Integrating the Use of Spreadsheet Software and VBA in Inventory Simulation

Changbing Jiang
College of Information Management, Zhejiang Gongshang University, Hangzhou, China
Email: johncabin@mail.zjgsu.edu.cn

***Abstract*—This article reviews the advantages and disadvantages of computer programming and spreadsheet modeling in logistics education and inventory control, and describes using Microsoft Excel and VBA in the classroom. One of these approaches, integrating the use of spreadsheet software and VBA, has been used in recent years in a logistics systems management course with a large enrolment at a major university. The article illustrates how, under the integrated paradigm, various computer software packages are integrated in the course to form a unique learning environment. At the last of the article, we give an illustration of the use of Microsoft Excel and VBA in inventory control.**

***Index Terms*—inventory simulation, spreadsheet software, VBA programming, logistics education**

I. Introduction

The use of computers in logistics management has increased dramatically in the past decade partly due to the rapid growth of personal computers (PCs) and the large number of software applications developed for them [1]. At the same time, business schools have reacted by bringing more computerized ingredients into the classroom [2]. As part of this trend, logistics educators are also computerizing their curricula to provide students with the necessary knowledge they will need to be an effective part of the workforce [3].

Many logistics decision-making software tools have exploded in the last decade driven by the need to optimize and integrate the supply chain. These tools are extremely effective in determining the optimum number of distribution facilities, the appropriate mix of transportation modes, production scheduling, inventory optimization, product rationalization and strategic planning exercises. They develop a decision capability within the firm to deploy assets in the most efficient manner possible. Most of these software packages have the additional benefit of providing output in a graphical format through the use of maps, charts and graphs that can be easily understood.

Spreadsheet software, notably Microsoft Excel, can be used very effectively for analyzing logistics and supply chain issues. Spreadsheet allow analysis from many different perspectives and can be modified and enhanced to reflect new situations and options. The methodology used for developing integrated spreadsheet models is similar to modeling with specialized software. The modeler develops a baseline model reflecting current operations, creates alternative scenarios and compares those scenarios to the baseline. Non-quantifiable factors and soft costs are also considered to develop a complete analysis. Using integrated spreadsheet the modeler can analyze the impact of business decisions on any number of variables such as logistics strategies, flow planning, inventory control, allocation and aggregate planning and network design and planning.

While there are many advantages to using logistics-specific software for analyzing supply chain problems, these specialized products may not always provide the flexibility required. Spreadsheet software, notably Microsoft Excel, can be used very effectively to analyze logistics problems. Spreadsheet allow analysis from many different perspectives and can be continually modified and enhanced to reflect new situations and options. The user can add complexity to the model as he or she gains experience and knowledge about the process. Spreadsheet models can be used for strategic or operations planning and in many cases can be used for both simultaneously.

II. The Advantages and Disadvantages of Computer Programming and Excel Modelling in Logistics Education

A. Computer programming

The first approach, computer programming, is a powerful and versatile approach because students can formulate problems in their own way. However, it is usually difficult for students without previous programming experience to model the problems successfully. This approach is frequently used in courses offered by computer science, statistics, or management science departments. Students may be required to take prerequisites or, where prerequisites are not mandated, considerable time may be spent in introducing basic concepts and algorithms of a language like C++ or JSP or a simulation language like MATLAB or GPSS.

While there is a role for this approach in special courses, the proliferation of software packages for PCs during the 21st century has meant the near disappearance of computer language classes in business schools curricula. However, upper-level and advanced courses on such topics as forecasting, mathematical programming, simulation, etc. may still require the use of symbolic languages and other specialized software.

doi:10.4304/jsw.5.5.498-505

B. Using spreadsheet and other general purpose packages

The second approach is a modeling approach combined with case analysis. It is very effective in problem solving and very beneficial if introduced in the early stages of the logistics education process. The most frequently used platform for this approach is spreadsheet software such as Microsoft Excel. The power of these platforms is continuously increasing, allowing problems of greater complexity or analysis of greater depth to be addressed. For example, Microsoft Excel can perform statistical tests and regression analysis, and, with the aid of add-in software such as What-If Solver and @Risk, can also do optimization and probability analysis.

However, general purpose spreadsheet software is not designed to solve every logistics problem and should not be used as the only tool in logistics education. Often the skills required to model problems in spreadsheet are too advanced, particularly in a higher sequence logistics course where the problems are more complex, and too much time may be spent in the course teaching spreadsheet skills rather than their applications in logistics concepts and problem solving. In addition, for complex applications, this approach may necessitate students acquiring some programming skills, as well as hardware and software support from the university (for example, for the add-in software).

Tab. I shows the advantages and disadvantages of each approach in the business curricula.

The Integrated spreadsheet software has been used for about five years in an undergraduate course called Business Logistics Analysis taught by the author at Zhejiang Gongshang University. Students majoring in logistics typically take seven to nine logistics courses in the undergraduate curricula during their junior and senior years, of which five are required and form a sequence. As part of the overall business curriculum, students also take a computer course in their sophomore or junior year where they get exposure to spreadsheet packages. The systems analysis course is the capstone of the required series and is typically taken in the senior year. Therefore, the course is intended to provide more in-depth knowledge in the process of integrated logistics management and the logistical relationships with other management functions and firms than taught in the previous core courses.

TABLE I.
THE ADVANTAGES AND DISADVANTAGES OF COMPUTER PROGRAMMING AND EXCEL MODELING IN LOGISTICS EDUCATION

	Advantages	**Disadvantages**
Computer programming	Provides customized solutions Familiarizes students in using the software	Requires a long learning curve
Excel modeling	Is easy to use for beginners Is the most widely used business software Is a versatile analytical tool	Does not include functions like simulation, statistical analysis, or linear programming without add-in software Takes time to develop advanced macros and/or application

Source: arranged by the author.

III. THE INSTRUCTION OF TWO CLASSIC INVENTORY CONTROL POLICY

Inventory control policies are primarily based on one of two major classes of review systems: the periodic review, Replenishment Interval, Order-Up-To (R,T) policy or continuous review, Re-order Point, Order Quantity, (Q,r) policy. Although rapid developments in data collection technologies (e.g. source data automation technologies such as barcode systems) have made continuous review approaches (also known as transactions reporting systems) easily applicable to a majority of inventory control systems, periodic review control systems are still in use [4,5,6]. They are applied especially when a seller contacts or visits its customers (e.g. retailers) in periodic time intervals and takes new orders for the upcoming epoch. If, for example, the seller picks up the orders once a week, there is no reason for reviewing the inventories more frequently. Another application of periodic review systems can be found in situations where the cost of operating a continuous review system is considerably high. A periodical review system is inevitable if the counting process for the items is difficult or expensive. In the periodic review control policy, inventory level is reviewed once every R time-units and a decision regarding how much to raise the inventories for the next period is made.

The choice of which control policy to use is based on the perceived advantages of each. These advantages span the spectrum of quantitative benefits (such as lower long-run costs) and qualitative factors (such as current technological capabilities and competitive factors). For instance, managers sometimes use periodic review instead of continuous review for a whole host of reasons (e.g., ease of execution). Although continous review is easier today than it was several years ago (due to sophisticated point-of-sale scanner systems at retail stores and automatic storage and retrieval systems at warehouses), continous review can require expensive technological investments. Further, despite technological innovations, retail inventory status records are still sometimes not accurate enough to trigger continuous replenishments. Even when the inventory status is accurate, a periodic review may be preferred due to reduced fixed costs resulting from combining order placements for different products, or due to qualitative benefits of following a regular repeating schedule of inventory replenishment. Sometimes, suppliers prefer customers to follow periodic review and replenishment since this reduces uncertainty in the timing of demands they see. Buyers may prefer to use periodic replenishment as a means to coordinate order placements with a supplier of several items, when the supplier offers a price discount on the total dollar value of the order placed.

While (*Q*,*r*) policy has been well studied in the inventory literature, the single-item (*R*,*T*) policy has not been as well analyzed when demand is uncertain. The latter policy is convenient in many practical situations because it allows control of the timing of order placements, which facilitates coordination of order epochs in multi-item or multi-echelon systems. As stated earlier, such coordination is commonly used to avail of quantity discounts or savings in transportation costs or operating efficiencies due to stable periodic planning. This feature of the (*R*,*T*) policy has been well exploited in deterministic systems where both order quantities, *Q*, and reorder intervals, *T* , can be kept constant [7]. However, the stochastic case of the (*R*,*T*) policy is yet to be similarly analyzed. In contrast, convexity and sensitivity properties of the single-item (*Q*,*r*) policy have been well studied by Zipkin and Zheng [8,9], with extensions by Chen and Zheng and Gallego [10,11]. Understanding the single-item case is a crucial step toward its application to more complex systems.

In this paper, we analyze the single-item (*R*,*T*) and (*Q*,*r*) policy and its resulting costs for different parameter settings in spreadsheet modeling and VBA programming. In (*R*,*T*) model, We assume that time is continuous, that lead time for order delivery is a known constant, and unsatisfied demand can be backlogged (backordered). There is a fixed cost for order placement; backorder and holding costs are proportional to the long-run, time-weighted average backorders, and on-hand stock, respectively. In particular, we consider a Discrete distributed demand process (distribution is described later; it capture the spectrum of stationary demand processes with independent increments). We treat both *R* and *T* as decision variables to be optimized in the (*R*,*T*) policy, and *Q* and *r* in the (*Q*,*r*) policy.

IV ILLUSTRATION OF THE USE OF SPREADSHEET MODELING FOR THE (*R*,*T*) MODEL

The simulation model has been built using a spreadsheet program and depicts a special case of several retailers supplied by a central warehouse. Simulation scenarios are created based on two factors: length of the review period, and product type in terms of the average and standard deviation of the corresponding product's demand distribution.

In this paper, we use Microsoft Excel in inventory control periodical review system. The simulator dashboard for inventory control is shown in Fig. 1.

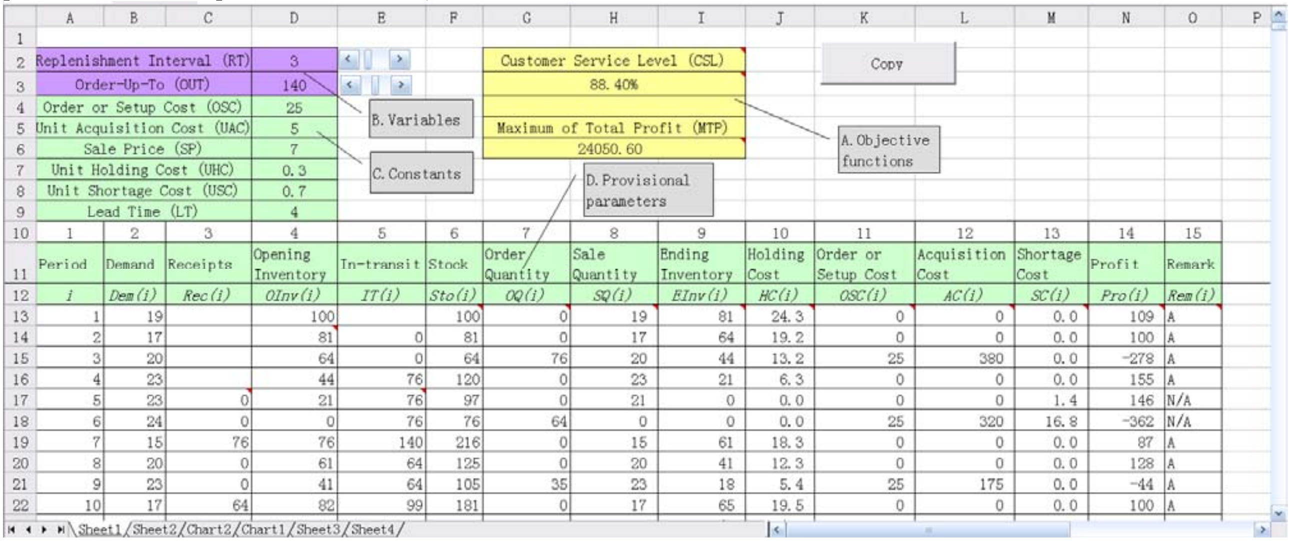
The following are definitions of the terms employed in the paper. The inventory model used periodical review policy where *R* designates the Replenishment Interval (*RI*) and *T* the Order-Up-To (*OUT*).

The following are definitions of the terms employed in the paper. The parameters of the model are set as following (see Tab. II):

A. Objective functions

1) Customer Service Level (CSL): The percentage of requisitions that can be met fully from stock. the simulator determines a different *R* and *T* for each simulation setting in order to reach the service level to 80 percent for each run.

2) Maximum of Total Profit (MTP): Maximum of the sum of profit in the 1,000 period.



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Period	Demand	Receipts	Opening Inventory	In-transit	Stock	Order Quantity	Sale Quantity	Ending Inventory	Holding Cost	Order or Setup Cost	Acquisition Cost	Shortage Cost	Profit	Remark
i	Dem(i)	Rec(i)	OInv(i)	IT(i)	Sto(i)	OQ(i)	SQ(i)	EInv(i)	HC(i)	OSC(i)	AC(i)	SC(i)	Pro(i)	Rem(i)
1	19		100		100	0	19	81	24.3	0	0	0.0	109	A
2	17		81	0	81	0	17	64	19.2	0	0	0.0	100	A
3	20		64	0	64	76	20	44	13.2	25	380	0.0	-278	A
4	23		44	76	120	0	23	21	6.3	0	0	0.0	155	A
5	23	0	21	76	97	0	21	0	0.0	0	0	1.4	146	N/A
6	24	0	0	76	76	64	0	0	0.0	25	320	16.8	-362	N/A
7	15	76	76	140	216	0	15	61	18.3	0	0	0.0	87	A
8	20	0	61	64	125	0	20	41	12.3	0	0	0.0	128	A
9	23	0	41	64	105	35	23	18	5.4	25	175	0.0	-44	A
10	17	64	82	99	181	0	17	65	19.5	0	0	0.0	100	A

Figure 1. The simulator dashboard for inventory control using Microsoft Excel spreadsheet

B. Variables

1) Replenishment Interval (RI): The interval of two reviews in the periodic review system

2) Order-Up-To (OUT): order is placed to raise the inventory position up to *T*.

C. Constants

1) Order or Setup Cost (OSC): The variable costs attributed to placing a single additional order; equivalent to the setup cost, here as a constant for $25/order.

2) Unit Acquisition Cost (UAC): The unit price acquisition from suppliers, here as a constant for $5/unit.

3) Sale Price (SP): The unit price sale to the customer, here as a constant for $7/unit.

4) Unit Holding Cost (UHC): The unit holding cost per period, here as a constant for $0.3/unit.period.

5) Unit Shortage Cost (USC): The unit shortage cost per period, here as a constant for $0.7/unit.period.

6) Lead Time (LT): The period from the time the re-order point is reached until the ordered material is available in inventory. here as a constant for 4 period.

TABLE II.
THE PARAMETERS OF THE MODEL

Parameters	Abbreviation	Description
Re-order Point	*ROP*	Inventory level at which a new order is placed.
Order Quantity	*OQ*	Purchase order for an input to the inventory, always for a specified quantity.
Period	*Per*	the unit time of simulation clock, It could be a day for assumptions. In this paper, we simulate 1,000 period.
Order or Setup Cost	*OSC*	Variable costs attributed to placing a single additional order; equivalent to the setup cost, here as a constant for $25/order.
Unit Acquisition Cost	*UAC*	Unit price acquisition from suppliers, here as a constant for $5/unit.
Sale Price	*SP*	Unit price sale to the customer, here as a constant for $7/unit.
Unit Holding Cost	*UHC*	Unit holding cost per period, here as a constant for $0.3/unit.period.
Unit Shortage Cost	*USC*	Unit shortage cost per period, here as a constant for $0.7/unit.period.
Step of Re-order Point	*SoROP*	Interval of *ROP* in two simulation process.
Time of Re-order Point	*ToROP*	Total number of different value of *ROP* in simulation process.
Step of Order Quantity	*SoOQ*	Interval of *OQ* in two simulation process.
Time of Order Quantity	*ToOQ*	Total number of different value of *OQ* in simulation process.

D. Provisional parameters

Consider a firm facing stationary cost parameters and revenue functions as well as a stationary demand process over the infinite horizon. For each period *i*, let

1) *i* = *i* is the unit time of simulation clock; It could be a day for assumptions. In this paper, we simulate 1,000 periods.

2) *Dem(i)* = demand in period *i*, *D(i)* is the device by which individual demands are placed upon the inventory. Demand is discrete distributed, mean demand per period is 20, and the distribution function is as following (see Tab. III).

3) *Rec(i)* = receipts in period *i*, *Rec(i)* is the quantity of inventory received in the period (*Rec*(*i*+ *LT*(*i*)= *OQ(i)*).

4) *OInv(i)* = opening inventory in period *i*, The quantity of inventory at the beginning of the period, (*OInv(i)=EInv(i*-1)).

5) *IT(i)* = in-transit in period *i*, *IT(i)* is the quantity of inventory in transition in period *i*, (form *IT*(*i*) to *IT*(*i*+*LT*(*i*))=*OQ*(*i*)).

TABLE III.
DISTRIBUTION FUNCTION OF DEMAND

Demand	Probability
15	2.5%
16	5.0%
17	7.5%
18	10.0%
19	15.0%
20	20.0%
21	15.0%
22	10.0%
23	7.5%
24	5.0%
25	2.5%

6) *Sto(i)* = stock in period *i*, *Sto(i)* is the sum of the opening inventory and in-transit inventory, (*Sto*(*i*)=*OI*(*i*)+*IT*(*i*)).

7) *OQ(i)* = order quantity in period *i*, *OQ(i)* is a purchase order for an input to the inventory (if *Sto(i)* is less than *OUT*, *OQ(i)* = *OUT- Sto(i)*, otherwise, *OQ(i)*=0).

8) *SQ(i)* = sale quantity in period *i*, *SQ(i)* equal to *Dem(i)* if *Dem(i)* is less than *OInv(i)*, otherwise *SQ(i)* equal to *OInv(i)*.

9) *EInv(i)* = ending inventory in period *i*, *EInv(i)* is the quantity of inventory at the end of the period, (*EInv(i)= OInv(i)-SQ(i)*)

10) *HC(i)* = holding cost in period *i*, *HC(i)* is the cost of carrying inventory (*HC(i)=UHC* × *Inv(i)*).

11) *OSC(i)* = order or setup cost in period *i*, *OSC(i)* is the average cost of ordering in dollars per order. If we ordered in period *i*, *OSC(i)* is a constant for $25/order, otherwise is a constant for $0/order, (if *OQ(i)*<>0, *OSC(i)=OSC* × *OQ(i)*, otherwise *OSC(i)*=0).

12) *AC(i)* = acquisition cost in period *i*, *AC(i)* is the acquisition cost of inventory (if *OQ(i)*<>0, *AC(i)* =*UAC* × *OQ(i)*, otherwise *AC(i)* =0).

13) *SC(i)* = shortage cost in period *i*, *SC(i)* is the cost resulting from experiencing a demand where there is insufficient stock available (if *OInv(i)* is less than *Dem(i)*, *SC(i)=USC* × (*Dem(i)- OInv(i)*), otherwise *SC(i)*=0).

14) *Pro(i)* = profit in period *i*, *Pro(i)* is the profit of each period (equal to *Dem(i)* × *SP* - *HC(i)* - *SC(i)* - *OSC(i)* - *AC(i)*).

15) *Rem(i)* = remark in period *i*, *Rem(i)* is the inventory availability in each period (if *OInv(i)* is less than *Dem(i)* we mark Not Availability "N/A", otherwise we mark Availability "A").

16) *LT(i)* = The period from the time the re-order point is reached until the ordered material is available in inventory. *LT(i)* is also discrete distributed, mean Lead Time per period is 4, the distribution function is as following (see Tab. IV).

17) *MTP* = maximum of total profit, *MTP* is the Maximum of the sum of profit in the 1,000 period ($MTP = \sum_{i=1}^{1,000} Dem(i) \times SP - HC(i) - SC(i) - OSC(i) - AC(i)$).

Tab. V shows the formulas of Microsoft Excel in the simulator dashboard; all the formulas should be filled to

1,000 periods. Tab. VI and Fig. 2 shows the process and the result of the simulation, From Tab. VI and Fig. 2, we found that the Maximum of Total Profit is $24050.60 when Replenishment Interval equal 3 and Order-Up-To equal 140, the Customer Service Level is 88.4%, reach the service level to 85%.

TABLE IV.
DISTRIBUTION FUNCTION OF LEAD TIME

Lead Time	Probability
2	10%
3	20%
4	40%
5	20%
6	10%

TABLE V.
THE FORMULAS OF MICROSOFT EXCEL IN THE SIMULATOR DASHBOARD

Definitions	Cell	Formulas in Excel
Rec	C17	=G13
OI	D14	=I13+C14
IT	E17	=SUM(G13:G16)
Sto	F13	=D13+E13
OQ	G13	=IF(F13<$D$3,IF(A13/$D$2=INT(A13/$D$2),$D$3-F13,0),0)
SQ	H13	=IF(D13>=B13,B13,D13)
EI	I13	=D13-H13
HC	J13	=I13*$D$7
OSC	K13	=IF(G13<>0,$D$4,0)
AC	L13	=G13*$D$5
SC	M13	=IF(H13<B13,(B13-H13)*$D$8,0)
PRO	N13	=H13*$D$6-J13-K13-L13-M13
Rem	O13	=IF(D13<B13,"N/A","A")
CSL	G3	=COUNTIF(O13:O1012,"A")/1,000
MTP	G6	=SUM(N13:N1012)+K1012+L1012+(F1012-100)*$D$5

TABLE VI.
THE PROCESS OF THE SIMULATION

RI	OUT	CSL	MTP
1	130	92.50%	17623.00
2	180	93.60%	16349.00
3	140	88.40%	24050.60
4	230	91.50%	15639.90
5	180	91.40%	21514.40
6	190	87.60%	19852.60
7	210	89.10%	17111.60
8	230	90.80%	14634.80
9	240	88.50%	12417.90
10	250	87.20%	10119.30

V ILLUSTRATION OF THE USE OF VBA PROGRAMMING FOR THE (*Q*,*R*) MODEL

Visual Basic for Application (VBA) is a programming language that is supported by many popular business applications, including the apps in the Microsoft Office Suite. All that's required to start programming is to turn on the VBA Macro Recorder, which is built into all the apps, perform the tasks you want the macro to do. So we can create Visual Basic code for a task that can be repeated whenever you wish, saving you loads of time.

In this paper, we also use Microsoft Excel VBA in inventory control periodical review system. The simulator dashboard for inventory control we call Inventory Simulator Dashboard (ISD) is shown in Fig. 3 and Fig. 4. In Fig. 3, we generate discrete distributed numbers using Macro Analysis in B and C rows. The distribution functions are same as *D(i)* and *LT(i)*.

Once these inputs have been introduced, the program follows the flow diagram shown in Fig. 5, where *ROPStept*, *ROPTime*, *OQTime* and *OQstep* are search area variables, and the step number of *k* and *l* are counter variables. This process is repeated until each step number is obtained. The subroutine will scan 1,000 rows in each cycle.

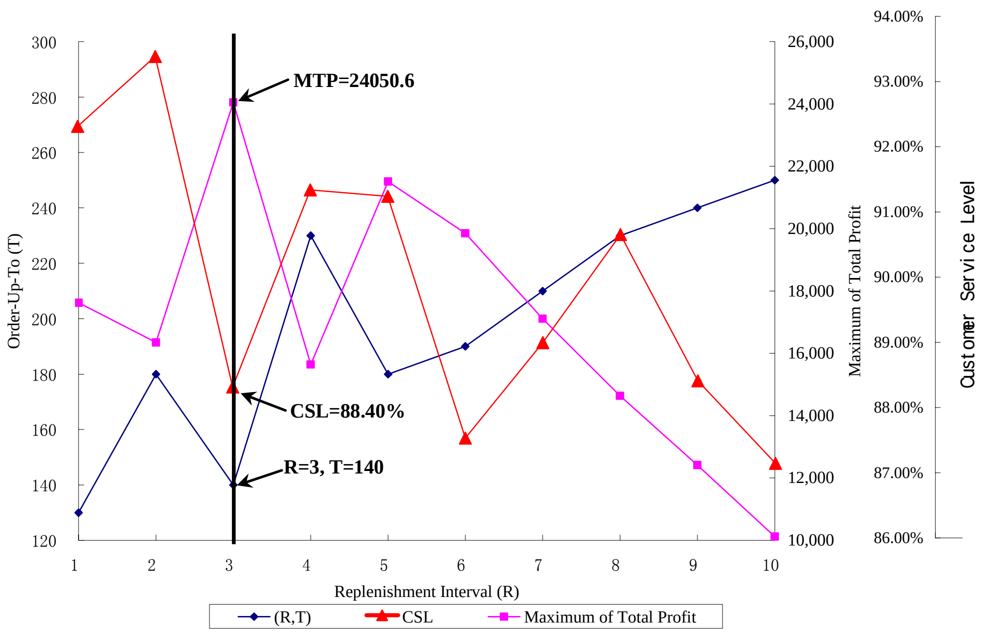


Figure 2. The result of the simulation

Once the system structure has been analyzed, it is possible to design the associated ISD VBA function. The final algorithm can be summarized as shown in Fig. 6.

At the beginning of the simulation, we do not know the exact value of *ROP* and *OQ* when total profit is maximum, but we can reduce the search range by the following step:

(1) Elementary search: Fig. 7(a) shows ISD results obtained after running 6×5 cycles and scanning 6×5×1,000 rows in Microsoft Excel VBA (Re-order Point form 25 to 125 step 20; Order Quantity from 60 to 140 step 20), In this step, we know that the Maximum of Total Profit is 21865 when Re-order Point is about 65 and Order Quantity is about 80.

(2) Junior search: Fig. 7(b) shows ISD results obtained after running 6×5 cycles and scanning 6×5×1,000 rows in Microsoft Excel VBA (Re-order Point form 50 to 75 step 5; Order Quantity from 65 to 85 step 5), The Maximum of Total Profit is 22045 when Re-order Point all equal 70.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Re-order Point	Order Quantity	Order or Setup Cost	Unit Acquisition Cost	Sale Price	Unit Holding Cost	Unit Shortage Cost	ROP Step	ROP Time	OQ Step	OQ Time		
2	78	77	25	5	7	0.3	0.7	5	10	10	10		
3	Period	Demand	Lead Time	In-transit	Receipts	Stock	Inventory	Holding Cost	Shortage Cost	Order or Setup Cost	Acquisition Cost	Profit	
4	20764.8						100						
5	1	19	4			81	81	24.3				108.7	
6	2	17	3	77		141	64	19.2		25	385	-310.2	
7	3	20	4	77		121	44	13.2				126.8	
8	4	23	5	77		98	21	6.3				154.7	
9	5	23	5	77	77	152	75	22.5		25	385	-271.5	
10	6	24	6	77		128	51	15.3				152.7	
11	7	15	2	77		113	36	10.8				94.2	
12	8	20	4	77		93	16	4.8				135.2	
13	9	23	5	154		147	-7		4.9	25	385	-253.9	
14	10	17	3	77	77	130	53	15.9				103.1	
15	11	18	3	77		112	35	10.5				115.5	
16	12	16	2	77		96	19	5.7				106.3	
17	13	16	2	77		80	3	0.9				111.1	
18	14	18	3	77	77	139	62	18.6		25	385	-302.6	
19	15	18	3	77		121	44	13.2				112.8	
20	16	15	2	77		106	29	8.7				96.3	

Inventory Simulator / Sheet2 / Sheet3 / Chart1 / Parameters Setting / Sheet1 /

Figure 3. The simulator dashboard for inventory control using Microsoft Excel VBA

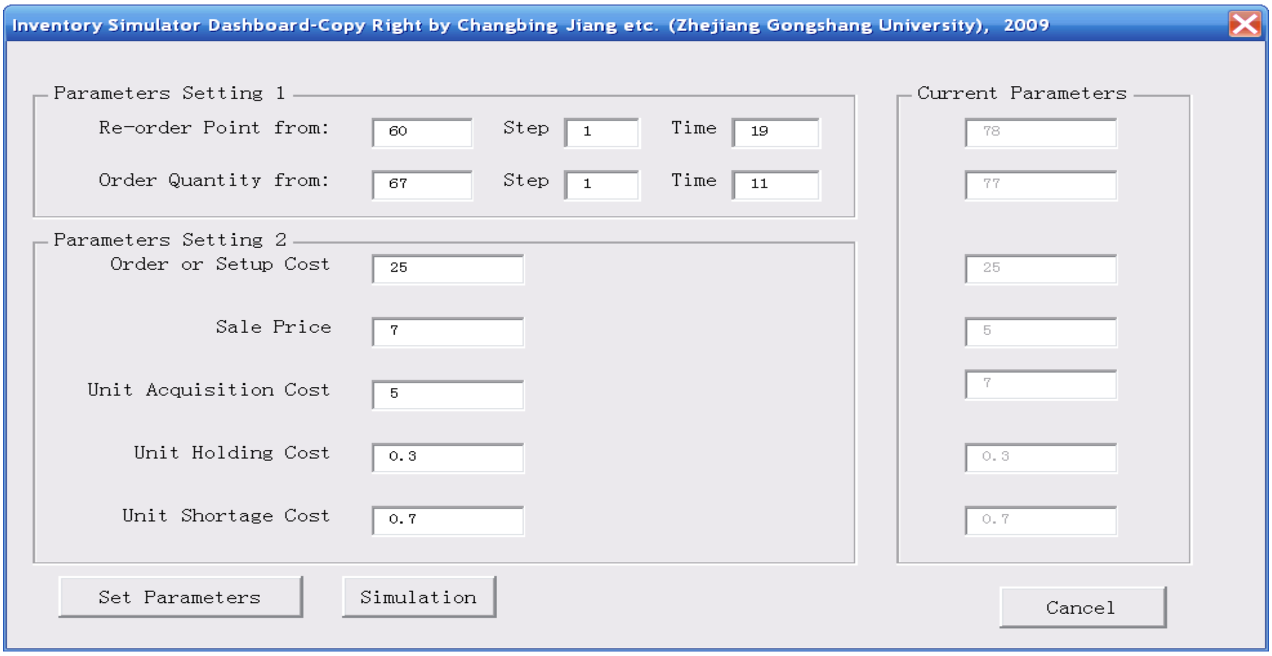


Figure 4. The ISD simulator dashboard

(3) Advanced search: Fig. 7(c) shows ISD results obtained after running 21×21 cycles and scanning 21×21×1,000 rows in Microsoft Excel VBA (Re-order Point form 60 to 80 step 1; Order Quantity from 60 to 80 step 1), The Maximum of Total Profit is 22368 when *ROP*=65 and *OQ*=72 (see Tab. VII). The result is basically the same as the result of spreadsheet software programming.

It is important to remark that the program needed less than 1 min to arrive at these estimation values using a common personal computer with a 1,500 MHz processor and 2 Gb DDR2 RAM.

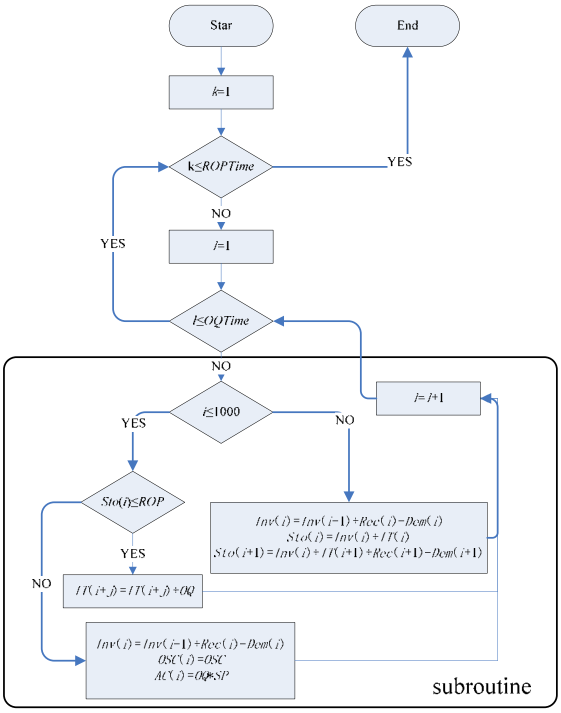


Figure 5. The ISD flow diagram

The development of an integrated spreadsheet model requires knowledge of the supply chain and distribution processes within the organization as well as the impact of alternative scenarios on suppliers, customers and on the organization itself. Integrated spreadsheet modeling and VBA is a powerful tool for analyzing opportunities and calculating benefits, and can be done very successfully within the confines of current spreadsheet software. This type of modeling lends itself well to the abilities of most engineers, consultants and managers that have a comprehensive knowledge of their company or client.

For k = 1 To *ROPTime*
  For l = 1 To *OQTime*
    For i = 1 To *Per*
      If *STO(i)*< *ROP* then
        Calculate the In-transit for $IT(i)$ to $IT(i{+}LT(i))$
        Calculate the Receipts for $Rec(i{+}\ LT(i))$
        Calculate the Order or Setup Cost for $OSC(i)$
        Calculate the Acquisition Cost for $AC(i)$
      End if
        Calculate the Inventory for $Inv(i)$
        Calculate the Stock for $STO(i)$
        Calculate the Stock for $STO(i{+}1)$
    If I(i)<0 then
        Calculate the Shortage Cost for $SC(i)$
    Else
        Calculate the Holding Cost for $HC(i)$
    End if
        Calculate the Profit for $Pro(i)$
    Next i
  Next l
Next k
Final: Total Profit $= \sum Pro(i)$.

Figure 6. ISD VBA function for the final algorithm

TABLE VII.
THE PROCESS OF THE SIMULATION

ROP	OQ										
	67	68	69	70	71	72	73	74	75	76	77
60	21088	21433	21392	21809	21243	22291	21381	21682	21549	21618	21749
61	21159	21488	21447	21701	21376	22248	21367	21659	21631	21631	21761
62	21278	21638	21465	21953	21306	22250	21432	21715	21659	21652	21820
63	21263	21574	21409	21929	21253	22298	21465	21723	21611	21788	21906
64	21191	21737	21546	21870	21256	22330	21492	21743	21599	21952	22102
65	21287	21771	21121	21860	21241	**22368**	21384	21783	21564	21896	21932
66	21383	21786	21125	22134	21242	22144	21293	21730	21799	21879	21847
67	21466	21601	21113	22208	21713	21965	21257	21681	21800	21736	21644
68	21582	21593	21047	22129	21709	21983	21389	21642	21668	21700	21609
69	21692	21493	21021	22073	21811	21905	21381	21617	21586	21635	21713
70	21585	21554	20961	22045	21888	21686	21587	21613	21434	21549	21735
71	21573	21384	20943	22059	21851	21359	21645	21565	21372	21384	21742
72	21336	21412	20920	22057	21900	21220	21717	21463	21353	21459	21768
73	21337	21344	20951	21905	21728	21244	21595	21264	21355	21363	21791
74	21190	21316	21027	21827	21652	21296	21361	21040	21476	21258	21692
75	21102	21230	20815	21355	21553	21263	21203	20924	21442	21193	21163
76	20866	21056	20987	21164	21375	21130	21211	20888	21282	21083	21209
77	20933	21055	21146	21158	20895	20985	21159	20789	21210	20887	21038
78	20833	20897	21107	21053	20741	20880	20912	20730	21117	20503	20765

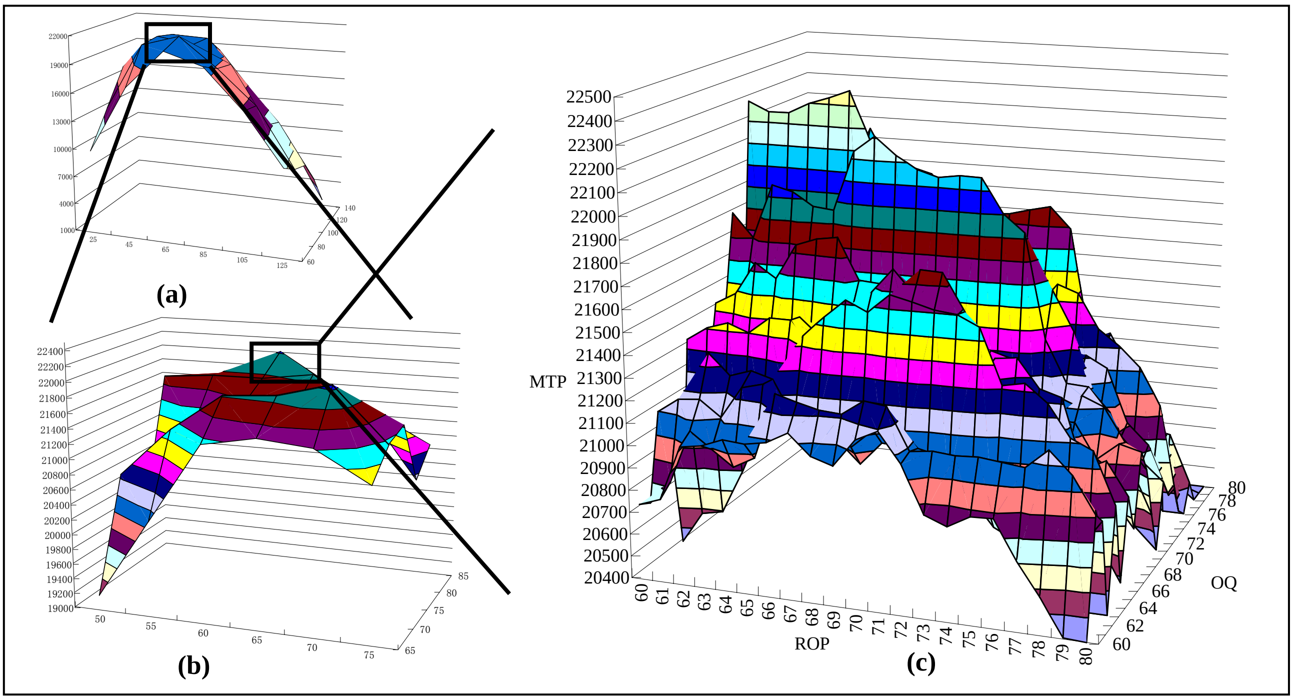


Figure 7. Three steps for searching the *MTP* in VBA programming

VI CONCLUSION

This article has described a integrated use of spreadsheet software and VBA in teaching a inventory control course. It differs from the traditional programming language approach in that it teaches students how to solve problems using packages which are representative of available logistics software. Another unique aspect is the use of general spreadsheet software to integrate the results from using the various special purpose software. This approach is different from the modeling approach where many spreadsheet models are built to address logistics issues.

ACKNOWLEDGMENT

The project is supported by Zhejiang Provincial Natural Science Foundation of China (Y6090015), the Key Foundation of Philosophy and Social Science of Zhejiang Province (09CGYD012Z), National Science Fund(70972137) and the Key Research Institute of Social Sciences and Humanities, Ministry of Education, and is supported by the Contemporary Business and Trade Research Center of Zhejiang Gongshang University (09JDSM25YB).

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Changbing Jiang is the instructor of Contemporary Business and Trade Research Center of Zhejiang Gongshang University, He obtained the Master of Management Science and Engineering from Beijing Wuzi University in Beijing, China.

He is the author of eleven books: Logistics System and Logistics Engineering (China Logistics Press), Logistics Engineering and management (China Renmin University press), Supply Chain Management Practice: A Logistics Perspective (Zhejiang University press) ect.. He has published more than 40 articles in journals and conference proceedings (more than 20 articles are indexed by EI and ISTP). As a researcher and a Chartered Member of the China Federation of Logistics & Purchasing, he is also a member of China Materials Storage & Transportation Association.