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Integration of sale and leaseback in the optimal design of supply chain networks

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ABSTRACT

Supply chain network (SCN) modeling has gain a great research interest as companies realized that scientific approaches in managing their SCN's, rather than “common-sense” heuristics, are the roads to achieve sustainability, profitability, growth, and competiveness. Ever since, the relevant literature is supplied with models that aim to optimize SCN's design and/or operation. The former is a strategic process that designs network's infrastructure and concerns long term investments which undertake huge amounts of capitals. SCN managers should be able to evaluate how these decisions contribute to the overall performance of the company and not assess them with only cost oriented indicators. By employing advance financial management methods, such as sale and leaseback (SLB), fixed assets could be the medium to improve liquidity and strengthen credit solvency. This paper aims to enrich the SCN design literature by introducing a Mixed-Integer Non Linear Programming (MINLP) model that integrates SLB technique with SCN design decisions. By exploiting the properties of the MINLP model it is reformulated into an exact Mixed-Integer Linear Programming (MILP) model that is solved to global optimality. A real case study from a consumer goods company is utilized in order to show model's functionality and to evaluate its adaptability, robustness, and benefit. The model could assist and support SCN managers in effective decision making in the strategic level.

1. Introduction

SCN management has recently become an area of great interest, among academics and practitioners in the Operations Research and in the Management Science (OR/MS) community [1], as its contribution in realizing business objectives has gained universal recognition. Therefore a notable number of mathematical models aiming at optimizing SCN's design and operation are found scattered in the extant literature. The design of SCN's is a strategic project addressing, according to Harrison [2], the infrastructure (e.g. plants, warehouses, distribution centers, transportation modes and lanes, production processes, etc.) that will be used to satisfy customer demands. Most of SCN design models use a time horizon of months or years, and typically assume little or no uncertainty with the data.

The bulk of SCN design models covers a broad spectrum of modeling aspects as a result of managers' need for effective decision making capable of capturing all operations within integrated SCN's. Traditional single product/single echelon/single period/single objective facility location models have gradually been substituted with multi-product [3–5], multi-echelon [6–8], multi-period [9], multi-objective [10] models either deterministic [11–13] or stochastic [14–17]. Advanced modeling issues concern uncertainty handling [18–22], environmental impact [23,24], reverse logistics flows/closed loops [25–28], vehicle routing [29,30], and inventory theory [31,32] among others.

In addition to modeling issues mentioned earlier, financial management is an emerging and vital issue within a SCN [33–37]. Production, distribution, procurement, and inventory operations are closely related to finance operations, within a SCN, as the latter provides the necessary funds in order to ensure perpetuity of the former. Moreover, sustainability and growth of the SCN rely heavily on financing. Scilicet expansion in new emerging markets, investment in new production processes, in new production equipment, and in new innovative products have new funds as a prerequisite.

The interface of OR/MS and finance is rooted in the early seventies, where advances in tools enable OR/MS researchers to tackle exciting financial problems effectively [38], and continues to gain popularity hitherto [39]. However, in the SCN design context, modeling of financial management aspects have gradually started to drawn OR/MS researchers' attention in the last decade. One of

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the first endeavors to address these issues was made by Puigjaner and co-workers who integrated cash flow management, budgeting, and corporate shareholder value to both SCN design and SCN operation/planning models [40–43]. Capital budgeting with management of loans and bonds was incorporated in a deterministic MILP SCN redesign model proposed by Naraharisetti et al. [44]. Moreover, a MILP SCN design model that integrates financial statement analysis and economic added value is presented by Longinidis and Georgiadis [45] while the same authors in a later contribution in SCN design area develop a multi-objective MINLP model that captures the tradeoffs between financial performance and financial distress possibilities inherent in SCNs, through EVA™ and Altman's Z-score indexes, respectively [46]. An innovative multi-stage stochastic MILP SCN design model was recently introduced by Nickel et al. [47] incorporating capital budgeting and leverage management under uncertainty in demand and interest rates.

Research on integrated SCN design models that capture financial matters is still in its infancy. However, as SCN managers require holistic decision support models that track and quantify the financial impact of their production and distribution decisions, this research stream is likely to become a mainstream. Along these lines, this paper aims to enrich the relevant literature by providing a SCN design model that incorporates SLB, a financial method that releases the value of real estate, improves balance sheet, and realizes tax benefits. The proposed model will assist SCN managers in strategic decision making.

The rest of the paper is structured as follows. Section 2 introduces briefly the SLB method and its relevance with SCN domain. Section 3 presents the SCN design problem and its mathematical formulation. The applicability of the proposed model is illustrated, through a case study, in Section 4 followed by concluding remarks, managerial implications and further research directions.

2. Sale and leaseback

Although SLB is not a new concept in financial management, since the mid-1990s the number, value, and industry dispersion of these deals have been following an accelerating trend [48]. Many studies have presented empirical evidence supporting that SLB is a value-increasing transaction [49] which provides wealth gains superior to debt financing [50], optimizes company's claims to real estate [51], improves liquidity that is directed either to finance expansion or to pay off existing creditors [52], reveals hidden value of company's assets [53], and achieves capital and supported business objectives [54].

In asset-intensive and asset-heavy industrial, manufacturing, and trade companies the SLB offers great potentials to realize all above mentioned benefits. In these companies the vast majority of their real estate portfolio concerns fixed assets dedicated to their SCNs. Plants, warehouses, distributions centers, retail outlets, and other facilities engaged in SCN operations are binding huge amounts of capitals. Funds shackled in these non-earning fixed assets deterring growth investments in other short-term and mid-term projects due to lack of liquidity. The trend towards releasing capital tied up in these real estate holdings is documented by the W. P. Carey Inc., the world's largest SLB financing provider which manages a portfolio of lease assets totaling $15.2 billion, as the lion share of its SLB agreements concerned manufacturing/industrial properties, warehouses/distribution centers, and retail outlets [55].

Integrating the SLB financing technique in the SCN design context offers decision makers the potential to gain the most from their real estate investments in SCN facilities, as they retain their control although they have monetize them, and thus comply with value maximization principle. A SCN design model that integrates SLB modeling yields an optimal configuration that takes into account not only cost savings but also additional quantitative and qualitative gains resulting from transforming non-earning facilities to profit generating mediums. Competitive alternative facilities are established by balancing the tradeoffs between infrastructure/operational cost and cash by SLB.

A SLB transaction is the one involving the sale of property by the owner (seller-lessee), who simultaneously leases it back from the new owner (buyer-lessor). The Financial Accounting Standards Board and the International Accounting Standards Board are responsible for setting the guidelines for accounting policies in the United States and in the European Union, respectively. The former has introduced the Statement No. 13 [56] while the latter has released the International Accounting Standard 17 [57] in order to prescribe accounting issues in SLB transactions. Although these boards have differences on the treatment of leases, a joint project, with the aim to develop a common standard that would ensure that all assets and liabilities arising under lease contracts are recognized in the balance sheet, was announced in 2006 [58]. As the trend in the standard setting bodies is towards capital/finance leases, this study is focused on capital/finance SLB transactions and for this reason the criterion that the lease term is equal to or exceeds 75% of the economic life of the asset will be used.

At the commencement of the SLB term, leases should be capitalized in the balance sheet of the lessee as assets and liabilities at an amount equal to the fair value of the leased property or, if lower, the present value of the minimum lease payments. The interest rate implicit in the lease should be used to discount the present value of the minimum lease payments, if this is practicable to determine, otherwise the lessee's incremental borrowing rate should be used. The fair value is the amount for which an asset could be exchanged between knowledgeable, willing parties in an arm's length transaction. The interest rate implicit in the lease is the discount rate that, at the inception of the lease, causes the aggregate present value of the minimum lease payments to be equal to the sum of the fair value of the leased asset while the lessee's incremental borrowing rate of interest is the rate of interest the lessee would have to pay on a similar lease or, if that is not determinable, the rate that, at the inception of the lease, the lessee would incur to borrow over a similar term, and with a similar security, the funds necessary to purchase the asset. The difference between the fair value and the book value is recognized as unearned profit on SLB and also the leased back asset is depreciated with a policy consistent with that for depreciable assets that are owned [56,57].

A SLB transaction can take place regardless of the fair value and the present value of the minimum lease payments. However, a company prefers the fair value to be higher than the present value of the minimum lease payments in order to yield a positive net present value and appraise the SLB investment. The following inequality presents the basic condition for a value creating SLB transaction for each specific fixed asset at each time period:

$$\mathrm{FV} \geq \mathrm{PVLP} \Leftrightarrow \mathrm{FV} \geq \mathrm{PMT} \times \frac{1-(1+\mathrm{LIBR})^{-\mathrm{T}}}{\mathrm{LIBR}}$$
$$\Leftrightarrow \mathrm{FV} \geq \frac{\mathrm{FV}}{1-(1+\mathrm{IRIL})^{-\mathrm{T}}/\mathrm{IRIL}} \times \frac{1-(1+\mathrm{LIBR})^{-\mathrm{T}}}{\mathrm{LIBR}} \quad \text{(I)}$$

The fair value of an asset (FV) should be greater or equal to the present value of minimum lease payments (PVLP). PVLP is calculated as an ordinary annuity, the product of minimum lease payments (PMT) and a discounting factor with inputs the lessee's incremental borrowing rate (LIBR) and the term of the SLB agreement (T). The PMT is also calculated as an ordinary annuity, the division of FV and a discounting factor with inputs the interest rate implicit in the lease (IRIL) and T.