financial development and rank Poland as number 4 and Romania number 12 (out of 16 CEE countries) in 2010.

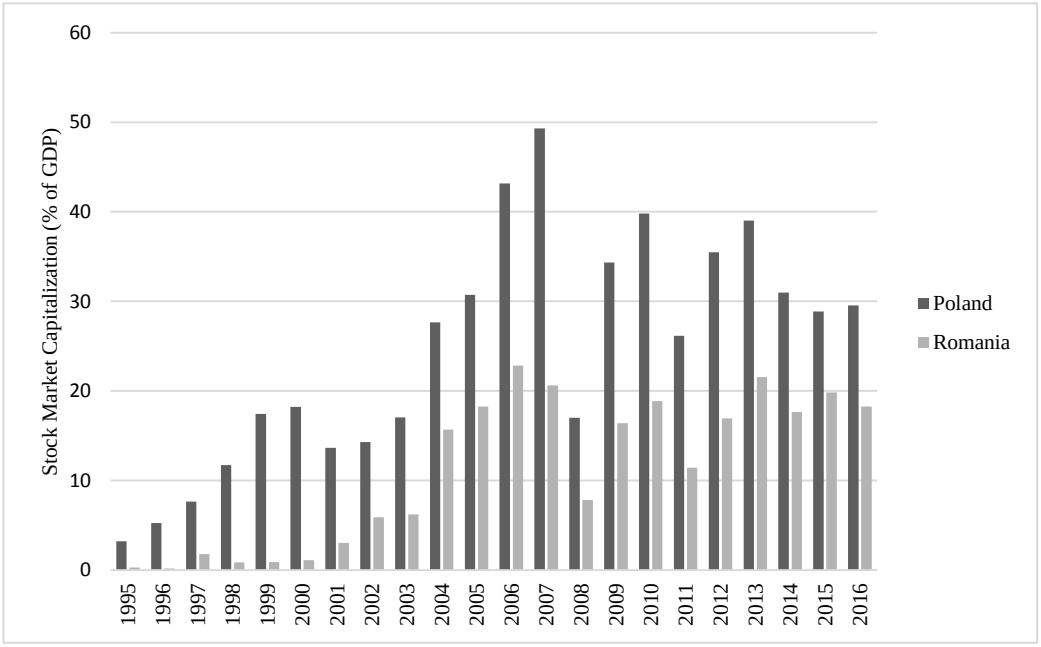

Figure 1. Stock market capitalization in Poland and Romania

Note. This figure shows the stock market capitalization expressed as percentage of GDP in Poland (dark grey) and Romania (light grey), from 1995 to 2016.

This paper focuses on the equity markets in these two CEE countries. We are interested in finding whether momentum or mean reversion exist in these countries and whether they manifest themselves differently, given the opposing characteristics mentioned above. Caporale and Spagnolo (2012) find that, following the EU accession, Hungary, Poland and Czech Republic became more integrated with one another and with the other EU countries. Reboredo et al. (2015) find evidence of a strong dependence between the stock markets in Hungary, Czech Republic and Poland, but very little between them and the Romanian market. The paper is organized as follows. Section 2 describes the model. Section 3 presents the data, while section 4 shows the results of our analysis. Section 5 concludes.

2. A Theoretical Model Combining Momentum and Mean Reversion

Following Fama and French (1988) and Summers (1986), we assume that all equity prices have both a permanent and a transitory component. The permanent component represents the fundamental value of a stock, while the transitory component is firm specific and represents the deviation from the fundamental value. More precisely, if we denote the logarithm of equity i's price at time t by p_t^i, then:

$$p_t^i = \beta^i y_t + x_t^i, \quad (1)$$

where y_t is the permanent component and x_t^i is the transitory component.

Following Balvers and Wu (2006), we assume that the transitory component can exhibit both momentum and mean reversion:

$$x_t^i = (1-\delta^i)\mu^i + \delta^i x_{t-1}^i + \sum_{j=1}^{J} \rho_j^i \Delta x_{t-j}^i + \omega_t^i, \quad (2)$$

where $(1-\delta^i)\mu^i + \delta^i x_{t-1}^i$ measures the mean reversion effect, while $\sum_{j=1}^{J} \rho_j^i \Delta x_{t-j}^i$ gauges the momentum effect. δ^i, ρ_j^i, and μ^i are the parameters of the model, as follows. If $\delta^i < 1$, then the temporary component converges towards its mean μ^i with a speed of $(1-\delta^i)$. The momentum coefficients ρ_j^i measure the strength of the momentum effect. They vary by asset *i* and by lag *j* and are strictly positive if the asset experiences momentum. *J* is the total number of lags when a stock experiences momentum (at most 12 months, according to Jegadeesh and Titman, 1993, 2001). Finally, ω_t^i is assumed to be white noise and uncorrelated with the explanatory variables.

Let us define the return on asset *i* at time *t* as:

$$r_t^i = p_t^i - p_{t-1}^i. \quad (3)$$

After substituting p_t^i and p_{t-1}^i from equation (1) into equation (3) and rearranging, we obtain:

$$r_t^i = \beta^i (y_t - y_{t-1}) + x_t^i - x_{t-1}^i. \quad (4)$$

It is straightforward to assume that the market return (r_t^m) has a β equal to one and no temporary component, so we can write:

$$r_t^m = y_t - y_{t-1}. \quad (5)$$

From equations (2), (4), and (5), we derive the following equation for the excess return (relative to the market return) on asset *i*:

$$r_t^i - \beta^i r_t^m = -(1-\delta^i)\left(x_{t-1}^i - \mu^i\right) + \sum_{j=1}^{J} \rho_j^i \Delta\left(r_{t-j}^i - \beta^i r_{t-j}^m\right) + \omega_t^i. \quad (6)$$

In this formulation, if we set $\delta^i = 1$, $\rho_j^i = \rho$, and $\beta^i = 0$, we obtain the basic momentum model of Jegadeesh and Titman (1991, 1993, 2001). Alternatively, if we set $\rho_j^i = 0$ and $\beta^i = 0$, then the returns are said to only experience mean reversion.

Balvers et al. (2000) show that a parametric approach is superior to a non-parametric approach (such as the one developed in De Bondt & Thaler, 1985, 1987) in capturing long-term mean reversal. Balvers and Wu (2006) build on the same model to also allow for the momentum effect. We use their parametric approach (equation 6) in testing whether a strategy combining mean reversion and momentum leads to abnormal positive returns for Poland and Romania. In other words, we examine whether mean reversion or momentum exist in these two very different CEE economies. This parametric approach was previously used by Balvers and Wu (2006) to show that a combination of momentum and mean reversion exists in 18 well-developed equity markets and that it outperforms a simple momentum or contrarian strategy. Wu (2011) uses the same approach to test mean reversion and momentum in China and finds similar results, even though the pure momentum strategies do not yield positive returns, while the mean reversion effect is much stronger. In Serban (2010), the same strategy outperforms others typically used in the foreign exchange markets.

3. Data and Summary Statistics

Data availability outside the developed world, together with the novelty of the stock markets in CEE and their low liquidity, leads to a fairly limited dataset. We collect daily data, but we transform them into monthly figures to reduce the noise.

For Poland, we collect data on stock prices from the Bank for Environmental Protection database for the time interval from May 1994 to June 2017 (Note 2). In total, there were 1,374 stocks traded during these 23 years, but around 45 percent of them were traded 12 days or less and around 6 percent were traded only once. The maximum number of stocks traded in one month was 905 in March 2017. From the same website, we also collect the values of the Warszawski Indeks Giełdowy 20 (hereafter, WIG20). WIG20 is a modified capitalization-weighted market index of 20 Polish stocks traded on the Warsaw Stock Exchange and was first introduced in April 1994. As a proxy for the risk-free rate, we use WIBOR, the three-month interbank rate in Poland, retrieved from the database of the Federal Reserve Bank of St. Louis.

For Romania, we collect stock prices from TradeVille, for the time interval July 2005 to August 2017 (Note 3). There were 2,330 stocks traded during that time period. However, due to the low liquidity in this new stock market, about 50 percent of them were traded only 12 days or less and 10 percent of them only once during that

entire period. The maximum number of stocks traded in one month was 814 in November 2007. As a market index, we use the Bucharest Exchange Trading (hereafter, BET) provided by the Bucharest Stock Exchange, a value-weighted index introduced in September 1997. As a proxy for the risk-free rate in Romania, we use the three-month ROBID (the interbank money market reference rate) retrieved from the website of the National Bank of Romania.

Table 1 shows our time-series analysis of the monthly returns for Poland and Romania. The average stock returns in the two countries are fairly similar and seem to follow a normal distribution centered at roughly zero. For both countries, the market return exhibits a low average, high standard deviation, and negative Sharpe ratio.

Table 1. Descriptive statistics

	Time-Series Average	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum	Market
			Panel A. Poland				
Mean	-0.0027	-0.5936	-0.0710	-0.0060	0.0610	0.5897	0.0027
St. dev.	0.0808	0.3729	0.0790	0.0736	0.0786	0.3615	0.0866
Sharpe ratio	-0.1369	-1.6141	-1.0047	-0.1946	0.6703	1.6080	-0.0658
Number of obs.	278	278	278	278	278	278	278
			Panel B. Romania				
Mean	0.0041	-2.2221	-0.0781	0.0001	0.0847	2.3133	0.0028
St. dev.	0.0587	1.0819	0.0577	0.0314	0.0647	1.1800	0.0834
Sharpe ratio	-0.0042	-2.0578	-1.4284	-0.1346	1.2427	1.9568	-0.0176
Number of obs.	144	144	144	144	144	144	144

Note. This table shows summary statistics of the monthly returns on all stocks traded on the Warsaw Stock Exchange from May 1994 to June 2017 (Panel A) and on the Bucharest Stock Exchange from July 2005 to August 2017 (Panel B). We report the mean, standard deviation, Sharpe ratio, and number of observations for the time-series averages, minima, 25th percentiles, medians, 75th percentiles, and maxima. The last column displays the same statistics for WIG20 (Panel A) and BET (Panel B), for the same time intervals specified above.

4. Estimation Results for Mean Reversion and Momentum Strategies

Following Balvers and Wu (2006), we estimate for each of the two countries parameters δ^i and ρ_j^i from equation (6) for the first third of the sample (the parameters can vary by asset and lag). For instance, we use the time period July 2005 – June 2009 for Romania to estimate a total of N δ's and NxJ ρ's for the combined mean reversion and momentum strategy, where N is the number of assets being traded during this time period and J is the number of lags. When creating a pure momentum strategy, we assume $\delta^i = 1$ and $\beta^i = 0$ and estimate NxJ ρ's. For the pure mean reversal strategy, we set $\rho_j^i = 0$ and $\beta^i = 0$ and only estimate N δ's.

Given these estimated parameters, we sort each stock from the highest to the lowest expected return. We construct an equally-weighted portfolio in which we buy the top and sell the bottom stocks and we hold this position for K months. As explained in section 3, some stocks have a fairly short life. Therefore, if a top or bottom one has a lifespan shorter than K months, then it is simply disregarded and the next stock in line is considered in its stead. We recognize that this approach may lower the profitability of the strategy, especially in highly illiquid markets. Next, using rolling windows, we perform the same procedure estimating the parameters for the time period August 2005 – July 2009, then September 2005 – August 2009, and so on.

4.1 Results for the Combined Mean Reversion and Momentum Strategy

We compute annualized averages of the returns obtained through the combined mean reversion and momentum strategy and we report them in Tables 2 (for Poland) and 3 (for Romania).

We allow the number of lags (J) to vary from 1 to 12 months and the holding period (K) to vary from 1 to 18 months, both in two or three-month increments, resulting in a total of 35 combinations. We construct portfolios formed with the top n (Max n) and bottom n (Min n) firms and we report the annualized mean returns, their t-statistics, and Sharpe ratios for Max n, Max n – Min n, and Max n – Market. Specifically, in Panels A, B, and C, we display these statistics when n takes the values 5, 10, and 15, respectively.

For Poland, the combined strategy Max n – Min n exhibits positive abnormal returns in more than half of the combinations (J, K). When considering the top 5 and bottom 5 assets, we obtain significant positive returns in 19 (out of 35 cases) at the 5 percent significance level or better. For 10 and 15 assets, the results improve slightly with 23 and 24 combinations (J, K), respectively. In Panel A, for instance, the annualized average returns that are significantly positive range from around 0.046 to 1.144. In some cases, the strategy exhibits positive returns even

when the Max portfolio does not. For instance, in Panel B, Max 10 is positive in only 22 and beats the market in only eight cases (out of 35). In terms of trends, the average returns seem to decrease as we increase the holding period (*K*). This result is expected as the strategy should work best when updating the portfolio more frequently. As the number of lags (*J*) increases, we typically observe an increase in average returns first, followed by a decrease (with the maximum usually at *J* = 6 months). Both trends are similar to the ones obtained for developed markets in Balvers and Wu (2006), though their highest returns typically arise at *J* = 9 or 12 months.

Table 2. Results for the combined mean reversion and momentum strategy – Poland

Panel A. 5-Stock portfolios

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	t-stat	Sharpe
J=1	Max 5	**0.4019**	3.6636	0.2396	0.0553	0.9439	0.0149	0.0019	0.0408	-0.0633	0.0039	0.1049	-0.0742	-0.0081	-0.2372	-0.1069	-0.0172	-0.5411	-0.1354	-0.0109	-0.3753	-0.1323
	Max 5-Min 5	**0.6687**	5.4642	0.4007	0.0321	0.5669	0.0416	-0.0589	-1.2061	-0.0884	-0.0779	-2.2446	-0.1646	-0.0709	-2.3811	-0.1746	-0.1021	-3.3842	-0.2481	-0.0765	-2.7627	-0.2026
	Max 5-Rm	**0.3718**	3.7848	0.2775	0.0198	0.3009	0.0221	-0.0405	-0.6238	-0.0457	-0.0495	-0.8122	-0.0596	-0.0544	-0.9249	-0.0678	-0.0694	-1.2001	-0.0880	-0.0543	-0.9167	-0.0672
J=3	Max 5	**0.5671**	5.5194	0.3743	**0.1515**	2.4394	0.1278	**0.1044**	2.3023	0.1002	**0.0928**	2.4775	0.0997	**0.0976**	2.7560	0.1166	**0.0729**	2.3186	0.0747	**0.0495**	1.7380	0.0227
	Max 5-Min 5	**0.9693**	7.4653	0.5474	**0.2299**	3.4015	0.2494	0.0760	1.5603	0.1144	0.0578	1.6007	0.1174	**0.0551**	1.7036	0.1249	0.0331	1.1578	0.0849	-0.0060	-0.2262	-0.0166
	Max 5-Rm	**0.5369**	5.6896	0.4172	0.1160	1.5543	0.1140	0.0620	1.0061	0.0738	0.0393	0.6472	0.0475	0.0513	0.9100	0.0667	0.0207	0.3567	0.0262	0.0060	0.1028	0.0075
J=6	Max 5	**0.6606**	4.9570	0.3400	**0.2078**	3.3068	0.1921	0.0641	1.4644	0.0363	0.0351	0.9196	-0.0129	0.0340	0.9753	-0.0156	0.0328	1.0600	-0.0195	0.0199	0.6584	-0.0507
	Max 5-Min 5	**1.1442**	7.2462	0.5313	**0.2995**	4.5370	0.3327	**0.0919**	1.9818	0.1453	0.0411	1.0702	0.0785	0.0420	1.3086	0.0960	0.0305	1.0150	0.0744	0.0097	0.3417	0.0251
	Max 5-Rm	**0.6305**	5.2947	0.3882	**0.1724**	2.4254	0.1778	0.0217	0.3648	0.0267	-0.0184	-0.3084	-0.0226	-0.0123	-0.2138	-0.0157	-0.0194	-0.3461	-0.0254	-0.0235	-0.4126	-0.0303
J=9	Max 5	**0.5263**	4.0085	0.2700	**0.1916**	2.5823	0.1466	**0.1366**	2.7500	0.1390	**0.1060**	2.6028	0.1157	**0.0825**	2.3114	0.0848	**0.0636**	1.9023	0.0499	0.0432	1.3394	0.0058
	Max 5-Min 5	**0.9294**	6.0593	0.4443	**0.2457**	3.3127	0.2429	**0.1744**	3.4651	0.2541	**0.1059**	2.5401	0.1863	**0.0677**	1.8822	0.1380	0.0464	1.3571	0.0995	0.0263	0.7655	0.0561
	Max 5-Rm	**0.4962**	4.0704	0.2985	**0.1561**	2.0070	0.1472	0.0942	1.4999	0.1100	0.0525	0.8569	0.0628	0.0362	0.6034	0.0442	0.0114	0.1923	0.0141	-0.0002	-0.0032	-0.0002
J=12	Max 5	**0.5412**	4.5467	0.3072	**0.1533**	2.1902	0.1154	**0.0827**	1.7407	0.0622	0.0570	1.3571	0.0266	0.0594	1.5807	0.0354	0.0497	1.4518	0.0187	**0.0519**	1.6921	0.0270
	Max 5-Min 5	**0.9198**	6.1624	0.4519	**0.2554**	3.5065	0.2571	**0.1205**	2.4682	0.1810	**0.0906**	2.2427	0.1644	**0.0826**	2.4920	0.1827	**0.0593**	1.9869	0.1457	**0.0458**	1.6779	0.1230
	Max 5-Rm	**0.5110**	4.9022	0.3594	0.1179	1.6120	0.1182	0.0402	0.6275	0.0460	0.0035	0.0573	0.0042	0.0131	0.2278	0.0167	-0.0025	-0.0418	-0.0031	0.0085	0.1410	0.0103

Panel B. 10-Stock portfolios

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe
J=1	Max 10	**0.2919**	3.3556	0.2092	0.0675	1.4097	0.0369	0.0430	1.1219	0.0011	0.0337	1.0111	-0.0179	0.0202	0.6458	-0.0498	0.0135	0.4725	-0.0713	0.0095	0.3677	-0.0891
	Max 10-Min 10	**0.5409**	6.4967	0.4764	**0.1041**	2.6800	0.1965	0.0312	1.0341	0.0758	-0.0030	-0.1245	-0.0091	-0.0192	-0.8613	-0.0632	-0.0366	-1.7564	-0.1288	-0.0324	-1.6785	-0.1231
	Max 10-Rm	**0.2618**	3.5753	0.2622	0.0320	0.5644	0.0414	0.0006	0.0098	0.0007	-0.0198	-0.3457	-0.0253	-0.0261	-0.4635	-0.0340	-0.0387	-0.6751	-0.0495	-0.0339	-0.595	-0.0436
J=3	Max 10	**0.4256**	4.6555	0.3066	**0.1269**	2.3461	0.1132	0.0599	1.4541	0.0310	**0.0590**	1.7534	0.0374	**0.0593**	1.8979	0.0422	**0.0485**	1.6970	0.0194	**0.0438**	1.6578	0.0087
	Max 10-Min 10	**0.7668**	8.0155	0.5877	**0.1947**	4.1356	0.3032	0.0532	1.5933	0.1168	**0.0497**	2.0299	0.1488	**0.0345**	1.6569	0.1215	0.0172	0.9621	0.0705	0.0055	0.3325	0.0244
	Max 10-Rm	**0.3955**	5.0450	0.3699	0.0914	1.4062	0.1031	0.0174	0.2994	0.0220	0.0055	0.0945	0.0069	0.0130	0.2336	0.0171	-0.0037	-0.0663	-0.0049	0.0004	0.0067	0.0005
J=6	Max 10	**0.5613**	5.1195	0.3469	**0.2015**	3.4831	0.2007	**0.0869**	2.0467	0.0767	0.0603	1.6445	0.0369	**0.0689**	2.1324	0.0625	**0.0709**	2.3876	0.0741	**0.0611**	2.1664	0.0532
	Max 10-Min 10	**0.9711**	8.4406	0.6189	**0.2791**	5.5320	0.4056	**0.1392**	4.0348	0.2958	**0.0909**	3.4778	0.2550	**0.0842**	3.9409	0.2890	**0.0718**	3.6784	0.2697	**0.0560**	2.9617	0.2172
	Max 10-Rm	**0.5311**	5.6049	0.4110	**0.1660**	2.4492	0.1796	0.0444	0.7718	0.0566	0.0068	0.1167	0.0086	0.0226	0.4065	0.0298	0.0187	0.3377	0.0248	0.0177	0.3114	0.0228
J=9	Max 10	**0.4922**	4.2689	0.2857	**0.1592**	2.3687	0.1265	**0.1188**	2.5812	0.1216	**0.0997**	2.6722	0.1137	**0.0808**	2.4055	0.0863	**0.0558**	1.7578	0.0344	0.0338	1.0673	-0.0162
	Max 10-Min 10	**0.8906**	7.5363	0.5526	**0.2510**	4.4143	0.3237	**0.1743**	4.7445	0.3479	**0.1127**	3.8361	0.2813	**0.0710**	2.6892	0.1972	0.0369	1.4625	0.1072	0.0083	0.3337	0.0245
	Max 10-Rm	**0.4620**	4.5209	0.3315	**0.1238**	1.7413	0.1277	0.0763	1.2837	0.0941	0.0462	0.7701	0.0565	0.0345	0.5984	0.0439	0.0036	0.0623	0.0046	-0.0097	-0.1666	-0.0122
J=12	Max 10	**0.5228**	4.6058	0.3103	**0.1524**	2.4443	0.1285	**0.0801**	1.8196	0.0628	0.0546	1.3772	0.0238	0.0532	1.4893	0.0245	0.0396	1.1745	-0.0029	0.0305	0.9668	-0.0239
	Max 10-Min 10	**0.9433**	7.5866	0.5563	**0.2807**	4.9973	0.3664	**0.1320**	3.6258	0.2659	**0.0868**	2.8994	0.2126	**0.0691**	2.7877	0.2044	0.0364	1.5270	0.1120	0.0186	0.8371	0.0614
	Max 10-Rm	**0.4927**	5.0027	0.3668	**0.1169**	1.7495	0.1283	0.0376	0.6145	0.0451	0.0011	0.0193	0.0014	0.0069	0.1190	0.0087	-0.0125	-0.2130	-0.0156	-0.0129	-0.2170	-0.0159

Panel C. 15-Stock portfolios

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe
J=1	Max 15	**0.2854**	3.6794	0.2284	**0.0838**	1.7561	0.0620	0.0458	1.2182	0.0064	0.0363	1.1159	-0.0125	0.0266	0.8878	-0.0361	0.0247	0.9052	-0.0440	0.0202	0.8157	-0.0611
	Max 15-Min 15	**0.4943**	7.6418	0.5603	**0.1134**	3.1536	0.2312	0.0349	1.4715	0.1079	-0.0009	-0.0427	-0.0031	-0.0115	-0.6194	-0.0454	-0.0187	-1.0851	-0.0796	-0.0239	-1.6832	-0.1234
	Max 15-Rm	**0.2552**	4.0326	0.2957	0.0483	0.8728	0.0640	0.0033	0.0593	0.0043	-0.0172	-0.3098	-0.0227	-0.0196	-0.3547	-0.0260	-0.0275	-0.4854	-0.0356	-0.0232	-0.4109	-0.0301
J=3	Max 15	**0.3535**	4.3198	0.2777	**0.1093**	2.1483	0.0950	0.0596	1.5025	0.0316	**0.0562**	1.6939	0.0319	**0.0614**	2.0185	0.0483	**0.0558**	1.9935	0.0391	**0.0507**	1.9684	0.0286
	Max 15-Min 15	**0.6736**	8.8999	0.6526	**0.1776**	4.6362	0.3399	**0.0572**	2.0719	0.1519	**0.0430**	2.0733	0.1520	**0.0340**	1.9621	0.1439	0.0210	1.4327	0.1051	0.0114	0.8113	0.0595
	Max 15-Rm	**0.3233**	4.8413	0.3550	0.0739	1.1887	0.0872	0.0171	0.2982	0.0219	0.0028	0.0480	0.0035	0.0151	0.2749	0.0202	0.0037	0.0658	0.0048	0.0073	0.1289	0.0095
J=6	Max 15	**0.4979**	5.1208	0.3430	**0.1629**	3.0296	0.1631	**0.0787**	1.9024	0.0642	**0.0652**	1.8559	0.0488	**0.0732**	2.3735	0.0758	**0.0732**	2.5763	0.0834	**0.0643**	2.3848	0.0644
	Max 15-Min 15	**0.8538**	9.7769	0.7169	**0.2382**	6.2489	0.4582	**0.1068**	4.0049	0.2937	**0.0772**	3.7766	0.2769	**0.0759**	4.5926	0.3367	**0.0644**	4.4099	0.3233	**0.0508**	3.5933	0.2635
	Max 15-Rm	**0.4678**	5.7868	0.4243	**0.1275**	2.0340	0.1491	0.0363	0.6327	0.0464	0.0117	0.2035	0.0149	0.0270	0.4826	0.0354	0.0210	0.3821	0.0280	0.0209	0.3738	0.0274
J=9	Max 15	**0.4639**	4.4358	0.2951	**0.1294**	2.0988	0.1024	**0.1055**	2.4609	0.1078	**0.0870**	2.4374	0.0929	**0.0728**	2.1846	0.0693	0.0508	1.6056	0.0228	0.0300	0.9528	-0.0250
	Max 15-Min 15	**0.8466**	8.3392	0.6115	**0.2167**	4.8042	0.3523	**0.1553**	5.4971	0.4031	**0.0934**	4.0433	0.2965	**0.0608**	2.7047	0.1983	0.0335	1.5534	0.1139	0.0069	0.3021	0.0221
	Max 15-Rm	**0.4338**	4.7991	0.3519	0.0939	1.4070	0.1032	0.0630	1.1013	0.0808	0.0336	0.5783	0.0424	0.0265	0.4646	0.0341	-0.0014	-0.0242	-0.0018	-0.0134	-0.2295	-0.0168
J=12	Max 15	**0.4667**	4.3135	0.2873	**0.1131**	1.8987	0.0861	0.0627	1.4120	0.0335	0.0353	0.8984	-0.0121	0.0381	1.0573	-0.0067	0.0198	0.5811	-0.0459	0.0100	0.3120	-0.0713
	Max 15-Min 15	**0.9020**	8.1528	0.5978	**0.2593**	5.0656	0.3714	**0.1269**	3.9744	0.2914	**0.0717**	2.7421	0.2011	**0.0544**	2.4345	0.1785	0.0269	1.2087	0.0886	0.0063	0.2920	0.0214
	Max 15-Rm	**0.4365**	4.6211	0.3388	0.0776	1.2006	0.0880	0.0202	0.3347	0.0245	-0.0181	-0.3065	-0.0225	-0.0082	-0.1408	-0.0103	-0.0324	-0.5519	-0.0405	-0.0335	-0.5601	-0.0411

Note. Using data from Poland, we estimate the parameters δ^i and ρ_j^i from equation (6) for the first third of the sample. Based on this, we sort each stock from the highest to the lowest expected return. We construct an equally-weighted portfolio Max *n* – Min *n*, for which we buy the top *n* and sell the bottom *n* stocks and we hold this position for *K* months. Then, using rolling windows, we apply the same procedure for month 2 to one third of the sample + 1 month, then month 3 to one third of the sample + 2 months, and so on. We report the mean, *t*-statistic, and Sharpe ratio for Max *n*, Max *n* – Min *n*, and Max *n* – Rm (where Rm is the market return obtained using WIG20). The average returns shown in boldface are statistically significant at the 5 percent level. In Panels A, B, and C, *n* takes the values 5, 10, and 15, respectively.

We obtain similar, but slightly better results for Romania in Table 3. The combined strategy creates positive average returns (significant at the 5 percent level or better) in 21, 19, and 24 combinations (out of 35) in Panels A, B, and C, respectively. These average returns are much higher compared with Poland's, ranging, for example, from 0.246 to 3.266 in Panel A. This improvement seems to be due to higher average returns for the Max portfolio, which are positive and significant in Panels B and C for all holding periods when *J* = 1 month. In terms of the trend, we notice again that, as *K* increases, the average returns of the portfolios tend to decrease.

However, differently from Poland's case, as *J* increases, the average returns diminish as well.

The results obtained in Tables 2 and 3 are consistent with the existence of mean reversion and/or momentum. For both countries, they are larger though more volatile than the ones obtained for the Chinese market by Wu (2011). The increase in volatility is also noticeable as we go from the more developed Polish to the Romanian stock market. For instance, even though the average returns are usually higher in Romania, the highest Sharpe ratio obtained for the Max 5 – Min 5 strategy is 0.547 for Poland and 0.533 for Romania.

Table 3. Results for the combined mean reversion and momentum strategy – Romania

Panel A. 5-Stock portfolios

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe
J=1	Max 5	**1.7593**	3.5629	0.3555	**0.7137**	2.4119	0.2341	0.2719	1.3932	0.1257	0.1277	0.7319	0.0570	0.1657	1.1195	0.0941	0.2267	1.4586	0.1304	0.1672	1.2825	0.1100
	Max 5-Min 5	**3.2661**	5.2505	0.5331	**1.3545**	3.9248	0.3985	**0.9166**	3.4650	0.3518	**0.8001**	3.6317	0.3687	**0.9485**	5.3137	0.5395	**1.0340**	5.5683	0.5654	**1.0383**	6.1839	0.6279
	Max 5-Rm	**1.6659**	3.5352	0.3589	**0.6330**	2.1341	0.2167	0.1970	0.9470	0.0962	0.0830	0.4648	0.0472	0.0872	0.5640	0.0573	0.1625	0.9003	0.0914	0.0985	0.6479	0.0658
J=3	Max 5	**0.9002**	2.9412	0.2881	0.0570	0.3056	0.0129	0.0001	0.0003	-0.0153	-0.0235	-0.1324	-0.0306	-0.0331	-0.2187	-0.0418	0.0000	0.0001	-0.0182	-0.0436	-0.3500	-0.0574
	Max 5-Min 5	**2.0367**	4.8595	0.4934	**0.4394**	1.7765	0.1804	0.4249	1.4251	0.1447	0.0688	0.2399	0.0244	0.1160	0.4372	0.0444	0.1090	0.3873	0.0393	0.1169	0.4721	0.0479
	Max 5-Rm	**0.8068**	2.6862	0.2727	-0.0237	-0.1283	-0.0130	-0.0748	-0.3477	-0.0353	-0.0682	-0.3543	-0.0360	-0.1117	-0.7046	-0.0715	-0.0642	-0.3739	-0.0380	-0.1122	-0.8434	-0.0856
J=6	Max 5	**0.8344**	2.5273	0.2464	0.2163	1.1978	0.1032	0.0793	0.4211	0.0260	0.0754	0.4250	0.0261	0.1066	0.5802	0.0431	0.1114	0.5485	0.0420	0.0575	0.3385	0.0186
	Max 5-Min 5	**1.6836**	4.3752	0.4442	**0.4431**	1.9895	0.2020	0.2910	1.2923	0.1312	**0.4398**	1.9048	0.1934	**0.5340**	2.3320	0.2368	**0.4512**	1.8508	0.1879	**0.5845**	2.9282	0.2973
	Max 5-Rm	**0.7410**	2.4169	0.2454	0.1356	0.7314	0.0743	0.0044	0.0228	0.0023	0.0307	0.1669	0.0169	0.0280	0.1523	0.0155	0.0472	0.2131	0.0216	-0.0111	-0.0621	-0.0063
J=9	Max 5	0.3229	1.4891	0.1353	0.0883	0.6691	0.0423	0.1962	1.4576	0.1247	0.0256	0.2085	-0.0037	-0.0238	-0.1950	-0.0442	0.0507	0.4367	0.0202	0.0190	0.1737	-0.0070
	Max 5-Min 5	**0.5544**	2.0704	0.2102	**0.3523**	1.8710	0.1900	**0.5060**	2.4938	0.2532	**0.2615**	1.7101	0.1736	0.2268	1.5542	0.1578	**0.2460**	1.8608	0.1889	0.1578	1.1460	0.1164
	Max 5-Rm	0.2295	1.0634	0.1080	0.0075	0.0532	0.0054	0.1213	0.7964	0.0809	-0.0191	-0.1330	-0.0135	-0.1023	-0.7432	-0.0755	-0.0135	-0.1014	-0.0103	-0.0496	-0.4078	-0.0414
J=12	Max 5	0.2718	1.3127	0.1167	-0.1227	-0.7319	-0.0952	-0.3473	-2.1860	-0.2432	-0.1015	-0.5856	-0.0774	-0.1522	-0.9487	-0.1153	-0.2103	-1.2819	-0.1477	-0.2047	-1.2597	-0.1448
	Max 5-Min 5	**0.6745**	2.0248	0.2056	0.0090	0.0385	0.0039	-0.5750	-2.2186	-0.2253	-0.4907	-1.6878	-0.1714	-0.6031	-2.0449	-0.2076	-0.6848	-2.2030	-0.2237	-0.7753	-2.4014	-0.2438
	Max 5-Rm	0.1784	0.8806	0.0894	-0.2034	-1.1326	-0.1150	-0.4222	-2.6567	-0.2698	-0.1462	-0.7505	-0.0762	-0.2307	-1.4261	-0.1448	-0.2745	-1.6104	-0.1635	-0.2733	-1.6858	-0.1712

Panel B. 10-Stock portfolios

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe
J=1	Max 10	**1.4672**	4.7376	0.4718	**0.6891**	3.3959	0.3298	**0.4680**	2.3776	0.2264	**0.4636**	2.4723	0.2360	**0.4488**	2.8469	0.2721	**0.3716**	2.3568	0.2224	**0.2389**	1.9285	0.1749
	Max 10-Min 10	**2.9789**	6.7619	0.6866	**1.3441**	5.1635	0.5243	**0.9177**	4.1236	0.4187	**0.9154**	4.0743	0.4137	**0.9451**	4.8353	0.4910	**0.9155**	4.8065	0.4880	**0.8477**	5.2315	0.5312
	Max 10-Rm	**1.3738**	4.7119	0.4784	**0.6084**	2.9566	0.3002	**0.3931**	1.9371	0.1967	**0.4189**	2.2742	0.2309	**0.3702**	2.3061	0.2341	**0.3074**	1.8093	0.1837	0.1703	1.2458	0.1265
J=3	Max 10	**0.9434**	3.7639	0.3698	0.1004	0.7605	0.0517	-0.0466	-0.3587	-0.0611	-0.0712	-0.5692	-0.0826	-0.0266	-0.2083	-0.0445	0.0381	0.2757	0.0077	0.0236	0.1924	-0.0024
	Max 10-Min 10	**1.9948**	6.5629	0.6664	**0.3542**	1.9801	0.2011	0.2388	1.3082	0.1328	0.0324	0.2088	0.0212	0.3193	1.5282	0.1552	0.3346	1.5893	0.1614	0.2263	1.3348	0.1355
	Max 10-Rm	**0.8500**	3.5461	0.3600	0.0197	0.1478	0.0150	-0.1215	-0.8258	-0.0838	-0.1158	-0.7982	-0.0810	-0.1052	-0.7786	-0.0791	-0.0261	-0.1657	-0.0168	-0.0450	-0.3447	-0.0350
J=6	Max 10	**0.9766**	4.1359	0.4062	**0.3783**	2.9181	0.2701	**0.2154**	1.8669	0.1625	0.1542	1.3335	0.1095	**0.2497**	2.0000	0.1807	**0.3065**	2.2139	0.2057	**0.3310**	2.5607	0.2409
	Max 10-Min 10	**1.8166**	6.4570	0.6556	**0.5808**	3.3335	0.3385	**0.4094**	2.7136	0.2755	**0.3339**	2.3961	0.2433	**0.4143**	3.0825	0.3130	**0.3628**	2.4781	0.2516	**0.4027**	3.0550	0.3102
	Max 10-Rm	**0.8832**	4.2336	0.4299	**0.2976**	2.1675	0.2201	0.1406	1.0902	0.1107	0.1095	0.8476	0.0861	0.1711	1.3596	0.1381	0.2422	1.5282	0.1552	**0.2624**	1.9072	0.1936
J=9	Max 10	**0.4552**	2.4644	0.2316	0.0770	0.7809	0.0451	-0.0450	-0.4590	-0.0791	-0.1357	-1.3351	-0.1660	-0.1276	-1.2917	-0.1620	-0.1277	-1.2914	-0.1604	-0.1607	-1.5484	-0.1839
	Max 10-Min 10	**0.8768**	4.3344	0.4401	**0.3255**	2.5622	0.2602	0.2183	1.5295	0.1553	0.1121	0.8240	0.0837	0.1377	1.0768	0.1093	0.0521	0.4365	0.0443	0.0388	0.3313	0.0336
	Max 10-Rm	**0.3618**	2.1033	0.2136	-0.0038	-0.0331	-0.0034	-0.1199	-1.0652	-0.1082	-0.1804	-1.4743	-0.1497	-0.2062	-1.8789	-0.1908	-0.1920	-1.7839	-0.1811	-0.2293	-1.7806	-0.1808
J=12	Max 10	**0.4737**	3.0172	0.2854	-0.0175	-0.1455	-0.0433	-0.2244	-1.8221	-0.2123	-0.1179	-0.9375	-0.1202	-0.1704	-1.3019	-0.1557	-0.2257	-1.6882	-0.1934	-0.1932	-1.4091	-0.1634
	Max 10-Min 10	**0.9121**	3.9433	0.4004	0.1039	0.6927	0.0703	-0.1829	-1.2138	-0.1232	-0.1426	-0.8786	-0.0892	-0.1828	-1.0280	-0.1044	-0.2089	-1.1616	-0.1179	-0.1622	-0.9281	-0.0942
	Max 10-Rm	**0.3803**	2.6033	0.2643	-0.0983	-0.7564	-0.0768	-0.2993	-2.2904	-0.2326	-0.1626	-1.1309	-0.1148	-0.2490	-1.8372	-0.1865	-0.2899	-2.0323	-0.2064	-0.2618	-1.9049	-0.1934

Panel C. 15-Stock portfolios

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe	Average	*t* -stat	Sharpe
J=1	Max 15	**1.3673**	5.7640	0.5740	**0.6974**	3.9597	0.3852	**0.5381**	3.1294	0.3012	**0.5649**	3.1991	0.3096	**0.7723**	4.1588	0.4093	**0.7599**	4.0195	0.3956	**0.6764**	3.8360	0.3765
	Max 15-Min 15	**2.8282**	8.2071	0.8333	**1.3535**	5.9288	0.6020	**1.0140**	5.1050	0.5183	**0.9790**	4.9350	0.5011	**1.2322**	6.5181	0.6618	**1.1804**	6.5196	0.6620	**1.1036**	6.3987	0.6497
	Max 15-Rm	**1.2739**	5.8434	0.5933	**0.6167**	3.4359	0.3489	**0.4632**	2.5746	0.2614	**0.5202**	2.9988	0.3045	**0.6937**	3.6889	0.3745	**0.6956**	3.3332	0.3384	**0.6078**	3.1616	0.3210
J=3	Max 15	**1.0217**	5.1194	0.5047	0.1864	1.6082	0.1348	0.0324	0.2940	0.0010	0.0644	0.6155	0.0337	0.1248	1.1677	0.0918	0.1729	1.4661	0.1258	0.1497	1.3362	0.1124
	Max 15-Min 15	**2.1121**	8.3075	0.8435	**0.5663**	3.3847	0.3437	**0.4166**	2.8952	0.2940	**0.4107**	3.0581	0.3105	**0.5746**	4.1195	0.4183	**0.5989**	3.8607	0.3920	**0.4676**	3.6217	0.3677
	Max 15-Rm	**0.9283**	5.0285	0.5106	0.1057	0.8608	0.0874	-0.0425	-0.3380	-0.0343	0.0197	0.1660	0.0169	0.0462	0.3793	0.0385	0.1087	0.7754	0.0787	0.0811	0.6341	0.0644
J=6	Max 15	**1.0232**	4.9803	0.4900	**0.3790**	3.1252	0.2897	0.1590	1.5457	0.1267	0.1473	1.4243	0.1158	0.1599	1.5364	0.1287	**0.2109**	1.8644	0.1656	**0.2678**	2.4331	0.2243
	Max 15-Min 15	**1.9875**	8.1534	0.8278	**0.6525**	4.0635	0.4126	**0.3711**	2.9290	0.2974	**0.4053**	3.3221	0.3373	**0.4311**	3.7525	0.3810	**0.4234**	3.5111	0.3565	**0.5091**	4.4768	0.4545
	Max 15-Rm	**0.9298**	5.1505	0.5230	**0.2983**	2.1395	0.2172	0.0841	0.7109	0.0722	0.1026	0.9030	0.0917	0.0813	0.6988	0.0710	0.1466	1.1144	0.1132	**0.1992**	1.7140	0.1740
J=9	Max 15	**0.5537**	3.6624	0.3492	0.0364	0.4072	0.0034	-0.1105	-1.2724	-0.1660	-0.1758	-2.1930	-0.2614	-0.1864	-2.2947	-0.2703	-0.1870	-2.2128	-0.2588	-0.1701	-2.0061	-0.2362
	Max 15-Min 15	**1.2568**	7.0880	0.7197	**0.2916**	2.3488	0.2385	0.0404	0.3167	0.0322	-0.0751	-0.6251	-0.0635	-0.0833	-0.7026	-0.0713	-0.1074	-0.8738	-0.0887	-0.0225	-0.1978	-0.0201
	Max 15-Rm	**0.4603**	3.2509	0.3301	-0.0444	-0.4068	-0.0413	-0.1854	-1.8881	-0.1917	-0.2205	-2.1120	-0.2144	-0.2650	-2.8406	-0.2884	-0.2512	-2.5335	-0.2572	-0.2387	-2.2082	-0.2242
J=12	Max 15	**0.5158**	3.8404	0.3659	0.0489	0.5298	0.0173	-0.1871	-1.6920	-0.2020	-0.1278	-1.1505	-0.1451	-0.2118	-1.8389	-0.2137	-0.2610	-2.1811	-0.2464	-0.2534	-2.0971	-0.2365
	Max 15-Min 15	**1.0535**	5.2797	0.5361	0.1466	1.2089	0.1227	-0.2130	-1.7348	-0.1761	-0.1942	-1.4732	-0.1496	-0.2670	-1.9314	-0.1961	-0.2811	-1.9888	-0.2019	-0.2606	-1.8621	-0.1891
	Max 15-Rm	**0.4223**	3.4437	0.3497	-0.0318	-0.3025	-0.0307	-0.2619	-2.2982	-0.2333	-0.1725	-1.3492	-0.1370	-0.2904	-2.4255	-0.2463	-0.3252	-2.5391	-0.2578	-0.3220	-2.6583	-0.2699

Note. Using data from Romania, we estimate the parameters δ^i and ρ_j^i from equation (6) for the first third of the sample. Based on this, we sort each stock from the highest to the lowest expected return. We construct an equally-weighted portfolio Max *n* – Min *n*, for which we buy the top *n* and sell the bottom *n* stocks and we hold this position for *K* months. Then, using rolling windows, we apply the same procedure for month 2 to one third of the sample + 1 month, then month 3 to one third of the sample + 2 months, and so on. We report the mean, *t*-statistic, and Sharpe ratio for Max *n*, Max *n* – Min *n*, and Max *n* – Rm (where Rm is the market return obtained using BET). The average returns shown in boldface are statistically significant at the 5 percent level. In Panels A, B, and C, *n* takes the values 5, 10, and 15, respectively.

4.2 Results for the Pure Mean Reversion Strategy

Due to the similarity in results for portfolios formed with 5, 10, and 15 assets, we report only the annualized average returns, their associated *t*-stats, and Sharpe ratios for Max 10, Max 10 – Min 10, and Max 10 – Market Return in Panel A (Poland) and B (Romania) of Table 4.

The outcomes for the pure mean reversion strategy are noticeably good. In all cases, the average returns for Max 10 – Min 10 are positive at the 1 percent level of significance. However, in Poland, Max 10 outperforms the

market in only two out of the seven considered cases. This result is due to the inability of our model to predict the best Max 10 portfolio as the holding period increases. In fact, Max 10 is statistically significant only for K = 1 or 3 months. Differently, in Romania, Max 10 outperforms the market for all holding periods (K).

Estimating the speed of mean reversion (δ) allows us to gauge the half-life of mean reversion as ln(0.5)/ln(δ). We find a half-life of 9.9 months for Poland and 9.3 for Romania. Wu (2011) also finds a half-life shorter than one year for the Chinese markets, while Balvers and Wu (2006) report it to be around 3.5 years for a sample of 18 developed equity markets. This suggests that mean reversion happens much faster in the developing world than in the developed countries.

It is not straightforward to compare these results with those in Tables 2 and 3, as those vary not only by K, but also by J. To alleviate the problem, we compute averages for each K over each J for the average Max 10 – Min 10 portfolio returns (not reported here) and we find that the pure mean reversion strategy outperforms the combined strategy for all K's. This conclusion is surprising considering that, for developed and Chinese markets, the combined strategy usually outperforms the simple mean reversion strategy (see Balvers & Wu, 2006, and Wu, 2011). We analyze the results for a pure momentum strategy in the next subsection.

Table 4. Results for the pure mean reversion strategy

	K=1			K=3			K=6			K=9			K=12			K=15			K=18		
	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe
Panel A. Poland																					
Max 10	**1.0445**	11.2040	0.7247	**0.2539**	4.5714	0.2418	0.0557	1.2940	0.0015	0.0237	0.6272	-0.0517	-0.0050	-0.1471	-0.1112	-0.0121	-0.4016	-0.1362	-0.0215	-0.7873	-0.1701
Max 10-Min 10	**2.5040**	21.8066	1.5084	**0.8630**	14.9455	1.0338	**0.4330**	12.0473	0.8333	**0.3267**	11.3865	0.7876	**0.2585**	10.6811	0.7388	**0.2281**	9.8126	0.6788	**0.1942**	9.3422	0.6462
Max 10-Rm	**0.9844**	11.9509	0.8267	**0.1878**	3.1381	0.2171	-0.0133	-0.2496	-0.0173	-0.0581	-1.0720	-0.0742	-0.0807	-1.4891	-0.1030	-0.0978	-1.8561	-0.1284	-0.1180	-2.2588	-0.1562
Panel B. Romania																					
Max 10	**4.2986**	12.3337	1.2441	**2.0930**	5.7411	0.5741	**1.3976**	4.8683	0.4838	**0.8956**	3.6058	0.3543	**1.0211**	4.0499	0.4001	**1.2501**	4.9919	0.4958	**1.5200**	5.7631	0.5749
Max 10-Min 10	**8.9056**	18.4396	1.8723	**4.7802**	9.6047	0.9752	**3.2522**	7.1078	0.7217	**2.2559**	6.1893	0.6284	**2.2793**	6.5118	0.6612	**2.3303**	6.6470	0.6749	**2.5522**	7.3027	0.7415
Max 10-Rm	**4.2052**	12.1364	1.2323	**2.0123**	5.4278	0.5511	**1.3228**	4.6083	0.4679	**0.8510**	3.3046	0.3355	**0.9425**	3.7162	0.3773	**1.1859**	4.5094	0.4579	**1.4514**	5.2733	0.5354

Note. We estimate the parameters δ^i from equation (6) for the pure mean reversion strategy (setting $\rho_j^i = 0$ and $\beta^i = 0$) for the first third of the sample, for each of the two countries. Based on this, we sort each stock from the highest to the lowest expected return. We construct an equally-weighted portfolio Max *10* – Min *10*, for which we buy the top *10* and sell the bottom *10* stocks and we hold this position for K months. Then, using rolling windows, we apply the same procedure for month 2 to one third of the sample + 1 month, then month 3 to one third of the sample + 2 months, and so on. In Panels A and B (for Poland and Romania, respectively), we report the mean, *t*-statistic, and Sharpe ratio for Max *10*, Max *10* – Min *10*, and Max *10* – Rm (where Rm is the market return obtained using WIG20 for Poland and BET for Romania). The average returns shown in boldface are statistically significant at the 5 percent level.

Table 5. Results for the pure momentum strategy

Panel A. Poland

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe
J=1	Max 10	**0.8509**	9.8860	0.6846	**0.2231**	4.1595	0.2448	**0.1164**	2.7717	0.1286	**0.1106**	2.9973	0.1362	**0.1007**	2.9936	0.1291	**0.0845**	2.7656	0.1044	**0.0699**	2.5380	0.0776
	Max 10-Min 10	**1.8444**	17.0007	1.2466	**0.5605**	9.9663	0.7308	**0.3319**	8.0846	0.5928	**0.2778**	8.0578	0.5908	**0.2248**	7.3172	0.5365	**0.1821**	5.9931	0.4394	**0.1315**	4.7387	0.3475
	Max 10-Rm	**0.8208**	9.7823	0.7173	**0.1876**	3.0003	0.2200	0.0739	1.2573	0.0922	0.0571	0.9814	0.0720	0.0544	0.9264	0.0679	0.0323	0.5675	0.0416	0.0265	0.4690	0.0344
J=3	Max 10	**0.8469**	9.1693	0.6361	**0.2833**	4.7708	0.2957	**0.1060**	2.5012	0.1098	**0.1016**	2.6879	0.1158	**0.0957**	2.7056	0.1126	**0.0741**	2.2673	0.0744	**0.0578**	1.9147	0.0416
	Max 10-Min 10	**1.9443**	17.1381	1.2566	**0.7229**	11.1354	0.8165	**0.3911**	9.7366	0.7139	**0.3062**	9.7596	0.7156	**0.2620**	9.0490	0.6635	**0.2200**	7.8170	0.5732	**0.1836**	6.8008	0.4987
	Max 10-Rm	**0.8168**	9.4355	0.6918	**0.2478**	3.6248	0.2658	0.0636	1.0491	0.0769	0.0481	0.8285	0.0607	0.0494	0.8621	0.0632	0.0220	0.3928	0.0288	0.0144	0.2524	0.0185
J=6	Max 10	**0.9080**	10.0963	0.7016	**0.3102**	5.5445	0.3480	**0.1528**	3.4254	0.1807	**0.1047**	2.6556	0.1168	**0.0863**	2.4202	0.0922	**0.0631**	1.9379	0.0497	**0.0541**	1.7840	0.0323
	Max 10-Min 10	**1.9500**	16.9930	1.2460	**0.7159**	11.3594	0.8329	**0.4188**	9.8034	0.7188	**0.3293**	10.6303	0.7795	**0.2769**	10.0995	0.7405	**0.2389**	8.5676	0.6282	**0.2195**	8.0747	0.5921
	Max 10-Rm	**0.8778**	10.7679	0.7895	**0.2747**	4.3481	0.3188	**0.1103**	1.8003	0.1320	0.0513	0.8956	0.0657	0.0400	0.7086	0.0520	0.0109	0.1936	0.0142	0.0106	0.1838	0.0135
J=9	Max 10	**0.7533**	8.6807	0.5975	**0.2282**	3.9672	0.2347	0.0650	1.3703	0.0348	0.0212	0.5140	-0.0365	0.0135	0.3628	-0.0551	0.0119	0.3523	-0.0630	0.0091	0.2883	-0.0739
	Max 10-Min 10	**1.7502**	16.8598	1.2362	**0.6406**	11.3213	0.8301	**0.3012**	7.6958	0.5643	**0.1966**	6.4459	0.4726	**0.1565**	6.6424	0.4870	**0.1336**	5.9872	0.4390	**0.1061**	4.9704	0.3645
	Max 10-Rm	**0.7231**	9.7475	0.7147	**0.1927**	2.9860	0.2189	0.0226	0.3717	0.0273	-0.0322	-0.5442	-0.0399	-0.0328	-0.5734	-0.0420	-0.0402	-0.7073	-0.0519	-0.0344	-0.5951	-0.0436
J=12	Max 10	**0.7080**	8.6329	0.5920	**0.2255**	3.9943	0.2357	**0.0867**	1.9861	0.0741	0.0598	1.6144	0.0355	**0.0575**	1.7027	0.0349	**0.0580**	1.9190	0.0412	**0.0519**	1.8301	0.0289
	Max 10-Min 10	**1.6375**	17.3882	1.2750	**0.6211**	11.5668	0.8481	**0.3305**	9.3044	0.6822	**0.2327**	8.4393	0.6188	**0.1913**	8.7510	0.6417	**0.1741**	8.3867	0.6149	**0.1553**	7.7261	0.5665
	Max 10-Rm	**0.6778**	9.6290	0.7060	**0.1901**	3.0179	0.2213	0.0443	0.7461	0.0547	0.0063	0.1113	0.0082	0.0112	0.2023	0.0148	0.0058	0.1027	0.0075	0.0084	0.1485	0.0109

Panel B. Romania

		K=1			K=3			K=6			K=9			K=12			K=15			K=18		
		Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe	Average	*t*-stat	Sharpe
J=1	Max 10	**3.2658**	11.0158	1.1081	**1.5089**	5.6753	0.5635	**0.7662**	3.6502	0.3563	**0.3947**	1.9552	0.1841	0.1878	0.9112	0.0785	-0.0526	-0.2413	-0.0376	-0.2225	-1.0394	-0.1186
	Max 10-Min 10	**6.8629**	14.5818	1.4806	**3.1496**	7.6090	0.7726	**1.4926**	4.1094	0.4172	**0.8504**	2.8933	0.2938	**0.5666**	2.1024	0.2135	0.2827	1.0003	0.1016	0.0774	0.2763	0.0281
	Max 10-Rm	**3.1724**	10.6734	1.0837	**1.4282**	5.3128	0.5394	**0.6913**	3.2712	0.3321	**0.3501**	1.7243	0.1751	0.1092	0.5323	0.0540	-0.1168	-0.5205	-0.0528	-0.2911	-1.3413	-0.1362
J=3	Max 10	**2.1976**	9.3236	0.9320	**0.8892**	4.4394	0.4342	**0.3510**	1.9506	0.1810	0.3149	1.6279	0.1503	**0.3953**	1.9085	0.1805	**0.3836**	1.6993	0.1608	**0.4679**	2.0798	0.2000
	Max 10-Min 10	**5.1351**	15.0492	1.5280	**2.9571**	8.3222	0.8450	**2.1782**	6.2406	0.6336	**1.9532**	6.3008	0.6398	**2.0354**	6.1365	0.6231	**2.0094**	6.1121	0.6206	**2.0140**	6.5761	0.6677
	Max 10-Rm	**2.1042**	9.1564	0.9297	**0.8084**	3.7847	0.3843	0.2762	1.4274	0.1449	0.2703	1.3479	0.1369	0.3168	1.5205	0.1544	0.3193	1.4023	0.1424	**0.3992**	1.7567	0.1784
J=6	Max 10	**1.2837**	5.6820	0.5610	**0.5719**	4.3810	0.4190	**0.3671**	3.5961	0.3342	**0.3851**	4.2567	0.3984	**0.4670**	5.0357	0.4805	**0.5319**	5.1224	0.4932	**0.4862**	5.5627	0.5327
	Max 10-Min 10	**3.0480**	8.8949	0.9031	**1.2397**	5.7288	0.5817	**0.8167**	5.1770	0.5256	**0.8649**	6.0023	0.6094	**1.0552**	7.6634	0.7781	**1.1768**	8.0961	0.8220	**1.2068**	9.0242	0.9163
	Max 10-Rm	**1.1903**	5.4789	0.5563	**0.4912**	3.5502	0.3605	**0.2923**	2.6661	0.2707	**0.3405**	3.1980	0.3247	**0.3884**	3.9438	0.4004	**0.4677**	3.8856	0.3945	**0.4176**	4.1263	0.4190
J=9	Max 10	**0.9873**	5.4658	0.5348	**0.3343**	3.0156	0.2753	**0.2065**	1.9711	0.1696	**0.1616**	1.6636	0.1369	**0.1794**	2.0618	0.1742	**0.2371**	2.7499	0.2454	**0.2415**	2.5325	0.2278
	Max 10-Min 10	**2.1308**	9.1735	0.9314	**0.6768**	3.5969	0.3652	**0.4468**	2.4236	0.2461	**0.2894**	1.6917	0.1718	**0.3819**	2.5283	0.2567	**0.4155**	2.7983	0.2841	**0.4455**	3.0158	0.3062
	Max 10-Rm	**0.8939**	5.0325	0.5110	**0.2536**	2.0285	0.2060	0.1316	1.0957	0.1113	0.1170	0.9955	0.1011	0.1008	0.9532	0.0968	0.1729	1.6444	0.1670	0.1729	1.5922	0.1617
J=12	Max 10	**0.9621**	5.4760	0.5354	**0.3176**	2.7400	0.2494	**0.3968**	3.5016	0.3291	**0.5008**	4.4737	0.4301	**0.4872**	4.5660	0.4397	**0.4843**	4.3640	0.4210	**0.5274**	4.9876	0.4851
	Max 10-Min 10	**1.9941**	8.6685	0.8802	**0.6392**	4.0501	0.4112	**0.6403**	4.2040	0.4268	**0.6944**	5.1099	0.5188	**0.7142**	5.9039	0.5995	**0.8208**	6.8992	0.7005	**0.8803**	7.3272	0.7440
	Max 10-Rm	**0.8687**	5.1604	0.5240	**0.2369**	1.9512	0.1981	**0.3219**	2.5285	0.2567	**0.4561**	3.3836	0.3436	**0.4087**	3.2758	0.3326	**0.4201**	3.2792	0.3329	**0.4588**	3.9897	0.4051

Note. We estimate the parameters ρ_j^i from equation (6) for the pure momentum strategy (setting $\delta^i = 1$ and $\beta^i = 0$) for the first third of the sample, for each of the two countries. Based on this, we sort each stock from the highest to the lowest expected return. We construct an equally-weighted portfolio Max *10* – Min *10*, for which we buy the top *10* and sell the bottom *10* stocks and we hold this position for K

months. Then, using rolling windows, we apply the same procedure for month 2 to one third of the sample + 1 month, then month 3 to one third of the sample + 2 months, and so on. In Panels A and B (for Poland and Romania, respectively), we report the mean, *t*-statistic, and Sharpe ratio for Max *10*, Max *10* – Min *10*, and Max *10* – Rm (where Rm is the market return obtained using WIG20 for Poland and BET for Romania). The average returns shown in boldface are statistically significant at the 5 percent level.

4.3 Results for the Pure Momentum Strategy

We report only the results for portfolios formed with 10 stocks in Panel A (Poland) and B (Romania) in Table 5.

The results are again surprising, as the momentum strategy outperforms the combined strategy in all cases for Poland and in about half of the cases for Romania. One possible explanation for this anomaly is that the combined strategy assumes the existence of mean reversion in the long run and momentum in the short run. However, in the considered countries, mean reversal takes place much faster than in the developed world, a duration that could hardly be considered long run. Therefore, there is a high probability that momentum and mean reversion are partially cancelling each other in the combined strategy. Another possible explanation is that the combined strategy requires the estimation of more parameters than each of the pure strategies taken individually. This might be an issue in the highly illiquid markets in the CEE countries, possibly failing to optimally select the best top and bottom stocks in the Max and Min portfolios, respectively. Regardless of the reasons behind these striking results, one thing is certain: both momentum and mean reversion exist in Poland and Romania. While, as shown before, mean reversion takes place much faster than in the developed countries, the momentum effect lasts only up to six months in Poland and one or three months in Romania (different from developed countries where it continues for nine to 12 months – see Balvers & Wu, 2006).

5. Robustness Checks

The previous section shows the existence of mean reversal and momentum in Poland and Romania, two CEE countries with very different levels of financial development. To begin with, let us analyze the baseline model with $K = 1$ and $J = 1$. As reported above, the combined strategy yields positive returns and high Sharpe ratios for Max 10 – Min 10 in both countries. Wu (2011) finds that, in China, about 50 percent of the variation in the portfolio resulting from the combined strategy can be explained through the market risk, which is different from the results obtained in the developed markets by a large number of studies (see, for instance, Jegadeesh & Titman, 1993, Rouwenhorst, 1998, Balvers et al., 2000). We find that the market beta is 0.08 in Poland and -0.57 in Romania (statistically insignificant at the traditional levels), the market risk explaining virtually nothing of the excess return of our baseline portfolios (with an R^2 less than 1 percent for both countries).

Then, we are interested in adding some variation to our model in order to check whether the trading strategy presented above continues to yield positive returns. For comparison, we report the baseline model and the robustness checks in Table 6.

Firstly, we assess how transaction costs may affect our results. TradeVille reports standard commission costs ranging from 0.30 to 0.65 percent for trading stocks on the Bucharest Stock Exchange. We decide to adopt a more aggressive one-way transaction cost of 1 percent (Note 4). Secondly, we consider one-stock portfolios, as well as portfolios based on the top – bottom return deciles (as in Wu, 2011). Thirdly, we change the initial estimation period from one third to one fourth of the time interval.

In all cases, the combined strategy continues to yield positive results.

Table 6. Robustness checks

Panel A. Poland

	Average	t-stat	Sharpe
Baseline Case (K=1, J=1)			
Max 10	**0.2919**	3.3556	0.2092
Max 10-Min 10	**0.5409**	6.4967	0.4764
Max 10-Rm	**0.2618**	3.5753	0.2622
Transaction Costs			
Max 10	**0.2919**	3.3556	0.2092
Max 10-Min 10	**0.4336**	5.2090	0.3819
Max 10-Rm	**0.2618**	3.5753	0.2622

1 stock per portfolio			
Max 1	**0.5201**	3.3768	0.2268
Max 1-Min 1	**0.6282**	3.1998	0.2346
Max 1-Rm	**0.4900**	3.2984	0.2418
Stocks Sorted into Deciles			
Max Decile	0.0351	0.6436	-0.0119
Max Decile-Min Decile	**0.1360**	6.8402	0.5015
Max Decile-Rm	0.0050	0.1397	0.0102
Estimation Based on One Fourth of the Sample Period			
Max 10	**0.2015**	2.9365	0.1445
Max 10-Min 10	**0.4142**	7.4282	0.5138
Max 10-Rm	**0.2025**	3.5854	0.2480

Panel B. Romania

	Average	t-stat	Sharpe
Baseline Case (K=1, J=1)			
Max 10	**1.4672**	4.7376	0.4718
Max 10-Min 10	**2.9789**	6.7619	0.6866
Max 10-Rm	**1.3738**	4.7119	0.4784
Transaction Costs			
Max 10	**1.4672**	4.7376	0.4718
Max 10-Min 10	**2.9340**	6.6693	0.6772
Max 10-Rm	**1.3738**	4.7119	0.4784
1 stock per portfolio			
Max 1	**1.3970**	2.0366	0.2019
Max 1-Min 1	**3.1337**	3.1954	0.3244
Max 1-Rm	**1.3036**	1.9411	0.1971
Stocks Sorted into Deciles			
Max Decile	-0.1518	-1.7580	-0.2202
Max Decile-Min Decile	**0.9061**	8.5738	0.8705
Max Decile-Rm	-0.2452	-2.9760	-0.3022
Estimation Based on One Fourth of the Sample Period			
Max 10	**1.6485**	5.0643	0.4749
Max 10-Min 10	**3.1883**	7.0493	0.6752
Max 10-Rm	**1.6118**	5.1156	0.4900

Note. In the baseline case, we estimate the parameters δ^i and ρ_j^i from equation (6) for the first third of the sample, for Poland (Panel A) and Romania (Panel B). Based on this, we sort each stock from the highest to the lowest expected return. We construct an equally-weighted portfolio Max *10* – Min *10*, in which we buy the top *10* and sell the bottom *10* stocks and we hold this position for *K* =1 month. Then, using rolling windows, we apply the same procedure for month 2 to one third of the sample + 1 month, then month 3 to one third of the sample + 2 months, and so on. In Panels A and B (for Poland and Romania, respectively), we report the mean, *t*-statistic, and Sharpe ratio for Max *10*, Max *10* – Min *10*, and Max *10*– Rm (where Rm is the market return obtained using WIG20 for Poland and BET for Romania). Then, we repeat the procedure including transaction costs or using only one-stock portfolios, or sorting stocks into deciles. The last robustness check uses one fourth of the sample instead of one third. The average returns shown in boldface are statistically significant at the 5 percent level.

6. Conclusions

The novelty of the stock markets in the CEE countries has limited extensive research, but has allowed fresh opportunities to compare investment strategies at different levels of financial development. We choose two of these countries in order to examine whether mean reversion and momentum, two phenomena well-documented in the developed financial markets, are also present in these formerly centralized economies. We find that in Poland and Romania momentum takes place much faster than in the financially-developed world, while mean reversion has a half-life of less than a year, which is about the same as that of China (see Wu, 2011), but significantly less than that of the developed countries analyzed by Balvers and Wu (2006).

The market risk cannot explain the abnormal positive returns obtained by using a combined mean reversion and momentum strategy, leading us to conclude that there must be behavioral reasons behind them. The CEE financial markets are characterized by relatively small firms and few investors, making them prone to behavioral biases and prevalent mispricing.

Albeit our study finds high mean returns and Sharpe ratios for the portfolios formed through the combined strategy (even when considering transaction costs), we are aware that more research needs to be done as these markets become more established and more liquid.

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Notes

Note 1. All of these indicators are still far below those in the developed countries. For instance, since 2014, the stock market capitalization has been hovering at around 30% of the GDP in Poland as opposed to over 100% in

the US. In terms of liquidity, in 2010, Poland had a turnover ratio of only 37%, while US had a ratio of 176%. Poland's financial market is less concentrated compared to other CEE countries, but it is still highly concentrated compared to US or Germany (Baele et al., 2015).

Note 2. http://bossa.pl/notowania/metastock/

Note 3. https://www.tradeville.eu/

Note 4. Wu (2011) also considers a 1 percent transaction cost for the Chinese markets.