DEVELOPMENT OF AN N-WORKING STAGES LOT SIZE MODEL CONSIDERING SEVERAL PRODUCTIVE AND LOGISTICS ISSUES AND ITS RESOLUTION BY NONLINEAR PROGRAMMING

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Abstract **- Since the Economic Production Quantity (EPQ) model was proposed by Taft almost a century ago, different authors have developed new models to obtain optimal lot size values closer to real ones. Even so, there is still much research to do in this field, mainly in taking into account not only productive but logistics costs when determining the optimal lot size. To fill this gap, the model proposed in this work considers several logistics and productive issues, while goes further by incorporating the possibility of working in *n* stages, idea almost not taken into account in previous works. Even more, the possibility of working with constraints – a main characteristic of real productive processes – is also considered. Finally, and as an additional contribution, a nonlinear programming that solves the proposed model – and how to face such programming with MS Excel® – is also detailed.**

Keywords **— Supply chain, logistics, lot size, lot-sizing problems, nonlinear programming.**

I. INTRODUCTION

According to several of the most important business journals (in works such as Zatzick *et al.*, 2009; and Kaplan and Porter, 2011) the global economic crisis has led managers worldwide to pursue cost reductions in order to keep companies alive. Even without such crisis, production processes optimization and cost reduction should always be in managers' agendas (Baykasoglu and Kaplanoglu, 2006; Devec and Herakovic, 2010).

There are different approaches when facing cost reductions, including: Reducing staff, outsource activities, and optimizing processes, among others. In this paper we focus on optimizing a key element of the production process: The lot size.

The importance of determining the optimal lot size was well established in the foundational works of Harris (1915) and Taft (1918); in these works the EOQ (Economic Order Quantity) and EPQ (Economic Production Quantity) models were introduced. The importance of the EOQ and EPQ models is such that, even nowadays, they are still studied and used in several organizations (Valencia *et al.*, 2014).

Due to the importance of establishing the quantity to produce, several modifications have been proposed to the seminal works of Harris (1915), Taft (1918), and the dynamic version of the model proposed by Wagner and Whitin (1958).

Most of the alternatives commented above have been focused on determining optimal lot sizes using only production costs in a unique working stage.

Literature reviews related with this topic are presented by Brahimi *et al.* (2006), Karimi *et al.* (2006), Yano and Lee (1995), Eftekharzadeh (1993), Maes and Wassenhove (1988).

From the analysis of works previously commented can be inferred that some of the most significant works where authors incorporate new costs and issues in lot size models can be found in Abolhasanpour *et al.* (2009), Kim *et al.* (2008), Chiu *et al.* (2009), Parveen and Rao (2009), Sicilia *et al.* (2013), Cheng and Ting (2010) and Yang *et al*. (2012).

Recently, some authors have not only incorporated new costs but have also started changing some assumptions about the seminal ones. Darwish (2008) replaces the continuous inventory issuing policy for a periodic one which is commonly used in production-shipment systems. Also, some costs which traditionally were supposed fixed are now considered variable (e. g. Darwish, 2008; Chiu *et al*., 2011).

Similarly, the idea that the optimal quantity to produce should be determined by considering not just production costs but supply chain (mainly logistics) costs has arisen from the analysis of different companies. Lee *et al.* (2003) come to this conclusion from the study of third-party logistics (3PL) and Chu and Chu (2007) come to the same conclusion by analyzing a refinery. The later being in concordance with Olivares *et al.* (2012) who established the importance of considering the logistics cost.

Some contributions to EPQ literature not only incorporate costs which were not previously considered but also deal with *n*-stage processes. Related to these contributions are the JELS (Joint Economic Lot Size) models. These models do not focus on optimizing a single element of the supply chain but the costs incurred in different echelons. A complete review related with JELS is presented by Glock (2012) in such work concludes that only two JELS models (Leung, 2010; Seliaman and Ahmad, 2009) truly considered an *n*-stage supply chain.

Other research line related with this paper can be found in the literature as: Multi-echelon serial systems, being some of the most representative works of such