Mars, Inc.

Inventory and Production Optimization of

Halloween M&M's®

Decision Support Tool User Manual

Contents

1. Introduction

The Decision Support Tool (DST) is a user-friendly, Microsoft Excel based program that can be used to create a production schedule for M&M's. This user-manual will provide information regarding the functionality and flexibility of the DST. The DST gives the Supply-Planning department at Mars the ability to save on holding cost by scheduling the production of seasonal M&M's closer to when seasonal demand is realized. The methodology that reduces costs consists of a stochastic linear program, built using the open-source Microsoft Excel add-in OpenSolver, which minimizes the sum of holding and unmet demand costs across the stock-keeping-units (SKUs) that are selected in the DST.

After the user has inputted the SKUs to be included in the production schedule, the quantity of each SKU to produce, the corresponding cost parameters per SKU, and the location that the SKU is produced in; the user will select the demand patterns to be applied to each SKU. An example of a demand pattern that the user could use for a SKU is the historical demand pattern from a previous year, such as 2011. The user also has the ability to select a different demand pattern for each SKU.

The DST allows for up to four possible demand scenarios to be considered in the creation of the production schedule. A demand scenario consists of a demand pattern chosen for each SKU listed in the DST. The demand scenarios are used in a manner analogous to creating a schedule based on differing forecasts of demand for the season.

After the user has assigned a probability to each of the demand scenarios selected, the user will determine the effective number of shifts available per period and the effective shift rate for each plant and product line. After populating the shift levels, the user can create a production schedule for the SKUs selected.

Once a production schedule has been created, the user can apply random demands to the production schedule through the process of Monte Carlo simulation of demand. This allows the user to view the holding and unmet demand costs that the DST created production schedule will incur.

Note that the DST has been built through VBA (Visual Basic for Applications). The code that was written to build the DST can be viewed by pressing the ALT + F11 keys. The code has been fully commented with an explanation of each section, so if the DST is required to be updated or changed, someone with knowledge of VBA can do so easily.

2. OpenSolver

OpenSolver is an open-source Microsoft Excel add-in created by a group of students from the University of Auckland. OpenSolver was necessary for the creation of the DST because OpenSolver does not constrain the number of decision variables or constraints that can be included in a linear program. It is a freely available add-in and must be installed before the DST is able to run. In order to install OpenSolver, follow the steps below:

1) Extract the files from the .zip file included in this package to create your OpenSolver folder containing all the OpenSolver files. (Please do not place the OpenSolver folder on your desktop, as this seems to cause problems for some users in Windows 7. Instead, place it in your Documents or Program Files folder.) Open the ReadMe.txt for reference.
2) Then double click on the OpenSolver.xlam file. This will open Excel and load OpenSolver. After enabling macros by clicking on the security warning dialog, OpenSolver will appear in the Data tab.
3) Enable the Analysis Toolpak, Analysis Toolpak - VBA, and Solver Add-ins via the Excel Options Dialog Box. This will ensure that the Solver will work properly. You are now ready to use the DST.

Once OpenSolver has been properly installed, the DST will have all of the external files installed that are needed to operate. For troubleshooting, please visit the OpenSolver website, http://opensolver.org/.

3. User Inputs

A benefit of the DST is the amount of flexibility the user has in creating a production schedule. This section of the user-manual will detail the steps that the user must take before a production schedule can be created. The Figure 1 below depicts the buttons show the features available while inputting the parameters for the model which are covered in the following subsections.

Figure 1

3.A. SKUs

The first step in the user-input stage involves selecting the SKUs to be included in the production schedule. The user has the ability to manipulate the following for the SKUs that are currently planned for the 2013 Halloween Season (see Figure 2):

- The type of M&Ms, either peanut (PNT) or milk-chocolate (MC), in the "Type" column
- The amount to produce, in the "Amount (Tons)" column
- The facility that the SKU is produced in, Hackettstown (HKT) or Cleveland (CLV)
- The Gross Sales Value (GSV) per ton, in the "GSV Per Ton" column
- The holding cost as a percentage of GSV, in the "Holding Cost (% of GSV)" column

- The last period holding cost as a percentage of GSV, in the “Last Period Holding Cost (% of GSV)” column
- The penalty cost of unmet demand as a percentage of GSV, in the “Penalty Cost of Unmet Demand (% of GSV)” column
- The decision to include the SKU into the model

	A	B	C	D	E	F	G	H	I	J
1	SKU	Type	Amount (Tons)	HKT	CLV	GSV Per Ton	Holding Cost (% of GSV)	Last Period Holding Cost (% of GSV)	Penalty Cost of Unmet Demand (% of GSV)	Include in Model?
2	DomesticMC	MC	57437.2	YES	YES	$ 6,975.18	30%	30%	100%	Yes
3	DomesticPNT	PNT	64164.9	YES	YES	$ 7,312.72	30%	30%	100%	Yes
4	M3135400	MC	658.3	YES	YES	$ 6,864.30	30%	50%	100%	Yes
5	M3135500	MC	426.4	YES	YES	$ 6,861.06	30%	50%	100%	Yes
6	M3471400	MC	242.9	YES	YES	$ 8,709.06	30%	50%	100%	Yes
7	M3472400	MC	240.8	YES	YES	$ 8,709.36	30%	50%	100%	Yes
8	M4103300	MC	108.1	YES	YES	$ 7,828.80	30%	50%	100%	Yes
9	M4348701	MC	660.7	YES	YES	$ 7,406.06	30%	50%	100%	Yes
10	M4597400	MC	110.3	YES	YES	$ 6,915.11	30%	50%	100%	Yes
11	M3134800	PNT	584.4	YES	YES	$ 6,864.30	30%	50%	100%	Yes
12	M3135000	PNT	363.0	YES	YES	$ 6,861.06	30%	50%	100%	Yes
13	M4103600	PNT	98.9	YES	YES	$ 8,825.78	30%	50%	100%	Yes
14	M4330501	PNT	167.9	YES	YES	$ 7,252.57	30%	50%	100%	Yes
15	M4468800	PNT	493.5	YES	YES	$ 6,656.96	30%	50%	100%	Yes
16	M4581200	PNT	137.6	YES	YES	$ 9,137.35	30%	50%	100%	Yes
17										
18										
19										
20										
21										

Figure 2

After the user has verified these parameters for the pre-populated SKUs, the user has the ability to add new SKUs to the model. Selecting the “New SKU” button will open a dialog box shown below that will allow the user to add a new SKU to the list of available SKUs for the model and input the same parameters discussed above. See Figure 3 If this new SKU is to be included in the model, type “Yes” for the SKU in the “Include in Model” column.

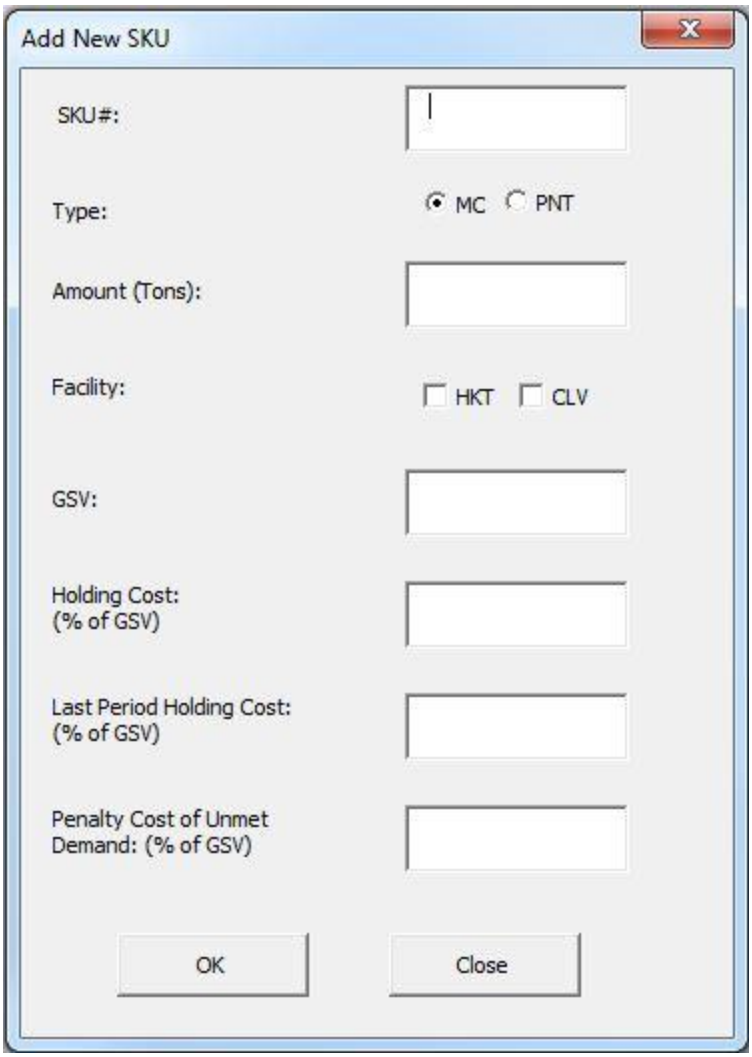

Figure 3

Within the "SKUS" tab of the DST, the user will press the "Populate SKUs" button which will include the Halloween peanut and milk-chocolate M&M's that have been selected to be included in the model. The "Populate SKUs" button will also include the aggregate "Open-Stock" or "Domestic" peanut and milk-chocolate M&Ms that are produced during the planning horizon. The populated SKUs will appear under column "Model SKUs".

3.B. Demand Patterns

The next user-input step involves setting the demand patterns to be used for each SKU included in the DST. A demand pattern represents the percentage of demand that is expected to occur in each period of the planning horizon. For instance, a Halloween SKU demand pattern will most likely start in period seven and extend to period eleven. The demand patterns included for the pre-populated SKUs in the DST consist of a combination of the following, depending on availability:

- Historical 2009
- Historical 2010

- Historical 2011
- Historical 2012
- Historical Average
- Linearly Increasing
- Linearly Decreasing
- Concave Parabola

These demand patterns are available for viewing in the “DemandOptions” tab of the DST. The user has the ability to select the demand patterns that can be applied to a SKU by selecting the “Manage Demand Options” button. This will open a dialog box that allows the user to select a SKU. See Figure 4 below for the dialog box.

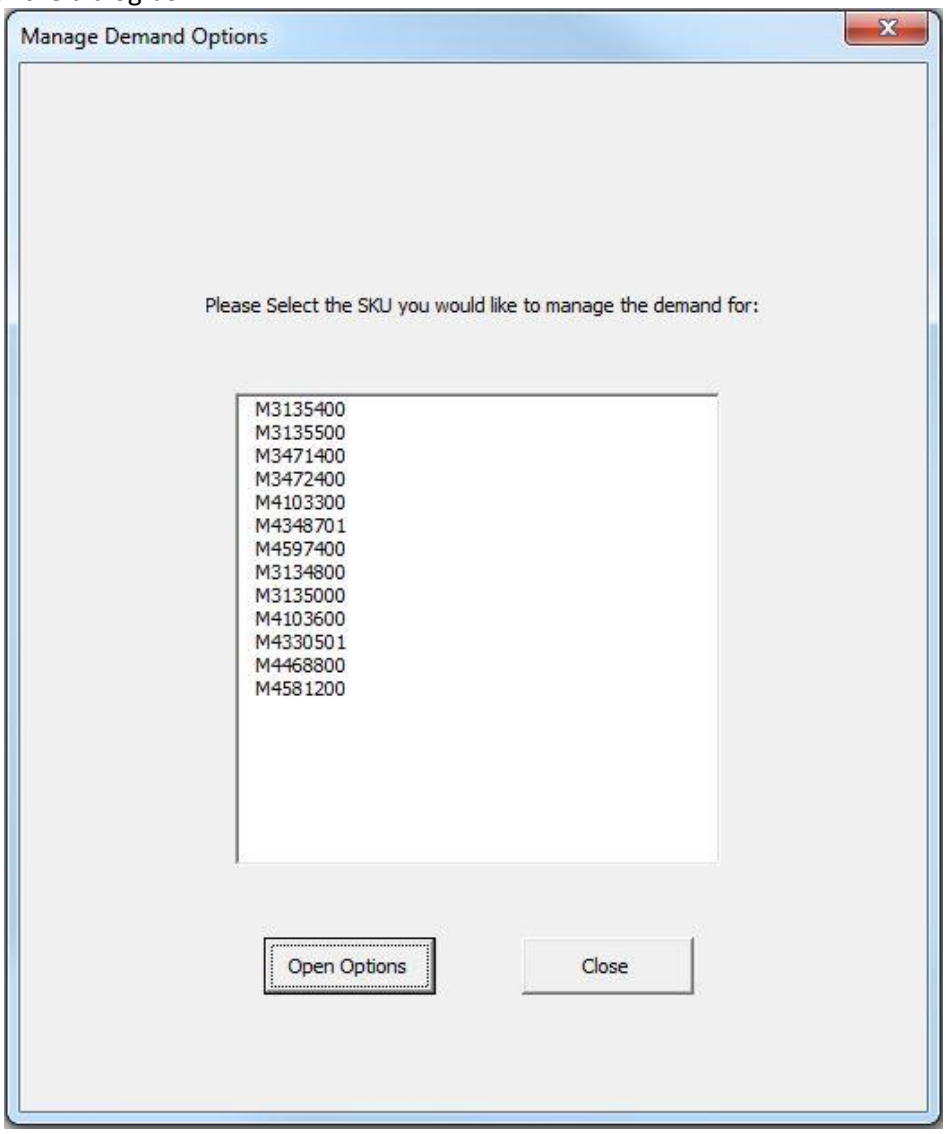

Figure 4

After selecting a SKU, the user presses the “Open Options” button to select the demand options that are available. The following Figure 5 depicts the dialog box.

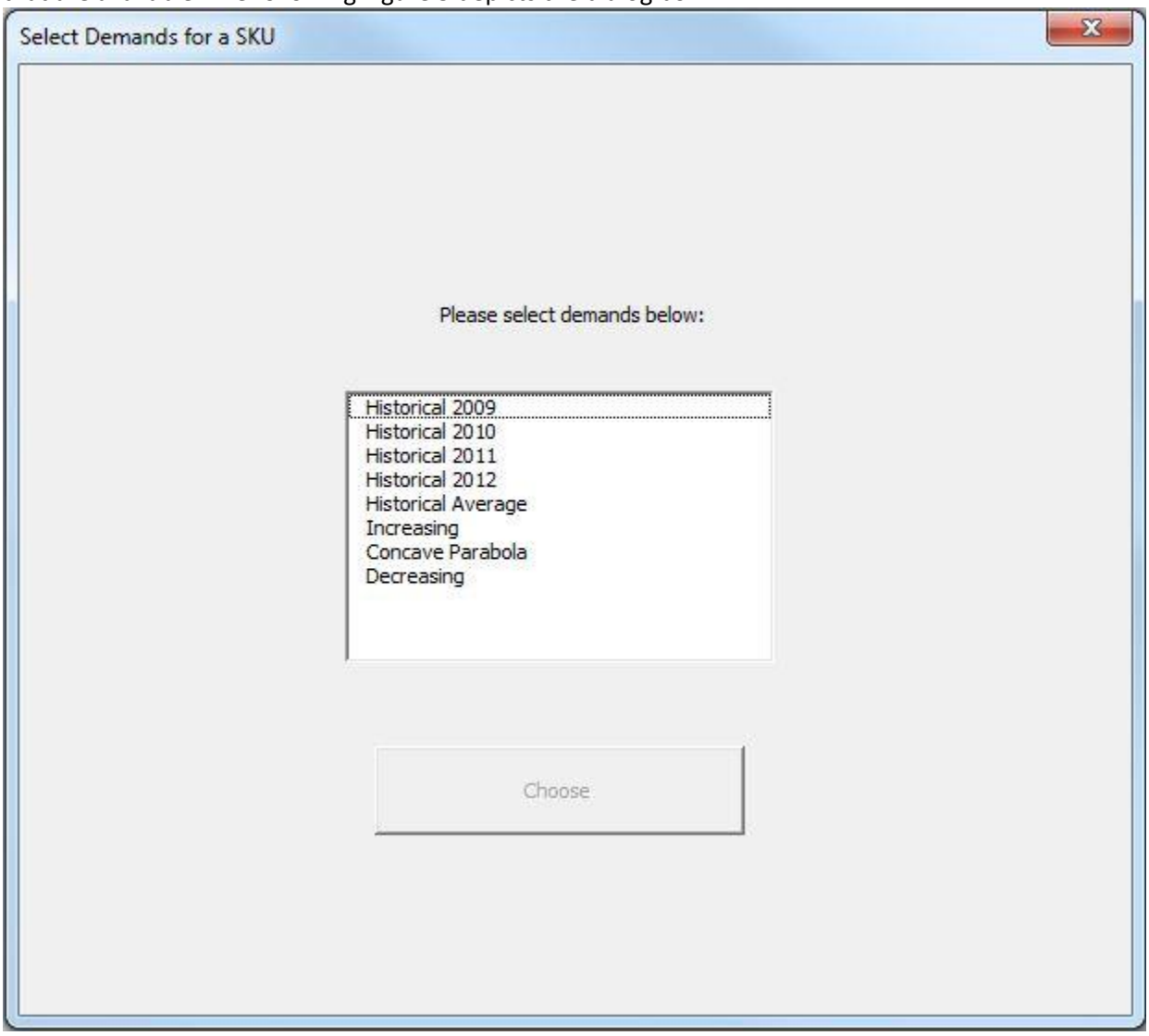

Figure 5

The user will iterate in this manner for all the SKUs to change demand options available for each SKU. The user will then go to the “Choose Demand Options” column and select from a dropdown box a demand pattern for each SKU. The drop-down box consists of the options chosen for the corresponding SKU. The “Manage Demand Options” feature is included to allow the user to input and save multiple demand patterns for a SKU but use a smaller subset when creating the inputs to the model.

By selecting the “New Demand Pattern” button, the user can create a specific custom demand pattern to be used for one SKU or multiple SKUs. To select multiple SKUs, the user must hold down the Control button on the keyboard while using the mouse to select SKUs. Figure 6 below depicts the “Custom Demand” dialog box.

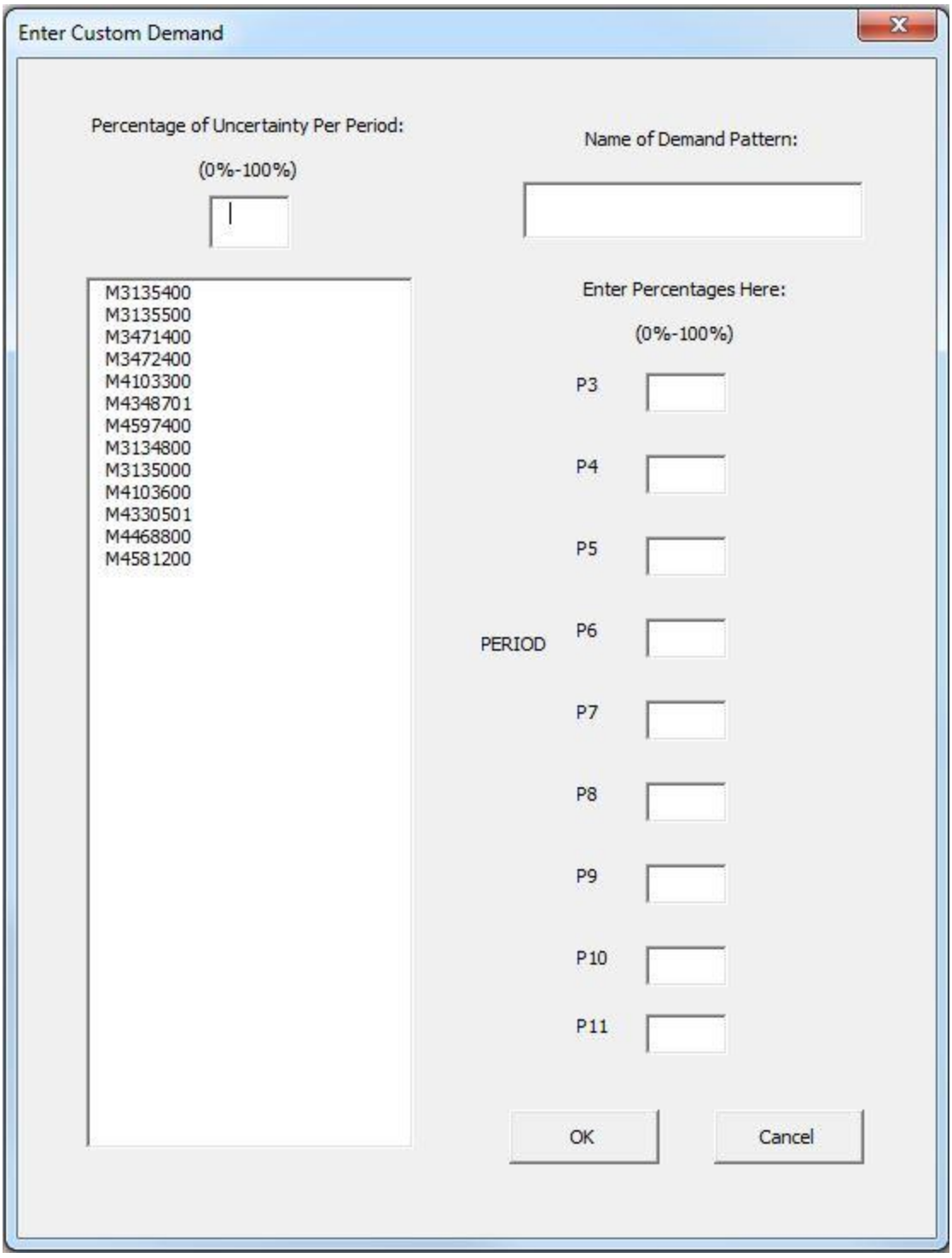

Figure 6

The percentages inserted per period must add up to 100% over the planning horizon. This custom demand feature allows the user to add a more conservative, or aggressive, demand pattern for a given SKU or set of SKUs. For example, if the user is concerned that a product will have excessive lead-times or handling times, then the user can create a demand pattern that contains more demand in earlier periods to ensure that demand will be met.

An additional feature for the demand patterns includes the “Uncertainty Level”. This allows the user to assign a percentage of variability to apply to each period of the demand pattern. For example, if the user selects an uncertainty level of 10% for a demand pattern, then in the process of simulating random demand, demands will be generated following a uniform distribution within a range of 10% of the percentage of demand for the given period.

If a new demand pattern is added in for a SKU or set of SKUs, the user must open the “Manage Demand Options” dialog box and complete the above steps again. This is necessary since the drop-down down box are populated based on the selections made in the “Manage Demand Options” dialog box.

The user must select a demand pattern for each SKU before a demand scenario can be created.

3.C. Demand Scenarios

Once a demand pattern has been selected for each SKU (under the “Choose the Demand Options” column), the user clicks on the “Add to Scenario A” button to save this combination of patterns to scenario A. Then the user repeats the same process selecting different demand patterns for each SKU and saving the combinations as Scenario B, C, or D by clicking on the respective buttons. The below Figure 7 is a sample collection of Scenarios.

L	M	N	O	P	Q
Model SKUs	Choose the Demand Options	Scenario A	Scenario B	Scenario C	Scenario D
DomesticMC	Inputted	Inputted	Inputted	Inputted	Inputted
DomesticPNT	Inputted	Inputted	Inputted	Inputted	Inputted
M3135400	Concave Parabola	Concave Parabola	Increasing	Concave Parabola	Decreasing
M3135500	Increasing	Increasing	Increasing	Concave Parabola	Decreasing
M3471400	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M3472400	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M4103300	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M4348701	Historical 2012	Historical 2012	Increasing	Concave Parabola	Decreasing
M4597400	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M3134800	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M3135000	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M4103600	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M4330501	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M4468800	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing
M4581200	Decreasing	Decreasing	Increasing	Concave Parabola	Decreasing

Figure 7

The next step is to assign probabilities to each of these scenarios by clicking on the “Assign Scenario Probabilities” button. If the user does not want a scenario to be included in the model, they

assign a probability of zero to that demand scenario. The below Figure 8 is the dialog box.

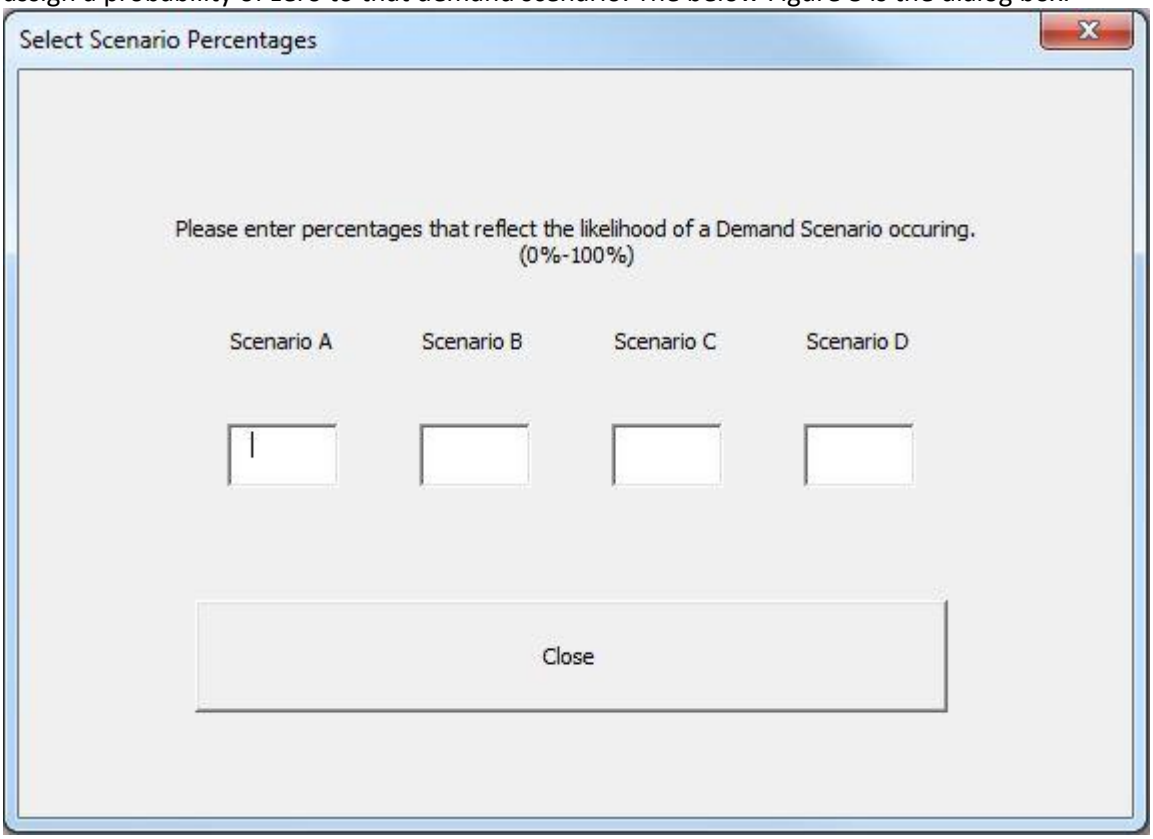

Figure 8

3.D. Domestic Production Level

By clicking on “Edit Domestic Production”, the user can change the amounts for domestic production for Milk Chocolate and Peanut. The user enters the tons to be produced for each period for both types of M&M’s. The sum of the amounts for all the periods for Milk Chocolate and Peanut entered will be reflected as the amount of tons to be produced for “DomesticMC” and “DomesticPNT”. The dialog box is depicted below as Figure 9.

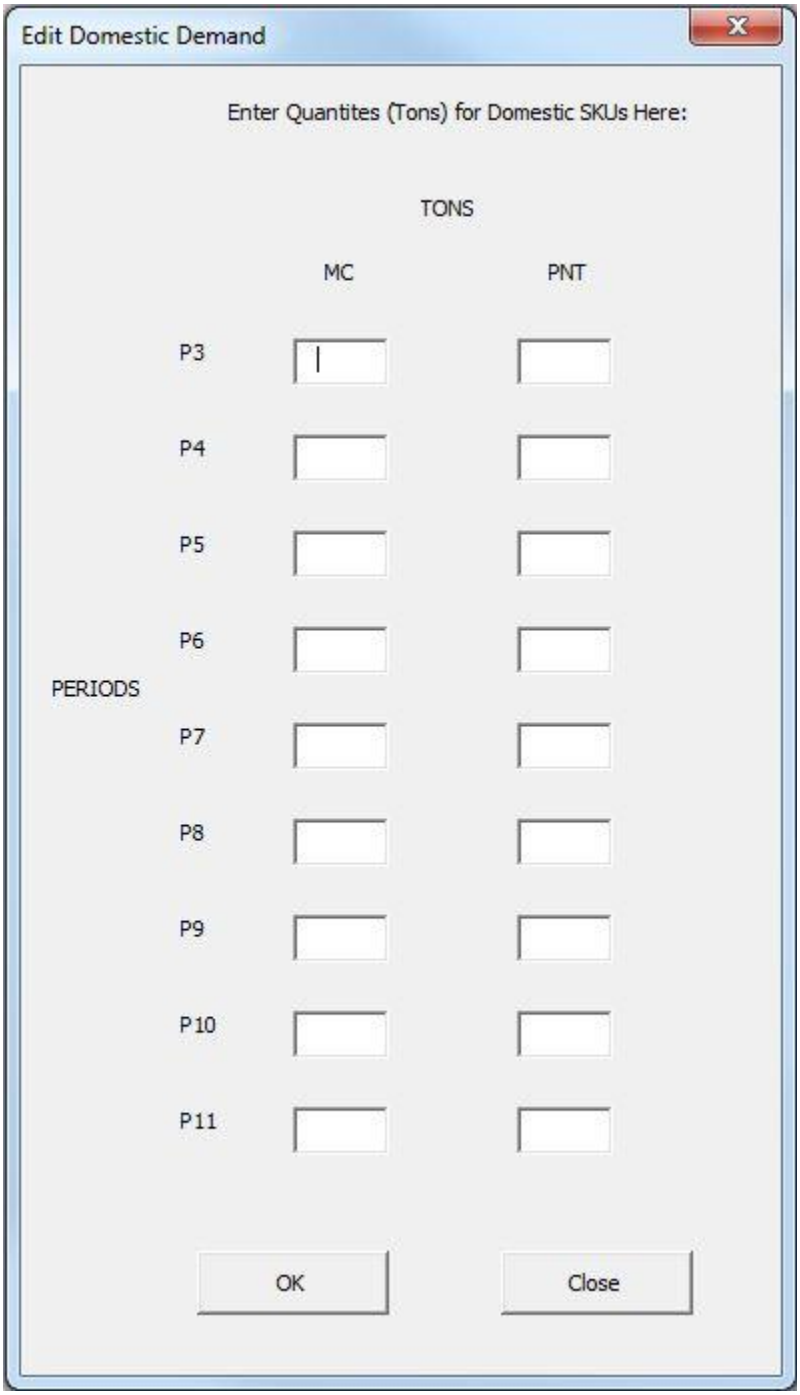

Figure 9

3.E. Shift Levels

On the “Shifts” tab, the user enters “Tons/Shift” and “Shifts Available” for each period for each line at CLV and HKT plants. The user also adjusts the starting period on this tab. The user then clicks on “Populate Shifts to bring this information to the “Inputs” tab. This button generates the production constraints that are used in the stochastic linear program. A portion of the “Shifts” tab is depicted below in Figure 10.

	A	B	C	D	E	F	G	H	I	J
1	MC Rate Tons/Shift - Cleveland	65	PNT Rate Tons/Shift - Cleveland	40	MC Rate Tons/Shift - Hackettstown	40	PNT Rate Tons/Shift - Hackettstown	80	Starting Period	3
2	P3 Shifts	70	P3 Shifts	66	P3 Shifts	72	P3 Shifts	60		
3	P4 Shifts	45	P4 Shifts	50	P4 Shifts	74	P4 Shifts	64		
4	P5 Shifts	70	P5 Shifts	62	P5 Shifts	75	P5 Shifts	60		
5	P6 Shifts	66	P6 Shifts	65	P6 Shifts	67	P6 Shifts	60		
6	P7 Shifts	65	P7 Shifts	60	P7 Shifts	51	P7 Shifts	59		
7	P8 Shifts	69	P8 Shifts	78	P8 Shifts	69	P8 Shifts	62		
8	P9 Shifts	66	P9 Shifts	69	P9 Shifts	65	P9 Shifts	58		
9	P10 Shifts	69	P10 Shifts	71	P10 Shifts	69	P10 Shifts	55		
10	P11 Shifts	52	P11 Shifts	55	P11 Shifts	70	P11 Shifts	61		
11										
12										
13										
14				POPULATE SHIFTS						
15										

Figure 10

4. Schedule Generation

To generate a schedule after entering all the inputs mentioned so far, the user activates to the "Inputs" tab. The "Inputs" tab provides the user with a snapshot of all the information that has been inputted so far. This information is populated when the user clicks on "Populate SKUs" and "Populate Shifts" on the previous two pages. Then to evaluate the model, the user clicks on "Run Model". The model is evaluated through OpenSolver after the user clicks on this button. The OpenSolver calculations can be seen on the "Model" tab. See the next page for the screenshot of the "Inputs" tab (Figure 11).

SKU	Type	Amount	HKT	CLV	GSV	Holding Cost (% of GSV)	Last Period Holding Cost (% of GSV)	Penalty Cost of Unmet Demand (% of GSV)
DomesticMC	**MC**	57437.2	YES	YES	$6,975.18	30%	30%	100%
DomesticPNT	**PNT**	64164.9	YES	YES	$7,312.72	30%	30%	100%
M3135400	**MC**	658.3	YES	YES	$6,864.30	30%	50%	100%
M3135500	**MC**	426.4	YES	YES	$6,861.06	30%	50%	100%
M3471400	**MC**	242.9	YES	YES	$8,709.06	30%	50%	100%
M3472400	**MC**	240.8	YES	YES	$8,709.36	30%	50%	100%
M4103300	**MC**	108.1	YES	YES	$7,828.80	30%	50%	100%
M4348701	**MC**	660.7	YES	YES	$7,406.06	30%	50%	100%
M4597400	**MC**	110.3	YES	YES	$6,915.11	30%	50%	100%
M3134800	**PNT**	584.4	YES	YES	$6,864.30	30%	50%	100%
M3135000	**PNT**	363.0	YES	YES	$6,861.06	30%	50%	100%
M4103600	**PNT**	98.9	YES	YES	$8,825.78	30%	50%	100%
M4330501	**PNT**	167.9	YES	YES	$7,252.57	30%	50%	100%
M4468800	**PNT**	493.5	YES	YES	$6,656.96	30%	50%	100%
M4581200	**PNT**	137.6	YES	YES	$9,137.35	30%	50%	100%

MC Rate Tons/Shift - Cleveland	65	PNT Rate Tons/Shift - Cleveland	40	MC Rate Tons/Shift - Hackettstown	40	PNT Rate Tons/Shift - Hackettstown	80	Starting Period	3
P3 Shifts	70	P3 Shifts	66	P3 Shifts	72	P3 Shifts	60		
P4 Shifts	45	P4 Shifts	50	P4 Shifts	74	P4 Shifts	64		
P5 Shifts	70	P5 Shifts	62	P5 Shifts	75	P5 Shifts	60		
P6 Shifts	66	P6 Shifts	65	P6 Shifts	67	P6 Shifts	60		
P7 Shifts	65	P7 Shifts	60	P7 Shifts	51	P7 Shifts	59		
P8 Shifts	69	P8 Shifts	78	P8 Shifts	69	P8 Shifts	62		
P9 Shifts	66	P9 Shifts	69	P9 Shifts	65	P9 Shifts	58		
P10 Shifts	69	P10 Shifts	71	P10 Shifts	69	P10 Shifts	55		
P11 Shifts	52	P11 Shifts	55	P11 Shifts	70	P11 Shifts	61		

Run Model

Run Monte Carlo **Create Pivot Tables**

Figure 11

To view the schedule, the user clicks on the “Create Pivot Tables” button. This creates Pivot Tables based on the output from the Model. The macro will activate the “Pivot Tables” tab where the user can see a production schedule in the form of a pivot table. The default schedule is for both lines and both plants, but the user can choose to filter on only one line and one plant if they wish to do so. The Pivot Table with all production lines and facility plants is below in Figure 12.

I	J	K	L	M	N	O	P	Q	R	S
Type	(All)									
Location	(All)									

Sum of Xij	Column Labels									
Row Labels	3	4	5	6	7	8	9	10	11	Grand Total
DomesticMC	7276	5729	6968	5650	5556	6566	6655	6985	6053	57437
DomesticPNT	7341	7008	6855	6575	6768	7915	7391	7232	7080	64165
M3134800	0	0	0	455	130	0	0	0	0	584
M3135000	0	0	0	363	0	0	0	0	0	363
M3135400	0	0	0	133	260	251	0	15	0	658
M3135500	0	0	0	426	0	0	0	0	0	426
M3471400	0	0	0	3	78	65	49	48	0	243
M3472400	0	0	0	0	80	64	48	48	0	241
M4103300	0	0	0	0	36	66	6	0	0	108
M4103600	0	0	0	0	33	57	9	0	0	99
M4330501	0	0	0	0	143	24	0	0	0	168
M4348701	0	0	0	2	218	176	132	132	0	661
M4468800	0	61	425	7	0	0	0	0	0	494
M4581200	0	0	0	0	46	83	0	8	0	138
M4597400	0	0	0	0	37	57	0	17	0	110
Grand Total	14617	12798	14248	13614	13385	15325	14290	14485	13133	125895

Figure 12

5. Schedule Evaluation

Once a production schedule has been generated, the user has the ability to simulate random demand against the production schedule to determine the holding cost and unmet demand cost. By clicking on “Run Monte Carlo”, the user can run a Monte Carlo simulation of the demands. The pattern for this simulation can be chosen on the “SKUs” page, as shown before, under the “Monte Carlo Values” column. The user clicks on “Run Monte Carlo” and enters the number of trials to run as depicted in Figure 13. Clicking on “OK” runs the macro in the background. In the lower left corner of Excel, there will be a status bar that keeps the user informed of the status of the simulation. After completion, the user can activate the “MonteValues” tab and see the calculated costs. In the first row are the values for holding cost and unmet demand cost obtained when the DST was originally run. The subsequent rows will contain the values for holding and unmet demand costs that were incurred when random demands were applied to the production schedule. In addition to the costs, the user also has the bookkeeping for what demand patterns were applied to each SKU. Subsequent runs of the Monte Carlo simulation can

be run on the production schedule by returning to the “SKUS” page and adjusting the demand patterns under the “Monte Carlo Values” column. After pressing “Run Monte Carlo” on the “Inputs” tab, the costs are added to the bottom. This functionality allows the user to be able to compare different Monte Carlo runs of varying numbers of trials to each other.

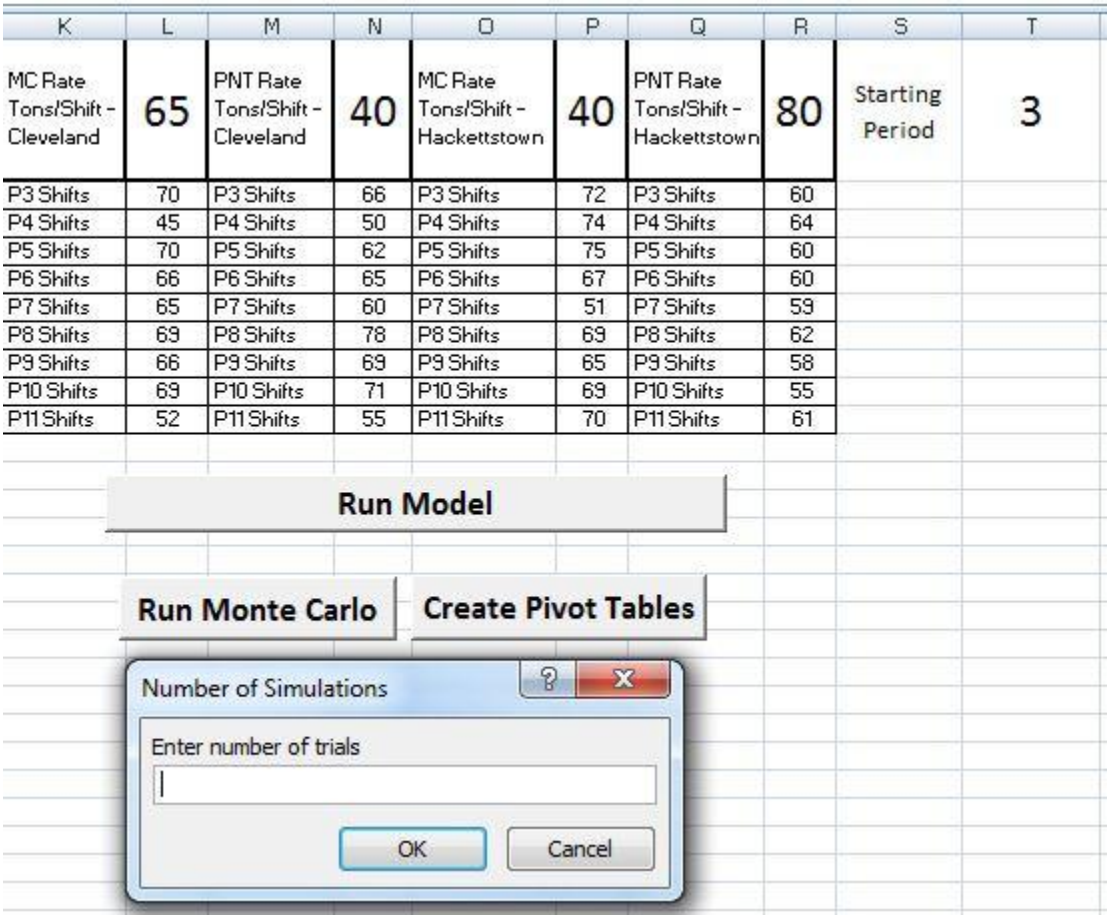

Figure 13

6. Summary

The Decision Support Tool (DST) gives the user the ability to set a production schedule that directly reflects the expected demand for the product, by scheduling the SKUs to be produced in periods that minimize expected holding and unmet demand costs. Furthermore, because the DST is wholly contained in Microsoft Excel, the user has the ability to quickly evaluate the impact of the parameters chosen for each SKU. The DST shows that there is room for improvement in holding costs by shifting production of seasonal products closer to when there is expected demand. The DST provides a mechanism to differentiate SKUs through the many user-input parameters. The user has the ability to manipulate SKU specific parameters, demand parameters, and plant-level parameters to reflect all of the salient factors involved in a production schedule.