

Mixed Poisson Processes with Panel Flow

Anatoly Zhigljavsky and Vippal Savani *

Abstract— The problem of parameter estimation and statistical inference when fitting an $M/G/\infty$ queueing process to data is considered in the situation where the times of arrival and departure are unknown; instead recurrent events, which occur according to a mixed Poisson process, are observed between the times of arrival and departure.

Keywords: *Mixed Poisson process, panel flow, $M/G/\infty$ system*

1 Introduction

This paper investigates the modeling of arrival and departure times of individuals in the case where precise arrival and departure times are unknown; instead we observe recurrent events between the times of arrival and departure. In the case where arrival and departure times are known, it is straightforward to fit a standard queueing model of the form $M/G/\infty$ where the arrival process is Markovian, the time spent between arrival and departure follows a general distribution G and there are no queues.

The situation described above occurs in many fields. In the field of market research we observe purchases made by individuals during an observation period. The time when an individual begins or ceases to buy (i.e. time of arrival and departure), however, is unknown. Such an example occurs for purchases of products such as baby food, where individuals “flow” in and out of the panel.

1.1 Panel flow

Consider a panel of individuals consisting of subjects that have recurrent events. Panel flow occurs when individuals move into and out of the panel. We assume that panel flow occurs according to an $M/G/\infty$ process so that: individuals enter the panel according to a Poisson process with

intensity ν ; individuals stay in the panel for a random period of time σ (independent and identically distributed for each individual) and that there are an infinite number of servers so that an individual will immediately enter into the panel.

When the problem of panel flow exists then recurrent events may no longer be analyzed under the assumption of stationarity. In this case, to model recurrent events, we require knowledge of N_t , the number of individuals in the panel at time t . If we know the intensity of the Poisson arrival process (ν) and the distribution of the time spent in the panel (G) then we can use the properties of $M/G/\infty$ processes to model N_t .

Let us assume that N_t , modeled by an $M/G/\infty$ process, is at a steady stationary state. For all t the random variables N_t have Poisson distribution with mean $\nu E\sigma$ and the covariances $\text{cov}(N_t, N_{t+s}) = \nu E[\max(0, \sigma - s)]$ for all $s > 0$ (see e.g. [4]).

The assumption that individuals enter the panel according to a Poisson process with intensity ν is a very natural assumption in practice. If the arrival process is non-stationary, it can be easily de-seasonalised (that is, made stationary). The intensity ν of the arrival Poisson is also simple to estimate.

1.2 Recurrent events

In estimating the parameters of the $M/G/\infty$ process we require the arrival and departure times for each individual. In our problem, the arrival and departure times are unknown. We consider the use of recurrent events to estimate these times.

We consider mixed Poisson processes as a model for the recurrent events. We define a mixed Poisson process as a pure Poisson process with random intensity λ .

In the case of panel data analysis, the mixed Poisson process has a natural interpretation in that each individual has events according to a Poisson process; however, the intensity of each process

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Mixed Poisson Processes

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