The Impact of Late Payments on The Financial Performance of a Multi-echelon Supply Chain: a System Dynamics Modelling Approach

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Abstract

The SMEs (small and medium-sized enterprises) constitute 98% of the Moroccan economics. They represent the real nerve center of our economy with 40% of production and 31% of exports. They are present in all sectors of Moroccan economic activity; however, an alarming report from inforisk notes an 8% increase in business failure in 2018, compared with only 1% of corporate default growth worldwide. Indeed, 40% of the failures of the Moroccan companies are due to unpaid bills, and 70% of our companies support delays of payment higher than 90 days. In a context of recession and economic crisis, banks are increasingly reluctant to grant credit, not having or having very few assets, such as machines, premises and vehicles. The SMEs cannot access to conventional financing except at quasi-prohibitive rates, which makes late payments very difficult for the latter to absorb. The purpose of our study is to understand through system dynamics causal loop diagram, the impact of late payments on the financial health of the supply chain by considering two variables, namely the cash in hand and the inventory. As we applied our model to a Moroccan distribution firm, the study showed that large firm absorbs delay in payment.

Keywords
Delay in payment, Supply chain, System Dynamics, Cloosed loop Diagram.

1. Introduction

Over the course of history, supply chains have emerged to meet the diverse needs of human societies, to exploit natural resources, and to enable humans to engage profitably in commerce and trade (Casson,2013). The very extensive supply chain literature addresses supply chain practices and performance (Swink et al., 2007; Flynn et al., 2010), supply chain strategies and their dynamics over time (Ketchen & Giunipero, 2004), and to some degree addresses changing supply chain configurations (Halldorsson et al., 2007; Ülkü & Schmidt, 2011), as manager strive to improve factory performance, the trouble is that often the meaning is lost (Zeng, 2017), while interest in SCM is immense, it is clear that much of the knowledge about SCM resides in narrow functional silos such as purchasing, logistics, IT and marketing(burgess,2006), Mentzer et al. (2001) proposed a definition that is broad, not confined to any specific discipline area and adequately reflecting the breadth of issues that are usually covered under this term. This definition to start our research:

"Supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole" (Mentzer et al., 2001, p. 18).

The different interactions constitutes a complex set of relationships among buyers and suppliers, between a buyer and a supplier as well as between competing suppliers (Nair, 2009), so the supply chain management involves adapting to changes in a complicated global network of organizations (Pathak et al, 2007), and thus it will not be examined as a set of sequential, vertically organized transactions representing successive stages of value creation (Mabert & Venkataramanan, 1998) but as a whole system. Managers must possess a mental model of a supply chain management that more accurately reflects its true underlying complexity and dynamism. (Choi et al, 2005), so due to our natural lack of understanding of organizational, functional and evolutionary aspects in supply chains. A key realization to tackle this problem is that supply-chain networks should be treated not just as a 'system' but as a 'Complex Adaptive System (Surana, 2005), and naturally it should be managed as such (Choi, 2006), however the dynamic and complex evolution of markets has encouraged many firms to implement various supply chain initiatives to try to boost efficiency (Sodhi, Son, & Tang, 2012). As a result, aspects such as operational complexity and dispersion are making the supply chain more vulnerable to risks that negatively affect both short- and long-term operational and financial performance (Saenz, 2017; Craighead, Blackhurst, Rungtsunatham, & Hatfield, 2007; World Economic Forum, 2008; Rao & Goldsby, 2009; Sheffi, 2001, 2015; Thun & Hoenig, 2011). In recent years, there have been a number of high-profile events and persistent problems that have severely disrupted the ability of firms to produce and distribute their products, including devastating earthquakes, political turmoil, fuel crises, diseases and terrorism (Chen, Sohal, and Prajogo 2013; Sodhi, Son, and Tang 2012; Mandal 2012; Singhal, Agarwal, and Mittal 2011; Sawik 2013). Indeed, a firm that responds to a disruption better than its competitors could improve its market position (Tukamuhabwa, 2015), so The potential impact of disruptions on a firm and its supply chain make a clear case for the importance of building resilience (Carvalho, 2012), there are even extreme cases where supply chains have completely collapsed and never recovered from a disruption (Tang 2006; Xu, Wang, and Zhao 2014). Disruptions in supply chains imply a phenomenon where one or more events taking place at one point in the supply chain adversely affect (or have the potential to affect) the operations performance of one or more members located elsewhere in the chain (Melnyk et al., 2009).

In this paper a large gap is identified in supply chain literature, then the authors will present the methodology for modeling delay in payment, as well as, the equation that illustrate the interaction of the elements of this system.

1. Financial flow in supply chain

Financial processes such as invoices, payments, foreign exchange and banking transactions have received very little attention in the supply chain literature because previous research has tended to focus almost exclusively on the movement of products and services in the supply chain and largely ignores the movement of money and related financial activities. (Blackman and al, 2015) Research on supply chain systems has focused on inventory cost, transportation cost and cost related to goods procurement in terms of information flow, there has been a real revolution with the rise of the Internet and information technology (popa,2013)
However, there has been very little research work that focuses on the upstream flow of money. Hartley-Urquhart (2006) argued that companies should manage financial flow as closely as they manage physical supply chains in order to deal with the inherent complexity and risk of global production systems. One of the substantiated issues in supply chain dynamics is resilience, which refers to development of the ability to remain robust and change (adapt) system behavior in dynamic environments in the case of severe disruptions with the achievement of acceptable performance (Craighead et al. 2007; Ivanov et al. 2016; Benyoucef et al. 2013; Ho et al. 2015; Gunasekaran et al. 2015; Tukamuhabwa et al. 2015; Khalili et al. 2017; Ivanov, 2017). Finance papers have tended to focus on the technical aspects of financial supply chains and failed to address the strategic and operations management issues (Blackman et al, 2015),In practice, the financial aspects of SCM are mostly left to corporate finance and accounting, which 'thinks' in terms of single companies or affiliated groups rather than supply chains (Gomm,2010). Taking into account the numerous SCM collaboration initiatives in areas such as procurement, transportation, distribution, R&D, marketing, and sales, it is remarkable how little research is undertaken on collaboration in financial aspects, even more so considering how high the potential cost savings might be. Successfully managing financial flows is critical for any business to survive and thrive in today's

business environment where all firms are highly financially connected in a complex global network. Therefore, it is increasingly important to better understand the nature of this financial network system as well as how it interplays with other economic activities While payment delays can be easily absorbed by larger companies with access to credit, late payments could have potentially devastating consequences for small firms, which struggle with cash flows and cannot easily secure overdrafts or bridging finance. A growing body of empirical literature suggests that financial constraints are the strongest reason for small business failures (Bradley and Rubach, 2015).

2. Model development

The objective of this study is to present a whole business system financial model of supply chain management and define interaction that will better insight on the relation between delay in payment and supply chain performance.
The problem is considered from the viewpoint of a wholesaler who receives finished products from several manufacturers (up- stream partners) and then distributes these products to several semi-wholesalers (downstream partners) who distribute these products to several retailers. The wholesaler receives money from the downstream partners and makes payments to the up- stream partners and so the semi-wholesaler.
Our model was developed on the basis of supply chain models reported in the literature, but was modified and refined to fit the case study presented in this article, thanks to different interview and dialogues with supply chain partners. In addition, relevant variables, parameters, and feedback loops related to the effect of late payments were added to the model from the interview results to provide a fully validated case study simulation model.

3. Modelling with system dynamics

System dynamics is a method to enhance learning in complex systems. "Just as an airline uses flight simulators to help pilots learn, system dynamics is, partly, a method for developing management flight simulators, often computer simulation models, to help us learn about dynamic complexity (Sterman, 2001)

J.W. Forrester developed System Dynamic methodology in 1961 to model and simulate dynamic management problems of operation and stock in companies (Forrester, 1961). And then, he gave out the structure and principles of System Dynamics model in 1968 (Forrester, 1968), in 1969, Forrester introduced System Dynamics model to the wider area of social science and summarized the evolution of American cities (forrester, 1969), In the 1970s, Forrester together with the Club of Rome published "World Dynamics", in which they analyzed the interactions and feedbacks of the five fundamental factors (population, agriculture, natural resource, industrial production and pollution) of global development. Researches of System Dynamics was booming since 1970s, which is being applied to areas of natural science, social science and engineering, etc. (Qui et al, 2015), Because these tools are applied to the behavior of human as well as physical and technical systems, system dynamics draws on cognitive and social psychology, economics, and other social sciences (Sterman, 2001).

It has long been acknowledged that people seeking to solve a problem often make it worse (More,1956), this is what forrester (1971) called "counterintuitive behavior of social systems." Often our policies may create unanticipated side effects. The unexpected dynamics as a whole complex often lead to policy resistance, the tendency for interventions to be delayed, diluted, or defeated by the response of the system to the intervention itself (Meadows 1982). As Thomas stated in the early 1974," You cannot meddle with one part of a complex system from the outside without the almost certain risk of setting off disastrous events that you hadn't counted on in other, remote parts. If you want to fix something you are first obliged to understand . . . the whole system."

To avoid policy resistance and find high leverage policies requires the managers to expand the boundaries of mental models so that they become aware of and understand the implications of the feedbacks created by the decisions they make. They must learn about the structure and dynamics of the increasingly complex systems in which they are embedded. (Sterman, 2001), To use a mental model to design a new strategy or organization they must make inferences about the consequences of decision rules that have never been tried and for which they have no data.(Simon, 1982), Every link by which they might learn can be weakened or cut by a variety of structures. Some of these are physical or institutional features (Yoo et al, 2015). Following convention, the structure of a system in System dynamics methodology is exhibited by causal-loop diagram (Qui et al, 2015) to map relevant variables, associated interrelationships, and delays (Gray, 2017 et al), Much of the art of system dynamics modeling is discovering and representing the feedback processes, which, along with stock and flow structures, time delays, and nonlinearities, determine the dynamics of a system, and most complex behaviors usually arise from the interactions (feedbacks) among the components of the system, and not only from the complexity of the components themselves. (Sterman, 2000 p12)

4. Invoice modeling

Let us assume, q_t be the total money received by the wholesaler from all downstream partners at time t. We denote Lk to be the invoice amount for the kth invoice from an upstream partner received at time s_k an invoice is generated by a supplier after shipping the products to the wholesaler. The objective of the wholesaler is to schedule the payments of these invoices to the upstream partners within the constraints of the receipt of the money from the retailers. If invoice k is paid before a certain date, denoted as b_k, the terms of payment of the invoice guarantees a discount u_k. (Gupta et Dutta,2011) This discount by upstream partners is given to encourage early payment of the invoice by the wholesaler. However, a penalty or interest v_k has to be paid if the payment for invoice k is not made within a due date d_k. It may be noted that sk ≤ bk ≤ dk. Any money that is accumulated with the wholesaler can be invested to earn an interest. The wholesaler's objective is to minimize cash out flow to pay all invoices.

$$A_k(t) = \begin{cases} l_k * (1 - u_k), & if\ s_k < bk \\ L_k, & if\ b_k < t < d_k \\ L_k * \left(1 + v_k\right)^{t-d_k} & if\ t > d_k \end{cases}$$

Cash balance equations need to be specified to ensure that the total cash in hand is more than or equal to the total payments made against one or more invoices in each time interval, on each day. The cash in hand in each time interval is equal to the total cash inflow received so far, plus the interest earned on the cash-in-hand minus the total payment of invoices made so far. Additionally, all cash transactions occur at the end of the each time interval.

We will have the following constraints to balance the cash inflow and outflow on each month

$$BC = \delta + q_t - \sum_{\forall k \in K} X_{kt} A_k(t)$$

where δ equale cash in hand at the begining and q is the amont received from all down Stream parteners.
The same rules and patterns will be applied to supliers, semi-wholesalers and retaillers.
The demande is modelised based on the work of Elkady et al (2014) where system dynamics was applied to Assess Grocery Retail Supply Chain Collaboration, and the work of Liu et al (2016) where systeme dynamics was used to analyze agri-food supply chain operation modes.

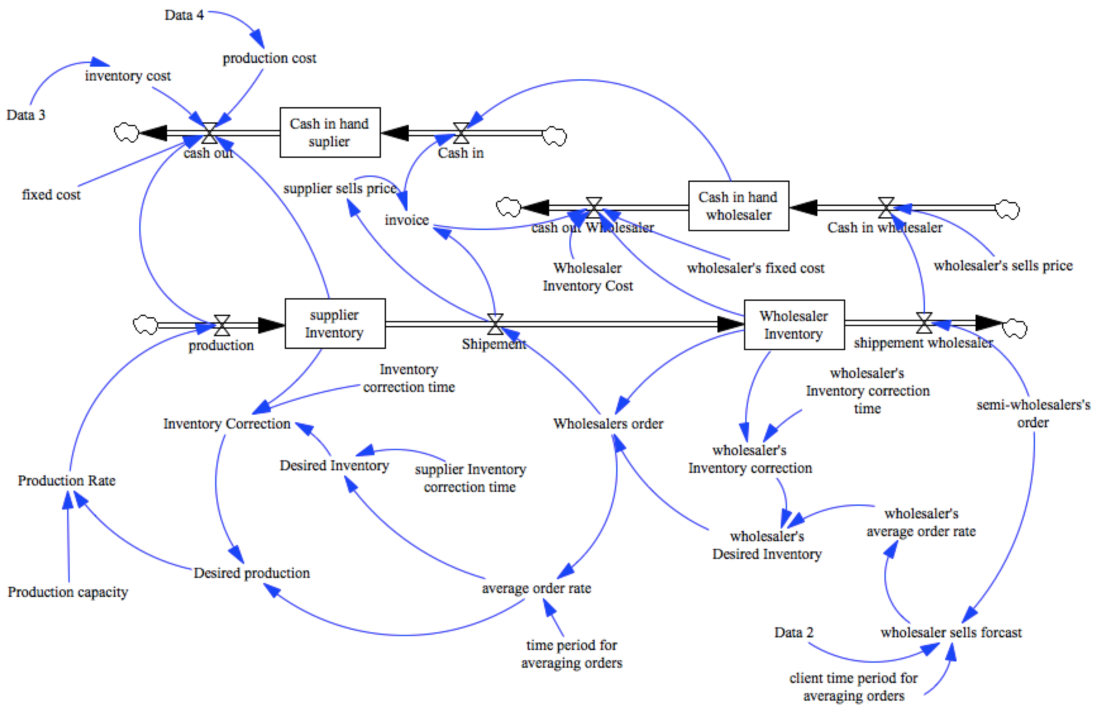

Figure 1 causal loop diagram of a one to one supply chain

- Average order rate=SMOOTH(Wholesalers order,time period for averaging orders), Units: units/Week : The firm forecast shipments by averaging past orders over time period as a way of smoothing out any noise or lumpiness in demand.
- Cash in hand suplier= INTEG (Cash in-cash out, initial), Units: Mad
- Cash in hand wholesaler = INTEG (Cash in wholesaler-cash out Wholesaler, initial) Units: Mad
- cash out supplier= (production*production cost)+(inventory cost*supplier Inventory)+fixed cost, Units: Mad/month
- cash out wholesaler= (wholesaler's order * supplier's sells price)+(inventory cost*wholesaler's Inventory)+wholesaler's fixed cost, Units: Mad/month
- Cash in suplier = IFTHENELSE (Cash in hand wholesaler>=invoice,invoice, cash in hand)
- wholesaler time period for averaging orders=constant , Units:month
- client time period for averaging orders=constant, Units :month
- Desired production=average order rate+Inventory Correction Units: units/Week
- Suplier fixed cost = auxiliary that need to be defined based on
- Inventory Correction= (Desired Inventory-supplier Inventory)/Inventory correction time, Units: units/Week
- Inventory correction time=constant, Units: Week
- Invoice =supplier's sells price*shippement, Units : Mad

- $invoice(t) =$

$$\begin{cases} \text{supplier's sells price} * \text{shippement} * (1 - uk)\,, & if\ s_k < bk \\ \text{supplier's sells price} * \text{shippement}\,, & if\ b_k < t < d_k \\ \text{supplier's sells price} * \text{shippement} * \left(1 + v_k\right)^{t-d_k}\,, & if\ t > d_k \end{cases}$$

- Production = Production rate, Units : units/month
- Production Capacity= constant, Units : units/month
- Production Rate : IF THEN ELSE (Desired production>=Production capacity, Production capacity, Desired production), Units: units/Week, the desired capacity can't exceed the production capacity
- Shippement=Wholesalers order, Units: units/Week
- Supplier Inventory= INTEG (production-Shippement, initial), Units: units
- Supplier Inventory correction time = constant, Units : Week
- Supplier Sells Price= IF THEN ELSE (Orders>n,N,M), Units : Mad, often the price change in regards of the order, if order exceed n the price is N, if not the price is M
- time period for Averaging orders= constant, Units: month
- Wolesaler's Inventory = INTEG (supplier's shippement –Wholesalers shippement) Units : units
- wholesaler's Inventory correction=Wholesaler Inventory/wholesaler's Inventory correction time, Units: units/month
- wholesaler's Inventory correction time=constant, Units: month
- wholesaler's sells price=constant, Units: Mad
- Wholesalers order=wholesaler's Desired Inventory-Wholesaler Inventory, Units: units/Week

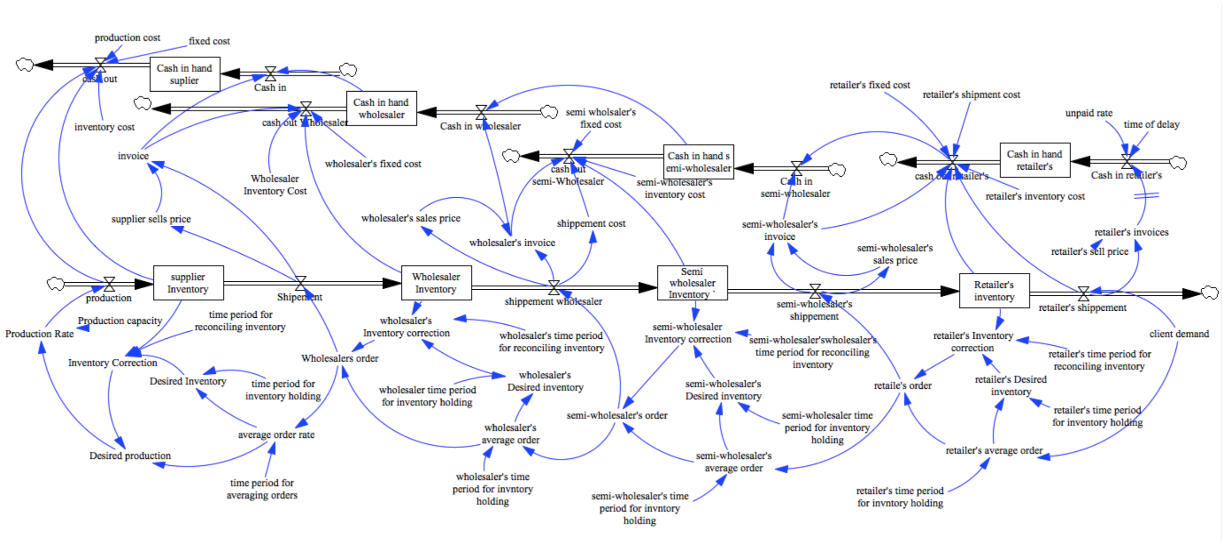

Figure 2 Multi-echelon supply chain causal loop diagram

5. Limitations and future research:

There are several limitations to the above modelling that the reader should be aware of.

The Models assume that the time for inventory correction is fixed between the partners. In reality there may be some variance, often due to external influences such as traffic congestion or incident. Additionally, in some circumstances it may be possible to use alternative modes of transport for shipment, and this would have an effect on cost.

The models also do not include any opportunistic factor; we assume that a supply chain partner will pay an invoice if he has enough cash in hand to do it.

The next step of the study is to simulate, based on thismodel, a real life case study to deduce a quantitative impact of the delay of payment on supply chain financial performance.

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