TRENDs in Distributional Characteristics: The case of Global Warming (Extended Abstract)
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In this paper the issue of Global Warming (GW) is analyzed to illustrate the introduction of a new methodology to study general trend behaviors in the distribution (not only in the mean) of economic variables.

The concern of GW raises an important chain of questions about: (i) The existence of GW; (ii) Wether GW is caused by human activities or not; (iii) The economic effects of GW; (iv) Economic policies to mitigate the effects of GW, etc. Obviously, without a clear answer to the first question, it makes no sense to ask the others. The goal of this paper is to offer a complete answer to the first question. This will be done by introducing a new methodology valid for the quantitative analysis of many other important economic issues that require a proper study of trend behaviors: trends in gdp, debt, inequality, etc.

We start by defining GW as an increasing trend in global temperatures. In this paper trend is understood in a much broader sense than in the literature so far (see Granger and White, 2011). We look for trends in many of the characteristics of the temperature distribution and not only in the average. For instance, a random walk has a trend in the variance but not in the mean. The average temperature might not show any growth pattern but the lower tail might a clear increase. According to the standard definition in the literature, this would not be GW while with our proposal it would. Even when the average shows some growth, to have a picture of the trending behavior of the whole distribution will help in the analysis of the other questions in the chain.

For the purpose of this research, global temperatures are seen as a stochastic process, $X_t(\omega)$, and therefore as a family of random variables $\{X_t : t \in T\}$ with T a given index set, on a probability space $(\Omega, \Im, P)$ taking values in a set $S = Real\ numbers$. For a given $t = \tau$, $X_\tau(\omega)$ is a random variable. This random variable can be characterized by its moments: $\mu_\tau = E(X_\tau(\omega))$, $\sigma^2_\tau = Var(X_\tau(\omega))$, ... and/or the quantiles of its distribution function $F_\tau(x) = P(X_\tau \leq x)$. These quantiles are defined as $Q_\tau(p) = inf\{x \epsilon \Re : p \leq F_\tau(x)\}$. Notice that μ_τ, σ^2_τ, $Q_\tau(p)$ can be seen as time series objects.

Suppose we observe m values, $x_\tau(\omega_1), x_\tau(\omega_2), ...x_\tau(\omega_m)$ of the random variable $X_\tau(\omega)$ in the time interval τ. From these m values, we can generate the Realized Volatility $RV^m_\tau = \sum_{j=1}^m (x_\tau(\omega_j) - \mu_\tau)^2$ as an estimator of σ^2_τ. Following the same logic, from these m observations we can generate the Realized Quantile, $RQ^m_\tau(p)$ as an estimator of $Q_\tau(p)$. There are many ways of generating $RQ_\tau(p)$: from order statistics, from a kernel estimator of the density, ..., etc. These realized quantiles (see Granger, 2010), form an observable time series and offer a global picture of the historical evolution of the temperature distribution, not only the mean. From these realized objects (moments and quantiles) we estimate a set of distribution characteristics C_{it} ($i = 1, ..., I$, and $t = 1, ..., T$) and test for the existence of a trend in each of them. Because the type of trend is unknown, the paper presents a simple t-test that is robust to most of the trend specifications used in the literature (polynomial, exponential, logistic, unit root and fractional models, local-level models, etc): $H_0 : \beta_i = 0$ in the OLS regression $C_{it} = \alpha_i + \beta_i t + u_{it}$. For those characteristics C_i where H_0 is rejected, we model and estimate their trend behavior. Different trend models are specified (via general to particular significance testing and model selection criteria) and a forecasting competition is run. Forecasting evaluation tests are used to choose the best trend model for C_{it}. With these trend models, we are able to produce forecasts of the trending behavior of temperature distribution. The paper finishes by modeling jointly all the considered characteristics C_{it} via a VAR model. This allows us not only to study possible causal relationships among C_{it} but to check the existence of common features (common trends, common dynamics, etc.). It will also produce an alternative forecast of the future evolution of the whole temperature distribution (not only the usual mean). The VAR quantile modeling approach will be very important for the analysis of the other questions in the chain.

In the application, we use as baseline data UK thermometer measured annual and monthly since 1659 and daily since 1772. To ensure the robustness of our results, we also work with other temperature series such as daily data from Stockholm and Cadiz, the annual Northern and Southern Hemisphere global data and some reconstructions and proxies for global temperatures that allow us to enlarge the sample. We find a trend in most of the C_{it} considered, very small for the mean and upper quantiles and much larger for the lower quantiles. Dispersion measures like IQR, Sd and Rank show a negative trend. Therefore, we conclude that GW is not so much a phenomenon of an increase in the average temperature but of an increase in the lower temperatures producing a decreasing dispersion. Predictions of these trends are provided.

Summarizing, the novelty of our approach includes our more general definition of global warming based on the existence of a particular trend in some of the characteristics of the temperature distribution (not only the average); the estimation of these characteristics through realized quantiles and therefore automatically converted into a time series objects; a robust simple test for the existence of a trend behavior; our trend analysis (inference and modeling) of these characteristics; forecasts of those trends and a join modeling of the distribution characteristics via a VAR quantile model.

Keyword: Distribution Trends; Forecasting Trends; Global Warming; Quantiles; Realized Quantiles; Trends; VAR for quantiles.

References:

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