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Modeling Latin-American stock and Forex markets volatility: Empirical application of a model with random level shifts and genuine long memory

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ABSTRACT

Following Varneskov and Perron (2017a,b), I apply the RLS-ARFIMA(p,d,q) models to the daily stock and Forex market returns volatility of Argentina, Brazil, Mexico and Peru. Further, two sets of high-frequency data are also used. The model is a parametric state-space model with an estimation framework that combines long memory and level shifts by decomposing the underlying process into a mixture model and ARFIMA dynamics. The results of the estimates are not conclusive as those obtained in Varneskov and Perron (2017a,b). In fact, the very small magnitudes of the fractional parameter estimates suggest that only the high-frequency series could be modeled as RLS-ARFIMA models. The other (daily) series would be modeled as RLS-ARMA models with measurement errors except in the case of the Forex market of Brazil where there is no evidence of measurement errors. Another possibility is to accept the small magnitudes of the estimates of the fractional parameter as evidence of genuine long memory and, in that case, a larger group of series can be modeled as RLS-ARFIMA models. The forecasts are evaluated from two perspectives: one using 10% of the Model Confidence Set of Hansen, Lunde, and Nason (2011) and the other using a recent statistic proposed by Knüppel (2015) to evaluate density forecasts. The results favor the RLS-ARMA and RLS-ARFIMA models although we found some differences between the two approaches for the cases of Brazil and Mexico (stocks) and Argentina (Forex). Finally, forecasts are used to calculate the VaR at 1%, 5% and 10%. The results support broadly the RLS-ARFIMA models with one or two exceptions.

1. Introduction

Typically, the volatility of financial time series exhibits long memory or long-term dependence. This feature (or property) is represented in the domain of time by the behavior of its autocorrelation function (ACF henceforth), which presents significantly different values from zero up to a large number of lags, indicating hyperbolic decay. In the domain of the frequencies, a higher weight of the low frequencies in the spectral density is observed, as is a rapid growth in this function as the frequencies approach the origin. Several authors document this characteristic; see Taylor (1986), Ding, Engle, and Granger (1993), Dacorogna, Muller, Nagler, Olsen, and Pictet (1993), Robinson (1994), among others and there are several possible formalizations for this feature; see McLeod and Hipel (1978), Beran (1994), Robinson (1994), Baillie (1996), Parke (1999), and Perron and Qu (2010), among others.

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Granger and Joyeaux (1980) and Hosking (1981) introduced the ARFIMA(p,d,q) model as a parametric way of capturing long memory dynamics in time series. There is also literature on semiparametric estimators of the fractional parameter d where the most used is the method of Geweke and Porter-Hudak (1983) using the log-periodogram; see also Robinson (1995b). In addition, there is the local Whittle estimator of Kunsch (1987) and Robinson (1995a). Another way to capture the long-memory behavior is by mixing it with GARCH effects, as in the Fractional Integrated GARCH (FIGARCH) model proposed by Baillie (1996) and Baillie, Bollerslev, and Mikkelsen (1996). Various researchers demonstrate that various realized volatility time series display characteristics compatible with fractional integrated series further improving the quality of the forecasts; see Andersen, Bollerslev, Diebold, and Ebens (2001a), Andersen, Bollerslev, Diebold, and Labys (2001b, 2003), Koopman, Jungbacker, and Hol (2005), Deo, Hurvich, and Lu (2006), Andersen, Bollerslev, and Diebold (2007), Corsi (2009), Chiriac and Voev (2011), and Varneskov and Voev (2013).

Recently, the literature has focused increasingly on the possibility of long memory behavior being confused with a short memory process contaminated by random level shifts (RLS henceforth). Important and interesting references at this respect are Lobato and Savin (1998), Diebold and Inoue (2001), Granger and Hyung (2004), and Perron and Qu (2007, 2010), among others. For instance, Diebold and Inoue (2001) argue that long memory and structural changes are related through the following models: the simple mixture permanent stochastic breaks model of Engle and Smith (1999) and the Markov-Switching model of Hamilton (1989). The authors show that stochastic regime shifts are easily confused with long memory, even asymptotically, provided that the probabilities of structural breaks are small. Granger and Hyung (2004) show that the slow decay in the ACF, bias in the estimator d, and other properties of the $I(d)$ models are caused by occasional breaks. Other references are Teverovsky and Taqqu (1997), Gourieroux and Jasiak (2001), Mikosch and Stărică (2004b, 2004a), and Stărică and Granger (2005). The overall conclusion is that non-linear time series with infrequent breaks could have long memory.

A recent study on the analysis of long memory and RLS is Perron and Qu (2010). The authors present some statistics for distinguishing between long memory and RLS. They also analize the behaviors of the ACF, the periodogram, and the estimates of the fractional integration parameter d. From a modeling perspective, Lu and Perron (2010), Li, Perron, and Xu (2017), and Xu and Perron (2014) propose parametric models, which allow for both RLS and short memory dynamics when they model volatility of stock and Forex markets returns. In recent years, in the same vein, Gonzáles Tanaka and Rodríguez (2016), and Rodríguez (2016) have contributed empirically to the study of Latin American stocks and Forex markets.

Other attempts to mix both RLS and short memory dynamics are Chen and Tiao (1990) and McCulloch and Tsay (1993), all of which reach the conclusion that the long-memory properties of the data are spurious. Similar conclusions have been reached by another branch of the literature dealing with semiparametric estimation of the fractional parameter in the presence of structural breaks; see Smith (2005), McCloskey and Perron (2013), and McCloskey and Hill (2017). A drawback of this approach is that level shifts are not identified, making it inappropriate for forecasting.[1]

From the above-mentioned results the principal finding of this branch of the literature is that if a short memory process is contaminated by level shifts, the time series will display many of the same properties as a genuine long-memory process. However, some of the literature argues the reverse; that is, that genuine long memory behavior may also cause spurious detection of level shifts. This issue is proposed by Nunes, Newbold, and Kuan (1995) and Granger and Hyung (2004). A solution to this dual problem has been advocated by Varneskov and Perron (2017a, 2017b), who propose a parametric model that allows for both RLS and long memory; that is, by modeling the latent volatility process as a combination of a RLS component and ARFIMA dynamics denoted as the RLS-ARFIMA(p,d,q) model. Varneskov and Perron (2017a) apply the model to daily series and high-frequency (HF henceforth) data. The empirical results suggest a noticeable pattern (i) the RLS are present in all series with more frequency in HF data (but with less variability); (ii) the HF has genuine long memory component; (iii) there are few ARFIMA dynamics remaining in the daily Forex series which are better modeled as a RLS model with ARMA dynamics with measurement errors.

In this paper, I apply the RLS-ARFIMA(p,d,q) models to the daily stock and Forex markets returns volatility of Argentina, Brazil, Mexico, and Peru. Two HF time series constructed using frequencies of 2 and 3 min are also used. My perspective is that there are enough episodes of turbulence in Latin American financial markets to support the use of RLS models. Furthermore, in the Forex markets there are also the exchange interventions of the Central Banks in some Latin American countries that suggests the inclusion of the RLS in the modeling. In addition, the empirical evidence for Latin American countries is scarce. In this sense, the contribution of this document is fundamentally empirical and forms part of a research agenda that is linked to other contributions such as Rodríguez (2016). The results show the presence of RLS in all series with greater presence in the HF series. The daily series have measurement errors (except for the case of the Forex market of Brazil) whereas the HF series have negligible measurement errors. Regarding the fractional parameter estimates in the RLS-ARFIMA models, our results are not conclusive as those obtained by Varneskov and Perron (2017a, 2017b). This situation leads me to contemplate two possible interpretations. In the first, analizing the small or reduced magnitude of the fractional parameter estimates compared to Varneskov and Perron (2017a, 2017b), only the HF series could be modeled as an RLS model plus an ARFIMA dynamics, that is, a RLS-ARFIMA(p,d,q) model. In the other cases, an RLS model with short memory (ARMA dynamics) with measurement errors would suffice. The small magnitude of the estimates makes it difficult to accept the fact that an ARFIMA dynamics dominates the dynamics of the series at zero frequency or the frequencies close to it. The second inter-

[1] Still similar conclusions are obtained from the branch of the literature that focuses on testing for true long memory against the alternative of a short-memory process contaminated by level shifts (with spurious or true long memory); see Ohanissian, Russell, and Tsay (2008), Perron and Qu (2010), and Qu (2011).