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THE BLOOD SUPPLY GAME

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ABSTRACT

Product and service supply chains are usually complex and difficult to manage. Making students of supply chain management (SCM) courses realise these complex principles of real life problems is not as easy. Business games played in the class or in computer labs is a pedagogical way which assists the understanding of theories, put ideas into action and educates in an interactive and enjoyable way.

In this paper, we present a business game which mimics the supply chain of blood units from donors to patients. The game models the material and information flows in a production-distribution channel serving patients in hospitals which need blood transfusions according to doctors' requests in different periods and with independent distributions. The game is played by individuals on a PC with Microsoft Excel exploiting a VBA environment. The game can be an effective teaching tool.

1 INTRODUCTION

Product and service supply chains are usually complex and difficult to manage. Making students of supply chain management (SCM) courses realise these complex principles of real life problems is not as easy. Relevant textbooks and case studies are one means of helping students understand fundamental ideas about SCM but these alone may be inadequate to present in the class the whole and real picture of supply chains or most importantly put students in the position of managers who have to make decisions and get the responsibility or credit for them. Business games played in the class or in computer labs is another pedagogical way which assists the understanding of theories, put ideas into action and educates in an active and enjoyable way.

The Beer Game (Sterman 1989) is one such business game which has won publicity and popularity and is abundantly used in supply chain management courses. Similar to the Beer Game, we propose in this paper a business game which is called the Blood Supply Game. The Game mimics the supply chain of blood units from donors to patients. Unlike the Beer Game the Blood Supply Game is about a perishable product with limited collection/production. The game models the material and information flows in a production-distribution channel serving patients in hospitals which need blood transfusions according to doctors' requests in different periods and with independent distributions. In more detail, the game simulates the processes of blood collection, production, testing, supplier's inventory holding, orders, distribution, hospital stocking, usage, returns and outdates together with product and transportation cost, revenue and profit functions. The Blood Supply Game is played by the distributor's point of view. Rational decisions from this player require deep understanding of the processes of the other players in the supply chain as well as the operations of the chain as a whole. The game is played by individuals on a PC with Microsoft Excel exploiting a VBA environment.

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2 APPROACHES FOR TEACHING SUPPLY CHAIN DYNAMICS AND BUSINESS GAMES

By focusing on the management of entire value chains, supply chain management has gained increasing popularity in management research and in the teaching of global businesses (Vollmann, Cordon and Heikkilä 2000). Many schools of management and engineering are adopting integrated curricula that prepare students to design and manage the resulting complex global SCM. Several studies present competent syllabi, popular case studies and teaching frameworks for supply chain management courses and highlight supporting material and pedagogy (Johnson and Pyke 2000, Vollmann, Cordon and Heikkilä 2000, Sparling 2002). Moreover, SCM curriculum often includes cross-border, experiential and interactive approaches such as the use of company-sponsored team projects (Kopczak and Fransoo 2000; Bandyopadhyay 2004) or SCM software packages (Knolmayer, Schmidt and Rihs 2007) for training professionals and students.

Business games utilisation has been increasingly grown over the past decades (Faria and Nulsen 1997). A plethora of business games are reported in The Business Games Handbook (Graham and Gray 1969) and The Guide to Simulations/Games for Education and Training (Horn and Cleaves 1980). Furthermore, over the last two decades, games of different types have been successfully used in particular for teaching courses like production and operations management and in the introduction of new planning methods and systems in industrial enterprises as described in Simulation Games and Learning in Production Management (Riis, 1995; Morecroft and Sterman 2000). The general pedagogic purpose of these games is threefold: to create awareness and insight from experiencing the interplay of different sections and functions; to teach by creating understanding and knowledge on the basis of try-outs of different planning principles; and to train by providing practical know how from planning a handling job (Riis 1995).

In SCM teaching, the most popular game which is part of many SCM curricula is the Beer Distribution Game developed at MIT almost 20 years ago (Sterman 1989, Senge 1990). The Beer Game is an exercise that simulates the material and information flows in a production/distribution system. Teams of players simulate the processes of a single product distribution supply chain by allowing individuals to manage the orders/inventory of a manufacturer, distributor, wholesaler or retailer. The game facilitates the students in acquiring direct knowledge of the "bullwhip effect" (Forrester 1958; Lee, Padmanabhan and Whang 1997a, 1997b) and the benefits of information sharing and lead-time reduction. In its original form, the game is set up as a physical simulation, however, over the years several versions of this game have been developed and adopted in class (Chen and Samroengraja 2000, Sparling 2002) available in computer simulation too (e.g., Simchi-Levi, Kaminsky and Simchi-Levi 1999).

Another game which was developed for teaching SCM is the Mortgage Service Game (Anderson and Morrice 2000). This is a simulation game designed to teach service-oriented supply chain management principles. Contrary to the Beer Game which is a finished good inventory supply chain, in the Mortgage Service Game there is no inventory and players can only manage backlogs through capacity adjustments. The game demonstrates the impact of demand variability and reduced capacity adjustment time and lead times. As far as our knowledge goes these are the main two published games which focus on teaching the specific principles of SCM.

3 AIMS OF THE BLOOD SUPPLY GAME

The pedagogic purpose of the Blood Supply Game is fourfold:

- to improve students understanding of complex principles of supply chains, such as variant supply and demand, distribution options, product and market characteristics;
- to evaluate the overall impact of these principles which is different from the sum of the impact of each one of them;
- to train them in making decisions under pressure and in complex situations where an outcome arises from interaction of multiple factors and interventions;
- to allow the students familiarise themselves with a business, graphically-oriented model.

The game is also useful for research and assessment purposes. The game gives students a real supply chain case study (Katsaliaki and Brailsford 2007, Katsaliaki 2008) which resembles the operations and principles of a supply chain taught in the class or in a text-book but has its own particularities. Students need to translate these processes and make decisions to solve the problems of the real simulated case. In particular, the game can assess students' competency of applying the supply chain principles that are taught in class and measure how well the students comprehend the interrelationships between the different function of a supply chain, how effectively use the given, incomplete information to make decisions which improve the chain's performance and how well they co-ordinate these processes in order to increase the satisfaction of the supply chain players and their profits. The Blood Supply Game, like other similar games, can help educators answer these research questions.

This game is geared to deal with planning issues pertaining to one single decision maker: the distributor (who is vertically integrated with the manufacturer). The player should work on a complex planning task but also demonstrate the interplay between different functions involved in supply chains. The aim is to teach the students the complexity of some supply chains and especially in products that are perishable and of special interest.

4 DESCRIPTION OF THE BLOOD SUPPLY GAME

The authors have developed a game which describes a supply chain with elements from both the Beer Game and the Mortgage Service Game and the types of decisions made within these contexts. However, it has some characteristic differences that makes this SC unique. The product is perishable, there is finite production and demand is usually greater than supply.

The main players of this supply chain are: the donors (supplier) who provide the raw material, which in this case are the unprocessed blood; the National Blood Service (NBS) Centre (manufacturer) which tests, processes and transforms blood into blood products ready for use; the NBS plays also the role of the distributor who stores the product in safe temperature and transports it to the receiver when an order is placed; the hospital blood banks (wholesaler) which place orders to and receive products from the NBS, handle the stock of these NBS issues as well as the returns from the next echelon of the supply chain; the doctors of each hospital (retailers) who place orders for blood products to hospital blood banks to satisfy the needs of the patients (end-user) in need for transfusion. The game is mainly focused on the activities of the NBS and hospitals/doctors orders. These are the main players of the supply chain. Furthermore, in a so vital product like blood, for which demand is usually greater than supply, the power is with the seller who has more control over the chain than the buyer (McAlister et al 1986). In our case this is the NBS manufacturer/distributor.

In more detail, the NBS in the UK collects blood by voluntary donation, mainly from local venues such as church halls or places of employment. The blood is transported back to the nearest process-testing and Issuing (PTI) Centre where it is tested for ABO and Rhesus grouping and infectious diseases such as HIV.

It is then processed into different products, of which the main one is red blood cells (RBC). RBC have a shelf life of 35 days. RBC comprises 80% of stock and is the chief source of wastage and shortages. RBC are measured in "units" of 400ml. Blood products are stored in the PTI Centre's (NBS) blood bank until they are requested by the hospitals served by that Centre. For reasons of simplicity when we refer to blood we mean the RBC units.

Delivery takes place mainly once per day either in a start like mode in which each hospital is serviced separately or on a multi-stop mode serving many hospitals at once.

The ordering system is highly complex. Local practice varies and all hospitals have slightly different ordering policies. However, the main ordering system is defined according to the following process: Individual doctors are responsible for the quantity of blood products ordered for each patient in the hospital specifying how much blood is required for a given operation. Although doctors try to be precise in their orders it is common that many of them over-order to be on the safe side and allow for cases where extra blood might be needed if complications arise.

Each hospital also keeps stock of blood in their blood bank (S_H). Hospitals get doctors' orders (O_{Dr}) daily and satisfy as much as they can from their stock (S_H) and order (O_H) the remaining units from the NBS Centre's blood bank stock (S_{NBS}). The NBS issues (I_{NBS}) the hospital's order on the same day if units are available. The delivered blood is cross-matched (tested for compatibility) for a named patient according to doctor's order. It is placed in the "assigned inventory" for that patient for a period of time until a transfusion is scheduled. Untransfused blood units are returned to the hospital bank and can be used for the next doctor's request. In practice, on average only 65% of the cross-matched blood units is actually transfused (T) and 35% return to the hospital blood bank to be assigned to other patients. Returns to the NBS Centre are not allowed. Hospitals purchase blood units from the NBS for the price of £140 each.

Figure 1 portrays the basic logic of the model in the form of a flow diagram. The dotted arrows represent information flow (orders) whereas the normal arrows represent product flow.

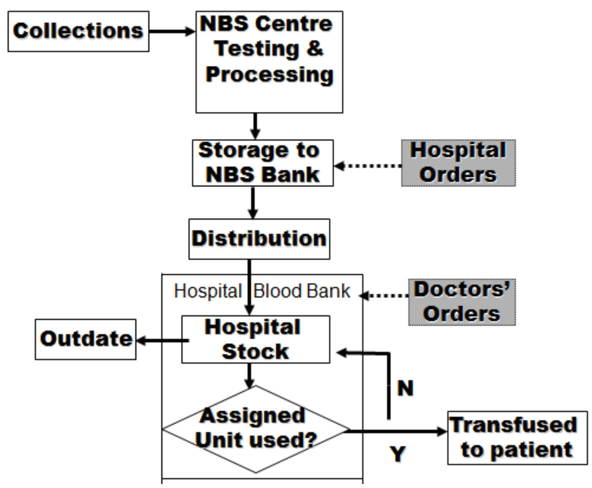

Figure 1: Flow diagram of the blood supply chain with orders from 1 hospital

5 DESCRIPTION OF THE MODEL

The game has been developed to mimics the routine processes of the supply chain of blood for a particular NBS Centre which supplies three hospitals of different size in terms of blood consumption.

Blood collections from the NBS Centre are gathered to match the requirements of all three hospitals together. Historic data have shown that weekly collections are approximately 580 units of blood. However the daily collections fluctuate according to the probability distribution shown in Figure 2a. This means that on Mondays, average collections are 20% of the weekly collection of 580 units and so on. During the weekend there are no collections or processing taking place. The processing and testing (Pr) takes a day to be completed and thus blood units are available in the NBS Centre's blood bank for stocking and shipping in the next morning. This implies that Monday collection reaches the NBS bank on Tuesday morning, Tuesday collection is stocked on Wednesday and so on. Friday collection is stocked only on the following Monday as the service closes on Friday evening and the available processing time is not sufficient. Unlike collections and processing, NBS deliveries operate on a 7 days a week basis.

Hospital Doctors' orders (O_{Dr}) are placed according to patients needs. Hence, doctors' orders in terms of blood units clearly differ between hospitals, since each hospital performs a different combination and number of transfusions according to the number of patients and needs. From past experience it is known that weekly doctors' requests for the for the small hospital (H1) are around 110 units, for the medium hospital (H2) are 300 blood units and for the big one (H3) are 495 units; 905 units all together of which the small hospital represents 12% of all doctors' orders, the medium represents 33% of all orders and the big 55%. However similar to collections, there is a daily fluctuation in doctors' orders which is usually common to all hospitals and is related to the patterns of patient arrivals to hospitals. These daily fluctuations are shown in Figure 2b:

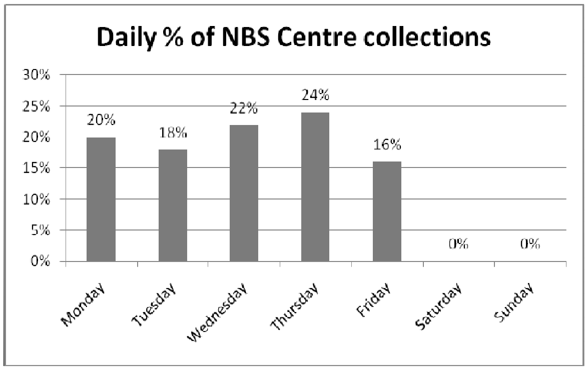

Figure 2a: Daily NBS Centre blood collections

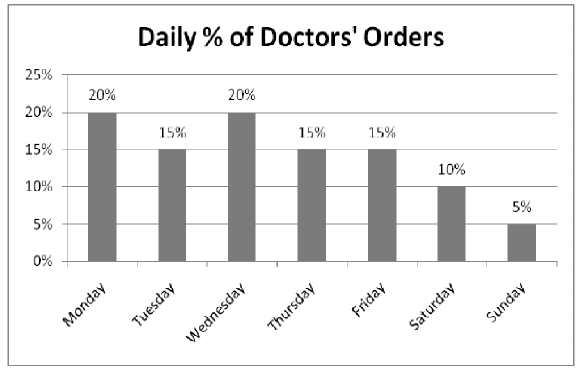

Figure 2a: Daily % of Doctor' blood orders

Doctors' orders (O_{Dr}) are usually placed once a day in the morning or afternoon. Each hospital checks its stock (S_H) in the hospital bank and satisfies the doctors' orders from its stock otherwise order from the NBS Centre stock (S_{NBS}) as many units as it is necessary to fulfill the doctors' request. As mentioned above, at the end of the day approximately only 65% of doctors' requests are actually consumed/transfused (T); the remaining 35% of the blood units are returned to the hospital stock and are used together with other residuals to satisfy next day's orders. For reasons of pedagogic simplicity we do not consider different types of blood groups or blood groups compatibility issues in the Game.

Mathematically, the structure of (1) the individual hospital stock (S_H), (2) transfused units (T) and (3) hospital orders (O_H), are given in Equations 1 to 3 (all measured in blood units):

$$S_H(i,d) = S_H(i,d\text{-}1) + I_{NBS}(i, d\text{-}1) - T(i, d\text{-}1) \quad (1)$$

If

$$65\% O_{Dr}(i,d) < S_H(i,d) + I_{NBS}(i,d)$$

$$T(i,d) = 0.65 * O_{Dr}(i,d) \quad (2a)$$

Else:

$$T(i,d) = S_H(i,d) + I_{NBS}(i,d) \quad (2b)$$

$$O_H(i,d) = O_{Dr}(i,d) - S_H(i,d) \quad (3)$$

Where I_{NBS}= NBS issues, O_{Dr}= Doctors' orders d= day number and i =hospital identification number

Hospitals requests in blood units (O_H) come in different times of the day in mixed order but mainly until 6pm. The Centre's stock changes during the day as follows: Early in the morning the new processed units (Pr) are added to the previous day Centre's stock (S_{NBS}). The hospitals orders (O_H) arrive later at the day and the player (distributor) needs to make a decision of how much of the hospital's order to satisfy (I_{NBS}). The stock goes down by this amount every time an order is issued/shipped to a hospital. Each delivery to the hospital and back costs the distributor (NBS) £30 regardless of the number of units transferred. This cost (C_{Tr}) covers the drivers' pay, fuel and maintenance variable expenses as well as fixed costs of purchasing the special vans with the freezers. The NBS stock is re-calculated up to 3 times after each decision of how much to issue to a hospital is made. Equation 4 computes the new NBS stock (S_{NBS}) at the end of the day.

$$S_{NBS}(d') = S_{NBS}(d) - \sum_{i=1}^{3} I_{NBS}(i,d) \quad (4)$$

Where $S_{NBS}(d) \geq 0$

Unsatisfied orders (UO_H) from the NBS to the hospitals (Equations 5) are considered as a major drawback of the NBS service and the approval and rating from the hospitals, public opinion and Ministry of Health diminishes. Moreover, an ultimate dissatisfaction arises when not only hospital orders but patients needs in blood are left unsatisfied (UP_H) (Equation 6). This means that a patient's life may be at risk because the patient will not get the amount of blood needed during the transfusion process due to over than 65% unsatisfied doctors' orders. To incorporate this dissatisfaction into the process of the supply chain there is a loss cost associated with each unsatisfied order (C_{UO}) of £40 and a much higher one of £500 which is associated with an unsatisfied patient (C_{UP}) who did not receive the amount of needed blood (In the real blood SC these costs are plasmatic.).

When $O_H(i,d) > I_{NBS}(i,d)$

$$UO_H(i,d) = O_H(i,d) - I_{NBS}(i,d) \tag{5}$$

When $0.65 * O_{Dr}(i,d) > T(i,d)$

$$UP_H(i,d) = 0.65 * O_{Dr}(i,d) - T(i,d) \tag{6}$$

Another point that needs to be taken into consideration is the importance of keeping stock balanced. If NBS stock increases, eventually blood outdates will occur and the stock will be reduced due to the perishability of the good. From experience it has been noted that if the sum of the weekly stock (S_{NBSw}) from Monday to Sunday increases in two consecutive weeks by more than 5%, then 50% of this increase is stock that has been outdated/perished (Pe) (Equation 7).

For d=14 and d= 28

$$Pe(d) = 50\% * [S_{NBSw}(w) - S_{NBSw}(w-1)] \tag{7}$$

where w=week number

This means not only that these blood units have to be subtracted from the NBS stock next day (Monday) (Equation 8) but also that handling costs occur (C_{Pe}) every other Monday which are estimated to £30 per outdated unit for discarding the perished blood.

For d=15 and d= 29

$$S_{NBS}(d) = S_{NBS}(d-1) - \sum_{i=1}^{3} Pe(i, d-1) + Pr(d) \tag{8}$$

The NBS pays £100 for PTI of each processed blood unit (Pr) but also losses money because of unsatisfied orders and unsatisfied patients. The NBS revenue (R_{NBS}) is generated by the hospitals which pay the NBS £140 for each delivered blood unit (I_{NBS}). There should be a good balance between the cost of production and distribution and the revenue gathered from hospital purchases. Any profit (P_{NBS}) made by the NBS goes to R&D which is vital for processing and testing breakthroughs which may have direct medical effect. One must also considered that the budget of the hospital is not unlimited.

Equation 9 exhibits the NBS profit function for each day of the game whereas the Total NBS Profit for 28 days that the game lasts is calculated in Equation 10:

$$P_{NBS}(d) = R_{NBS}(d) - C_{PTI}(d) - \sum_{i=1}^{3}[C_{UO}(i,d) + C_{UP}(i,d) + C_{Pe}(i,d) + C_{Tr}(i,d)] \tag{9}$$

where C_{Tr} = Transportation Cost

$$\sum_{d=1}^{28} P_{NBS}(d) = \sum_{d=1}^{28}[(R_{NBS}(d) - C_{PTI}(d)) - (\sum_{i=1}^{3}(C_{UO}(i,d) + C_{UP}(i,d) + C_{Pe}(i,d) + C_{Tr}(i,d)))] \tag{10}$$

6 TEACHING APPROACHES

The game described in this paper is played in a computer station. A Visual Basic for Excel application was developed for this purpose. With the program, the game is easy to run and fun to play. The only requirement is a computer with Excel for Office '97 or more recent. The structure of the game and the customizability of the parameters allow different hypotheses to be tested under controlled conditions. The ease with which data is recorded and compiled lets players build their understanding as the game progresses. Also it allows instructors to build a comprehensive database of experimental results. Below we present teaching approaches for playing the game together with some screenshots from the game's results. The game's graphical user interface is given in Figure 3.

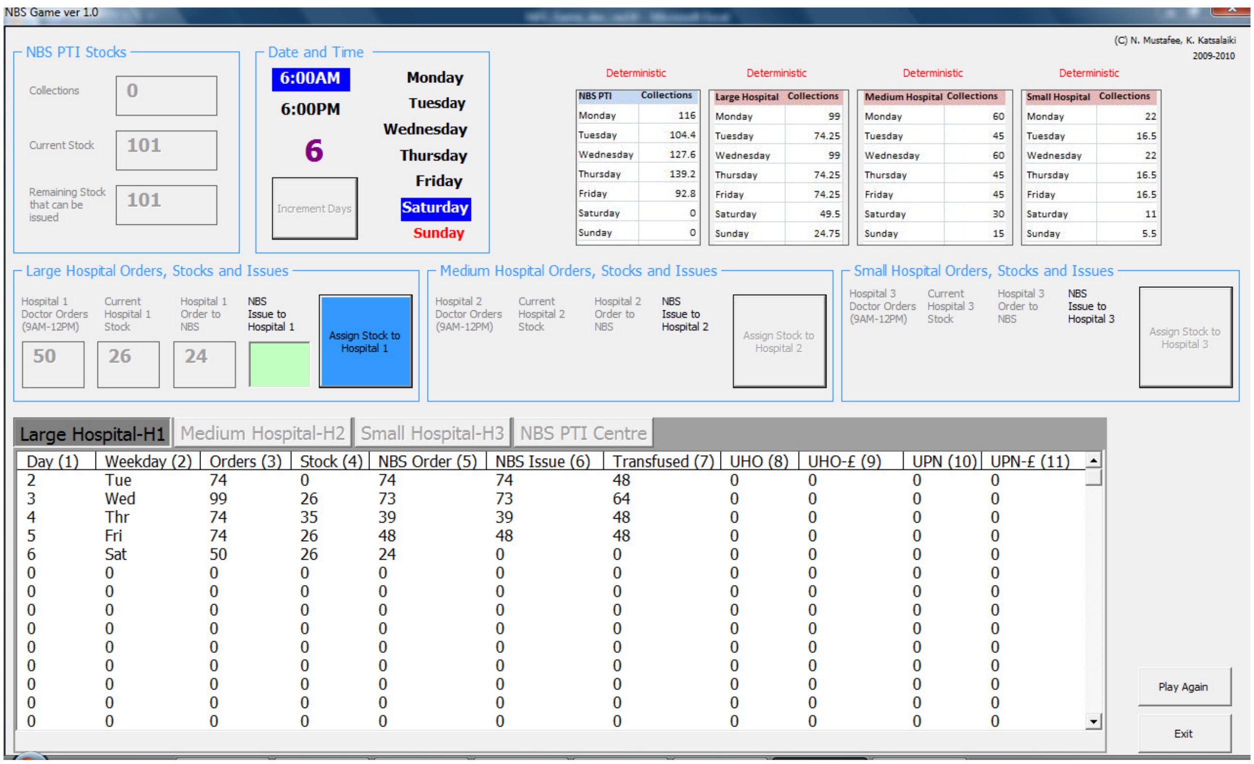

Figure 3: Graphical user interface of the Blood Supply Game

Following the logic of the game described above, the aim of the player is to make such decisions that maximise the 'profit' of the NBS which is highly related with satisfying as many hospital patients as possible and as many hospital orders as possible. The main question that the player has to answer is how much of each hospitals' order to satisfy considering its limited stock. At the beginning of the game the players are usually encouraged to satisfy the whole amount of order with the sequence that this arrives to the NBS until stock runs out. The remaining amount of orders will be left unsatisfied and usually this affects the hospital that requests blood last. They are advised to monitor unsatisfied orders and patients as well as occurring costs. They are also advised to examine whether a particular hospital is unhappy with this policy as its orders are left more often unsatisfied than other hospital orders. Therefore, the game is played by satisfying the whole amount of orders in the sequence they arrive until there is no more NBS stock left.

Typical results are shown below. As we see in Figure 4 the pattern of the NBS stock is repeated every week and is steady. Unsatisfied orders and patients are much more in the big hospital (Figure 5). In table 1 we observe that the NBS generates profit for R&D although there are unsatisfied orders and patients.

No blood units have perished and there is a close match between NBS issues to hospitals and NBS processed units.

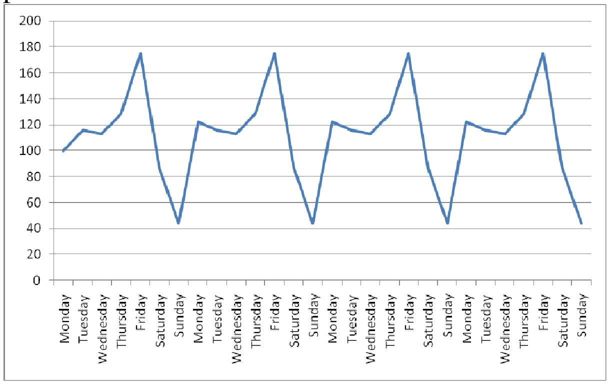

Figure 4: NBS stock units (scenario 1)

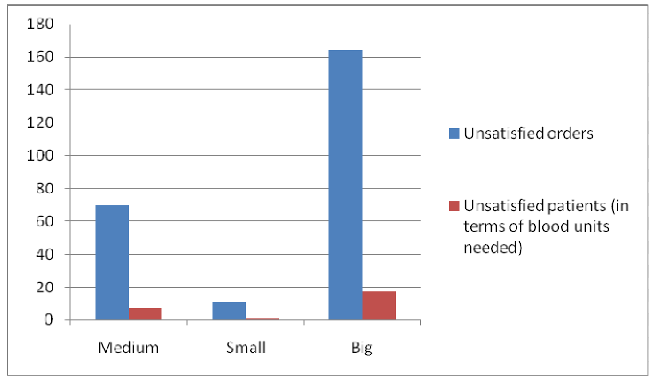

Figure 5: Unsatisfied Orders/Patients per hospital (scenario 1)

Table 1: NBS profit calculation (scenario 1)

Revenue	Units	Cost
NBS Issues	2298	£321,720
Expenses		
NBS PTI	2327	£232,700
Unsatisfied orders	245	£26,560
Unsatisfied patients	25	£12,500
Perished units	0	£0
Transport	28	£2,520
NBS profit for R&D		£47,440

After the first results are shown on the computer screen and relevant comments are made by the students and instructor, the players are encouraged to play the game and decide on how much of each hospital orders to satisfy according to their judgment. In this case results depend on how well the player has understood the process of the supply chain. However, although the values are deterministic and all variables can be predicted with appropriate calculations, due to the complex interconnection of these variables, some players may get the impression that there is some randomness in the process of hospital orders that cannot be easily predicted.

The players are then advised to follow other policies to correct the problems. A suggested one is to try to collect more blood and thus satisfy more hospital orders. The player can change the number of units collected per year by the NBS. Below you can see results when choosing to collect 15% more than the initial. Thus around 670 units per week. The results shown in Figures 6 and 7 and Table 2 are not satisfactory. The NBS stock (Figure 6) in the duration of two weeks' time has an increasing trend and then falls due to perishable units been removed from the bank. This latter produces waste of 576 blood units (see Table 2). The distance between processed and issued units has increased as well as the number of unsatisfied hospital orders and patients. These causes overall loss of £47,320. So, although increased NBS collections do not satisfy more hospital orders because of the complex mechanisms of the system and basically the perishability of the product.

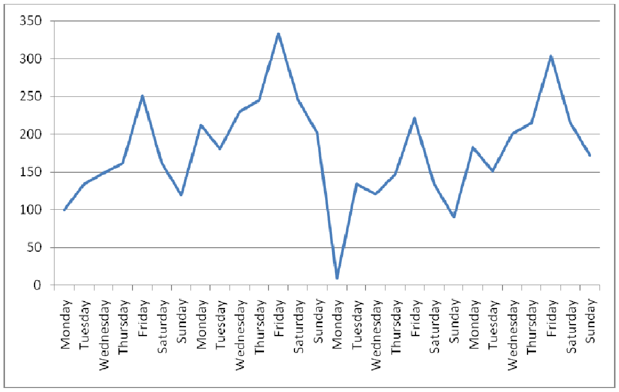

Figure 6: NBS stock units (scenario 2)

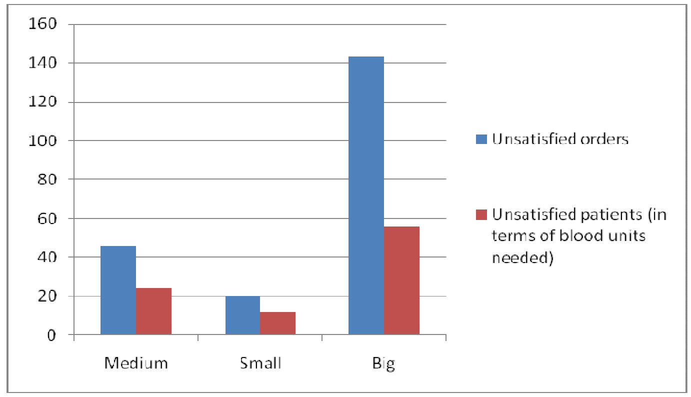

Figure 7: Unsatisfied Orders/Patients per hospital (scenario 2)

Table 2: NBS profit calculation (scenario 2)

Revenue	Units	Cost
NBS Issues	2231	£312,340
Expenses		
NBS PTI	2673	£267,300
Unsatisfied orders	664	£26,560
Unsatisfied patients	92	£46,000
Perished units	576	£17,280
Transport	28	£2,520
NBS profit for R&D		-£47,320

Following this disappointment the instructor can try to elicit from the players new strategies which could follow as distributors of this supply chain to improve results. This can happen by allowing them to interfere in the logic of the game more drastically. A new distribution strategy that can derive from this brainstorming is the following:

The NBS-distributor can exercise more control over the hospitals. It could delay shipping until all orders from hospitals have been placed and then decide on the units to be issued in each hospital. It could also request that hospitals should place orders until e.g. 2pm otherwise no delivery will take place on the same day (nevertheless we should note that hospitals may not place orders every day as they may satisfy doctors' orders from their own stock). Then the decision maker (distributor) can work out a fair policy to satisfy all hospitals taking into consideration its total NBS stock for the day and the total hospital orders for the same day. Such a fair policy could be that all orders are satisfied by an equal proportion (Equation 11).

$$\text{If } S_{NBS}(d) \leq \sum_{i=1}^{3} O_H(i,d) \text{ then}$$

$$a = \frac{S_{NBS}(d)}{\sum_{i=1}^{3} O_H(i,d)} \cdot 100\%$$

And each hospital is receiving:

$$I_{NBS}(i,d) = a \cdot O_H(i,d) \tag{11}$$

In this case the transportation cost will also differ. Following this distribution policy NBS can use the multi-stop transport mode which costs only £50 returned journey to satisfy deliveries in more than one hospital. Results from this option are shown in Figures 9&10 and Table 3. (The number of collections is decided by the player. For the results below the initial scenarios' collections were used). Under these circumstances NBS stock is stable again. In Figure 9 surprisingly we observe a big number of unsatisfied orders but no unsatisfied patients. This is the effect of satisfying a proportion of each hospital's orders and this although for each hospital some order are undelivered overall there is steady stock in the hospital's bank to satisfy patients real needs. The NBS also makes a bigger profit that the initial scenario. Some savings are also observed due to the use of multi-stop transport.

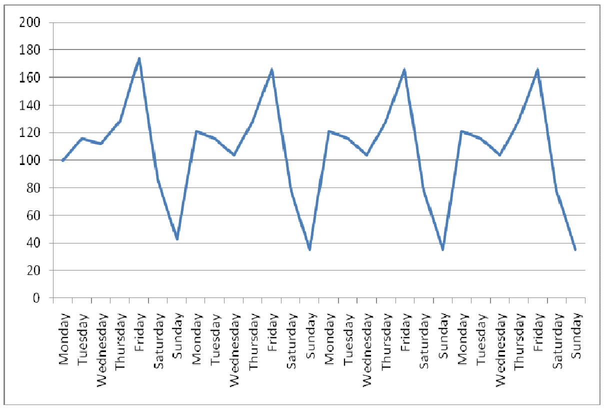

Figure 8: NBS stock units (scenario 3)

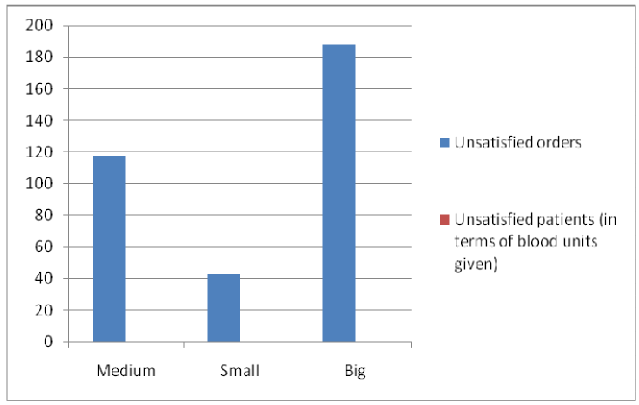

Figure 9: Unsatisfied Orders/Patients per hospital (scenario 3)

Table 3: NBS profit calculation (scenario 3)

Revenue	Units	Cost
NBS Issues	2323	£325,220
Expenses		
NBS PTI	2327	£232,700
Unsatisfied orders	664	£26,560
Unsatisfied patients	0	£0
Perished units	0	£0
Transport	28	£1,400
NBS profit for R&D		£64,560

The players can be asked to propose further solutions to this supply chain that may improve its overall performance by being able to interfere in the processes of the hospital side of the supply chain too. These recommendations can be used to extend the game by allowing more policies to be tested.

7 CONCLUSIONS

In this paper, we have introduced a simulation game to teach some of the main supply chain management principles. Like the Beer Game, we chose to model a specific application as opposed to using a generic model. A specific application has much greater pedagogical value because participants are more likely to assume the roles within the game and make the simulation more closely mimic reality (Anderson and Morrice 2000). Moreover, we use a PC version of the Game as an effective tool for teaching SC management strategies in an easy and funny way.

In general, the Blood Supply Game describes a real supply chain of a vital product. It can be used to illustrate supply chain management principles in a special make-to-stock environment. The Game provides a realistic application as well as an initial analysis of players' behaviour during the Game. Some of the Game rigours are that processes are not too simplistic and the assumptions made are logical without compromising much of the complexity involved in the process.

Three main points of the Game were identified. The first point was to illustrate the supply chain dynamics resulting from different orders and stock distribution. The second point was to illustrate how fragile is the balance of supply and demand of a perishable product. The third point was to identify practices that improve the supply chain performance within the given circumstances. Therefore, during the class each player executed at least three scenarios.

As future research and development, we plan to design a probabilistic (and more realistic) version of this game to incorporate random variables regarding the distributions of collections, doctors' orders, and % of transfused units. We also plan to further elaborate on the existing scenarios and introduce new ones. Then the game will be tested in class and present students results and extracted lessons from classroom experience. Further plans include the development of a multi-player version of the NBS game, wherein multiple players will be able to collaboratively play the game over a network.

We suggest that a feedback session be conducted after the Blood Supply Game is played under all recommended strategies. The provision of aggregated results is of great pedagogical value. Game participants learn from their own results as well as of the results of others. Additionally, they get the opportunity to observe trends in the data, which is especially important for understanding the process of improving performance measures and SC effectiveness.

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