Confirmation of Poissonian properties in high precision sales data of convenient stores

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We analyze high-precision point-of-sale data of convenience stores consisted of about 100 million receipts including all information about sold items with time stamp in second. As a representative of commodity we focus on rice balls which are quite popular foods like sandwiches. The sales share of rice balls are generally about a half of the whole sales of convenient stores in Japan.

From theoretical viewpoint it is a natural assumption that the process of sale is approximated by a Poisson process in general. We firstly check this by observing the time intervals between two successive sales. If the Poissonian assumption holds, then the distribution of intervals follows an exponential function and the autocorrelation of interval sequence decays quickly to zero. It is clarified from the data that these Poissonian properties are confirmed in time scale of an hour, in other words, the process of sale can be approximated by a Poisson process with its parameter changing slowly in 24 hour period and weekly period.

For a given Poissonian model of sale it is easy to solve a theoretical strategy that maximizes the profit. So, the important next step is to estimate the Poisson parameter from the data. It should be noted that the sales data do not give the true demand when rice balls are sold out, namely, the sold numbers only give the lower bounds. In order to overcome this difficulty we apply a kind of maximum likelihood method to estimate the true Poisson parameter from such incomplete real time series of sales number. As a result, we are able to determine the most likely value of Poisson parameter and we can determine the best strategy automatically from the data. We also have detail data of disposal, and we can check adequacy of supply strategy for each commodity at each store.

Keywords: POS data, Poisson process, maximum likelihood estimation