International Journal of Information Systems and Social Change
Volume 9 • Issue 4 • October-December 2018

Demand Biorhythm Estimation for Setting Service Capacity

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ABSTRACT

This article is based on an analysis of empirical data on various service demand patterns such as electricity and water consumption, banks, hospitals, communications and others. The research findings show similar patterns of demand for various different services in different parts of the world. The patterns reflect the relevant population's level of activity. Daytime services have typical peak hours during a workday. This is nicely explained by what the authors call the 'Demand Biorhythm.' Many daytime services experience a double hump demand, whereas in the US the service demand may also have a single hump. The analysis shows a striking demand similarity of the same weekdays, and a significant difference between the demand of workdays and weekend days. Also, the first day of the week always experiences a demand surge. The article discusses ways to efficiently plan the service workforce and capacity based on the relevant demand patterns.

KEYWORDS

Daily Consumption, Demand Pattern, Load Pattern, Rush Hour, Service Capacity, Service Level

INTRODUCTION

Services depend on the flow of customers that typically arrive in a stochastic process that has dynamic behavior during each day (Daskin, 2011; Shtub & Cohen, 2015). The majority of service arrival processes is statistically independent and varies during the hours of the day. This characterization strictly defines it as a non-homogeneous Poisson process – characterized by its momentary mean arrival rate $m(t)$ (Daskin, 2011; Mandelbaum & Zeltyn, 2009; Yom-Tov & Mandelbaum, 2014).

In this paper we establish the term "Demand Biorhythm" to describe a typical intensity profile of certain activity throughout the day, which characterizes certain population. Meeting this dynamic profile of demand is especially crucial to service organizations as they strive to satisfy their customers and ensure customer loyalty.

While studying a large variety of services from different types of organizations and different types of industries, we examined activities that occur during the day and came across a striking similarity of demand patterns. Regular daylight services typically open their gates at 8:00 AM (some even at 9:00 or 10:00 AM) and close their operations at night. The customer arrival rate during each day generates a typical profile with typical peak hours that we call the "Demand Biorhythm".

During the last few decades, numerous organizations transformed themselves from "product-centric" to "customer-centric" for various reasons. Becoming customer centric is one of the most important aims of most organizations. Hence, exceeding customer satisfaction demands has attracted the attention of both practitioners and researchers over the last few years. Despite, or maybe due to, the attention drawn to the subject, there is no common denominator on how to tackle workforce assignment

DOI: 10.4018/IJISSC.2018100103

in a dynamic demand service environment. It is now commonly understood that determining service capacity drives customer services sales and marketing. It is often approached as a business strategy to set a threshold for the service level to ensure service availability, short waiting times, and customer contentment. This indeed creates profitable long-term relationships with customers. Significant progress has been made in identifying and researching the components of capacity analysis and its impact on the achieved service levels. The roles of projected demand profile and capacity analysis to the service industry cannot be underestimated, and are deeply rooted in the Service Science domain (Fitzsimmons & Fitzsimmons, 2006; Kandampully, 2011; Maglio & Spohrer, 2008; Silvestro, Fitzgerald, Johnston, & Voss, 1992; Spohrer & Maglio, 2008). What is more, the advancements in society and technology leading to convergence of information, communication, and technology, coupled with acceleration in globalization, competitive environments, and changing customer's preferences have created new challenges as well as opportunities for leveraging knowledge about customers and their behavior patterns.

In terms of demand pattern definitions, the main US energy information administration webpage defined daily patterns, weekly patterns and monthly patterns (U.S. Energy Information Administration (EIA), 2016). The following is the definition for daily patterns, and later we shall introduce the weekly and monthly patterns: "Daily patterns: Demand levels rise throughout the day and tend to be highest during a block of hours referred to as 'on-peak'."

Customer behavior patterns are directly related to their daily arrival profiles, their purchases during a typical day, and their activity level in general. Consumer behavior has a very clear repetitive profile. However, no comprehensive research has been conducted to identify and understand the nature of this type of behavior. This paper tries to fill this void and bridge this gap.

The surprise is that most daylight services reflect a behavior that characterizes the total population. Such activity for example, is depicted in Figure 1, which shows a profile of average electricity demand per hour of a certain month.

The graphs of daily patterns use the horizontal axis for the daytime hours and show the hourly demand on the horizontal axis. Figure 1 depicts a typical daily pattern of electricity demand for a specific date of the Pennsylvania-New Jersey-Maryland Interconnection (PJM) electricity grid with typical two peaks (Avalon Energy, 2016).

Figure 1 shows clearly that most people were not active during night hours, and activity started picking up in the early morning to the morning peak hours, then there was a reduction and a climb to a second peak in the afternoon. This double-hump pattern represents the overall population activity profile, which we call demand biorhythm.

Of course, Figure 1 includes some information that is not relevant to daylight service providers (such as night hours activity). However, we found a very similar behavior in many diverse service organizations, as will be elaborated in this paper.

This paper shows that similar demand patterns characterize all daylight service profiles, and that capacity planning and workforce assignments could be based on this analysis.

The paper is structured as follows: the next section discusses service dominant logic and its relationship with demand biorhythm, followed by the research questions and hypotheses. The following section discusses finding similarity in daily patterns, and shows many such cases, followed by description of a validation study which was conducted in a local hospital. Next, we present and discuss the single-hump demand biorhythm. The results and conclusions sections close the paper.

SERVICE DOMINANT LOGIC AND DEMAND BIORYTHM

The concept of Service Dominant Logic (SDL) presented a framework that pivots around the customer experience and revolves around co-creation of value (Lusch & Vargo, 2006; Vargo & Lusch, 2004, 2008a, 2008b). SDL has the potential for better understanding of the demand biorhythm's significance, its potential in general and its research potential in particular. SDL endorsed the concept that all human