QATAR UNIVERSITY

COLLEGE OF ENGINEERING

LEARNING SUPPLY CHAIN MANAGEMENT DYNAMICS

THROUGH USE OF AN INTERACTIVE ONLINE GAME

BY

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ABSTRACT

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Title: Learning Supply Chain Management Dynamics Through Use of an Interactive Online Game

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Supply chains consist of a multitude of processes related to procurement, manufacturing, inventory, transportation, logistics, distribution, and so on. These processes are subject to various sources of variability and randomness, and generally, involve activities of several independent business entities. One of the challenges of teaching Supply Chain Management (SCM) themes is that traditional students often have no – or limited – practical work experience and then have several difficulties in translating conceptual knowledge into a concrete plan of action. The use of only textbooks may be inadequate to present the real-world complexities of supply chains and, more importantly, put students in the position of managers and decision-makers who have to make real practical decisions. Simulation games, however, provide an alternative pedagogical approach that can assist the understanding of theories, put ideas into action and educate in an interactive and enjoyable way. This paper presents an example of a web-hosted spreadsheet game bridging the gap between the theoretical and practical aspects of SCM. The model can be used to learn a wide range of SCM aspects including demand forecasting, production, inventory and transportation management as well as demand elasticity and marketing related aspects. Moreover, the game explicitly addresses sustainability topic by considering control policies on carbon emissions.

DEDICATION

I dedicate this work to my loving parents for their greatest motivation and continuous

support, it will always be remembered.

I dedicate this work also to my beloved wife and children for their endless support and

patience, couldn't achieve this work without it.

ACKNOWLEDGMENTS

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Background

The new generation of young people becoming university students and new entrants in the workforce are most likely born after 1990 together with the Internet, and mobile technologies are commonly known as the "Digital Natives." Unlike those who just a shade older, this new generation is different along many dimensions.

For instance, digital natives play, access information, communicate with each other and learn in a complete digital immersion; they only know the world they grew up in, a world that is digital.

The digital revolution did not only transform the new generation's profile, but it transformed most significant aspects of modern life: Information is, for instance, more than ever available and accessible, the business can be done over greater distances, and most of our daily routines are no longer the same.

With such a fast life rhythm, however, there is a worldwide concern that most educational systems are outdated and are no longer tailored for the native digital generation. People are demanding to know things differently. They lost the patience of spending hours reading books or look into library publications. Moreover, they cannot hold on to a couple of hours lecture of dry speech with their minds entirely focused trying to follow up while the lecturer is jumping from one concept to another. Nevertheless, the traditional source of information and knowledge like books or newspaper are no longer a preferred choice. On the other hand, it is noticed that the digital revolution has not driven enough transformation of teaching and learning processes in classrooms to cope with this these lifestyle evolutions.

1.2 Problem Statement

In the field of engineering management, supply chain management is one of the most complicated topics that teaching it with narrative classes away from real life experience can be a challenging task.

The question is how to develop a functional and productive learning and studying approach to teach supply chain management that better engage and fit the needs of the new generation, and deliver a better understanding of this topic, including the complicated concepts that may require more than a projector and a speech.

1.3 Literature Review

A first significant step towards the achievement of this noble objective is that educators and instructors admit that –as pointed out by Marc Prensky (2012, p.68)- "today's students are no longer the people our educational system was designed to teach". Although the notion of digital natives is very controversial, and there is no scientific evidence that their cognitive systems are profoundly different from previous generations (Euro CULT,2015), educators need, however, to recognize that the knowledge practices of the digital natives are entirely different and present many specificities mostly driven by the new ICT tools. Typical knowledge practices for this generation are claimed to be multi-tasking, they are also reading comfortably from screens, are fond of computer games, and are using social media extensively (Euro CULT,2015). A deep understanding of these knowledge practices is the success key to designing the adequate learning and teaching approaches. In fact, any learning approach that is not presenting a digital footprint would be more likely to be rejected by the digital natives. On the other hand,

digital natives will be more responsive to learning approaches that are closely related to what they are already using in their daily lives (i.e., mobile technologies, tablets, YouTube, digital interactions, etc.). In other words, educators should take advantage of the emerging ICT tools to make their teaching approaches more dynamic, innovative and appealing.

Simulation games, either in the manual participative or computer-based form, have become popular teaching tools for active learning in education (see (McClartyet al.2012) for an extensive review. In particular, educators felt the need to go beyond the boundaries of the traditional lecturing in teaching SCM since many decades. The most popular game which is part of many SCM curricula is the Beer Distribution Game developed at MIT about 25 years ago (Sterman J D, 1989). The beer game went through several improvements and different versions have been created since then. With the development of ICT technologies and tools, many other simulation games have emerged and have been used extensively to teach SCM aspects. For example, Anderson & Morrice (2000) have designed a mortgage service game to teach service-oriented SCM principles with no inventory where backlogs are managed through capacity adjustments. Barari et al. (2012) designed a game related to the analysis of green supply chain contracts with emphasis on sustainable development through proper pricing and marketing exposure. A game-based approach towards facilitating decision making for perishable products with an application to blood supply chain can be found in (Katsaliaki et al. 2014). Tobail et al. (2011) developed an interactive business game called Automobile Supply Chain Management Game (AUSUM) where, using theories learned in class as a knowledge base, participants have to develop effective supply chain partnership strategy to enhance

their supply chain networks. This list is not exhaustive but gives a close picture of different games developed in the field.

When it comes to deciding on a game to be used in the classroom, there are some COTS (Commercial Off the Shelf) games that can be used for educational purposes, but the question what be if they are suitable for classroom or not? Some argue about the usability of such games in the classroom for many reasons such as the requirement for higher hardware (Benson, 2014) or it may not match the exact need of the material being discussed in the classroom. Which raises the concern to have customized education games where the purpose of them are tailored to the educational goals of the taught classes.

1.4 Project Objective

This project is devoted to seek an alternative way of teaching supply chain management topic. That is by developing an interactive online game that is customized to the use of the classroom, and help freshmen students/beginners to be familiar with supply chain concepts and recent trends. Most importantly to allow students to play the role of supply chain managers, which in turn will help them learn the supply chain concepts by doing/practicing. The developed game should achieve below main goals:

1. The game should be implemented using modern web technologies that provide interactive features.

2. It should encourage collaboration between students by using multi role approach.

3. It should address sustainability aspects, namely carbon emissions.

4. It should leverage sense of competition between playing teams.

Different from other existing games, the model discussed in this paper is presenting several advantages and has overcome many of the existing limitations.

First, to the best of our knowledge our model is covering the broadest SCM scope. For instance, many of the existing games are oriented to teach only one or few concepts of SCM, and some of the game is even dedicated to a particular SCM practice such as production or inventory management. It is believed that emphasizing on only one or few aspects of SCM will not give a close picture of the reality where decision makers are supposed to get involved in an integrated series of decisions over the entire supply chain. In addition to capture a wide range of operational decisions related to forecasting, inventory, production, and transportation, the game is capturing marketing decisions where players can adjust their advertisement strategy and understand the notion of demand elasticity. Moreover, the game includes explicit consideration and targets on carbon emission in the SC decisions to emphasize on the recent trend on sustainability. Finally, the game presented in this project differs by its creative structure, for instance, it supports both individual or team play mode and can be played in a competitive environment where teams compete against each other which creates a more enjoyable environment and gives a close picture to market competition.

The project report will be organized as follows; in the next section, the game structure and model will be presented. In section 3, the educational purposes and lessons learned will be discussed. Section 4 will conclude by providing the findings and recommendation

CHAPTER 2: GAME CONCEPT AND DESCRIPTION

2.1 Game Concept

Supply chain management is an extensive topic and presents infinity of structures. Therefore, the first challenge was to identify the boundaries of the learning concepts. In this setting, the game will be centered around basic supply chain fundamentals including Production management, Inventory management, transportation decisions and demand forecasting. In addition to these basic notions, the scope is extended to cover some recent trends and challenges such as pricing decisions and sustainability.

2.2 Covered Supply chain topics in the game

The production, distribution, and sales processes are essential elements on supply chain network, and whether they belong to the same organization or different entities, they require a considerable amount of planning and control, in addition to analyzing both actual and previous demand data to determine future trends and control the flow of items accordingly. During supply chain classes, the student is being taught many topics and concepts like the following:

- Inventory Management

- Production scheduling

- Demand forecasting and trends

- Price elasticity

- Sustainability in supply chain management

In most cases, those topics are being taught in separate chapters/classes or even courses, and the student most likely will not link between them or work them out in parallel to experience the effect of one topic against the others, which the soul concept

behind the supply chain management concepts. Besides, in each of the above topics, multiple mathematical models, equations and concepts being taught, and even practiced throughout the course or during the exam. However, in such a separation of topics, the student will deal with them as numbers of paper or as mathematical questions to be solved using the selection of correct corresponding model or equation, which may lack the understanding of the concept or reason behind it.

The objective of this supply chain game is to bring those concepts close to the understanding of the student by showing them how each of those decisions and parameters contributes to the overall performance of the supply chain. Through this interactive exercise, the student should gain the following learning outcomes:

- Understand the dynamics of the production line, and the factors that need to be considered to deiced how much to produce each month

- Understand the challenges in controlling inventories, stocking items or using order to produce strategies, and the characteristics of each approach

- Determine the mechanism for when and how much to move items between the plant warehouse and retail inventory based on market readings, forecasts and changes in demand.

- Learn how to adjust the demand and make use of price and demand elasticity features of the market by adjusting the price to achieve better revenue or to control demand for limited stock items

- Control   the   emissions   out   of   the   supply   chain   stages

(production/transportation/inventory) within the mandated limits to avoid high penalties or an increased tax on revenue, and to invest on carbon reduction equipment as needed to keep the emission levels as low as possible.

2.3 Supply chain structure

The supply chain of this organization consists of three two parties located in two different locations: one location that has a production plant where it runs the production line and a warehouse to hold the inventory of the produced items. In another location within the city, there is the retail store to sell the items, and another warehouse to store stocked inventory for sales.

Items are shipped from "plant" warehouse to "retail" inventory using Air or Vessel (with different shipment costs and lead times for each shipment type). Also, items are being sold in the retail store considering a given demand and subject to stock availability and defined price.

All production, transportation, and retail operations have their associated carbon emission levels that needed to be controlled throughout the game. The overall supply chain can be illustrated as in *Figure 1*.
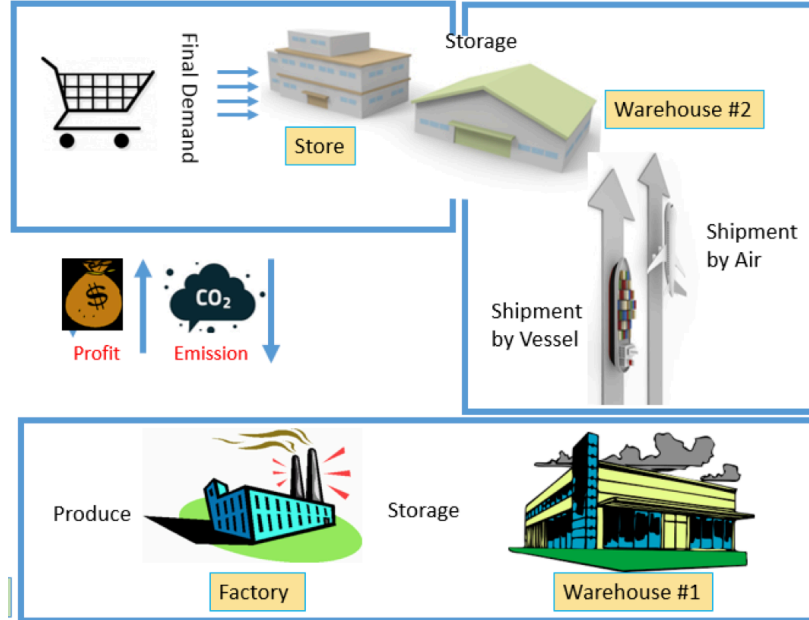
Figure 1. High-level view of the Supply Chain

The Revenue for each month is calculated by multiplying total net demand of the current month by the price point set for the same month

However, the cost structure is composed of multiple elements across the entire supply chain as demonstrated in the following chart:

Figure 2. Cost Structure Breakdown

Similarly, the total carbon emissions from the entire supply chain are aggregated and summed up as follows:

Figure 3. Emission Sources Breakdown

2.3.1 Cost structure details

The overall cost of the supply chain consists of the following:

- Production Costs consist of the following items:
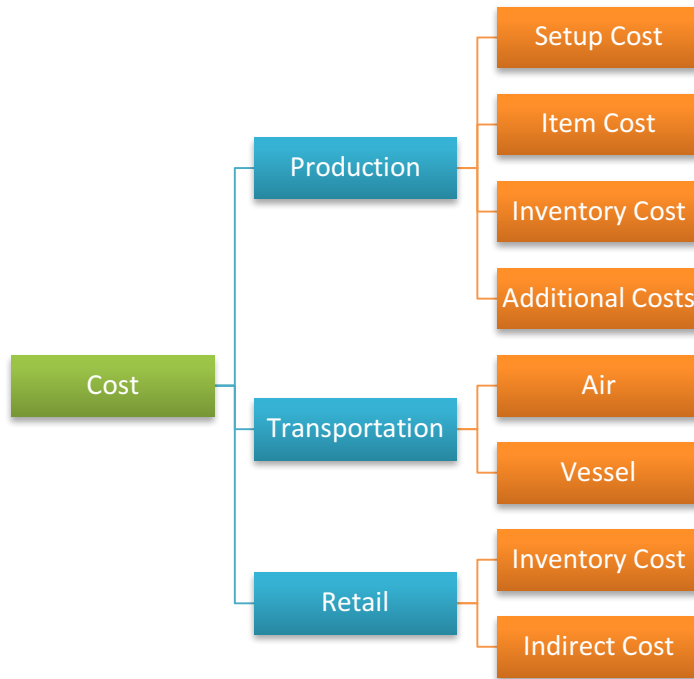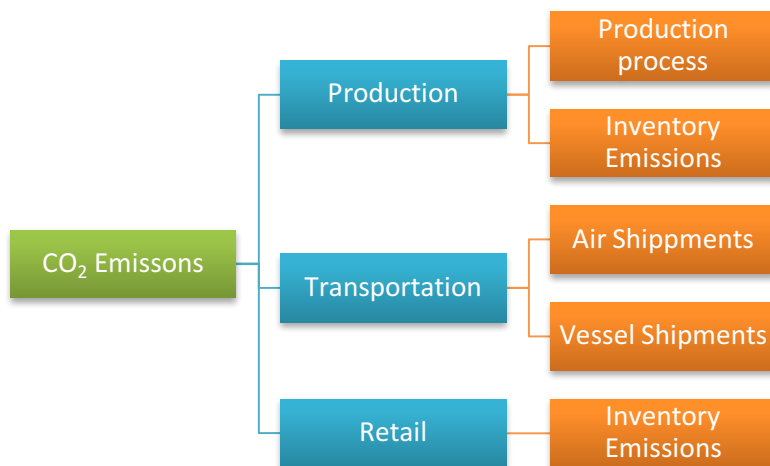
  - Production Setup costs: the one time cost associated with initiating the production line to produce one batch/order of items.

  - Item production cost: The calculated cost of producing one item

  - Inventory costs: the monthly cost of holding one item in the plant warehouse before transporting it to the retail warehouse.

- Transportation Costs which consist of:

  - Cost of shipping one container by vessel (each container can hold #X# Items)

  - Cost of shipping one item by Air

- Retail Costs which is the monthly cost of holding items in the retail inventory warehouse.

A complete detail out of all parameters that the game model consists of, and how cost, revenue, and emission levels are being calculated considering those parameters, can be found in Game Model section.

2.3.2 Emissions constraints and policies

As mentioned earlier, all the operations in throughout the supply chain contribute to the overall carbon emissions as follows:

- Production emissions which come from the running the manufacturing process, as well as storing the items in the plant warehouse.

- Transportation emissions are yielded by the vehicles that transport the items from plant warehouse to retail warehouse.

- Retail emissions are produced mainly from storing items in the retail inventory.

Total emissions levels result from above operations should be controlled according to one of the below carbon policies (depends on the type of the game selected by the instructor or game moderator):

Policy A: Carbon Tax policy

In this policy, the organization will be charged a tax amount that is proportional to their emission levels. Therefore, it's in the best interest of the company to keep their total emitted carbon levels as low as possible to avoid paying higher taxes.

Policy B: Carbon Cap policy

Using this policy, the total emitted carbon out of all operations should not exceed a defined limit; otherwise, a substantial penalty will be applied that will significantly impact the net profit.

Reducing production line emissions

The default amount of carbon emissions for the production line can be reduced by investing on cleaner production line methodologies and equipment, which will be factored in the overall production cost but can lead to lower emission levels as will be demonstrated in the game scenario.

2.4 Game Model

2.4.1 Cost parameters

TC is the sum of all costs of the operations at the end of the game

C_P = Total production costs

C_T = Total Transportation costs

C_R = Total retail costs

    a. **Production Costs:**

N_i is the number of produced items in month i (*a decision variable*)

S   is the setup cost to initiate the production line per one order

C   is the cost of producing one item

PIE_i is the number of items in the plant warehouse at the end of month i

PHC   is the holding cost of one item at plant warehouse

INV_i is the invested amount on carbon reduction equipment at month i

C_{Pi} is total production costs in month i

C_{Pi} **= S + N_i x C + PIE_i x PHC + INV_i**

Production Constraints:

PCap   is the maximum number of items that the plant can produce in one

         month (production capacity)

PWC   is the capacity of plant inventory warehouse

N_i <= PCap

PIE_i + N_i <= PWC

    b. **Transportation Costs:**

TA_i is number of items shipped to Retail warehouse by Air in month

     (decision variable)

TB_i is number of items shipped to Retail warehouse by Boat / Vessel in

     month i (decision variable)

TBC_i is number of containers shipped to Retail warehouse by Boat /

     Vessel in month i (decision variable)

BC   is the capacity of one container

TBC_i = ceil(TB_i / BC)

A   is the cost of shipping one item by air

B   is the cost of shipping one container by boat / vessel

C_{Ti} is the total cost of shipped items from plant warehouse to Retail

     warehouse

$\mathbf{C_{Ti}}$ $\mathbf{= TA_i \ x \ A + TBC_i \ x \ B}$

Constraints:

RWC   is the capacity of retail inventory warehouse

$\mathbf{TA_i + TB_i <= RWC}$

c. **Retail Costs:**

RIB_i is the number of items in the retail warehouse at the beginning of

     month i

RIE_i is the number of items in the retail warehouse at the end of month i

RHC   is the holding cost of one item at retail warehouse

$\mathbf{C_{Ri}}$ $\mathbf{= RIE_i \ x \ RHC}$

Total Cost at end of month i is

$$TC_i = C_{Pi} + C_{Ti} + C_{Ri}$$

2.4.2 Revenue parameters

P_i is the price point set on month I (decision variable)

P_1 is the initial price point for first month (always given)

D_i is the net demand on month i

ΔP is the relative difference between month i price and previous month's

price i-1

ΔP_i $= \frac{P_i - P_{i-1}}{P_i + P_{i-1}}$

D_e is the demand elasticity based on the price changes ΔP_i for month I

(configured value)

LS_i is the lost sales occurred on month i because of shortage of items on

inventory against the given demand of month i

LS_i $= | \min(RIB_i - RD_i, 0) |$

α_{LS} Is the percentage of predicted lost opportunity that wont come back in next

month

RD_i is the actual demand value for month i impacted by price changes and

demand elasticity

Real demand for month I will depend on below factors:

-   Actual predefined demand Di

-   Alternation factors:

    o   Previous lost sales

- Price change (in case of individual / parallel markets)

- Difference from average price across the teams (in case of Shared market game)

Real Demand equation in case of parallel markets:

$$RD_i = \frac{1 - D_e * \Delta P_i}{1 + D_e * \Delta P_i} D_i - \alpha_{LS} * LS_{i-1}$$

Real Demand equation in case of Shared markets:

ΔP^x_i is the price change for player x at month i

$$\Delta P^x_i = \frac{P_i^x - Avg(\sum_{x=1}^{X} P_i^x)}{P_i^x + Avg(\sum_{x=1}^{X} P_i^x)}$$

Where X is the number of players in the game

$$RD_i^x = \frac{1 + D_e * \Delta P_i^x}{1 - D_e * \Delta P_i^x} D_i - \alpha_{LS} * LS_{i-1}^x$$

For a player x

R_i is the revenue made on month i

$R_i = P_i \times RD_i$

$R = \Sigma R_i$

2.4.3 Constraints

PC   is the change percentage of the price from previous month

PCLimit   is the maximum allowed increment of the price in one month

PC = $|\Delta P / P_{i-1}|$

PC <= PCLimit

2.4.4 Emission parameters

    a. **Production Emission**

        EP_i is the amount if emitted CO_2 from producing one item in month i

        RED   is the percentage of reduction of emitted carbon due to the invest in carbon reduction equipment

        EPI_i is the amount of emitted CO_2 from storing one item at plant inventory in month i

        TEP_i is the total emissions of CO_2 from productions' operations in month i

        TEP_i $= EP_i \times N_i \times (1\text{-}RED) + EPI_i \times PIE_i$

    b. **Transportation Emission**

        TAE_i is the amount if emitted CO2 from shipping one item in month i

        TBE_i is the amount of emitted CO2 from shipping one container at in month i

        TTE_i is the total emissions of CO2 from trasnportaions' operations in month i

        TTE_i $= TBE_i \times TB_i + TAE_i \times Ta_i$

    c. **Retail Emissions**

        ERI_i is the amount of emitted CO2 from storing one item at retail's inventory in month i

        TRE_i is total amount of emitted CO2 in month i

             $= ERI_i \times RIE_i$

d. **Total Emissions**

TEi　　is total emissions produced from all operations at month i

TEi　　$= TEPi + TTEi + TREi$

TE　　is the total carbon emissions throughout the whole game

TE　　$= \Sigma TE_i$

ETx　　is the amount of tax for carbon emissions out of the organizations'

operations (in case carbon tax emissions approach was used)

ETx　　$= TAX \times TE$

EC is the maximum amount of carbon emission that can be produced

during the game (in case of Carbon Cap emission game approach is used)

2.4.5 Profit parameters:

π　　is the net profit made at the end of the game

Net profit can be calculated in two ways, based on the type of carbon policy used

in the game as follows:

A. Use carbon tax policy:

π　　$= (\Sigma R_i - \Sigma TC_i - ETx)$

B. Use carbon cap policy:

π　　$= (\Sigma R_i - \Sigma TC_i) - P \times \max(TE\text{-}EC, 0)$

The objective of the game is to maximize the total net profit at the end of the

session by driving the revenue and costs through the decision variables and considering

the emission levels that will eventually impact the achieved` net profit.

3.1 Roles Description

The game scenario is built based on the game model to highlight three key aspects of operations management and supply chain:

- Production

- Distribution
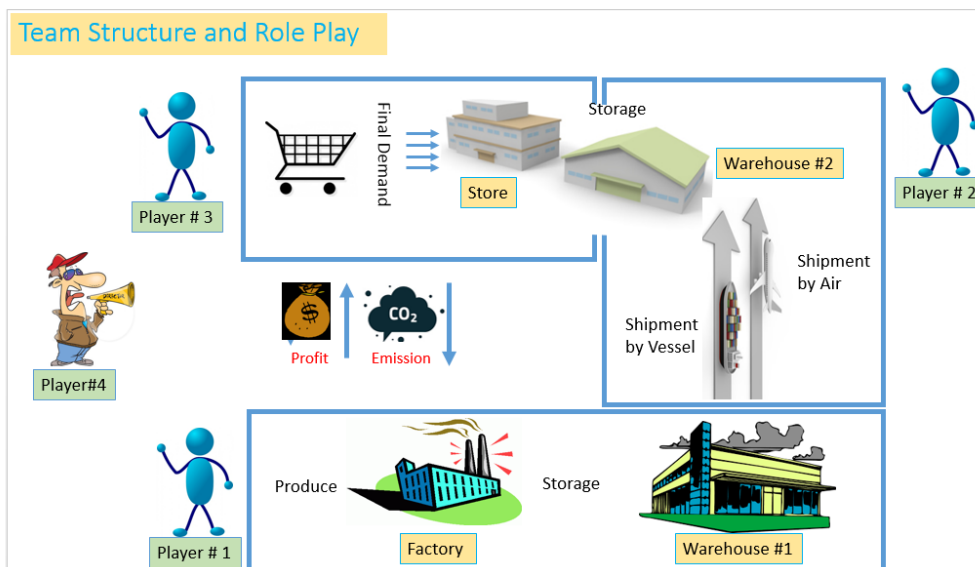
- Retail/Sales

- General Manager

Figure 4. Team Structure and Role Play

The game is supposed to be played in the class by dividing the students into groups (which will represent different companies). Each group will consist of 3 primary roles:

3.1.1 Producer

This role is responsible for managing the production line in the plant by deciding the amount of produced items every month, based on the discussion about demand with other team members, and considering items currently in inventory and their associated holding costs.

This role has to watch for following data:

- Inventory level

- Holding cost

- Carbon emissions amount

- Total production and holding cost

- Consideration Production lead time

3.1.2 Distributor

This role is responsible for controlling the transportation of items between plant warehouse and retail warehouse, as well as the inventory management of retail warehouse, considering the demand forecasts given by the Sales manager. So the main decisions to be taken by this role are:

- How many items to be shipped by Air

- How many containers to be shipped by Boat

This role should watch for following data:

- Plant warehouse inventory level

- Retail inventory level

- Retail inventory holding cost

- Total transportation costs and emission levels

- Consideration of Transportation lead times (if any)

- Boat shipments can be transported on blocks of #XX# which is considered as one container, so shipping any number under this block capacity will still cost as shipping the full container.

3.1.3 Sales Manager

This role will observe the demand in the market, forecast the future demand (that will affect production and transportation decisions) as well as deciding upon the monthly price change.

Sales manager should watch for following data:

- Retail inventory level

- Retail inventory holding cost

- Previous demand data

- Price changes

- Total Revenue and cost

- Possible demand loss in case of no enough inventor

- Carbon emissions from stored items in the inventory.

3.1.4 General Manager

The general manager is an additional role that can be added if the number of students in the class is sufficient to cover bigger team size. The role is responsible for monitoring other three roles' performance from an overall perspective and participate/control their decisions as needed. In addition to that, the general manager can

decide on investing on equipment to reduce production carbon emissions with a relative percentage of the amount invested. This investment is paid one time, and the resultant reduction will carry on from current month onwards. However, there is a predefined cap of maximum reduction that can be achieved with the usage of such equipment.
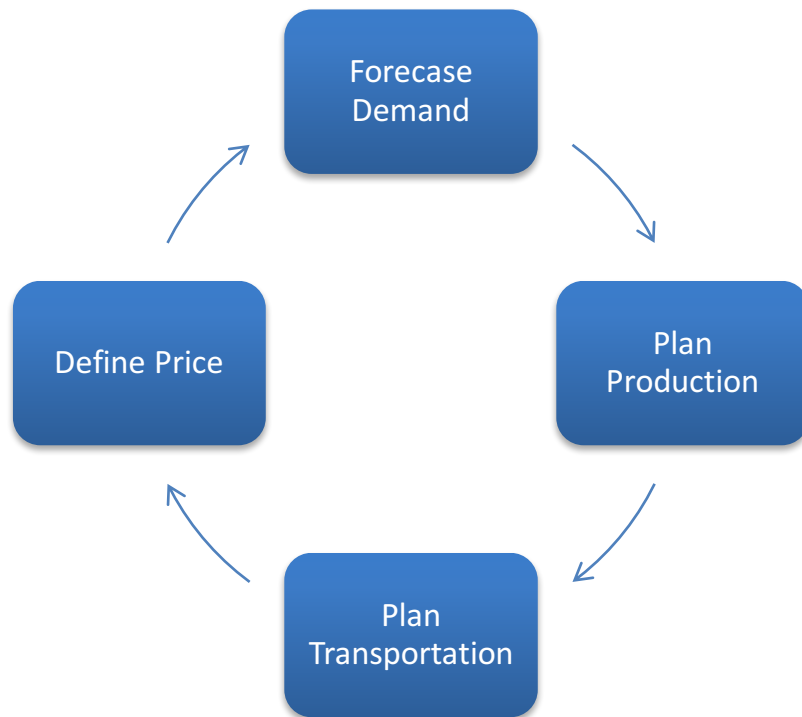
Figure 5. Decision Cycle

The table below summarizes the roles and responsibilities of each team member in the team:

Table 1

Roles Summary

Role	Observing Parameters	Decision Parameters
Producer	Plant Warehouse Capacity Plant Warehouse Level Total emission from production Total emission from inventory Forecasted Demand	Production Amount Ni
Distributor	Plant Warehouse Level Retail Warehouse Level Retail Warehouse Capacity Forecasted Demand Total emission from air shipments Total emission from vessel shipments	Number of items to be shipped by Air Number of items (containers) to be shipped by Vessel
Sales Manager	Retail Warehouse Level Total emission from inventory	Forecasted Demand Price point for current month
General Manager	Total Cost Total Emission of operations Net Revenue	Investment on cleaner equipment

3.2 Storyboard Design

This educational game is a web-based application that is built using HTML, CSS, and JavaScript for frontend and PHP as a server-side scripting language. It runs on an online web server connected to a database as the data repository. [The technical details of the application is found on Appending B. Web Application Design].

The game consists of several views (summarized below) that represent each of the roles described earlier, and each role has restricted access using a username and password that is created and provided by the Game Moderator.

[*A complete manual and screenshots for the game pages can be found on Appendix A. Game Manual*]

3.2.1 The Moderator View
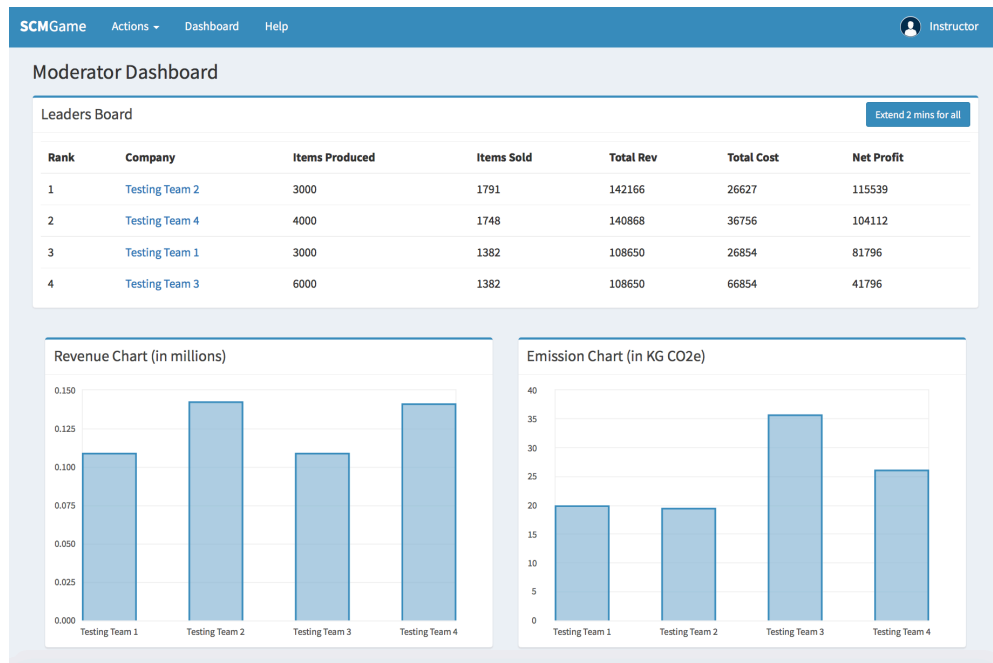
Figure 6. Moderator Main View

The master interface of the game is the Moderator view (which is used by the class instructor). In this view, the game moderator will be able to:

- Configure game settings and environment parameters

- Generate and configure market demand data

- Create and manage playing teams

- Start and cleanup game sessions and view progress of the teams

- View performance reports of the teams

3.2.1.1 Game configuration

The moderator uses this page to set all game parameters before the game starts, such as the cost of production, inventory capacities, cost of transportation and so on.

A list of all parameters that can be configured by the moderator in this section, along with their description can be found in *Appendix B*. Game Configuration Parameters

The Moderator can change any of these parameters at the beginning of a session. Any changes of those parameters will require restarting any ongoing session to take effect of new settings.

3.2.1.2 Managing companies and teams

The game is supposed to be played with competing teams; each team represents a company or organization in the market. Moreover, each team – as previously said – has four rules.

The Moderator can invite Team leaders to create their teams by generating an invitation link and sending it over to team leaders.

Team leaders then can use this link to create their accounts and their team member

accounts as well

Each company (team) should have one production manager, one distribution manager, one sales manager and one General manager which is the Team leader.

3.2.1.3 Creating and managing Demand Profiles

The moderator can generate new demand profile using a predefined uniform distribution in the code. The uniform distribution will create an initial random profile that has some seasonality on it, and then the moderator can adjust this profile and save it to be used during the game. The demand profile can then be selected in the configuration page demonstrated earlier.

3.2.1.4 View team performance

The Moderator can view overall performance of the participating teams along with the decisions that were taken during the game. This view will be typically what each student can view on his screen.

The charts presented will reflect: Total Revenue and Total Emissions chart in case of Parallel markets, and Market Share and Revenue Share in case of the Shared market game.

3.2.2 The Producer View
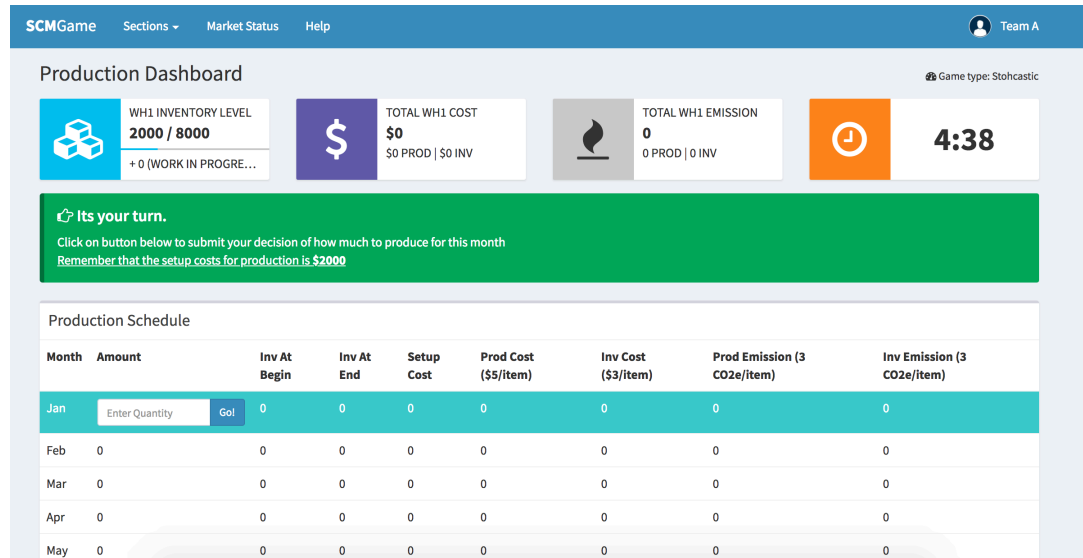
Figure 7. Producer View

The producer role is responsible for controlling the production line of the company and maintain the inventory in the plant warehouse. The primary decision that producer has to take every month cycle throughout the game is how much to produce this month, considering the demand level, inventory level and continuity of production process with least cost possible, keeping in mind the lead time to finish the requested order as well.

In production view, primary essential information is shown to the student to help in his month decisions. Those details are:

- Current inventory level and upcoming items from production orders
- Total production costs up to current (including inventories)

- Total emission levels up to the current month

- Records of previous months showing inventory levels at beginning and end of that month, how much it was produced, and how much the cost and the emissions of these produced quantities.

- Access to previous demand levels records for previous years for reference, and a view of all monthly demand of current year in case the demand type of the session was set as Deterministic

Once the game starts, the student is given a time (defined in session parameters) to discuss with the team about production decision given the information above. He is required to submit his decision before timeout.

3.2.3 The Distributor View
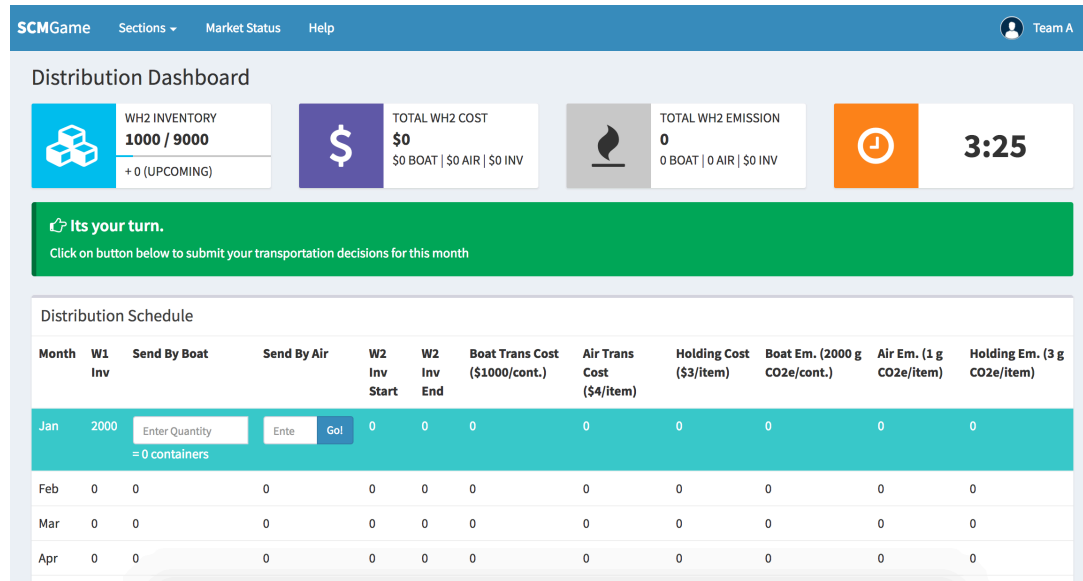
Figure 8. Distribution View

The Distributor role is responsible for moving produced items between the plant and retail warehouses. The main decision taken by the disruptor role is how much items to be shipped to retail warehouse using Air shipments and how much using Vessels.

There will be a tradeoff of using one way over another, depend on the parameters configured by the Moderator before the game starts. However, in general, Air shipment is assumed to be faster but more expensive. In the other way around Vessel shipments will release more emission than Air shipment.

The Distributor view will provide the student the below key information to help him in his decision:

- Current inventory level at retail warehouse

- Current inventory level at plant warehouse

- Total shipping costs up to current months broken down to Air and Vessel shipments costs

- Total calculated emissions released form shipping items by Air or Vessel.

- Records of previous months showing inventory levels at beginning and end of that month, how much it was shipped by Air and Vessel, and the costs and emissions of each shipment

- Access to previous demand levels records for previous years for reference, and a view of all monthly demand of current year in case the demand type of the session was set as Deterministic

Once the game starts, the student is given a time (defined in session parameters) to discuss with the team about shipment decision for this month given the information above. He is required to submit his decision before timeout.

3.2.4 The Sales View

SCMGame	Sections ▾	Market Status	Help								👤 Team A

Sales Dashboard

📦	W2 INVENTORY **1500 / 9000** + 1000 (UPCOMING)	$	TOTAL COST **$16000 Cost** 11.5 KG CO2E	🔟	TOTAL REVENUE **$0** $0 NET PROFIT	🕐	**3:00**

👍 **Its your turn.**
Click on button below to set price point and provide your forecast for this month

Distribution Schedule

Month	W2 Inventory	Demand	Price (US$)	Forecast		Actual Demand	Real Demand	Real Sales	Lost Sales	Revenue (US$)
Jan	1500	1234	80	Enter Forecast	Go!	0	0	0	0	0
Feb	0	535	0	0		0	0	0	0	0
Mar	0	1132	0	0		0	0	0	0	0
Apr	0	750	0	0		0	0	0	0	0
May	0	775	0	0		0	0	0	0	0
Jun	0	1930	0	0		0	0	0	0	0

Figure 9. Sales Manager View

The Sales Manager role is responsible of the sales for the produced items. The main decisions taken by the sales manager role is to forecast current month's demand and set the selling price point accordingly. This will eventually influence production and distribution decisions. Also, sales decision will be based on current demand levels (in case of deterministic game type) or forecasted demand level (in case of stochastic game type).

The Sales Manager role is provided with below crucial information to help in forecasting the demand and setting the selling price point:

- Current inventory level at retail warehouse

- Records of previous months showing retail inventory levels at beginning and end of that month.

- Students forecasts and decided selling price for previous months, in addition to actual demand revealed (in case the game type was stochastic) and the amount of sales based on this demand, total revenue and lost sales if any.

- Access to previous demand levels records for previous years for reference, and a view of all monthly demand of current year in case the demand type of the session was set as Deterministic

It is important to note that below factors impact total sales for the current month:

- Increment or decrement of the price compared to last month. If the price is increased, then demand will be decreased accordingly, and the other way around if the price is decreased, where the demand expected to increase. The change in demand based on price is calculated using price elasticity equations demonstrated in the game model section

- Any lost sales in the previous month will negatively impact current month as some percentage of customers are expected not to return in the next month in case they did not find what they want in the previous month. The reduction in demand based on this factor is calculated as shown in the game model section.

Once the game starts, the student is given a time (defined in session parameters) to discuss with the team about shipment decision for this month given the information above. He is required to submit his decision before timeout.

2.5 The General Manager View
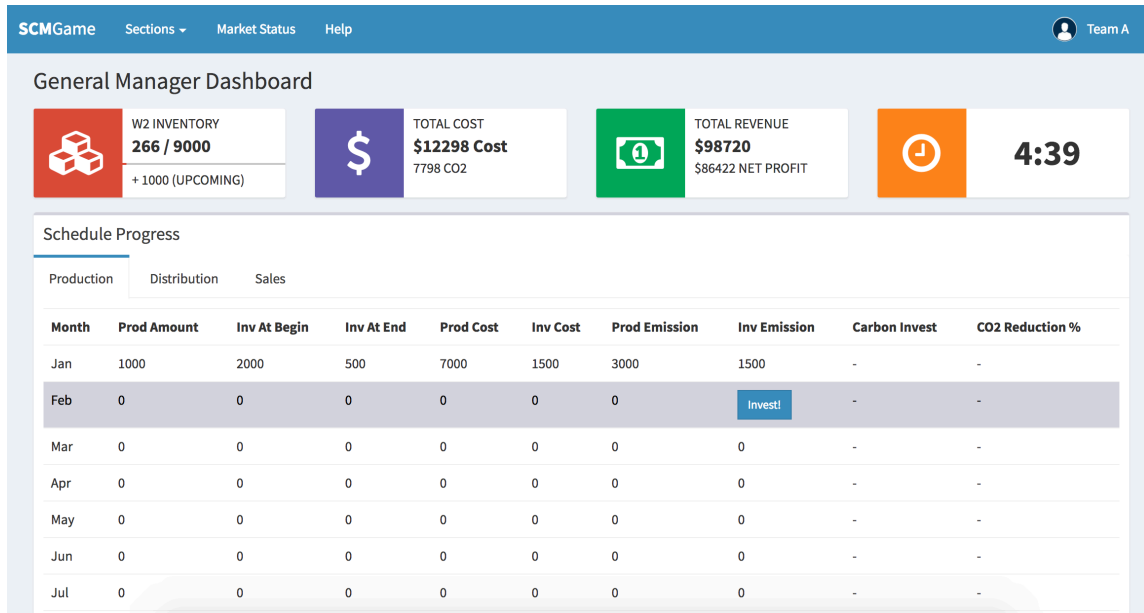
Figure 10. General Manager View

The General manager is a supervision role that view-only access to the other three roles: The producer, the disruptor, and the sales manager, besides some other correlation reports that help in providing insights about company performance in the bigger picture. The main purpose of this role is to support the team and supervise their decisions by separating his role from operations, to have an independent view from the other focused roles.

3.2.5.1 Controlling emission levels

The typical approach of maintaining the carbon policies is by controlling the emission levels through careful handling of production and transportation amounts as

well as the level of inventories.

However, the team can reduce the default emission levels of their production line by investing in cleaner production equipment that results in fewer emissions levels. The decision of this investment is taken only by the General Manager role at any month, and it will take effect only for that specific month.

3.2.5.2 Market Status View

Starting fourth cycle (month of April), the General Manager can get a quarterly performance report of all the teams so he can know how his team is doing against other teams. The available report will be Total Revenue, and Total Emissions chart in case of Parallel markets, and Market Share and Revenue Share in case of the Shared market game.
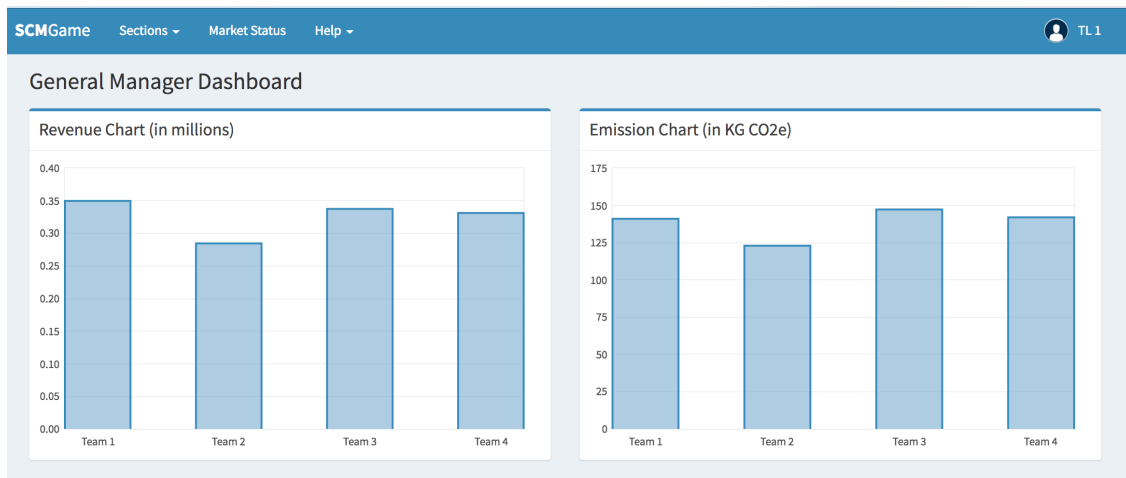
Figure 11. Market Status View – Parallel Market Mode
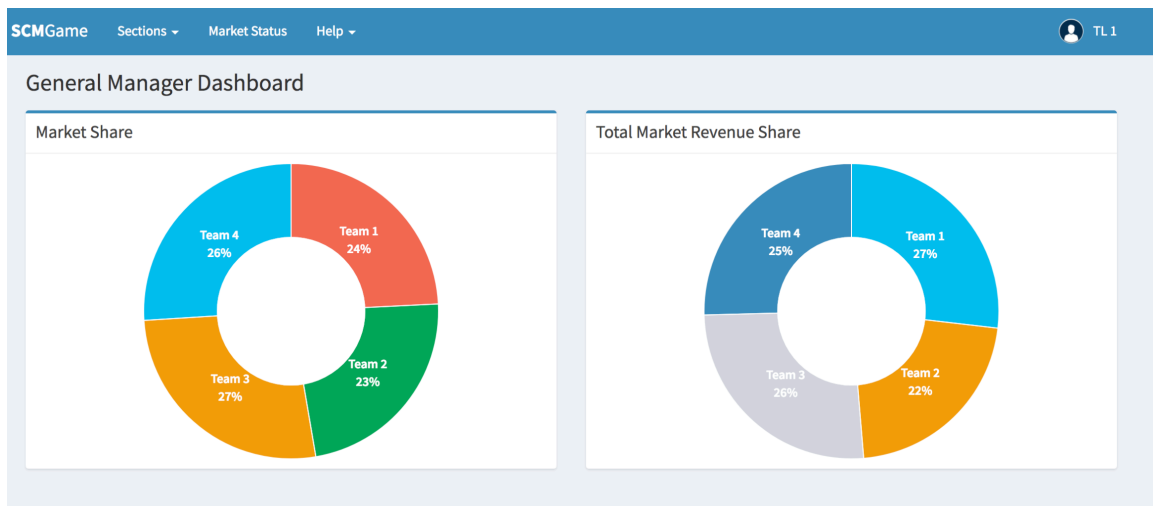
Figure 12. Market Status View – Shared Market Mode

3.3 The Shared market concept

One of the powerful features of this game is that it is built on the concept of the shared market. That is, all competing teams will be contributing to one market space. That means the defined demand levels are shared across all playing teams, and the decided selling price points can affect the balance of the demand as the demand will most likely be pulled towards the lower price.

This concept will achieve several goals:

- This concept gives the students a simulation of real world scenario where the market space is shared and doesn't work in isolation

- It encourages the students to count for possible decisions of other team players in taking their decision, not just the given numbers and factors.

- Several competition principles will be applied instead of just learning the basics of production planning and scheduling concepts.

- The game can be developed later to support for alliances features where one team may try to create an alliance with another by sharing some resources or operational costs. This improvement will increase the value of the game by introducing the concepts of alliances and the applications of game theories in the market.

The shared market will influence the demand distribution over teams using below factors (as demonstrated in the game model section):

- Lost sales in the previous month (stock outs)

- Distance from average price across the teams

- Predefined Demand elasticity against price changes (preconfigured by game moderator)

- Predefined Lost sales factors (preconfigured by game moderator)

3.4 Session Setup and Approach

The following lines will describe the arrangements required to be done in order to prepare the classroom and the students to play the game and get the desired benefit out of it.

3.4.1 Setup the game

The first step to prepare for the session is to define the players and their roles. The instructor shall divide the students into groups of 4 students and invite them to register in the platform as described on *Appendix A*. Team size can be 2 or 3 if the students' count is not sufficient to create enough competing teams. In this case, some team members may play multiple roles. Each group will be given a name that represents a company in the

market (or students can be encouraged to come up with their company names).

The second step will be to adjust the game parameters (mentioned in Game Configuration section) according to the desired scenario. The configured parameters will include: the demand type which will determine if the students will be given the demand upfront (deterministic game), or the students are assumed to forecast the demand and then a hidden demand for each month will reveal at the end of every month cycle (stochastic game).

Additionally, the instructor shall use one of the stored previous demand records or generate a new one for this session. The current demand generation function configured in the system has the following uniform distribution:

Table 2

Randomization of Demand Data

Period	Uniform Distribution
January – April	rand(800,1200)
May – August	rand(2100,3900)
September - December	rand(1200,1800)

The instructor may adjust the outcome of the generation process by changing the equation parameters.

Finally, the instructor can proceed to start the game by resetting the session (to clear data from any previously played game). After that, all students can log in using their

accounts, and they will be all shown the waiting screen until the instructor starts the game.

3.4.2 Prepare the classroom

The next step after preparing the game is to prepare the classroom and orient the student about the instructions. The orientation can be done by providing the students with a link to help section under the game menu, where they can get the necessary information about the game concept, roles overview, screens and instructions to play. Also, the instructor may give the students an overview of the game in the class before the class time where it's supposed to be played

It is also essential that the instructor map the fundamental concepts taught in the operations management and supply chain classes with the concepts in the game.

3.4.3 Proposed approach

The proposed approach to run this game is to allocate around 60 to 90 mins of class time for playing the game including the following:

- 20 minutes' presentation showing an overview of the game.

- 15 minutes' preparations and alignment of all teams

- 30 – 60 mins to run the game session to complete all 12 months' decisions and the analysis required for them. (each month decision period can be set to 5min minimum and ten mins maximum)

- 15 minutes for analysis and aftermath.

3.4.4 Running the session

To start the game session, the students should be seated in groups of 4, each group

of students represents a company. Each team member shall login using their account and select the current session as instructed by the instructor.

The session will officially start once the instructor pushes the Run button from his side. Once started, the duration of the first month will start for all students together, and a countdown will be shown for the students to keep track of the time. Once the duration finishes, the system shall close the submission of this month (and only accept whatever submitted) and moves to the next month. All previous month data will be calculated automatically and stored in the activity table for students to review what is the status of their operations and the result of the decisions they made after each month submission and closure.

Once the submission is closed for the one month, the demand for each team will be calculated and distributed to each team as illustrated earlier. However, the assigned demand amount will be impacted by the availability of stock in the Inventory. If Actual demand exceeded available items in the inventory, it would consume all inventory items, and the rest will be counted as lost sales.

3.4.5 Finishing the session

Once all students finish providing their decisions and receiving the feedback for all 12 months, the session will end, and a result page will be displayed that shows the final results of the game and the winning team, which will be selected based on the highest profit achieved.

CHAPTER 4: TESING THE GAME ON CLASSROOM

4.1 Objective

To measure the impact of using the game in a classroom, the game was tested on a graduate class that is currently studying a related topic. The aim was to observe the outcomes of playing the game on the material that the students currently studying if it achieved the objectives of it.

In order to do this assessment, the plan was as follows:

1. Select a suitable class that is taking a related course to supply chain management

2. Orient the class about the game without highlighting the objectives behind it.

3. Provide a questionnaire to be answered by the participating students prior to the game.

4. Run the game session as explained in the previous section

5. Provide another questionnaire with some similar questions to be answered by the students after they have completed the game session

6. Collect and analyze survey results as well as game data

7. Provide the resulted outcome of the analysis, and the conclusion based the outcome.

4.2 Class details

The chosen class for the trial was a graduate class under engineering management program, studying the topic of Production and Operation Management. The students were already studying central concepts of production control, inventory management, and demand forecasting, which are essential elements of the Supply chain management that the game is built around.

The class consisted of 16 students from different study background, age groups and occupations, as demonstrated on the below chart:
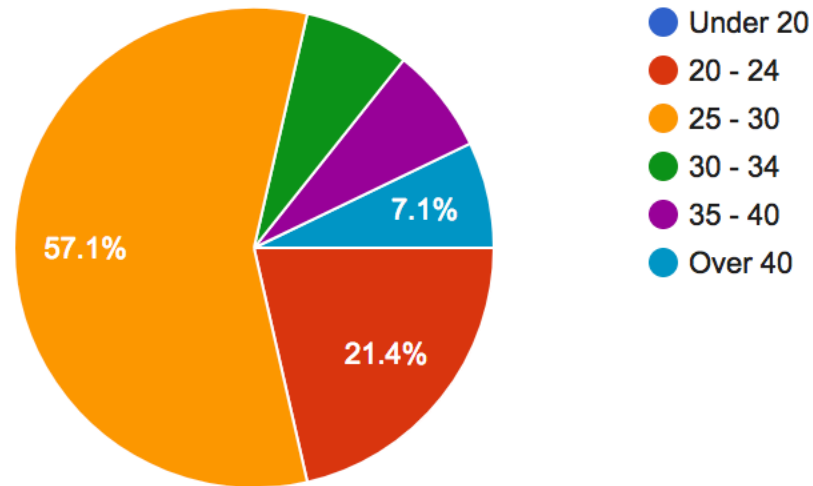
Figure 13. Students Age Group Distribution
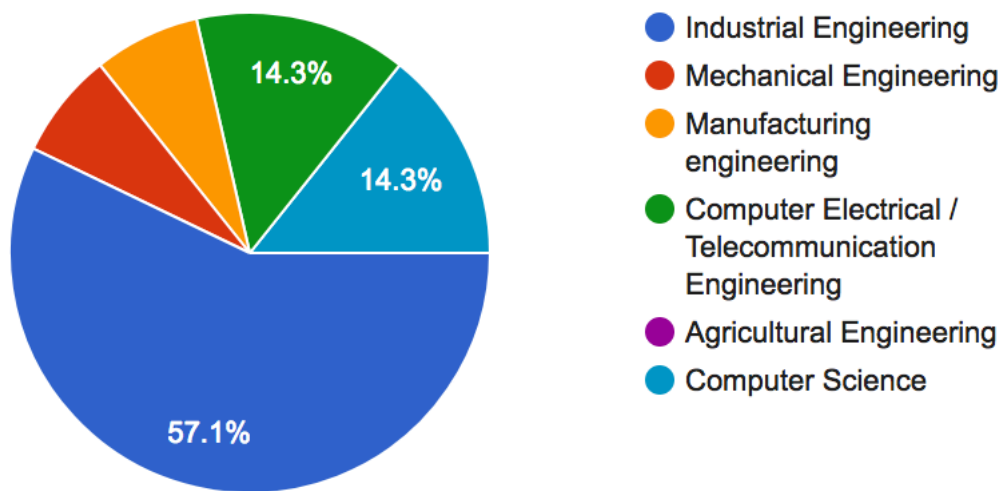
Figure 14. Students Study Background Distribution
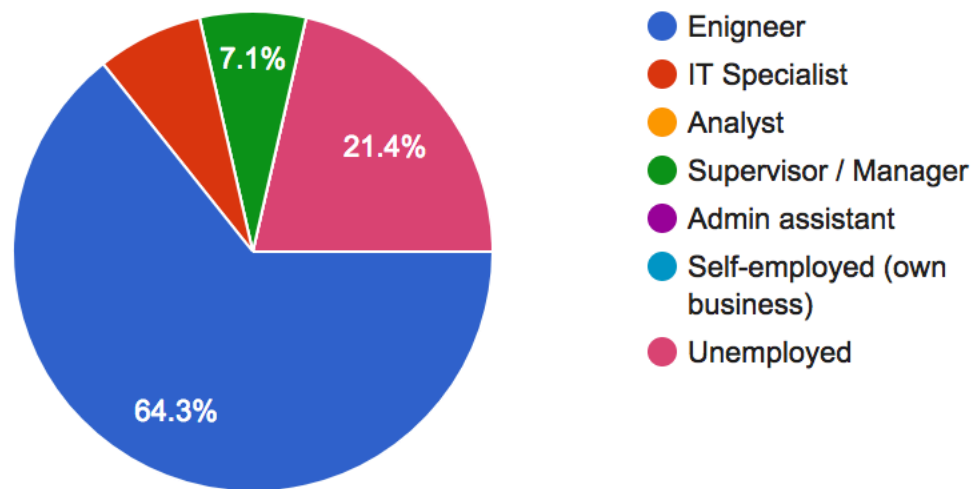
Figure 15. Students Current Occupation

From the above, we can see that most of the students are from different age groups, which reflects a different level of experiences. Majority of the students are engineers with 57% coming from an industrial engineering background, which is very related to this topic.

4.3 Survey used

The survey questions were designed to determine what are the favorite methods of learning for the students in general, as well as capturing the level of understanding supply chain management fundamental concepts out of the classroom or textbook. [*Complete list of questions can be found in Appendix C. Class Surveys*]

The survey was divided into two parts; the first part was distributed to the students before the game, concerning about their background information as well as some fundamental questions on supply chain management. The second part was given to the

students after the game addressing same fundamental concepts in addition to some questions about what they have learned from the game. Considering survey questions, the first set of questions from 1 to 4 were about collecting personal details about the student like name, age group and study major. Next two questions 5 and 6 identifies students learning and reading patterns. After that, questions 7 to 9 evaluates the overall understanding of the supply chain principles.

In the second part of the surveys which is supposed to be answered after the game, the first question was to identify what was the foremost concept cleared out to the student by playing this game. The second question was to evaluate the learning outcomes gained by the student through the understanding of each role in the supply chain game. Questions 3 to 4 are to evaluate the difference of students understanding of supply chain before and after playing the game. Finally, last two questions capture students overall feedback about the game platform itself and ways of improvements.

4.4 Game session

The students were divided into groups of 4; each group consisted of a team leader (who played the General manager role) and other three roles of Production Manager, Distribution Manager, and Sales Manager. They were asked to bring their laptops beforehand so every student will use his account to log in and participate.

At the beginning of the class, a short presentation was presented to the students to explain the objectives of this session and quick orientation on the game principles and how to use it. After that, a registration link was sent to team leaders to create their accounts and assign their team members. Then the moderator of the game (instructor) initiated the session and started the game.

4.4.1 Chosen game options

The game configuration was set to match a scenario of producing and selling footwear, with plant located at China and Retail store located at Los Angeles / USA. Below table summarize main Demand configuration and Market type

[*Detailed listing of game configuration used in class can be found in Appendix D. Class Game Parameters*]

Table 3

Demand and Market Options

Parameter Name	Value
Demand Elasticity	1.6
Lost Sales Elasticity Factor	0.9
Demand Environment	Deterministic / Stochastic
Actual Demand List	38
Reference Demand List	36
Market Type	2
Carry Over Lost Sales	Yes: Carry over No: deduct from next month sale
Price Change Limit (%)	10%
Initial Price (US$)	25
Time to close decision submission (in minutes)	7 mins

4.4.2 Observations during the sessions

Looking at the classroom while the game was running, the below points were observed:

- The students' behavior in each team were reflecting the actual roles in within the game scenario, mainly the team leaders who took the responsibility of leading their teams and drive their decisions

- The students took some time to adapt to the game dynamics in the first couple of months, after that they took less time in average on their following decisions.

- The general atmosphere of the class was full of excitement and enthusiasm to achieve better results and beat other teams, in a way that the time went very fast that they realized they stayed in the class more than usual days without feeling it.

After the game was completed, the final performance. Results were revealed, and the winning team was announced. Then the students were given the second survey to provide capture their feedback about the game and knowledge gained.

4.5 Analysis of the results

The results of the second survey came as follows:

- In the first part of the survey, more than half of the students claimed that the most transparent concept for them is the inventory management and demand forecasting. However, after they played the game, they confirmed the game has cleared out more aspects of inventory management, in addition to the importance of planning production ahead of time.

- None of the students mentioned sustainability understanding on the first part of the survey. However, in the second part after playing the game we found, many students mentioning sustainability aspects as an important factor in the supply chain management. This concept was cleared out by introducing the concept of

controlling emissions on throughout the supply chain to achieve better sustainability results.

- More than 70% of the students confirmed that they had fundamental supply chain management concepts in mind, but playing the game gave them a real taste and better realization of how all these concepts work together.

- Giving the students the opportunity to play different roles in the team gave them more depth in understanding the mechanics of the supply chain. That was demonstrated on their answers to the survey questions before and after the game. Most of the students mentioned before playing the game that they believe the production control cost, net profit, and demand forecasting as the main aspects of supply chain management. However, after playing the game, new concepts have been realized and appeared in their answers after the game was played, such as: determining price points, price change, carbon emissions control, transportation of items, challenges of production capacities and inventory size limits.

CHAPTER 5: CONLUSION AND RECOMMANDAITONS

5.1 Summary

From Game observations and survey results, it is concluded that students learned from the game. The answers to questions in part one of the survey reflected some basic understanding of general supply chains management concepts such as inventory management and demand forecasting. However, after playing the game, some repeated questions from the second survey showed that the students have realized different aspects of supply chain and captured new concepts like sustainability aspects

This exercise and the associated survey results demonstrated a noticeable impact of hands-on experience on the level of understanding for supply chain management. This was reflected the question about how much the student evaluated themselves regarding the overall understanding, and the majority of the students confirmed that they got a real taste of how the different supply chain mechanics work together, lending credibility to this conclusion.

An interesting question may raise out of this research which is how to evaluate the results of learning from a particular pedagogical technique (without including learning from others). For instance, some studies report that students who had engaged in an in-classroom game performed better on the following exam, but how can this be confirmed for sure if these students did not also study more and prepared themselves before the exam? The best way to evaluate their learning from a game is likely either with before and after surveys, like what was done on this class, or by playing the game twice in the same class, which may be a challenging exercise regarding class time limitation. In either way, it is ensured that no learning from other sources occurs in between.

Moreover, students most likely express more engagement toward a course in which games are used, thus improving the chance of paying attention and learning even during other class sessions, which was observed during the game session. A possible drawback to in-class games is the time taken. In general, less material can be covered in a game is used, which is an expected outcome because not only the abstract concepts being taught but also the simulated real-life situation along with it.

However, the conceptual learning and the "aha" effect may be much more valuable than the learning of numerous facts.

5.2 Future improvements

Now considering the supply chain game, itself, this game meets all the objectives mentioned in the beginning. However, a lot more can be done in this field, and many improvements can be added to enhance the experience and reflect more real-life scenarios, such as:

- Considering possibilities to introduce alliances in the market were 2 or more players can cooperate to share resources, costs or revenue.

- Considering carbon quota trading, where one company can buy excess carbon quota from another.

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APPENDIX A: GAME MANUAL

This manual will help different Supply Chain Game users to use the web app step by step. Since the game is role based and cannot be used by anonymous access, the manual will be divided by users' roles.

All users accessing the game link will be landed initially at the login page below:

Below users are considered that they have been given their credentials and used above screen to access the game.

Instructor / Game operator
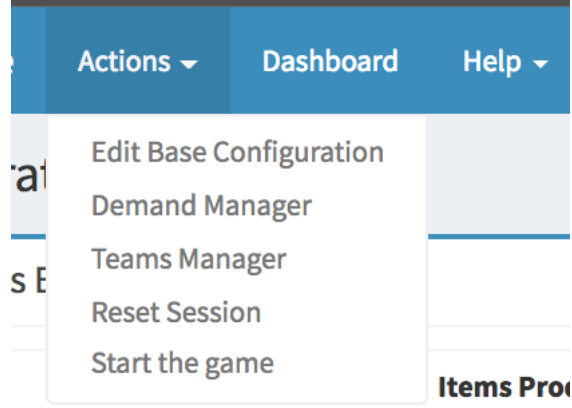
This is role is considered as the admin of the application with all necessary privileges to create teams, generate demand, manage game configuration and start a game

session.

Below is the home screen of the moderator
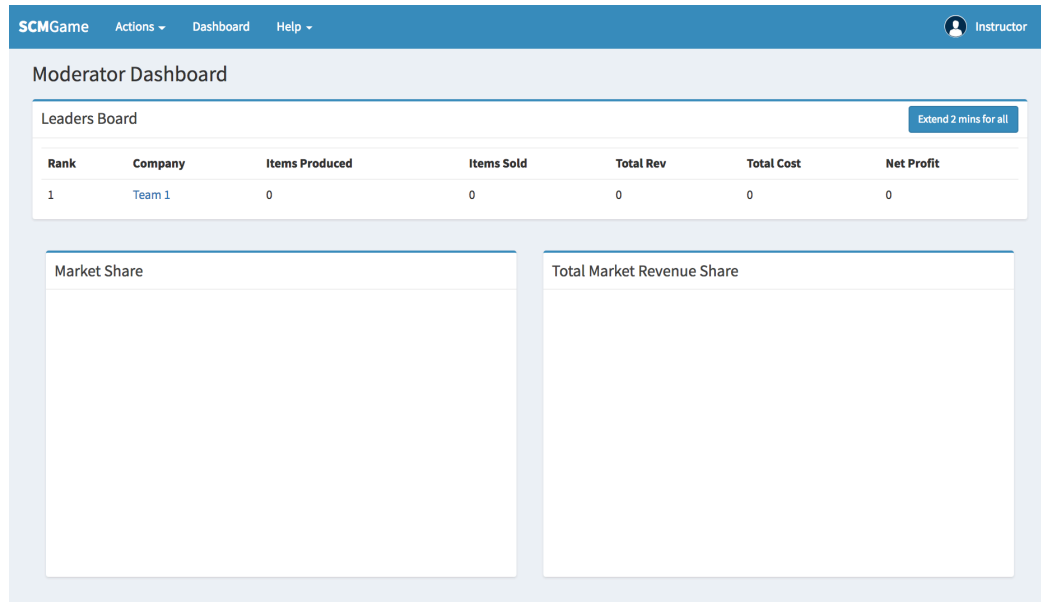
The header menu is structured as follows:

	Actions
	1. Edit Base Configuration: this is used to setup game parameters
	2. Demand Manager: To generate and manage demand profiles
	3. Team Manager: To manage and participate teams
	4. Reset Session: Clears out all previous data and prepare the fame for a new session
	5. Start the game: once the game is set, this action will kick off the session and start the countdowns
	6. Dashboard: Goes to

	landing screen where it shows overview of teams progress 7. Help menu: content page dedicated to brief students about the game

Invite new teams

In order to start a game session, first step is to invite teams to register to the game:

1. Go to **Actions** > **Team Manager**

2. In the team management page, click on "**Invite new team**"
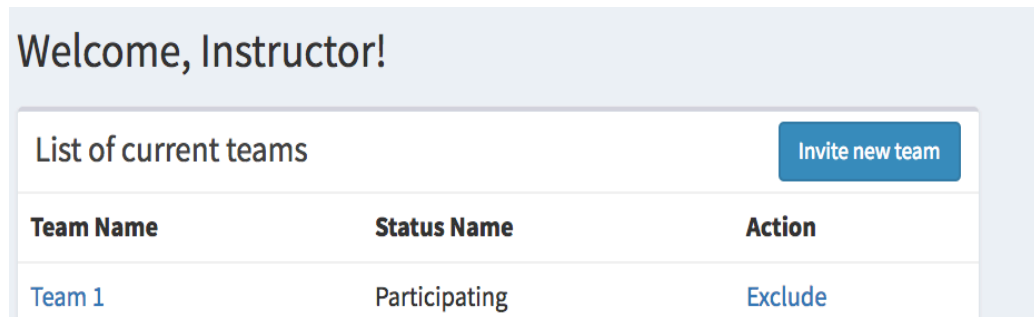
3. From the pop-up box, click "**Generate Link**" and copy the result link from the text box:
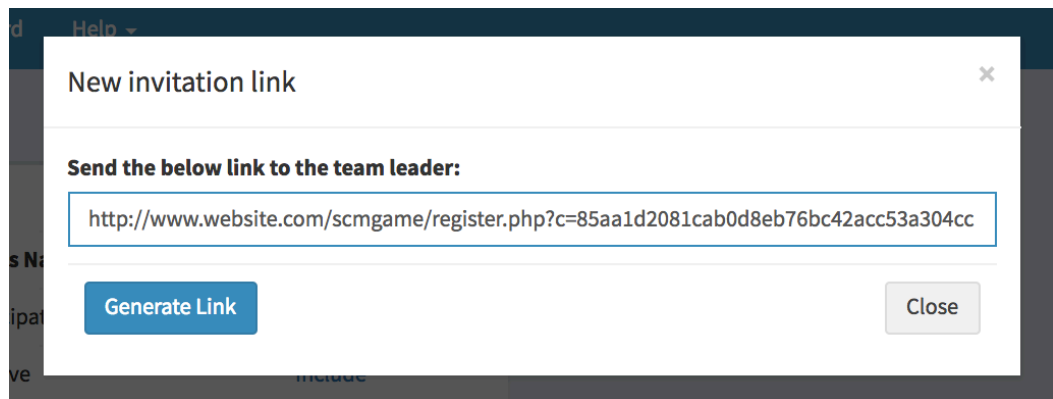
4. Send this link to the student team leader in order to register his team

5. Generate more links for more teams and send them to the respected Team Leaders. Remember to send individual links to individual team members

[Details of Teams registration will continue in *General Manager Role* section]

Once all team registered, the will be listed in the team list like below:

You can Include/Exclude teams for the next game session by clicking "**Include / Exclude**" action link

Create / Manage Demand Profiles

You can generate random Demand Profile and adjust them using **Demand Manager** from

Action Menu:

To Generate New Demand, click "**Generate New**" button in the left demand list box. A new random values will be populated in the **Demand Values** box at the right side. You can adjust the values as needed, then choose a list name on the top the click **Save**.

To edit a previously created list, click **Edit** action link for the required demand profile in the list, adjust the demand values and then click **Save**

You can delete any created Demand Profile using **Delete** action

Edit Game Configuration

You can adjust game parameters by clicking on **Edit Base Configuration** from Action Menu:

You may adjust any value from the above screen as needed and then click **Save**.

[Please refer to Game Configuration Section on Chapter 3 for information about each parameter].

Initiate a new session and start the game

In order to initiate new game session, click "**Reset Session**" form **Action** menu.

A confirmation message will confirm this action since all data for the previous game will be cleared out. Click OK to confirm.

Once all team players login to the game, they will see the "**Waiting to start**" screen. To start the game, Go **Actions > Start the game**

Dashboard

Once game starts, player can provide their decision, using the Dashboard section you can track down their progress, overall market result, or drill down in details of each team
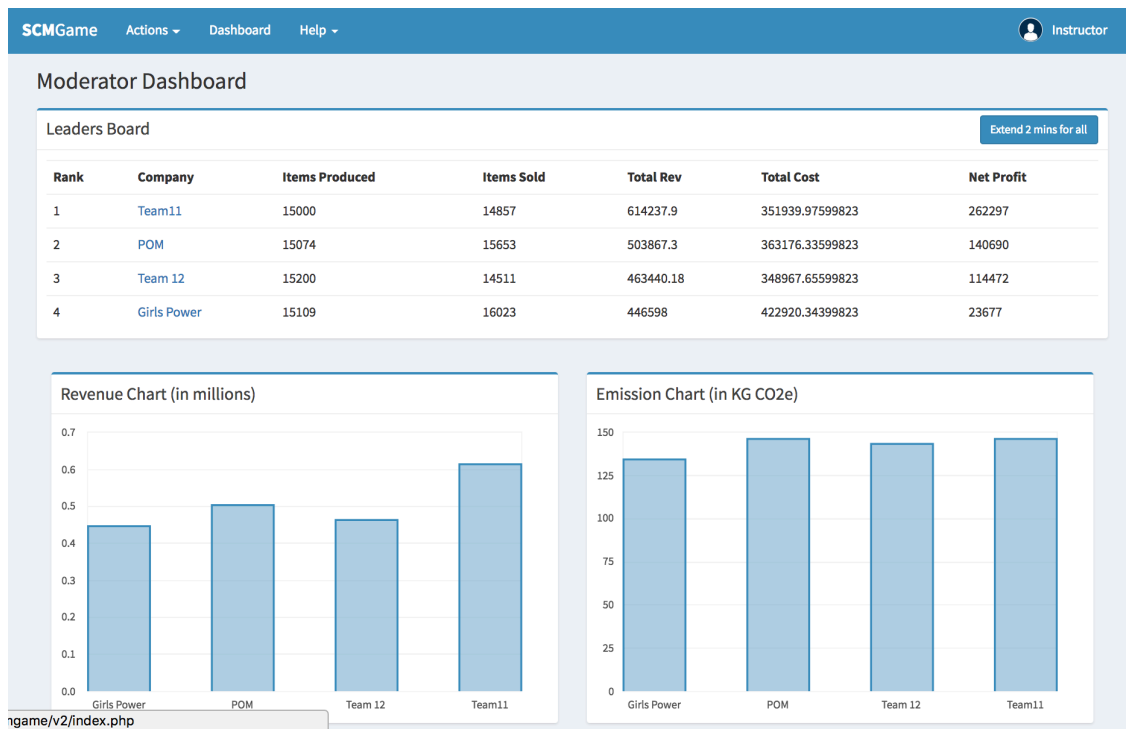
The charts presented will reflect: Total Revenue and Total Emissions chart in case of Parallel markets, and Market Share and Revenue Share in case of Shared market game.

In order to drill down into team detailed decisions, click on the team name listed under the Leader Board. You will have dashboard for that team as below:

Month	Prod Amount	Inv At Begin	Inv At End	Prod Cost	Inv Cost	Prod Emission	Inv Emission	Carbon Invest	CO2 Reduction %
Jan	3000	1000	0	53000	0	27000	0	-	-
Feb	3000	3000	0	53000	0	27000	0	-	-
Mar	2000	3000	0	36000	0	18000	0	-	-
Apr	0	2000	2000	0	1000	0	600	-	-
May	4000	2000	1000	70000	500	36000	300	-	-
Jun	1000	5000	3107	19000	1553.5	9000	932.1	-	-
Jul	1500	4107	165	27500	82.5	13500	49.5	-	-
Aug	500	1665	0	10500	0	4500	0	-	-
Sep	0	500	500	0	250	0	150	-	-
Oct	0	500	500	0	250	0	150	-	-
Nov	0	500	500	0	250	0	150	-	-
Dec	0	500	500	0	250	0	150	-	-

You can switch between the different team roles and their decisions using the tabs under the *Schedule Progress*

General Manager Role

The General Manager acts like a team leader, and is responsible to create other team members account.

Registration

Once a link is received by the game moderator, accessing it will show below page:

Once all fields are populated, click Register. Then you will land in your Home Page like below one
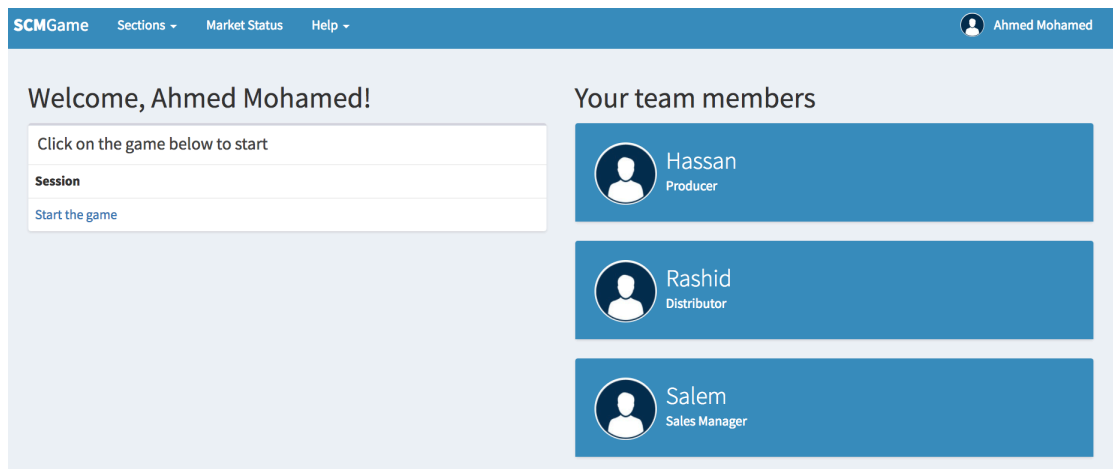
Next, you need to create your team members account, by clicking "Hire Now" on each Role. A popup box will appear to fill team member's details:

Once all fields are populated, click Submit. Repeat same steps for the rest of team roles.

When you create all team accounts, provide the credentials to your team members and let them login using game link. Then you should all clikc "Start the game" from your screens.

All members will see below screen until moderator start the game.
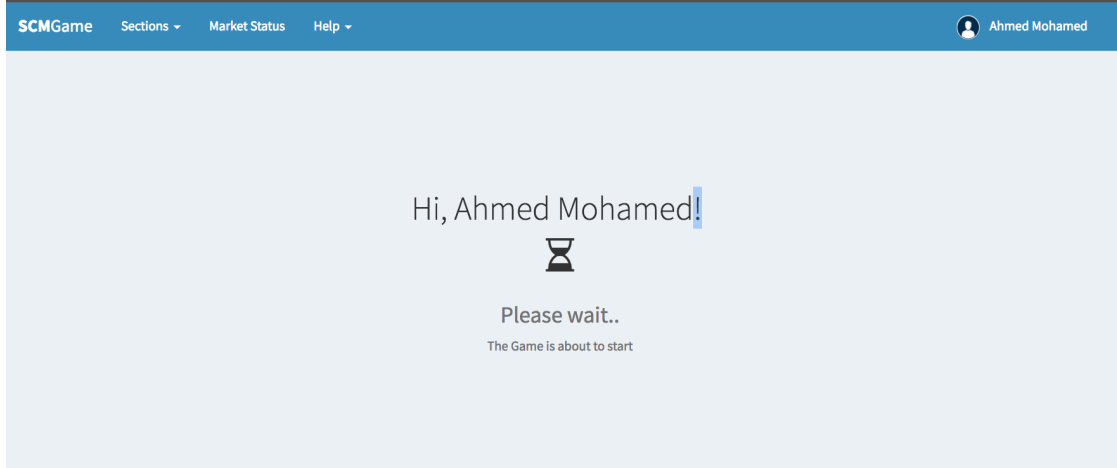
Once the moderator starts the game, the screen will refresh to show the dashboard below:

The General Manager will be monitoring team's performance, he can navigate to other team members dashboard to view their decisions using Sections menu on the top.

Also he can decide on investing on Carbon emissions reduction by clicking on "Invest"

Button next to the corresponding month. Note that this decision can be taken only before Production amount is decided for the current month.

When clicking on "Invest" button, a popup box shows with options of investment to select from
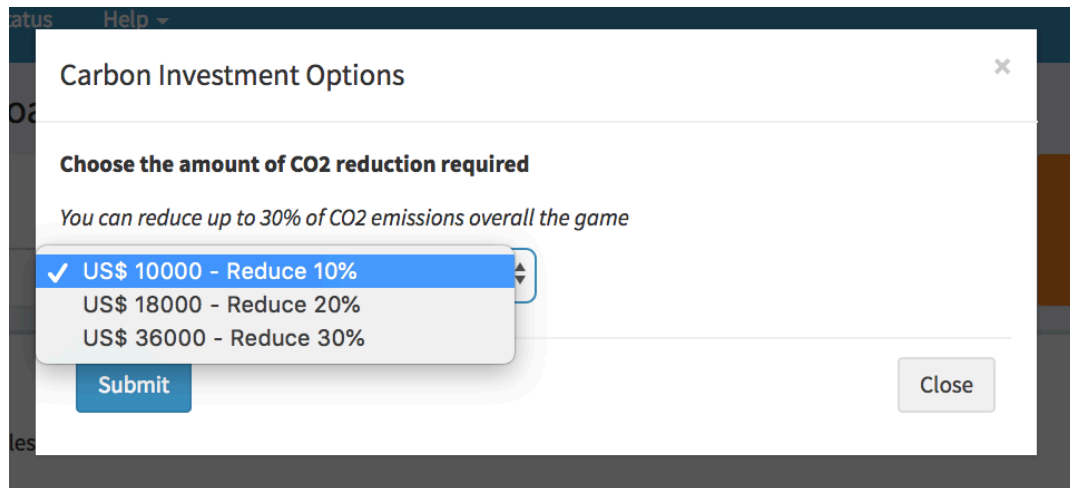
If one option is selected, it will show in the corresponding line in the dashboard, and the cost will be added to current month's production cost.

Month	Prod Amount	Inv At Begin	Inv At End	Prod Cost	Inv Cost	Prod Emission	Inv Emission	Carbon Invest	CO2 Reduction %
Jan	0	0	0	0	0	0	0	18000	0.2

The investment amount will be charged once, and the reduction on carbon emissions from production process will happen starting current month onwards.

Market Status

In order to see overall market status and some information about other teams progress, you can click on "**Market Status**" link on top menu. However this option will be only available after first quarter only as described in Chapter 3.

Production Manager Role

After the production role account is created, logging in first time will show the wait for game to start screen as shown before. Once the game has started, below dashboard will appear for production role:

The production manager can enter the required amount and click on "GO" Button. If the decision is not provided within time window, the quantity box will be disabled and the amount of 0 will be submitted automatically. Once the amount is provided, you will have to wait for other team members to provide their decisions for current month.

Note that you can produce only within production capacity provided in the configuration of the game, and with amount that is less than or equal the available capacity in the plant inventory.

Distributor Role

After the distribution role account is created, logging in first time will show the wait for game to start screen as shown before. Once the game has started, below dashboard will appear for distribution role:

The distribution manager can enter the number of items to be shipped to Retail Inventory by Boat or Air and click on "GO" Button. If the decision is not provided within time window, the quantities boxes will be disabled and the amount of 0 will be submitted automatically. Once the amount is provided, you will have to wait for Sales Manager to provide their decisions for current month.

Note that you can send items by boat in containers only, which has a defined size as per

game configuration. Under the boat shipment field, numbers of containers will be calculated automatically the corresponds to the provided number of items to be shipped.

Sales Manager Role

After the Sales Manager role account is created, logging in first time will show the wait for game to start screen as shown before. Once the game has started, below dashboard will appear for sales manager role:

The sales manager should provide the selling price for this month and a forecast of what the demand will be and click on "GO" Button. If the inputs are not provided within time window, the quantities boxes will be disabled and the previous month's price will be used automatically (Forecast will be sent as zero) Once the amount is provided, The actual sales will be calculated along with other results, then decisions will open for next month starting with the producer (repeating like this month until December)

Notes:

- first month's price will be preset as configured in game configuration and won't be changeable.

- Also for following month the price change can be only within 10% increase or decrease from previous month price.

- In case of the Market type was set to Shared Market, the dashboard will let you wait after you enter your decision and will not let you move to next month until all other teams finish their decisions as well, so that the platform can calculate the demand for each team based on the approach provided in the Game Model Section.

APPENDIX B: GAME CONFIGURATION PARAMETERS

Production line Setup	
Capacity per month	Maximum number of items can be held at plant inventory
Cost per item (US$)	The cost of producing one item
CO2 / produced item (kg CO2e)	The calculated average of emission released when producing one item
Lead Time (in months)	The amount of time required to produce one order of items
Setup Cost (US$)	The cost of initiating one batch of production

Plant Warehouse parameters	
Inventory Capacity	Maximum number of items can be held at plant inventory
Holding Cost (in US$)	The holding cost of one item at plant inventory
CO2 per stored item (kg CO2e)	The calculated average of emission released when storing one item at plant inventory
Initial Stock Level	The initial number of items available at plant inventory

Transportation parameters	
Container Cost by Boat (US$)	How much it costs to send on container by boat
CO2 per container by Boat (kg CO2e)	Calculated average of emissions released when sending one container by boat
Boat Lead Time (in months)	Amount of time needed (in months) for a shipment sent by boat to arrive at Retail warehouse from Plant

Container Size	Number of items can be put in one container
Air Shipment Cost (US$)	How much it costs to send one item by Air
CO_2 per item by Air (kg CO2e)	Calculated average of carbon equivlent emissions released when sending one item by air
Air Lead Time (in months)	Amount of time needed (in months) for a shipment sent by air to arrive at Retail warehouse from Plant

Retail Inventory parameters	
Inventory Capacity	Maximum number of items can be held at retail inventory
Holding Cost (US$)	The holding cost of one item at retail inventory
CO_2 per stored item (kg CO2e)	The calculated average of emission released when storing one item at retail inventory
Initial Stock Level	The initial number of items available at retail inventory

Demand and Market Options	
Demand Elasticity	Defines the percentage of changing on demand in responding to price changes
Lost Sales Elasticity Factor	Defines the percentage of non-returning demand because of lost sales in previous month
Demand Environment	Deterministic / Stochastic
Actual Demand List	Selection of predefined demand list to be used as the actual demand list in the game
Reference Demand List	Selection of predefined demand list to be used as the reference demand list in the

	game
Market Type	Set market type in the market to be Shared or Individual parallel markets
Carry Over Lost Sales	Yes: Carry over / No: deduct from next month sale
Price Change Limit (%)	The maximum increment or decrement percentage of price per month cycle
Initial Price (US$)	The initial price per item when the game starts
Time to close decision submission (in minutes)	The time given to players to finish decisions of one month cycle

Carbon Policy Settings	
Current Carbon Policy	Define which policy will be applied on the game (Carbon Tax, Carbon Cap)
Carbon Emission Cap (kg CO2e)	Maximum amount of emissions released during production to sale process
Policy Breach Penalty	Amount the company will be charged on the excess amount of emissions exceeding the carbon cap limit per year
Carbon Emission Tax (US$/kg)	The charging rate per KG of carbon emissions produced in the supply chain
Max Reduction Factor Allowed (%)	Maximum possible reduction of carbon emissions when investing on carbon reduction equipment

APPENDIX C: CLASS SURVEYS

Part I:

- What is your Name

- What is your age group?

    - Under 20
    - 20-24
    - 25-30
    - 30-34
    - 35-40
    - above 40

What is your study background?

    - Industrial Engineering
    - Mechanical Engineering
    - Manufacturing engineering
    - Computer Electrical / Telecommunication Engineering
    - Computer Science
    - Agricultural Engineering
    - Others (Specify)

- What is your occupation?

    - Enigneer

    - IT Specialist

    - Analyst

    - Supervisor / Manager

    - Admin assistant

    - Others

    - Self-employed (own business)

    - Unemployed

- What is your preferred way for reading?

    - Read a paper book

    - Read a newspaper

    - Read using Tablet / Kindle

    - Read on computer / laptop

- Read on your mobile

- Listen to Audio books

- Listen to book summaries

- I don't read!

- If you are searching to understand a concept, what do you do?

  - Read a book

  - Read an article

  - Watch a video on Youtube

  - Attend a lecture

  - Watch a real life application / example

  - Ask an expert

- What is the most understandable concept of Supply chain management and operations management for you out of class room?
  - Production control
  - Inventory Management
  - Transportation and logistics
  - Demand management and forecast
  - Sustainability

In production and operations management, what are the most factor(s) that reflect good supply chain management?

From your opinion, what is the main thing that you need to know in order to judge the performance of a supply chain (from high level - Select all that applies)

  - Total Revenue
  - Total net profit
  - Amount of carbon emissions
  - Total Costs
  - Market Share
  - Market Revenue Share

Part II:

- What is the most aspect of SCM that was cleared out by the game

    -- Production scheduling

    -- Lead time and transportation

    -- Demand elasticity to price

    -- Carbon emissions and impact on operations

    -- Inventory management and cost

    -- Importance of planning production ahead of time

- What are the main challenges that faces below roles:

Production Manager

_____

Distribution Manager

_____

Sales Manager

_____

General Manager

_____

From your opinion, after playing the game, what is the main thing that you need to know in order to judge

the performance of a supply chain (from high level - Select all that applies)

- Total Revenue

- Total net profit

- Amount of carbon emissions

- Total Costs

- Market Share

- Market Revenue Share

- After playing the game, how do you evaluate your improvement of understanding of SCM concepts?

  -- I was far beyond! The game helped me understand the main SCM Concepts

  -- I had the main concepts in mind, but the game gave real taste of how it works all together

  -- I had good understanding of SCM throughout the class, and the game improved my knowledge and confirmed my understandings

  -- No change !- I feel no difference from before and after playing the game

- How much do you ran the platform from below aspects (from 1-worse to 10-Perfect)

  o Learning outcomes

  o User Design and Interface

  o Usability and user experience

  o Game structure and design

- What would you suggest to improve the game?

Production line Setup	
Capacity per month	4000
Cost per item (US$)	17
CO_2 / produced item (kg CO_2e)	9
Lead Time (in months)	1
Setup Cost (US$)	2000

Plant Warehouse parameters	
Inventory Capacity	5000
Holding Cost (in US$)	0.5
CO_2 per stored item (kg CO_2e)	0.3
Initial Stock Level	1000

Transportation parameters	
Container Cost (US$)	1000
CO_2 per container (kg CO_2e)	50
Lead Time (in months)	1
Container Size	2000
Air Shipment Cost (US$)	5
CO_2 per item by Air (kg CO_2e)	0.6
Lead Time (in months)	0

Retail Inventory parameters	
Inventory Capacity	3000
Holding Cost (US$)	1
CO_2 per stored item (kg CO_2e)	0.3
Initial Stock Level	0

Demand and Market Options	
Demand Elasticity	1.6
Lost Sales Elasticity Factor	0.9
Demand Environment	Deterministic / Stochastic
Actual Demand List	38
Reference Demand List	36
Market Type	2
Carry Over Lost Sales	Yes: Carry over No: deduct from next month sale
Price Change Limit (%)	10%
Initial Price (US$)	25
Time to close decision submission (in minutes)	7 mins

Carbon Policy Settings	
Current Carbon Policy	Carbon Tax / Carbon Cap
Carbon Emission Cap (kg CO2e)	150000
Policy Breach Penalty	0.5
Carbon Emission Tax (US$/kg)	0.04
Max Reduction Factor Allowed (%)	0.3
Carbon Investment Budget (US$)	5000

APPENDIX E: APPLICATION DETAILS

Application Type   : Web Application with Relational DB

Development Languages   : PHP for Server Side

                                       HTML / CSS / JS for Front end

Database Type   : MySQL Community Edition

Server Type   : Apache Web server with PHP 5.6+