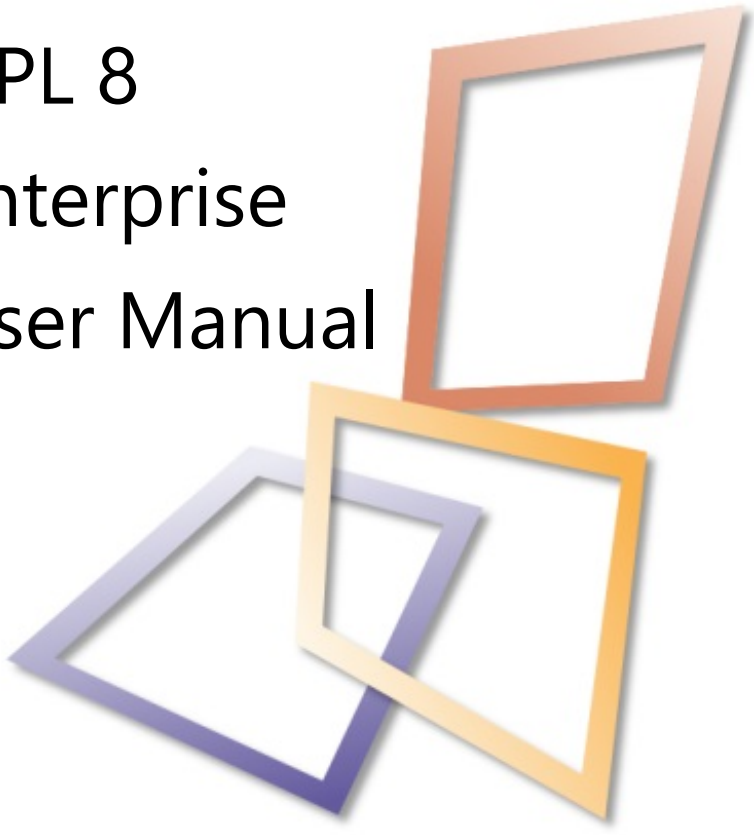
DPL 8

Enterprise

User Manual

SYNCOPATION
SOFTWARE

DPL 8 Enterprise User Manual



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1 Introduction

1.1 Welcome to DPL 8 Enterprise

This *DPL 8 Enterprise Manual* is designed to supplement the *DPL 8 Quick Start Guide and DPL 8 Professional Manual* that you received with your DPL 8 Enterprise software. This manual assumes you have significant experience using DPL, and parts of it also assume familiarity with database and programming concepts. This manual contains six chapters that cover the features of DPL Enterprise.

If you are new to DPL, you should review the contents of the *DPL Professional Manual* before proceeding to this manual. You may also wish to complete the tutorials contained in those manuals. The *DPL Professional Manual* also contains information on how to install DPL and how to get help.

This manual is intended to be read while working with DPL. The chapters of this manual are intended to be "stand-alone" and can be read in any order.

A few conventions have been used in the text of the tutorial chapters. An instruction to you in a tutorial will be contained in a bulleted paragraph with an arrow, as follows:

⇨ Please do this step now.

Information to be entered in edit boxes, Excel cells, etc. is contained within double-quotes. Do not include the double-quotes when entering the information.

A brief outline of the contents of this manual follows.

Chapter 2 documents DPL Enterprise's database linking capabilities. Throughout the chapter, you will complete a tutorial on how to set up and run a database-linked model.

Chapter 3 illustrates how to link DPL Enterprise to a spreadsheet that contains a calculation macro.

Chapter 4 covers DPL's expert aggregation interface and contains a tutorial on how to create models with expert aggregation nodes in them.

Chapter 5 covers the Application Programming Interface (API). This feature allows you to control and run DPL from other applications, such as Visual Basic for Applications (VBA), C# and VB.NET.

Chapter 6 covers DPL's user function library interface.

2 Database Linking in DPL

2.1 Overview

With DPL Enterprise you use data stored in a database to initialize nodes in much the same way you can store data in Excel and use Excel initialization links. In situations where some of the data you need for your DPL model is already stored in a database and is subject to revision, using database initialization links will ensure you have the most recent data and will reduce errors due to data re-entry. In situations where multiple people need access to the data and may be revising it, you can configure the database to keep track of revisions.

This chapter discusses how to use database linking in DPL Enterprise.

2.2 ODBC Data Sources

DPL communicates with a database via the Windows ODBC (Open Database Connectivity) mechanism. See Figure 2-1.

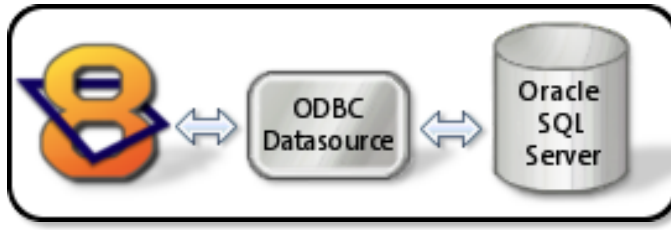


Figure 2-1. DPL/Database Communication uses ODBC

By using ODBC, DPL gives you the flexibility to choose your database management system or even change it as requirements evolve.

2.2.1 Setting up an ODBC Data Source for a Desktop Database

Before using database links in DPL, you must set up an ODBC data source for the database with which you wish to communicate. You will do this now for the example database delivered with DPL Enterprise. Depending on the version of Windows you are running, the following steps for setting up the data source may vary.

DPL is presently a 32-bit program. If you are running DPL on a 64-bit version of Windows, the 32-bit ODBC Datasource Administrator is in a different location from the one specified below. If you follow the steps below you will likely open the 64-bit Data Source Administrator, which will not communicate with the example databases provided. You will need to find the correct odbcad32.exe file and create a shortcut to it to set up the Data source. For example, on the 64-bit version of Windows 7, the 32-bit version of the Data Source Administrator is in C:\Windows\SysWow64\odbcad32.exe. Oddly, the 64-bit (i.e., wrong) version is in C:\Windows\System32\odbcad32.exe!

- ⇨ Open your Control Panel.
- ⇨ Click System and Security
- ⇨ Click Administrative Tools.
- ⇨ Double-click on Data Sources (ODBC). As mentioned above, be sure you open the 32-bit Data Source Administrator. The ODBC Data Source Administrator dialog appears. See Figure 2-2.

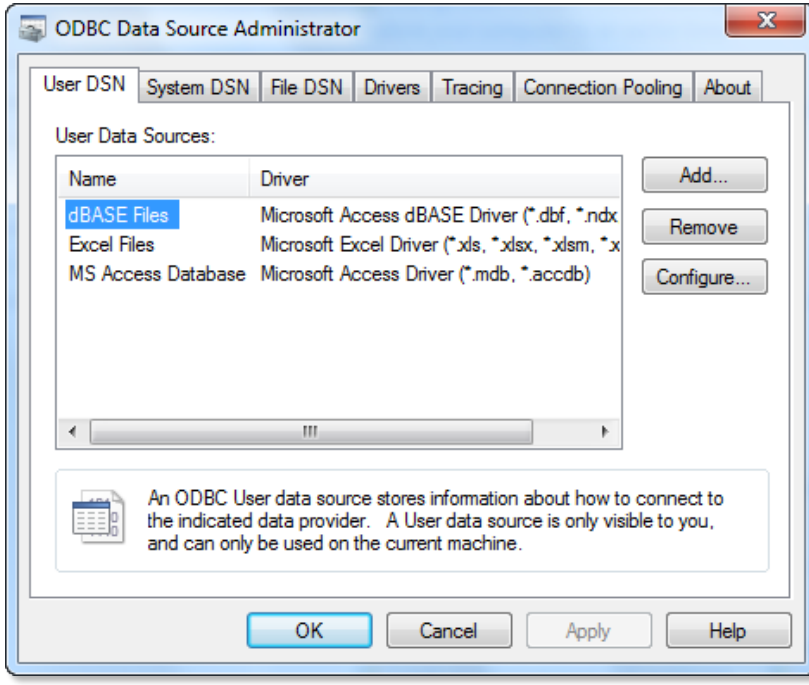


Figure 2-2. ODBC Data Source Administrator Dialog

Among other things, the ODBC Data Source Administrator dialog displays all the data sources currently configured on your computer. On the User DSN tab, data sources that are available only to the logged in user are displayed. On the System DSN tab, data sources available to all users of the machine plus services are displayed.

The ODBD Data Source Administrator dialog allows you to add new data sources and delete or configure existing ones. You will now add a data source.

⇨ Select the User DSN tab.

⇨ Click the Add button. The Create New Data Source dialog appears. See Figure 2-3.

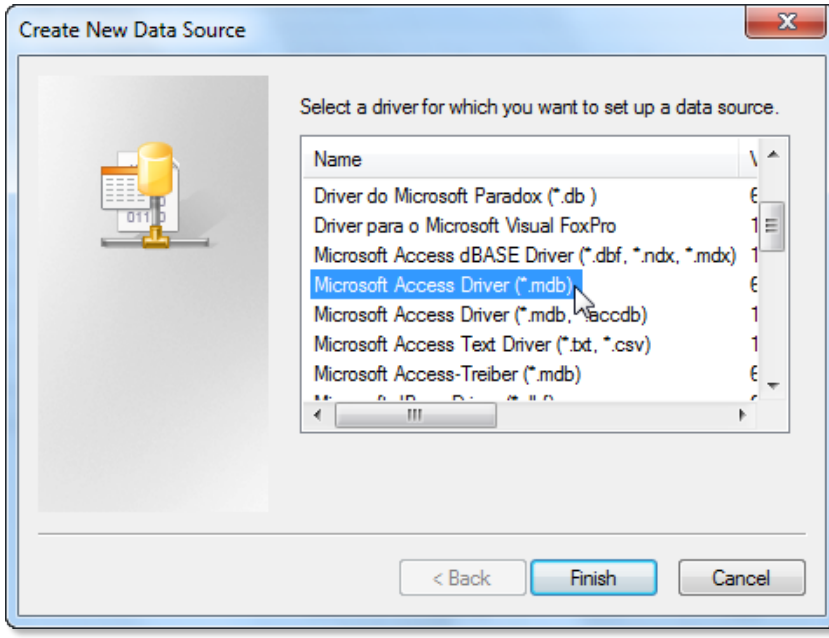


Figure 2-3. Create New Data Source Dialog

⇨ The sample database delivered with DPL Enterprise is a Microsoft Access database. Select Microsoft Access Driver (*.mdb) from the list.

⇨ Click Finish. The ODBC Microsoft Access Setup dialog appears. See Figure 2-4.

Figure 2-4. ODBC Microsoft Access Setup Dialog

- ⇨ For the Data Source Name, enter "R&D Projects".
- ⇨ You may optionally give the data source a description.
- ⇨ In the Database section, click the Select… button.
- ⇨ Use the Select Database dialog to browse to the Examples folder below where you installed DPL Enterprise. If you used the default installation path, it will be C:\Program Files (x86)\Syncopation\DPL8\Examples.
- ⇨ Select R&D Projects.mdb for the Database Name.
- ⇨ Click OK. The ODBC Microsoft Access Setup dialog should now look like Figure 2-5.

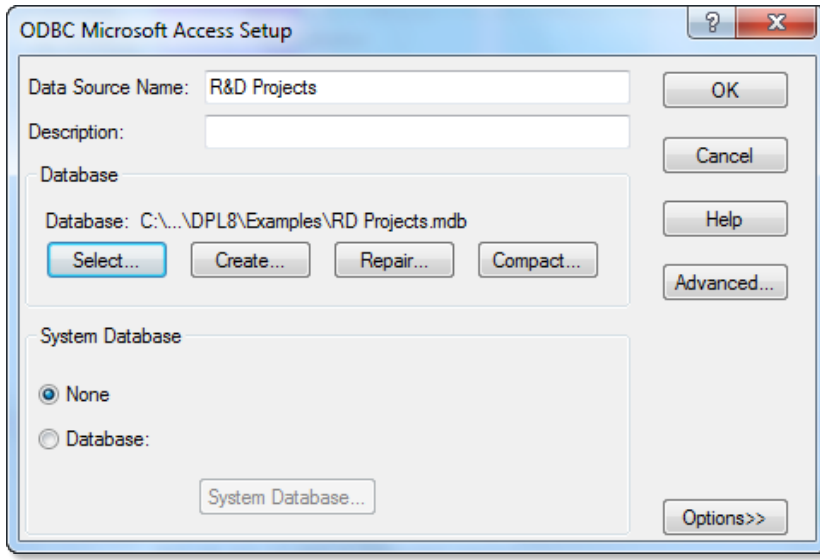


Figure 2-5. Completed ODBC Microsoft Access Setup Dialog

⇨ Click OK to close the ODBC Microsoft Access Setup dialog. The new data source should appear in the User Data Sources list.

⇨ Click OK to close the ODBC Data Source Administrator.

Note: the information required to set up an ODBC Data Source varies depending on the database to which the data source refers. For Access, the only thing you had to specify was a file name and location. Access is a desktop database. To configure a data source for a server-based database such as Oracle, you will likely need to get information from your IT department or database administrator.

2.3 DPL Compliant Databases

A database that is going to be linked to DPL needs to have the tables or queries that DPL will access structured in a particular way. If the database is being developed primarily to store data that DPL will use, then you can configure the tables in the database directly so that they meet the requirements of DPL. If the database is pre-existing and/or will store data for purposes other than for use with DPL, the tables within the database do not need to be structured to be DPL compliant; rather queries and/or views can be written to provide the necessary structure for DPL. Put another way, the underlying tables can be structured in whatever way it is deemed

appropriate as long as they contain the necessary information so that a query or view of the table can be developed to provide the structure that DPL requires.

For simplicity, we will refer to tables in the discussion below when talking about the structure that DPL requires, but remember that it may be a query or view of the table that provides the needed structure.

2.3.1 Required Fields

Table 2-1 summarizes the fields that are required in a table that stores data DPL will access.

Field	Purpose	Type	Default Name
Model ID	Identifies which model the record belongs to. One of this field or Project ID is required.	Integer	ModelID
Project ID	Identifies which project the record belongs to. One of this field or Model ID is required.	Integer	ProjectID
Node ID	Identifies the specific data item to DPL. It is used in the Data tab of the Node Definition dialog.	String	NodeID
Dimensions	Tells DPL whether the data item stored in the record is scalar (0), a one-dimensional array (1) or a two-dimensional array (2).	Integer	Dims
Rows	Tells DPL the number of rows for the data item.	Integer	Rows
Columns	Tells DPL the number of columns for the data item.	Integer	Cols

Table 2-1. Required Fields for a DPL Compliant Table

A combination of the Model ID and/or Project ID fields is used to identify which model and/or project the data belongs to. Depending on the overall design of the decision and data management system you are developing, you may want to use both. For example, if you are storing data in a database for multiple different DPL models, you may want to identify which model the data in each record belongs to by using the Model ID field. If

you are developing a system in which multiple sets of data (e.g., each associated with a specific project) will be used with a single DPL model, you may want to use the Project ID field to identify these project data sets. If the system will have both multiple models and multiple sets of data per model, you may wish to use both fields.

A DPL compliant table needs to meet one more requirement. The fields in each record that will store the data for each item must all begin with the same prefix and must be numbered sequentially from 001 on. The default data fields prefix is "Data_". A record that stores numeric information should store the data for the data item in Data_001, Data_002, etc. You may change the data fields prefix but the fields storing the data must end with 001, 002, etc. For example, if your data fields prefix is "fld", then the fields storing the data will be fld001, fld002, etc.

DPL can also access string data stored in a database. If a table stores string data, then you must specify the String fields prefix. The default prefix is "Str_". A record that stores string information should store the data for the data item in Str_001, Str_002, etc.

Node IDs in a DPL compliant database cannot contain any punctuation or spaces. They can contain letters or numbers but they must start with a letter. Node IDs are case sensitive, i.e., "cost" is different from "Cost".

The order of the fields in each table does not have to match the order shown in Table 2-1 above or Figure 2-6 below. However, the order in which the data is stored within the data fields is important. If a record contains a Node ID for a one-dimensional array with 3 elements, then the data for the first element needs to be stored in the first data field (Data_001 by default), the data for the second element needs to be stored in the second data field (Data_002 by default), etc. Similarly if a record contains a Node ID that is storing probabilities for a chance node, then the probability for the first branch needs to be stored in the first data field, and so forth.

2.3.2 Required Fields for Revision Tracking

If you wish to set up a database that tracks revisions of data, then you need to have two additional fields in a DPL compliant table. Table 2-2 summarizes these fields.

Field	Purpose	Type	Default Name
Revision ID	Identifies which revision this record is.	Integer	RevisionID
Revision Date	The date the revision was made.	Date	RevisionDate

Table 2-2. Required Revision Tracking Fields

The Revision ID field must be an integer greater than or equal to zero, where a higher number indicates a more recent revision. For each table in the database, every Model ID/Project ID/Node ID combination should have an ascending set of Revision IDs without duplicates.

Figure 2-6 shows the Access design view for a DPL compliant table called Project_Tbl.

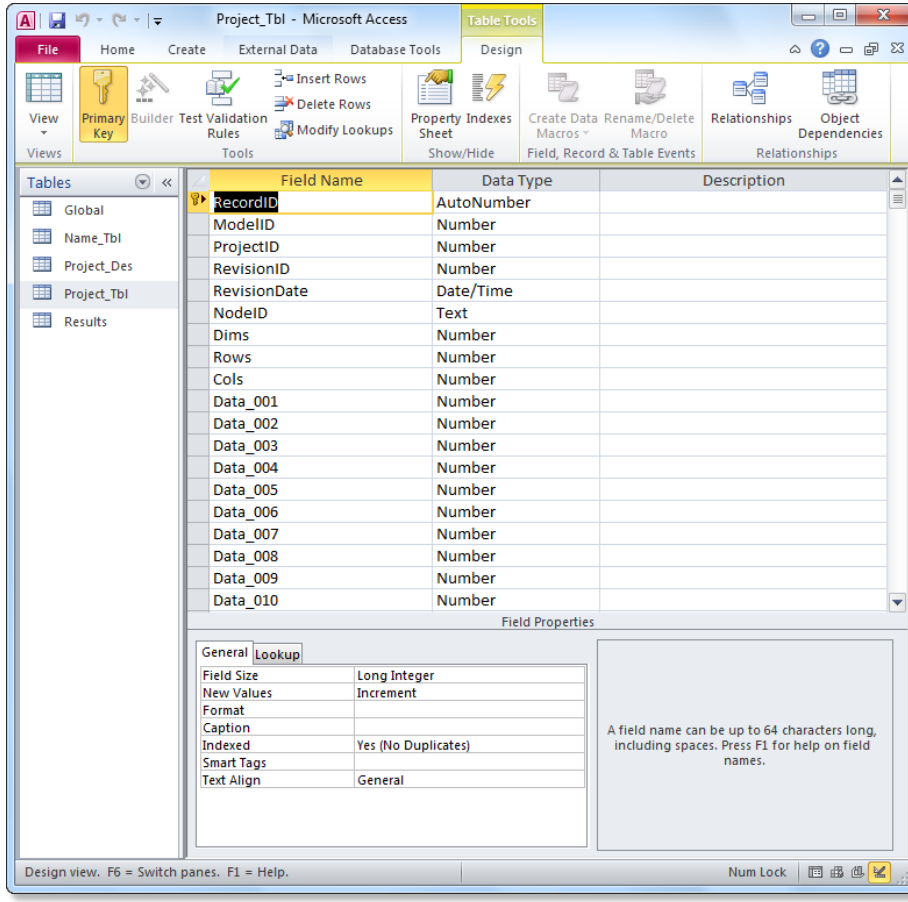
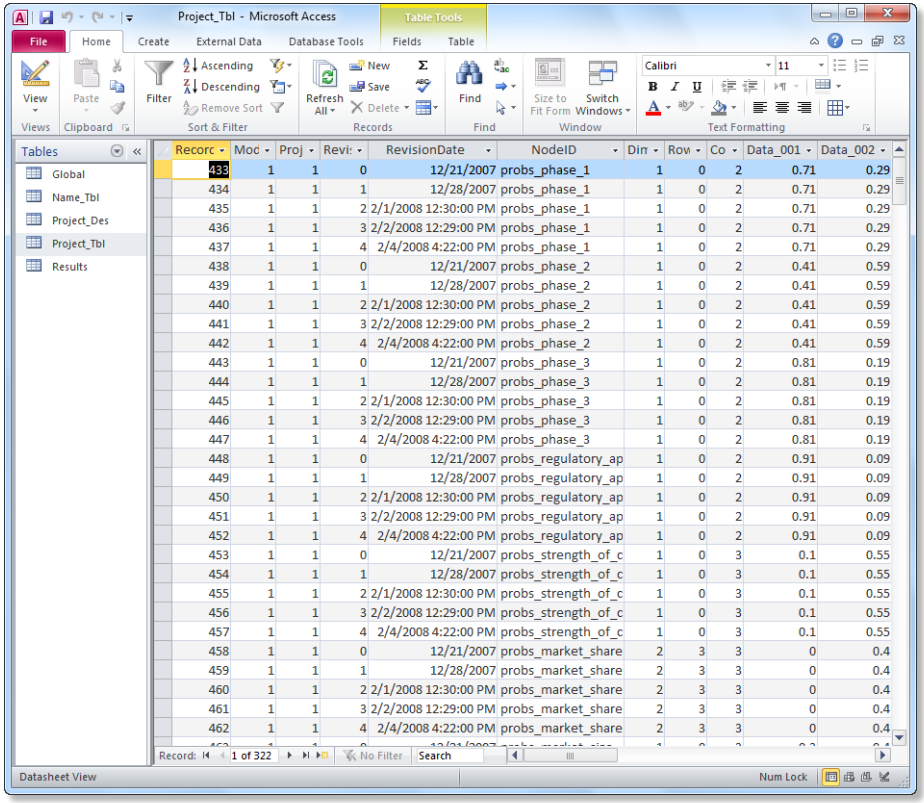


Figure 2-6. Access Design View of Project_Tbl

Figure 2-7 shows the Access datasheet view for Project_Tbl.



Record	Mod	Proj	Revi	RevisionDate	NodeID	Dim	Row	Co	Data_001	Data_002
433	1	1	0	12/21/2007	probs_phase_1	1	0	2	0.71	0.29
434	1	1	1	12/28/2007	probs_phase_1	1	0	2	0.71	0.29
435	1	1	2	2/1/2008 12:30:00 PM	probs_phase_1	1	0	2	0.71	0.29
436	1	1	3	2/2/2008 12:29:00 PM	probs_phase_1	1	0	2	0.71	0.29
437	1	1	4	2/4/2008 4:22:00 PM	probs_phase_1	1	0	2	0.71	0.29
438	1	1	0	12/21/2007	probs_phase_2	1	0	2	0.41	0.59
439	1	1	1	12/28/2007	probs_phase_2	1	0	2	0.41	0.59
440	1	1	2	2/1/2008 12:30:00 PM	probs_phase_2	1	0	2	0.41	0.59
441	1	1	3	2/2/2008 12:29:00 PM	probs_phase_2	1	0	2	0.41	0.59
442	1	1	4	2/4/2008 4:22:00 PM	probs_phase_2	1	0	2	0.41	0.59
443	1	1	0	12/21/2007	probs_phase_3	1	0	2	0.81	0.19
444	1	1	1	12/28/2007	probs_phase_3	1	0	2	0.81	0.19
445	1	1	2	2/1/2008 12:30:00 PM	probs_phase_3	1	0	2	0.81	0.19
446	1	1	3	2/2/2008 12:29:00 PM	probs_phase_3	1	0	2	0.81	0.19
447	1	1	4	2/4/2008 4:22:00 PM	probs_phase_3	1	0	2	0.81	0.19
448	1	1	0	12/21/2007	probs_regulatory_ap	1	0	2	0.91	0.09
449	1	1	1	12/28/2007	probs_regulatory_ap	1	0	2	0.91	0.09
450	1	1	2	2/1/2008 12:30:00 PM	probs_regulatory_ap	1	0	2	0.91	0.09
451	1	1	3	2/2/2008 12:29:00 PM	probs_regulatory_ap	1	0	2	0.91	0.09
452	1	1	4	2/4/2008 4:22:00 PM	probs_regulatory_ap	1	0	2	0.91	0.09
453	1	1	0	12/21/2007	probs_strength_of_c	1	0	3	0.1	0.55
454	1	1	1	12/28/2007	probs_strength_of_c	1	0	3	0.1	0.55
455	1	1	2	2/1/2008 12:30:00 PM	probs_strength_of_c	1	0	3	0.1	0.55
456	1	1	3	2/2/2008 12:29:00 PM	probs_strength_of_c	1	0	3	0.1	0.55
457	1	1	4	2/4/2008 4:22:00 PM	probs_strength_of_c	1	0	3	0.1	0.55
458	1	1	0	12/21/2007	probs_market_share	2	3	3	0	0.4
459	1	1	1	12/28/2007	probs_market_share	2	3	3	0	0.4
460	1	1	2	2/1/2008 12:30:00 PM	probs_market_share	2	3	3	0	0.4
461	1	1	3	2/2/2008 12:29:00 PM	probs_market_share	2	3	3	0	0.4
462	1	1	4	2/4/2008 4:22:00 PM	probs_market_share	2	3	3	0	0.4

Figure 2-7. Access Datasheet View of Project_Tbl

Figure 2-8 shows the Access design view for a DPL compliant table containing string information called Project_Des.

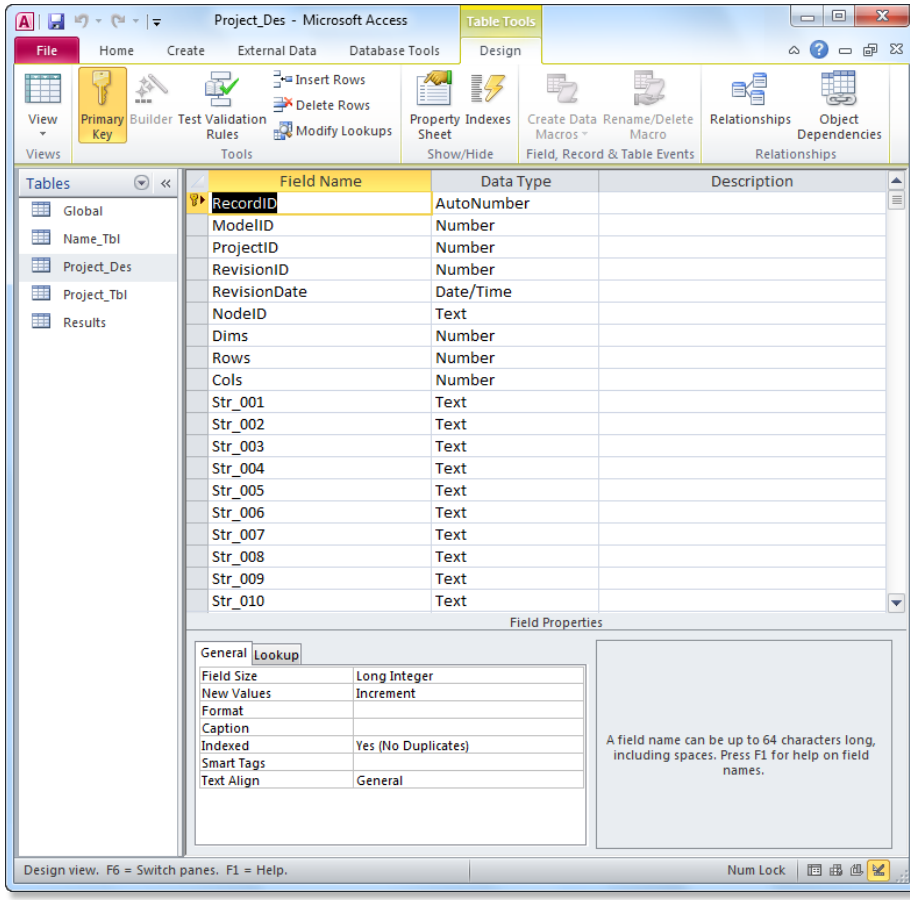
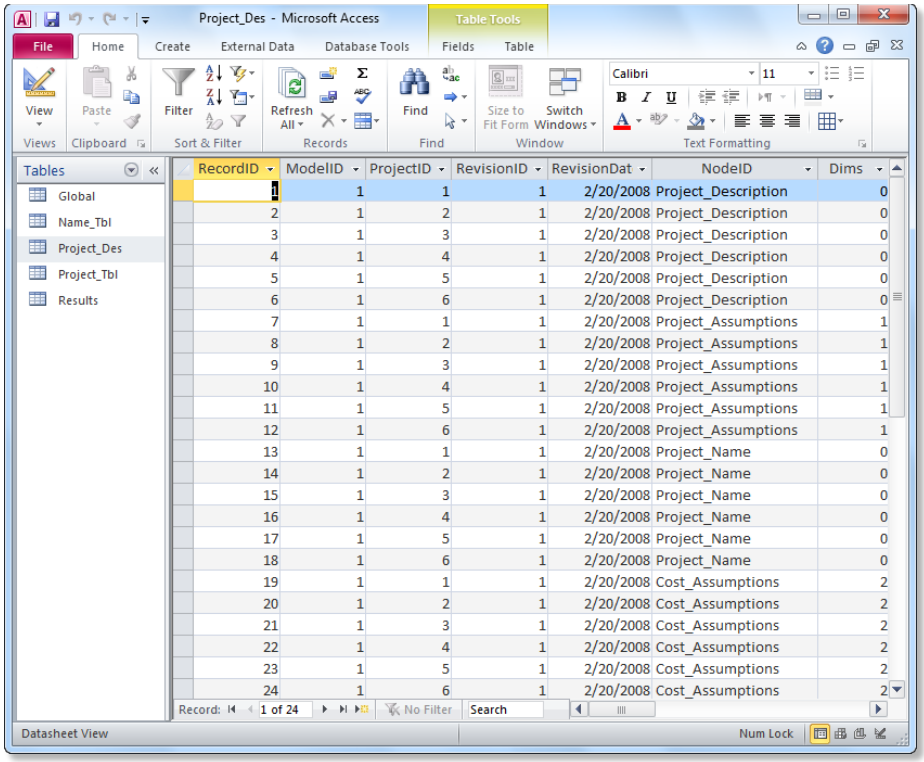


Figure 2-8. Access Design View of Project_Des

Figure 2-9 shows the Access database view for a DPL compliant table containing string information called Project_Des.



RecordID	ModelID	ProjectID	RevisionID	RevisionDat	NodeID	Dims
1	1	1	1	2/20/2008	Project_Description	0
2	1	2	1	2/20/2008	Project_Description	0
3	1	3	1	2/20/2008	Project_Description	0
4	1	4	1	2/20/2008	Project_Description	0
5	1	5	1	2/20/2008	Project_Description	0
6	1	6	1	2/20/2008	Project_Description	0
7	1	1	1	2/20/2008	Project_Assumptions	1
8	1	2	1	2/20/2008	Project_Assumptions	1
9	1	3	1	2/20/2008	Project_Assumptions	1
10	1	4	1	2/20/2008	Project_Assumptions	1
11	1	5	1	2/20/2008	Project_Assumptions	1
12	1	6	1	2/20/2008	Project_Assumptions	1
13	1	1	1	2/20/2008	Project_Name	0
14	1	2	1	2/20/2008	Project_Name	0
15	1	3	1	2/20/2008	Project_Name	0
16	1	4	1	2/20/2008	Project_Name	0
17	1	5	1	2/20/2008	Project_Name	0
18	1	6	1	2/20/2008	Project_Name	0
19	1	1	1	2/20/2008	Cost_Assumptions	2
20	1	2	1	2/20/2008	Cost_Assumptions	2
21	1	3	1	2/20/2008	Cost_Assumptions	2
22	1	4	1	2/20/2008	Cost_Assumptions	2
23	1	5	1	2/20/2008	Cost_Assumptions	2
24	1	6	1	2/20/2008	Cost_Assumptions	2

Figure 2-9. Access Datasheet View of Project_Des

2.3.3 Table Names/Field Names

Table names and field names in a DPL compliant database cannot contain any punctuation or spaces. They can contain letters or numbers but they must start with a letter. Database management systems may vary regarding whether table names and field names are case sensitive. To be consistent with other identifiers in DPL, table names and field names are case sensitive in DPL. Because a particular database management system may or may not be case sensitive with regard to table and field names, you cannot have table(field) names that differ only in case, e.g., both "field1" and "Field1" are not allowed. The specific database management system you are using may have other restrictions on table names and field names. Please check with your database documentation.

2.3.4 Scalar/Simple String Data

If you have a large number of scalar values and/or simple string values (i.e., not arrays of strings) that DPL needs to access, these data can be stored in a table that does not use the DPL compliant structure (i.e., having Node ID, Dims, Rows, Cols) described above. These data may be stored in tables in which the field/column names in the table identify the data, i.e., a more standard database table structure. Tables not using the DPL compliant structure must still have Model ID and/or Project ID fields as appropriate and revision tracking fields as appropriate. Only scalar values and simple string values can be stored in a table not using the DPL compliant structure.

2.4 Configuring Database Access within DPL

Once you have set up the database that you wish DPL to access, you need to give DPL some database configuration information. You do this via the Database Specification dialog. You must give this configuration information to DPL before you can set up any database links within a model in DPL.

You will do this now.

- ⇨ Start DPL.
- ⇨ Select File | Open.
- ⇨ Navigate to the Examples folder underneath where you installed DPL. If you used the default location, the path is C:\Program Files (x86)\Syncopation\DPL8\Examples.
- ⇨ Select R&D Project No Links.da and click Open.

DPL opens the Workspace as shown in Figure 2-10.

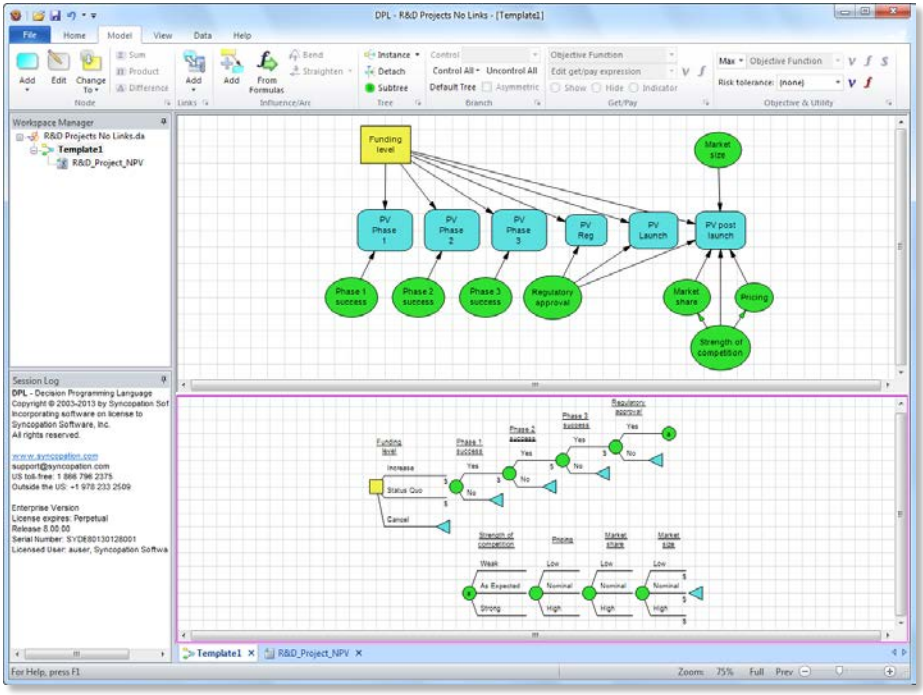


Figure 2-10. R&D Projects No Links Workspace

This Workspace contains a template model called Template1 for a pharmaceutical development example. The data required for the model is stored in the database R&D Projects.mdb for which you set up an ODBC Data Source in Section 2.2.1. If you did not complete those steps, you will need to do so before proceeding with the tutorial below.

Further, the model uses a converted Excel spreadsheet in a DPL program (R&D_Project_NPV) to perform the cash flow calculations. The chance and decision nodes in the Influence Diagram are calculation linked as export nodes to the program. As DPL analyzes the Decision Tree, the export nodes send data to the program. The value nodes in the Influence Diagram are linked as import nodes to the program; as DPL calculates get/pay expressions throughout the Decision Tree, calculated results are sent back from the program.

⇨ Click Data | Database | Set Up

The Database Specification dialog appears as shown in Figure 2-11.

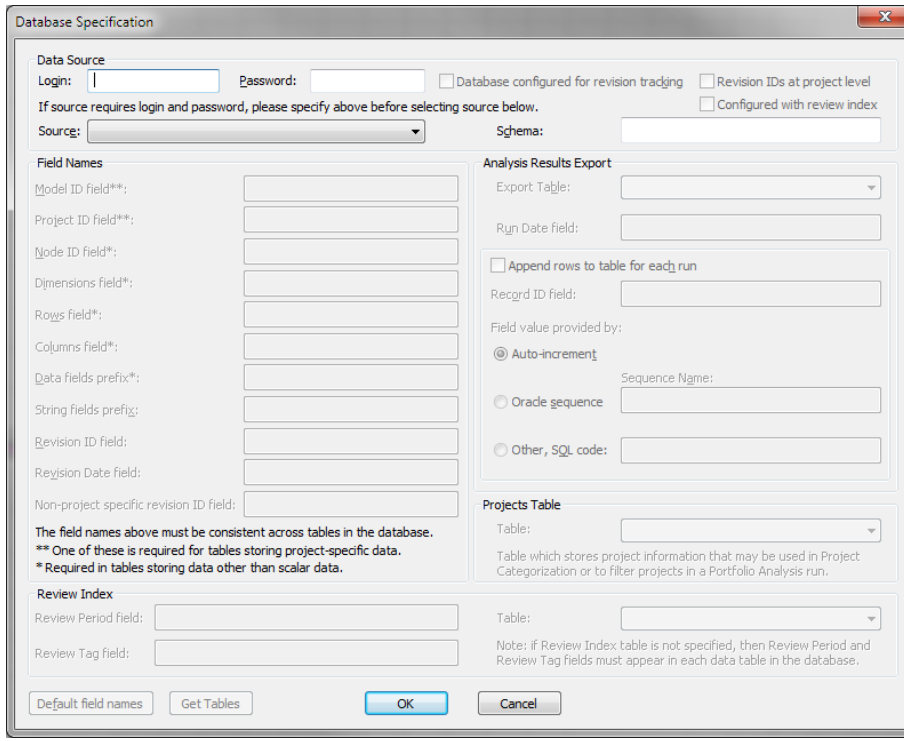


Figure 2-11. Database Specification Dialog

⇨ In the Source drop-down list, select R&D Projects from the list.

Note: Often a Data Source for a corporate database or other multi-user database will require a login and password. R&D Projects does not. If the Data Source requires a login and password, you should specify those before selecting the Data Source from the drop-down list. When you select a Data Source from the drop-down list, DPL attempts to connect to the database for the Data Source. If the Data Source requires a login and password, the connection will fail unless these have been provided first.

The R&D Projects database contained in R&D Projects.mdb uses the default field names for the fields that DPL requires to access the tables. DPL provides a quick way to set up the field names in this situation.

⇨ Click the Default field names button. DPL fills in the required field names. See Figure 2-12.

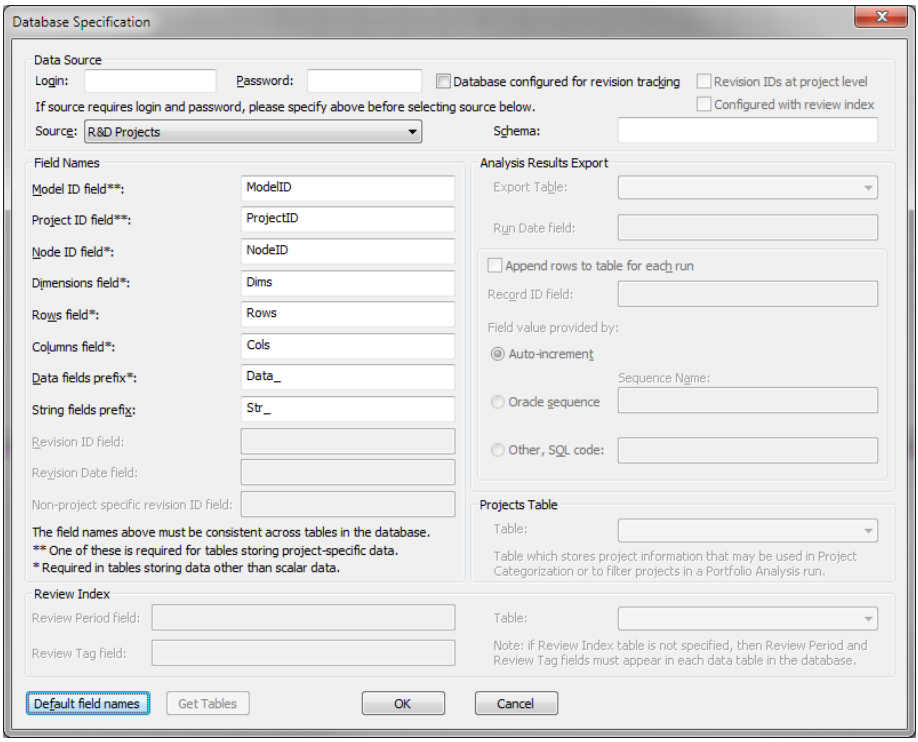


Figure 2-12. Database Specification Dialog with Field Names

Note: if your database does not use the default field names, then you may edit the field names in the edit boxes on the dialog.

⇨ Click OK to close the Database Specification dialog.

You have now told DPL what it needs to know in order to access the data stored in the R&D Projects database. Since you have changed the Data Source using the Database Specification dialog, when you click OK DPL will load information about the database for the data source. See the section below for more information.

⇨ Save your Workspace file under a new name.

2.5 Loading Database Schema

When you change the Data Source in the Database Specification dialog, DPL loads the database schema for the Data Source. Specifically, DPL gathers the table names, field names within each table and other

information about the database. For a database that is on a remote server or is sizeable, it may take a few minutes to load this information and you may notice a delay. DPL uses this information in a number of places. This information only needs to be loaded once (and only needs to be re-loaded if the structure of the database has changed, e.g., if new tables have been added, or new fields to tables). The schema information is saved with the DPL Workspace file when you save it.

If you know the structure of the database has changed, you may ask DPL to load database schema by going to Data | Database | Load Schema. Further, when you first set up a DPL Workspace file with a Data Source specified, DPL will prompt you as to whether you wish to load database information each time the Workspace is opened. See Figure 2-13.

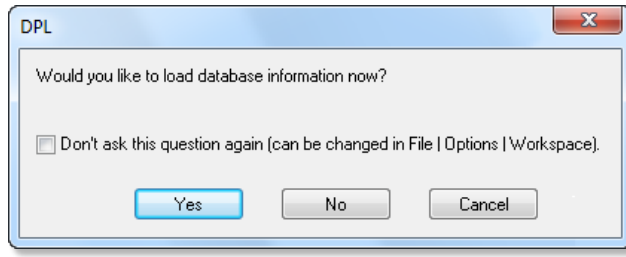


Figure 2-13. Load Database Information Prompt

During the development phase of the database, the structure may change and you may wish to answer Yes to this question and check the "Don't ask this question again" checkbox. DPL will then automatically load the database schema each time the Workspace is opened. Alternatively, if you don't check the checkbox, you will be asked each time the Workspace is loaded. Leaving the checkbox unchecked may be wise for large and/or remote databases, particularly if you work offline and might not have access to the database. Once you have finalized the design of the database, you no longer need to regularly load the schema. At this point, it makes sense to change the setting to "Don't load" via File | Options | Workspace.

Lastly, as indicated above, the information that DPL gathers when loading the database schema is structural in nature. DPL is not loading the actual data stored in the tables when it loads the schema information. DPL does the data extraction from the database when you run a database-linked model or when you create a program from a database-linked model.

2.6 Creating Database-Linked Models

In order to create a database-linked model, you must first set up the Data Source using the Database Specification dialog via Data | Database | Set Up. This is explained in Section 2.4. If you have not already completed the tutorial in that section, please do so now.

⇨ If it is not already open, browse to find the file that you saved from Section 2.4 and open it now.

⇨ If the Load Database Information prompt comes up, select No and check "Don't ask this again".

2.6.1 Linking Existing Nodes to a Database

The file that you started with in Section 2.4 contains a number of nodes that are missing node data and that are ready to be linked to the database. This section will show you how to add database links to an existing node. Before you do this, you will explore the database R&D Projects database. If you do not have Access on your computer, you will not be able to explore the database but you may wish to read through this section and explore the figures.

⇨ If you have Access on your computer, use Windows Explorer to Navigate to the Examples folder underneath where you installed DPL. If you used the default location, the path is C:\Program Files (x86)\Syncopation\DPL8\Examples.

⇨ Double-click on R&D Projects.mdb to open it in Access. See Figure 2-14.

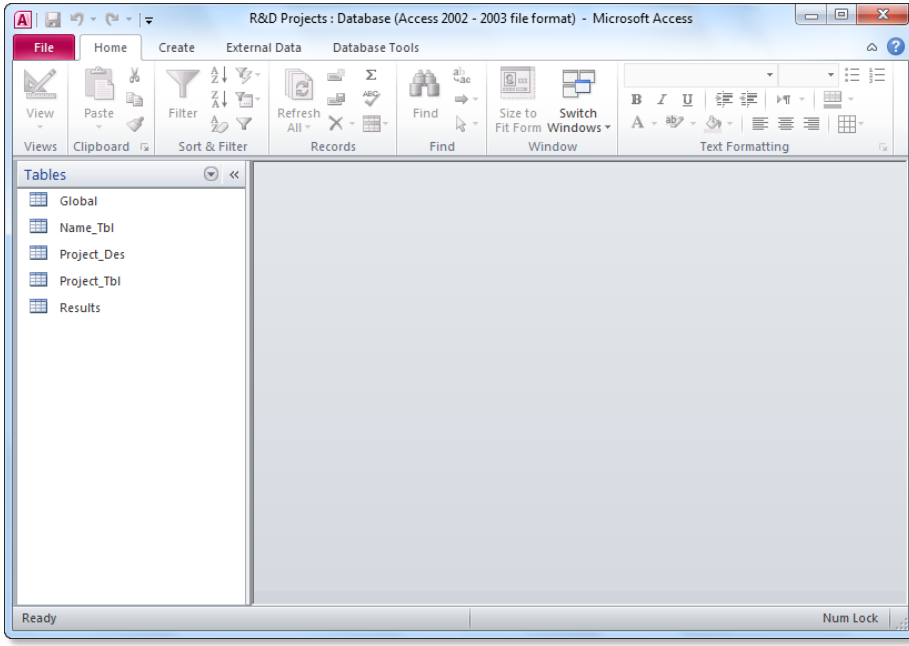


Figure 2-14. R&D Projects Database Open in Access

⇨ In the Navigation pane on the left, double-click on Project_Tbl to open it in datasheet view. See Figure 2-15.

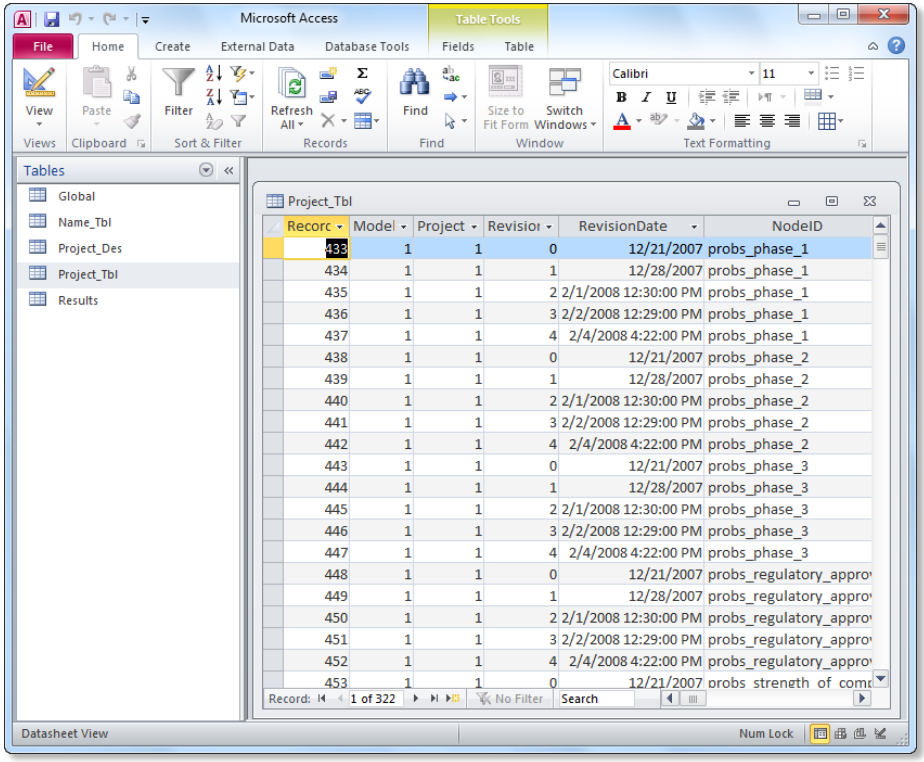


Figure 2-15. Project_Tbl Open in Datasheet View

Note that there are a number of datasets in the table. Specifically there are records with Node IDs for six projects which are identified by Model ID = 1 (all of them have the same Model ID) and Project IDs 1 through 6. This database is also configured for revision tracking (this will be covered in Section 2.7), so each Model ID and Project ID combination has a number of revisions for each Node ID. For example, the first five rows of the table all store different revisions for the Node ID probs_phase_1. Note: the data may be the same for each of the revisions.

⇨ Explore the table some more if you'd like.

⇨ Do not make any edits to the data.

If you are unfamiliar with Access, you should know that any edits you make are instantly saved. You are not prompted to save changes when you close Access; the edits are automatically saved as you make them.

Note in particular that there is a project with Model ID = 1 and Project ID = 1. You will use this in DPL.

⇨ Close Access.

⇨ Switch back to DPL.

⇨ Double-click on the Phase 1 success node in the Influence Diagram. Note that the node has no probability data. See Figure 2-16.

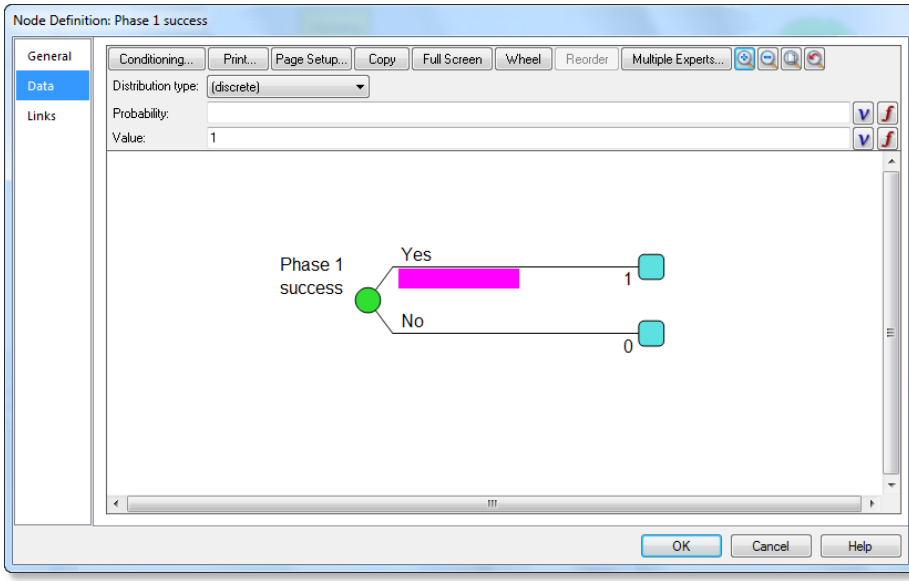


Figure 2-16. Node Definition Dialog for Phase 1 Success

As you may have noticed while exploring the database, the probability data for this node as well as the other chance nodes in the model are stored in the database in a table called Project_Tbl.

⇨ Switch to the Links tab.

⇨ In the Initialization Links section, select Database.

Note: database links are always initialization links. I.e., DPL will get the data for the node from the database once at the beginning of a run. The data is then used in the subsequent analysis.

When setting up a database link for a node, you must tell DPL the Model ID and/or Project ID of the record you wish to link to. This is also done in the Initialization Links section, and DPL displays the Model ID and Project ID edit boxes on the Links tab when Database is selected as the Initialization Link type.

⇨ Type 1 in the Model ID exit box.

⇨ Type 1 in the Project ID edit box. Note: this is the project that you saw when you browsed the database table. The Links tab should now look like Figure 2-17.

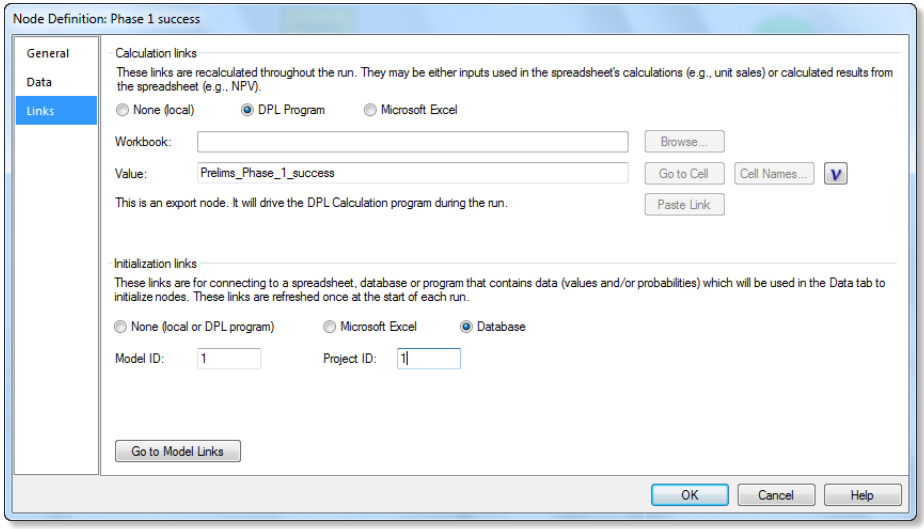


Figure 2-17. Completed Links Tab for Phase 1 Success

⇨ Switch back to the Data tab. Note: that there is now a Link button () next to the probability and value edit boxes. See Figure 2-18.

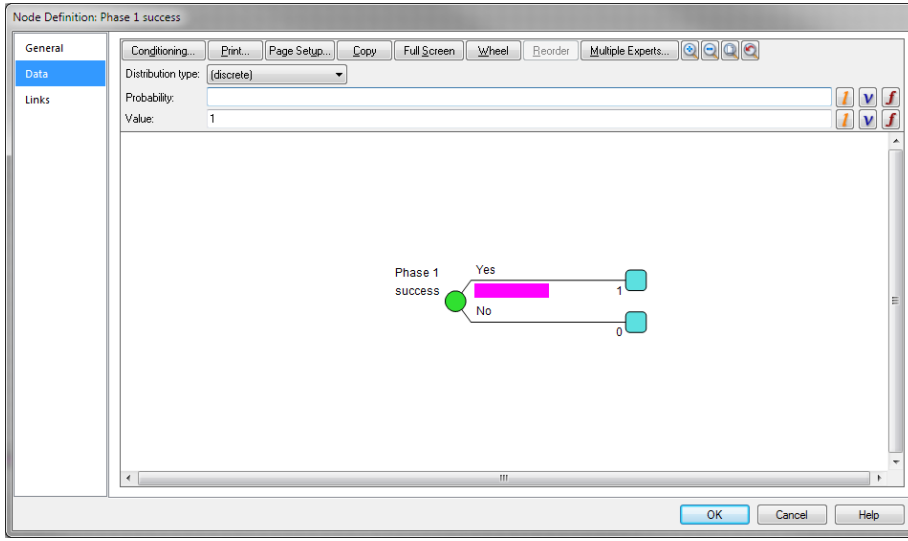


Figure 2-18. Data Tab with Link Button

The Link button allows you to tell DPL the table and Node ID that the node is linked to via the Select Database Link dialog.

⇨ Click the Link button ( ) next to the probability edit box. See Figure 2-19.

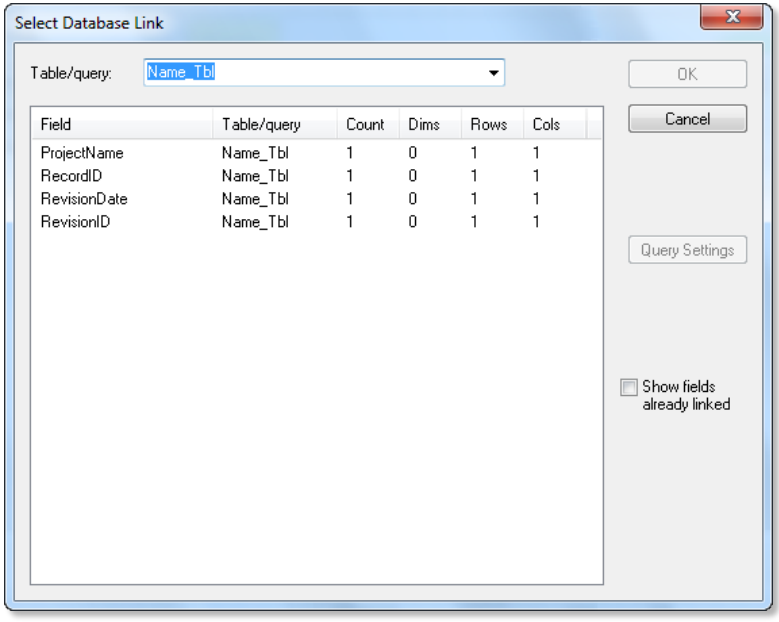


Figure 2-19. Select Database Link Dialog

The Select Database Link dialog provides a combo box at the top for you to select the table in the database for the link. When you select a table, the list below the combo box is populated with the Node IDs within that table. Currently, the table selected is Name_Tbl (this is a descriptive table with string data in it; you will not be using this table).

⇨ Use the drop-down list to select Project_Tbl.

The list of Node IDs also contains information about the data for each Node ID. The list tells you the total count of data elements for the item, the dimensions, rows and columns.

⇨ In the list below, select probs_phase_1 as the Node ID. See Figure 2-20.

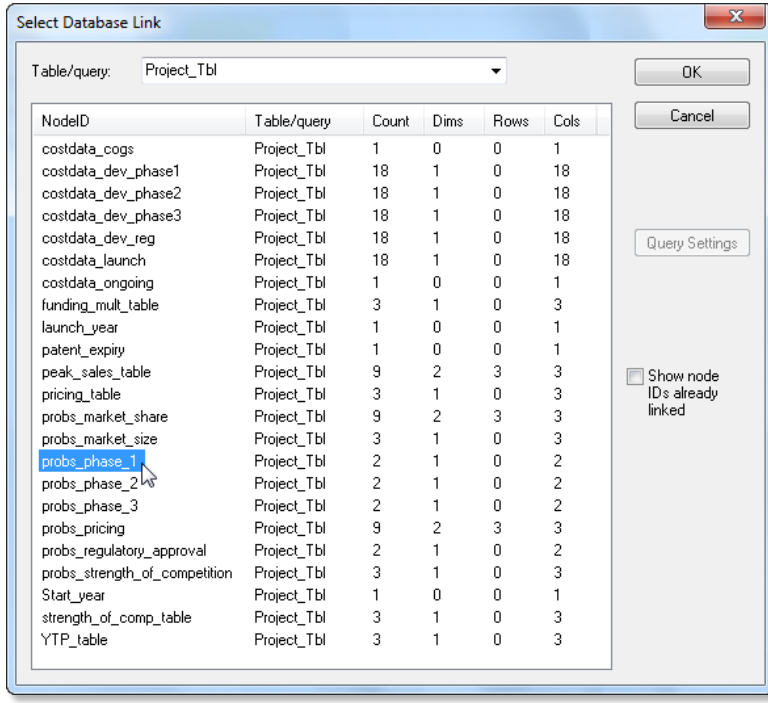


Figure 2-20. Probs_phase_1 Selected in Select Database Link

Note that Phase 1 Success is a two-outcome chance event and that you are selecting a Node ID with two data elements for its probabilities, so the Count column reads "2".

Also note that the "Show Node IDs already linked" checkbox is unchecked by default. As you link additional Node IDs to your model later in this section, you will want to leave this checkbox unchecked so that you will only be selecting from Node IDs that are not yet linked.

⇨ Click OK to close the Select Database Link dialog. DPL fills in the database link for the probability node data. See Figure 2-21.

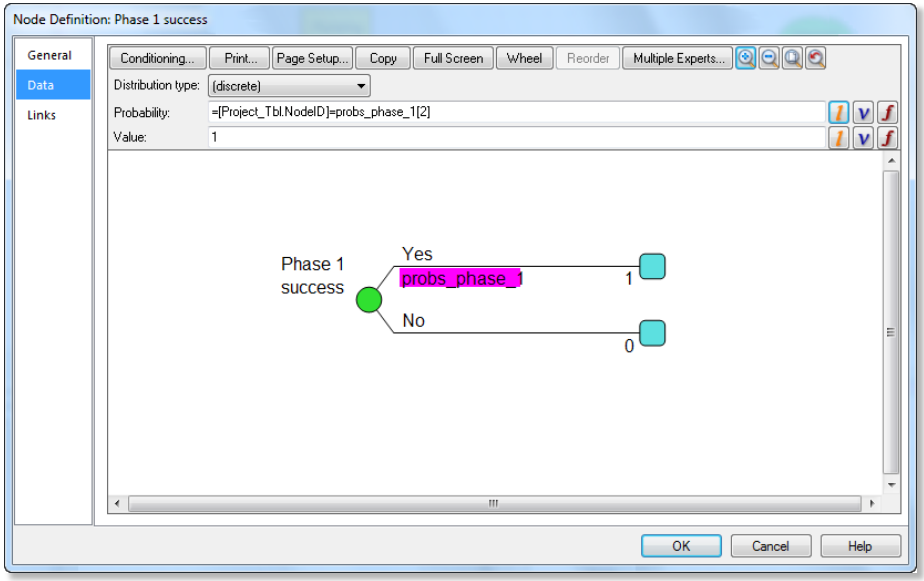


Figure 2-21. Database Link Node Data for Phase 1 Success

The syntax for the database link node data is as follows.

```
=[Project_Tbl.NodeID]=probs_phase_1[2]
```

The node data must start with "=[" to indicate a database link. The information contained within the square brackets is of the form table_name.NodeID which indicates to DPL which table the Node ID is in, e.g., Project_Tbl. Immediately following the closed square bracket is another equal sign. Following this second equal sign is the Node ID that the node is linked to, e.g., probs_phase_1. The information following the Node ID tells DPL the dimensionality of the data, i.e., this is a two column row array. For more information on arrays within DPL, see Chapters 9 and 15 of the *DPL Professional Manual*.

As with Excel initialization links, when you use a database initialization link, the link only appears on the first branch of the node (for Phase 1 Success this is the Yes branch). In this example, you are using a database initialization link for the probability data. Therefore, the remaining probability data for the node must be blank. The same applies for value data. The initialization link appears on the first branch and all remaining value data must be blank.

DPL will only allow you to put an initialization link on the first branch.

⇨ Press the down arrow key twice to move the selection to the probability data for the No branch.

Note that the Link buttons for both the probability data and the value data are now disabled.

⇨ Click OK to close the Node Definition dialog.

You have now specified a database link for the Phase 1 Success node. Note: the value data for the node (1, 0) is not stored in the database.

⇨ Double-click Phase 2 success to edit its definition.

⇨ Switch to the Links tab.

⇨ Select Database in the Initialization Links section.

Note that DPL fills in the Model ID and Project ID that you used previously. You can have database links to multiple Model ID/Project ID records within a model, though in most cases this won't be necessary. DPL assumes you want to use the same Model ID/Project ID as the existing link(s).

⇨ Switch to the Data tab.

⇨ Click the Link () button. The Select Database Link dialog appears. This time it has Project_Tbl already selected since that is the last table you used.

⇨ Select probs_phase_2 in the list.

⇨ Click OK to close the Select Database Link dialog. Again, DPL fills in the database link for the Yes branch of the node and leaves the No branch blank.

⇨ Click OK to close the Node Definition dialog.

Repeat the above procedure to create database initialization links for the probabilities of the remaining chance nodes in the model using the Node ID for each node as indicated in Table 2-3. You may need to delete probability data from some of the nodes. As mentioned earlier, leave the Show Node IDs already linked checkbox unchecked, so that after you link a Node ID it will not appear in the list the next time you use the dialog.

Node	Node ID
Phase 3 success	probs_phase_3
Regulatory approval	probs_regulatory_approval
Market size	probs_market_size
Market share	probs_market_share
Pricing	probs_pricing
Strength of competition	probs_strength_of_competition

Table 2-3. Node IDs for Probability Database Initialization Links

⇨ Save your file.

When you created the database initialization link for the Market share node, you may have noted that the syntax for the database initialization link for it is:

```
=[Project_Tbl.NodeID]=probs_market_share[3][3]
```

The Node ID for the market share probabilities is a two-dimensional array. Market share is conditioned by Strength of competition. Both Market share and Strength of competition are three-outcome chance nodes. Therefore, nine probabilities are needed for Market share and these are stored in a 3 by 3 array. DPL indicates this dimensionality in the database initialization link by adding "[3][3]" following the Node ID.

The Pricing node is also conditioned and also uses a two-dimensional (3 by 3) array link.

The model is now ready to run.

⇨ Press F10 to run a decision analysis.

DPL extracts the data for the probabilities for each chance node from the database and produces the requested results.

2.6.2 Changing Records for Database Initialization Links

The Model Links dialog displays all the records (Model ID, Project ID combinations) that the model is linked to. In this dialog you can also change records that the model is linked to. You will do this now in order to see results for a different project in the R&D Projects database.

⇨ Click Model | Links | Options. The Model Links dialog appears as shown in Figure 2-22.

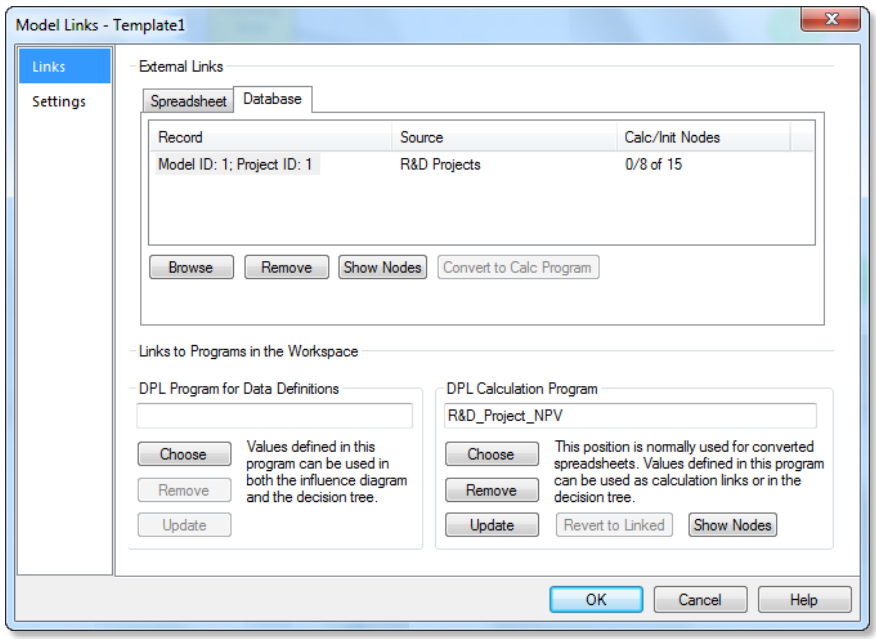


Figure 2-22. Model Links Dialog

This model is currently linked to one record (Model ID/Project ID combination), namely Model ID = 1 and Project ID = 1.

⇨ Select the record in the first row of the Database Links list box.

⇨ Press F2 to edit the record. Note that the record changes to two comma separated numbers. See Figure 2-23.

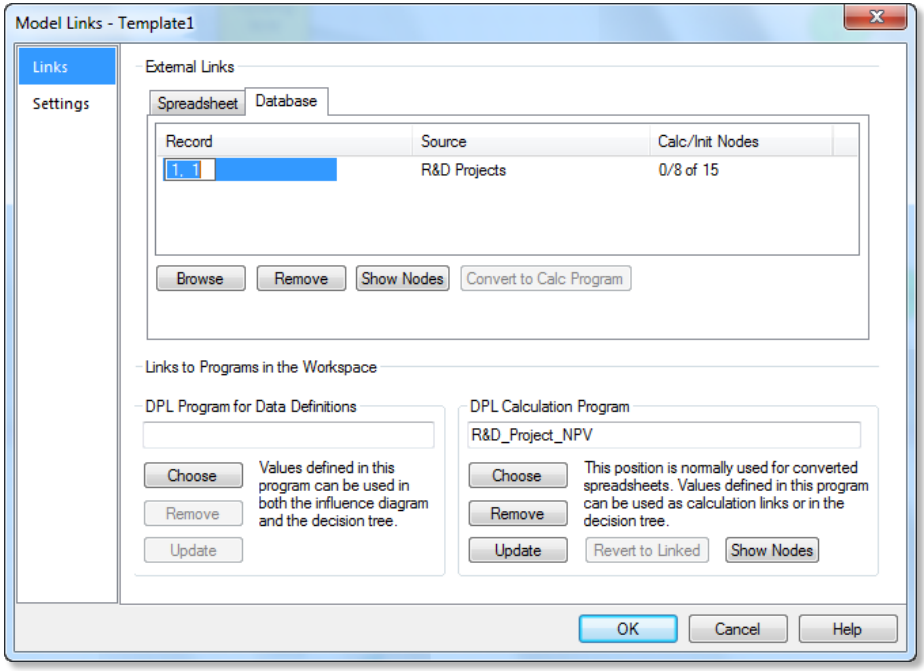


Figure 2-23. Editing a Record in the Model Links Dialog

- ⇨ Type "1, 2" for the record. Note: you must separate the two numbers with a comma.
- ⇨ Press Enter.
- ⇨ Click Close to close the Model Links dialog.
- ⇨ Double-click Phase 1 success to edit its definition.
- ⇨ Switch to the Links tab. Note that the Project ID is now 2.
- ⇨ Click Cancel.
- ⇨ Press F10 to run a Decision Analysis. The results are substantially different from what you got for Model ID = 1, Project ID = 1.

Note: when you change the record that a model is linked to, none of the tables it is linked to change. If you look at the node data for Phase 1 success, you can see it is still linked to Project_Tbl.

As mentioned previously, you can link a model to multiple records (Model ID/Project ID combinations). If you wish to link a node to a new record, you do this via the Links tab. You will try this now.

- ⇨ In the influence diagram, double-click Phase 1 success to edit its definition.
- ⇨ Switch to the Links tab.
- ⇨ Set Project ID to be 1.
- ⇨ Click OK. You will get the prompt shown in Figure 2-24.

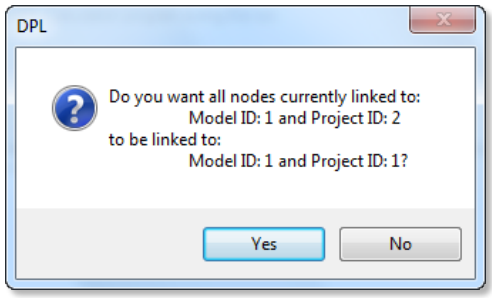


Figure 2-24. Change Record Prompt

- ⇨ Answer No to the prompt.

By answering no, you are telling DPL not to change any other nodes linked to record Model ID = 1, Project ID = 2. Phase 1 success will now be linked to Model ID = 1, Project ID = 1, while the remaining chance nodes are linked to Model ID = 1, Project ID = 2. Therefore, the probability of success for phase 1 is from project 1 in the database, while the rest of the probabilities are from project 2.

- ⇨ Go to Model | Links | Options to see this.
- ⇨ Click Close.
- ⇨ Press F10 to run a decision analysis. The results are different yet again.
- ⇨ Go to Model | Links | Options again.
- ⇨ Restore your model to only be linked to Model ID = 1, Project ID = 2 by editing the record for Model ID = 1, Project ID = 1 to be 1, 2. DPL updates the linked records in the model.
- ⇨ Click Close.

2.6.3 Creating New Database-Linked Nodes

You may have noticed that there are a number of costs and other assumptions associated with each R&D project stored in the R&D Projects database. When evaluating each project in the database, you would want to take into account these project specific assumptions. As the model currently stands, when you changed from analyzing Project ID = 1 to Project ID = 2, the costs and other assumptions did not change. You will correct this now.

To see the costs and other assumptions that are currently being used, you will look in the DPL program R&D_Project_NPV.

⇨ Double-click R&D_Project_NPV in the Workspace Manager to activate it.

The first twenty lines of the program contain a number of assumptions that are likely to change by project. See Figure 2-25. In fact, the R&D Projects database contains project specific assumptions for all of these except discount rate.

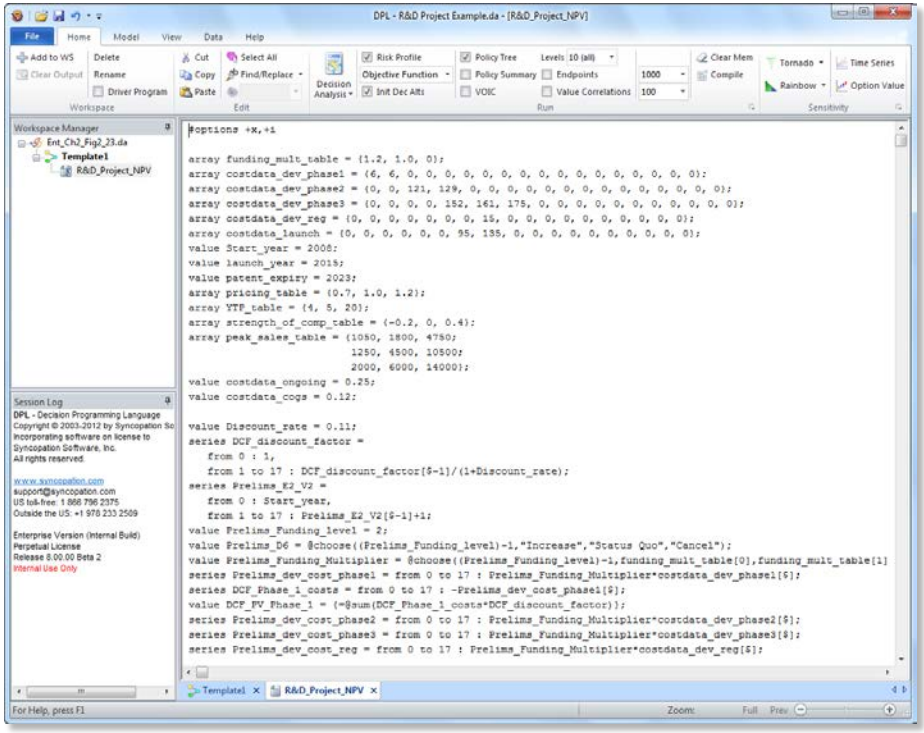


Figure 2-25. Project Specific Assumptions in R&D_Project_NPV

You will create database linked value nodes for these project specific assumptions.

⇨ Double-click Template1 in the Workspace manager to activate it.

⇨ Drop-down the Model | Links | Add split button and choose Database Initialization-Linked... from the list. The Create Database Linked Values dialog comes up as shown in Figure 2-26.

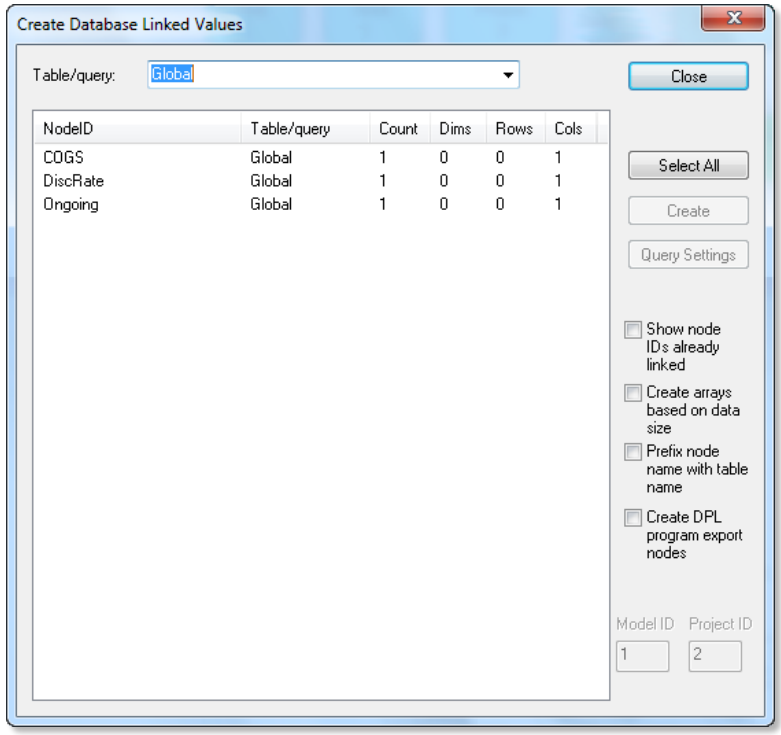


Figure 2-26. Create Database Linked Values Dialog

This dialog allows you to select one or more Node IDs from one or more tables in the database that the DPL Workspace is connected to, and create database-linked value nodes for each. It displays similar information to the information in the Select Database Link dialog. In addition, you can tell DPL whether to prefix node names with the table name, whether to create arrays based on the dimensions of the data in the database, and whether to create DPL export nodes.

⇨ If Project_Tbl is not selected in the combo box, select it.

- ⇨ Make sure the Show Node IDs already linked checkbox is still unchecked.
- ⇨ Check the Create arrays based on data size checkbox.
- ⇨ Check the Create DPL program export nodes checkbox.
- ⇨ Click the Select All button. The dialog should look like Figure 2-27. You have selected all the Node IDs in the Project_Tbl table that were not already linked to your model.
- ⇨ Click Create.

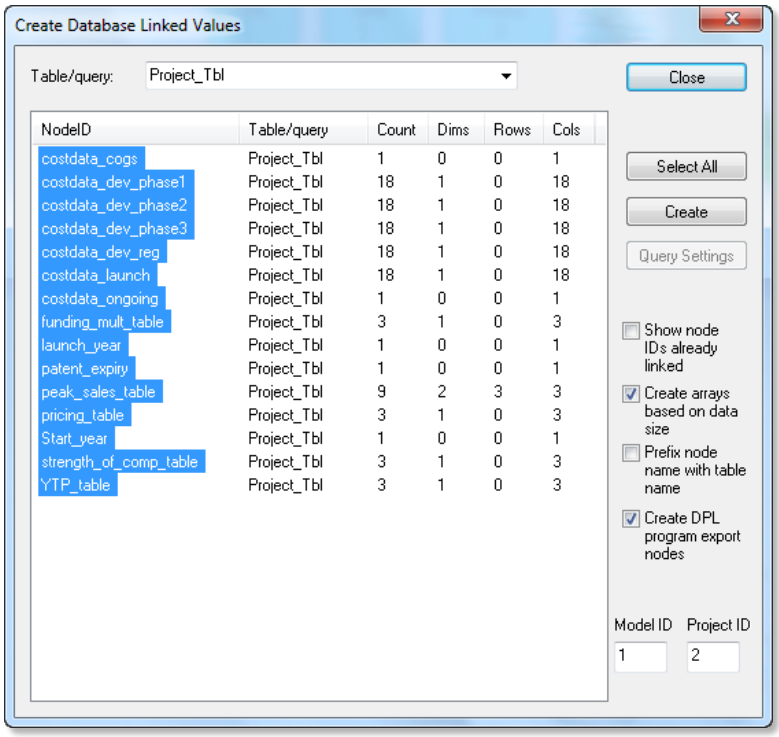


Figure 2-27. Selected Node IDs

If you needed to create database-linked nodes for Node IDs from another table, you could select that table now, select the Node IDs and click Create again. In this example, you do not need to do that.

- ⇨ Click Close to close the Create Database Linked Values.

⇨ Click the Full button on the status bar or press Ctrl+L to Zoom Full. The newly created nodes are off to the right of the previously existing nodes. See Figure 2-28.

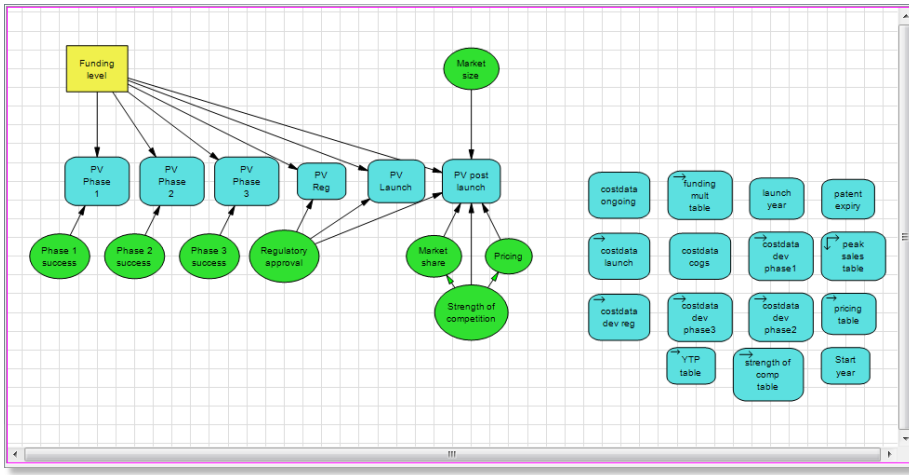


Figure 2-28. Influence Diagram with New Database-Linked Nodes

⇨ Double-click the costdata ongoing node. You can see that it is linked to the Node ID costdata_ongoing.

⇨ Switch to the Links tab. The node is database initialization linked to Model ID = 1, Project ID = 2. Also the node is calculation linked to the value costdata_ongoing in the DPL program R&D_Project_NPV.

When you created these nodes, you told DPL to create DPL program export nodes. Now when you run the model, DPL will extract the data from the database for these new nodes and export it to the DPL program (i.e., the data extracted from the database will override the data for these values/arrays in the DPL program). Note for the export nodes to work correctly the items being overridden in the DPL program must have the same names as the Node IDs in the database.

⇨ Double-click the peak sales table node. You can see that DPL created a two-dimensional array with 3 rows and 3 columns and that the array is linked to the 3 by 3 Node ID peak_sales_table.

⇨ Run a Decision Analysis.

The results are different from when you first changed the model link record to Model ID = 1, Project ID = 2 because the costs and other assumptions DPL is using are now extracted from the database for project 2, whereas

previously DPL was using the assumptions in the DPL program which differ from what is in the database for project 2.

2.6.4 Node Data Syntax for Non-DPL Compliant Tables

As mentioned in Section 2.3.4, you may store scalar and simple string data in a non-DPL compliant table. The syntax for the database link node data is slightly different in this case. The syntax is as follows

```
=[Project_Info.InPortfolio]
```

As with nodes linked to tables containing Node IDs, the node data must start with "=[" to indicate a database link. In this case though, the information contained within the square brackets is of the form table_name.field_name which indicates to DPL which table the data is in, e.g., Project_Info and which field the data is in, e.g., InPortfolio. Nothing follows the closed square bracket. No dimensionality information is needed since the node must be a scalar or simple string.

You may use same the methods described in Sections 2.6.1 and 2.6.3 to link existing nodes and create new database linked nodes to non-DPL compliant tables for scalars and simple strings.

2.7 Databases Configured for Revision Tracking

One reason to store data in a database is to keep track of the various revisions that the data may go through while the project or asset is being analyzed.

If you have set up your database so that it tracks revisions, you must tell DPL this and provide it with some more information about the field names in the database. You do this in the Database Specification Dialog. For databases that are configured for revision tracking, both a Revision ID and Revision Date field must exist in each table storing project data.

- ⇨ Click Data | Database | Set Up.
- ⇨ Check the Database configured for revision tracking checkbox. The Revision ID and Revision Date field edit boxes are enabled.
- ⇨ Click Default field names to set the field names for the two revision fields.
- ⇨ Click OK.

The R&D Projects database was already configured for revision tracking, although you have not been using it as such up to this point. Therefore, you did not have to change the Source or change the database in any way. Normally you would probably set the Database is configured for revision tracking at the same time as initially specifying the data source and DPL would automatically load the database schema information. In this case you have not changed the data source and DPL did not automatically load the database schema, so you need to do it now.

⇨ Select Data | Database | Load Schema. Click Yes for the prompt.

⇨ Save the Workspace.

⇨ Run a Decision Analysis.

Note that the results are slightly different. Previously when DPL did not know the database was configured for revision tracking, it was using the first data set it found for Model ID = 1, Project ID = 2. Now that DPL knows the database is configured for revision tracking, it uses the most recent revision which is slightly different.

3 Running Excel Macros from DPL

3.1 When to Use Excel Macros

Most spreadsheet models are built in such a way that the outputs (e.g., NPV) are updated as part of a normal Excel recalculation. However, some models may include calculations that are difficult or impossible to express solely in terms of Excel formulas, but can be readily programmed as Excel Visual Basic for Applications (VBA) macros. For this reason, DPL provides support for running an Excel macro in lieu of the Excel Calculate command normally sent on each path through the decision tree.

3.2 Tutorial: Building a DPL Model for a Spreadsheet Updated by a Macro

In this example, assume you are the owner of a gas-fired combustion turbine electricity generating plant. The plant is part of a system consisting of many generating stations using various energy sources: nuclear, wind, coal, gas, etc. The system operator dispatches these power plants efficiently based on their variable costs per generated megawatthour (MWh). The lowest variable cost plants run nearly all the time, whereas the more expensive ones run only during periods of peak demand. The plant you own is a "peaking" unit that typically runs about 20% of the time.

For planning purposes, you would like to estimate how many hours the plant will be operating next year. The problem is made difficult by the uncertainty in fuel prices as well as the level of a recently enacted carbon tax.

3.2.1 The Dispatch Spreadsheet

Assume you have a spreadsheet that approximates the logic employed by the system operator in dispatching the power plants in the system.

⇨ Open PowerPlantMacro.xls and select the Dispatch tab.

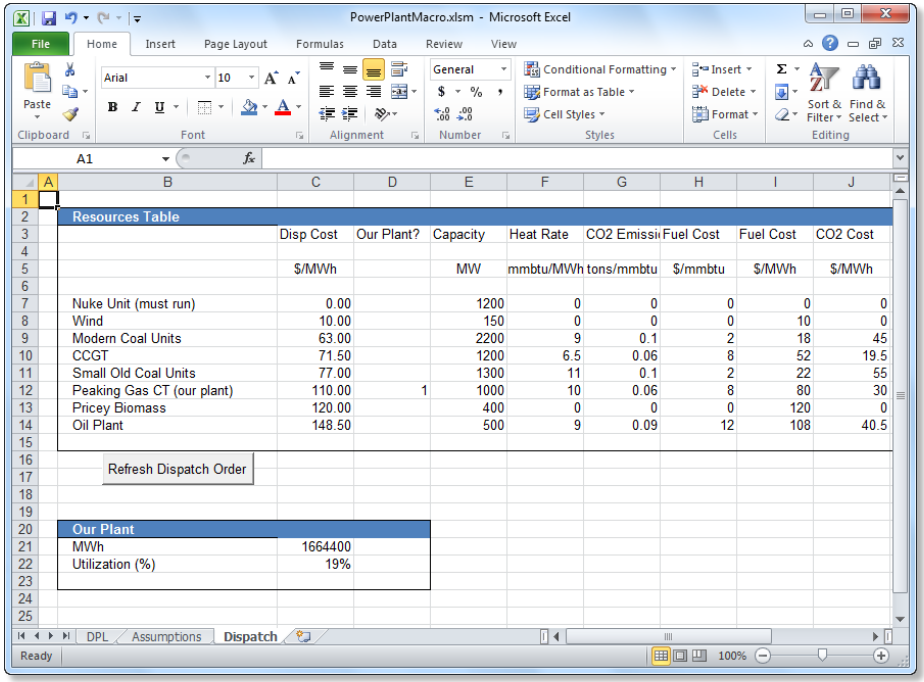


Figure 3-1. Power Plant Dispatch Sheet

Under base case assumptions, the plant falls in the bottom half of the dispatch order and runs about 19% of the time (cell C22). The units immediately ahead of the plant are old, less efficient coal-fired plants. A high carbon tax might mean that your plant runs more, since it would push up the costs of plants currently above yours more than your costs.

⇨ Select the DPL tab.

⇨ Change the green CO2 Price cell to 150.

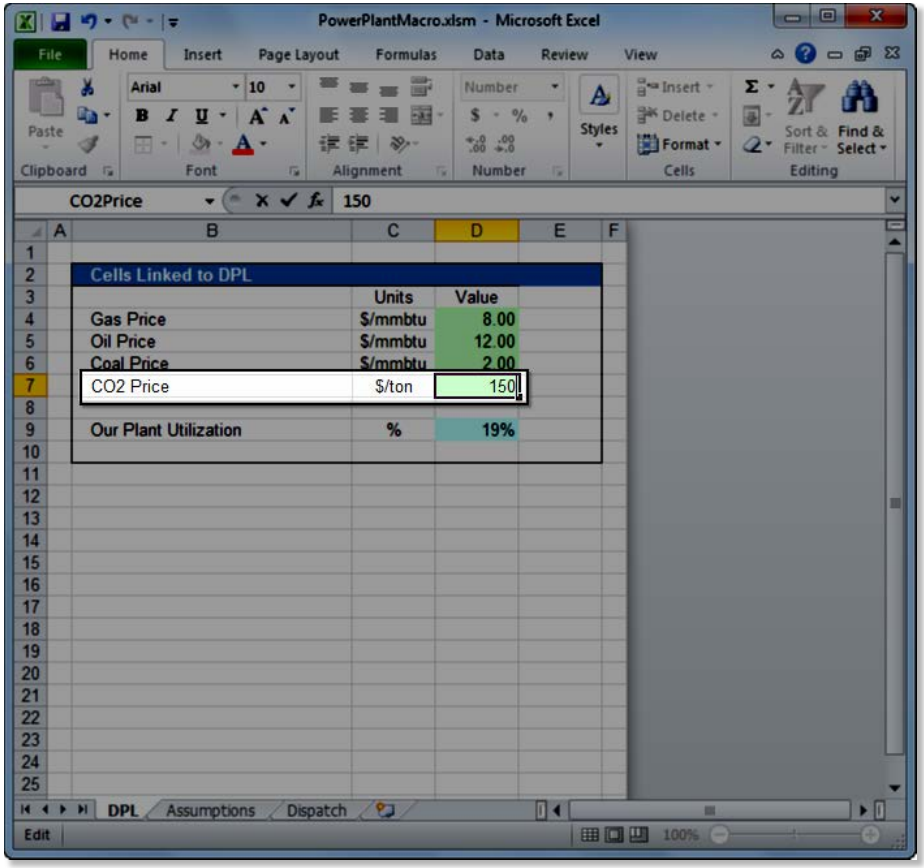


Figure 3-2. Power Plant DPL Sheet

⇨ Select the Dispatch tab.

⇨ Press the Refresh Dispatch Order button.

Note that with the higher carbon tax the plant moves up in the dispatch order and runs 34% of the time.

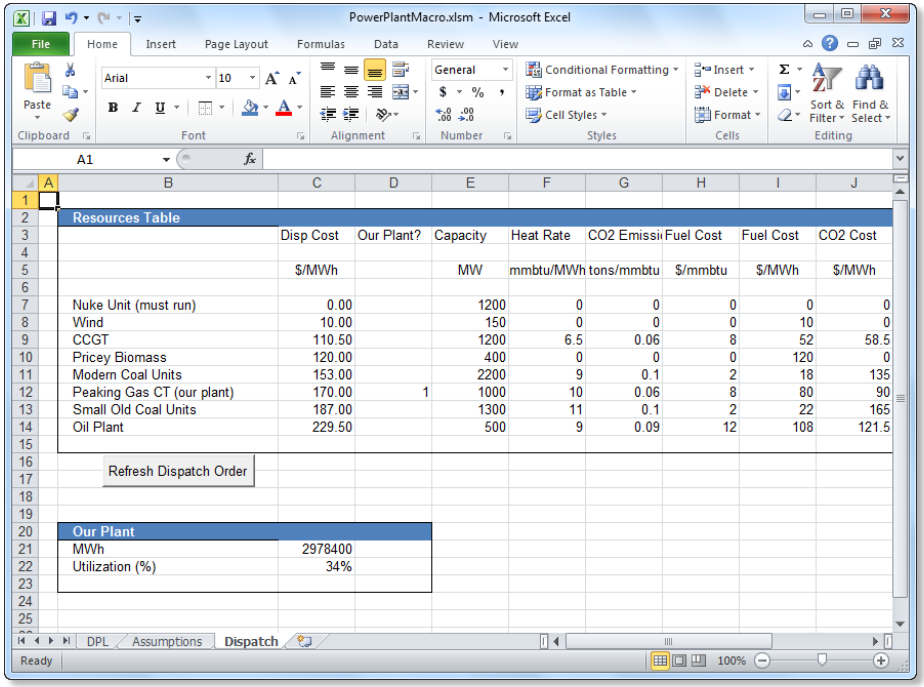


Figure 3-3. Power Plant Dispatch Sheet Updated

The Refresh Dispatch Order button runs a macro that sorts the power plants by their variable costs to update the dispatch order.

⇨ Click Developer | Code | Visual Basic. If the Developer tab isn't visible in the Excel Command Ribbon go to File | Options | Customize Ribbon and click the checkbox next to Developer in the Customize the Ribbon section on the right.

⇨ Once Visual Basic is open, in the left-hand pane, double click on Module1.

The SortResources() macro is displayed in the Visual Basic Editor.

```
Sub SortResources()     Calculate
Worksheets("Dispatch").Activate
Names("ResourcesTable").RefersToRange.Select     Selection.Sort
Key1:=Names("DispCost").RefersToRange     CalculateEnd Sub
```

⇨ Close the Visual Basic Editor.

⇨ Select the DPL tab and change CO2 Price back to 50.

3.2.2 Building the DPL Model

You will now create a DPL Model for the spreadsheet.

- ⇨ Start DPL Enterprise.
- ⇨ Click Model | Links | Add.
- ⇨ Press the Browse button and find PowerPlantMacro.xls, then click Open and then OK.
- ⇨ In the Range Names dialog, select CO2Price, CoalPrice, GasPrice, OilPrice and Utilization (see Figure 3-4), then click OK.

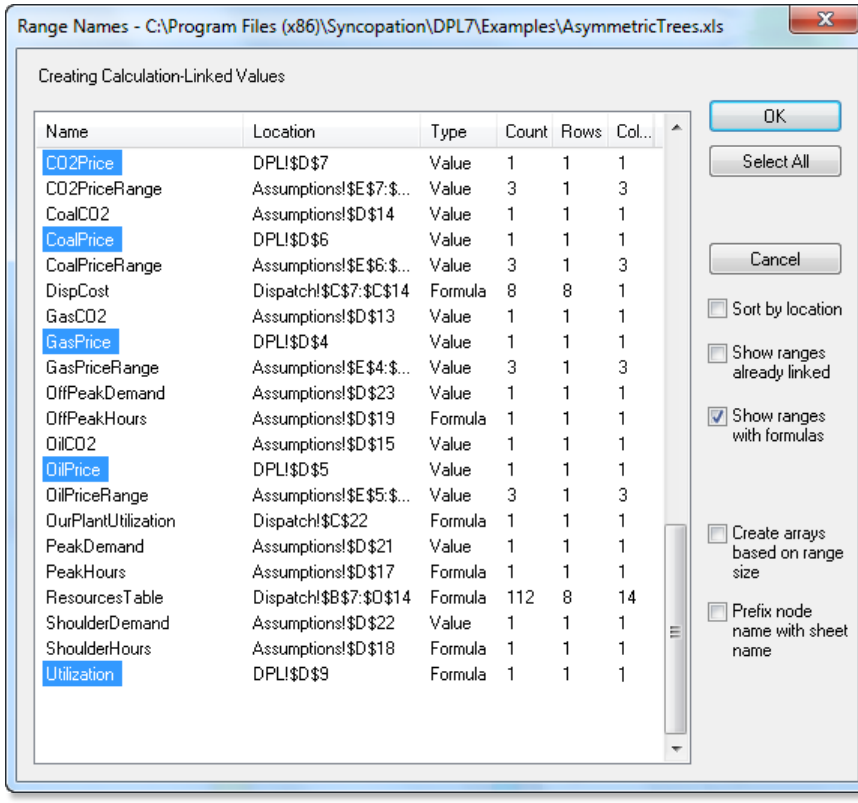


Figure 3-4. Range Names Dialog

- ⇨ Click Model | Influence/Arc | From Formulas.
- ⇨ Move your nodes so your influence diagram looks like Figure 3-5.

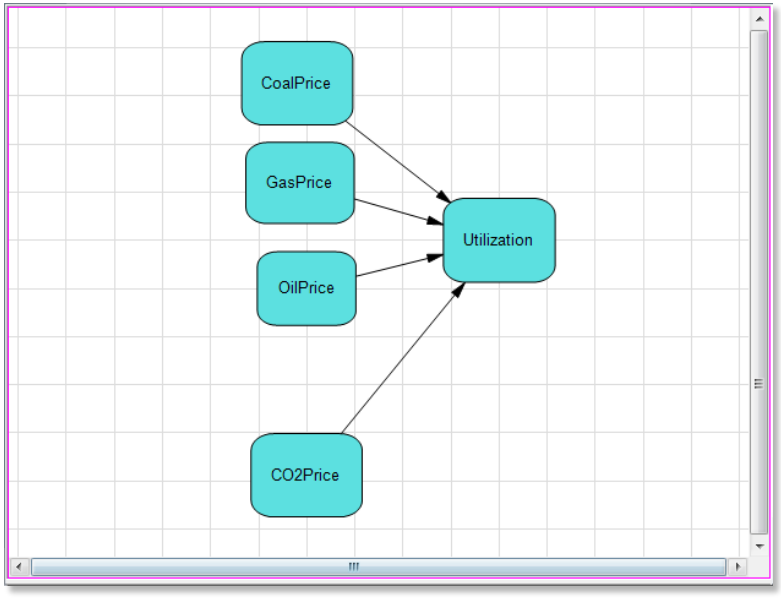


Figure 3-5. Deterministic Influence Diagram

- ⇨ Select the nodes CoalPrice, GasPrice, OilPrice and CO2Price (hold down the Ctrl key as you click to select more than one node at a time).
- ⇨ Drop-down the Model | Node | Change To split button and select Discrete Chance from the list. See Figure 3-6.

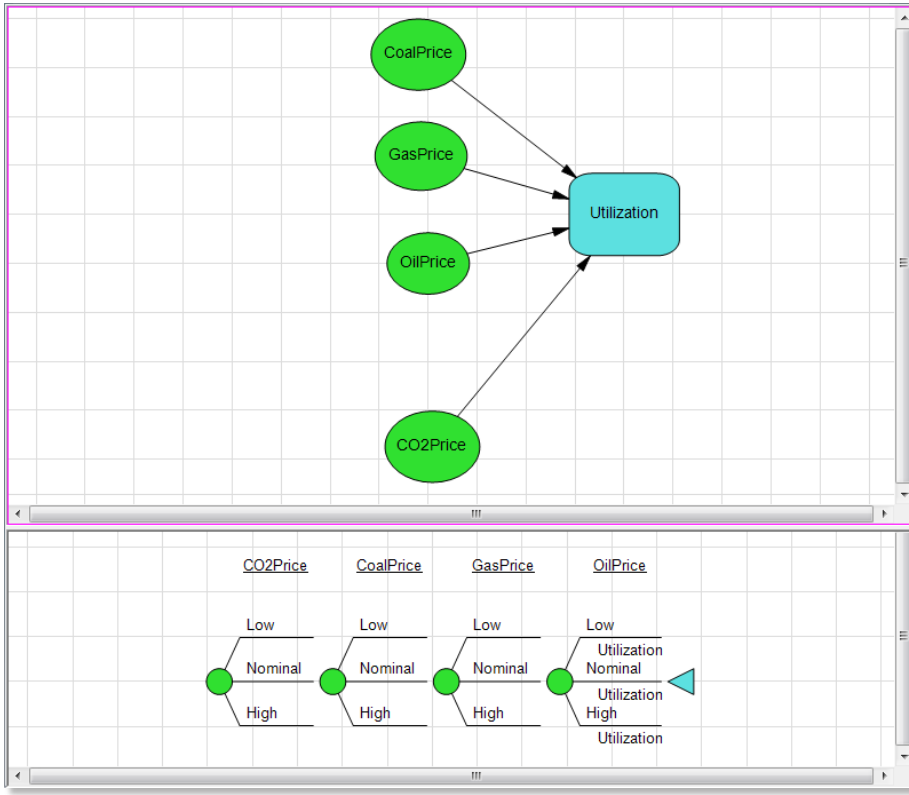


Figure 3-6. Probabilistic Influence Diagram

You now need to provide data for the chance nodes. The Assumptions sheet in the spreadsheet has Low-Nominal-High ranges for each of them. You'll use Initialization Links to tell DPL to use the range data in the spreadsheet.

⇨ Double-click on CoalPrice to bring up the Node Definition dialog.

⇨ Switch to the Links tab and in the Initialization links section click Microsoft Excel. See Figure 3-7.

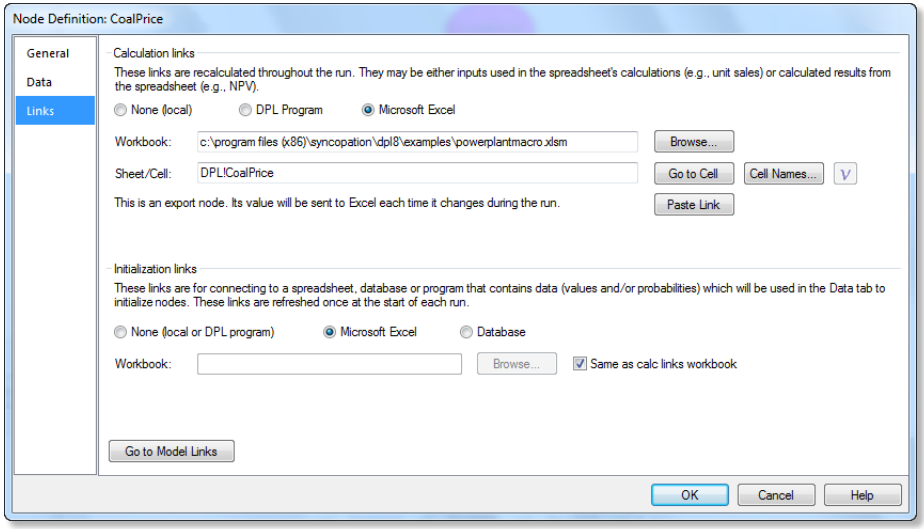


Figure 3-7. Node Definition Links for CoalPrice

- ⇨ Switch to the Data tab.
- ⇨ Delete the three values (the number 2 on each of the branches).
- ⇨ Select the first branch and click the link button () next to the Value edit box.
- ⇨ In the first column, select CoalPriceRange (see Figure 3-8) and then click the Select button.

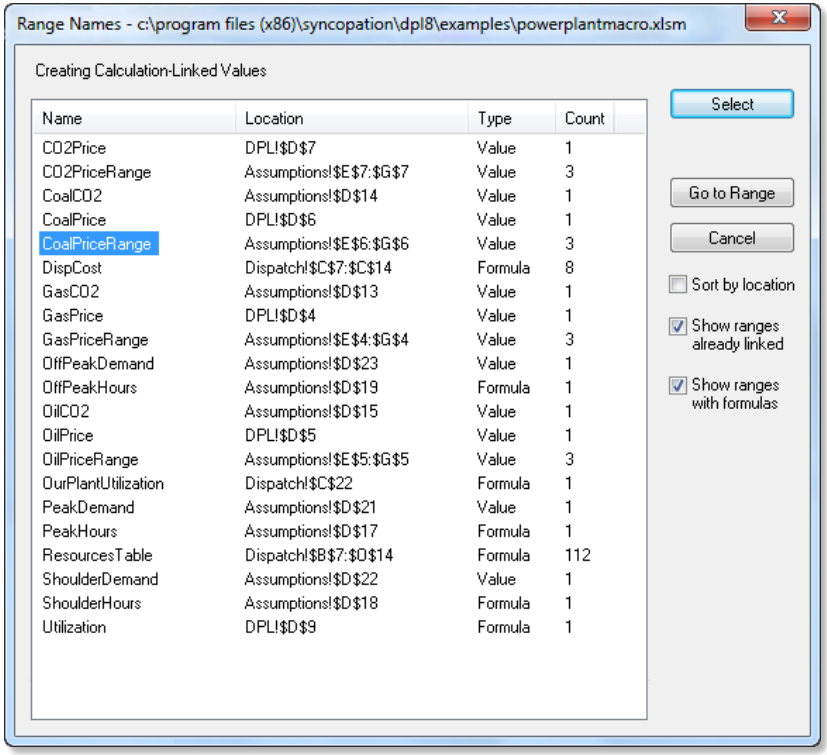


Figure 3-8. Range Names Dialog

You have now set up the initialization links so that the CoalPrice chance node will use the three values in the spreadsheet for its Low, Nominal and High branches. You will use the default probabilities of .3, .4, .3 for this example. See Figure 3-9.

⇨ Click OK to close the Node Definition dialog.

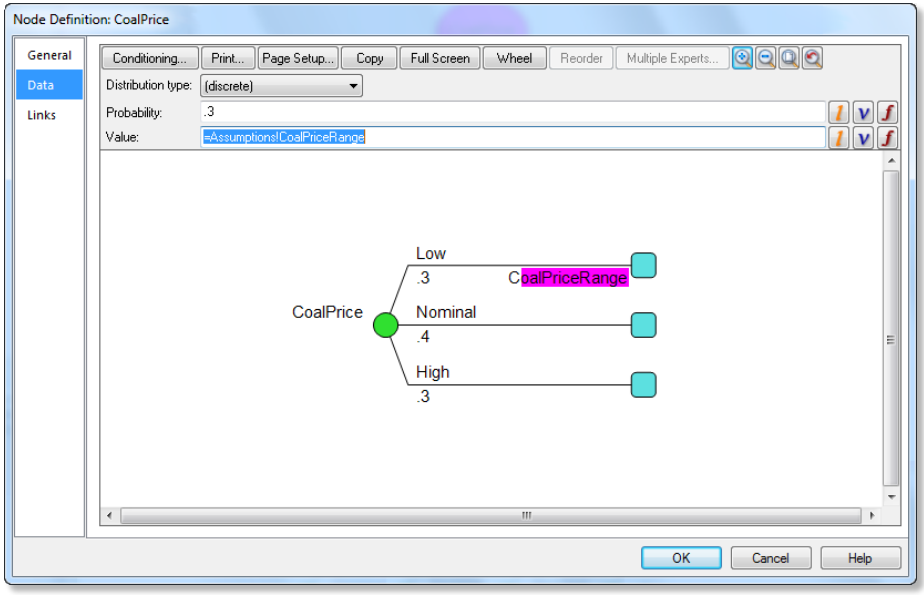


Figure 3-9. Node Definition Data for CoalPrice

⇨ Repeat the preceding steps to establish initialization links for the GasPrice, OilPrice and CO2Price nodes, using GasPriceRange, OilPriceRange and CO2PriceRange, respectively.

⇨ Save your DPL model.

3.2.3 Connecting the Calculation Macro

The DPL model is now set up and could be run, however the results would not be correct since a simple recalculation wouldn't sort the table. You need to make the SortResources macro run at the end of each path in the decision tree. To do that, you will create a special macro node. As you will see in the following, you indicate to DPL that the node is a macro node on the Links tab. You specify the macro to be run on the Data tab.

⇨ Create a new value node.

⇨ In the General tab, name the node Sort Resources.

⇨ Switch to the Links tab and in the Calculation links section click Microsoft Excel.

DPL fills in the Workbook edit box for you.

⇨ In the Sheet/Cell edit box, type in "XLMACRO.CALCULATE". See Figure 3-10.

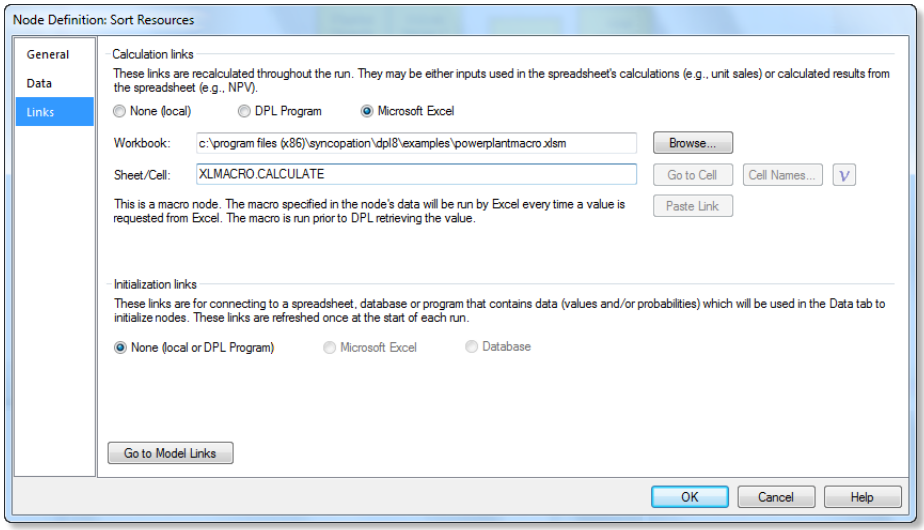


Figure 3-10. Node Definition Links for the Sort Resources Macro Node

DPL recognizes the special cell name as the code for a calculation macro node. You will now specify the name of the macro to run on the Data tab.

⇨ Select the Data tab and type SortResources. See Figure 3-11.

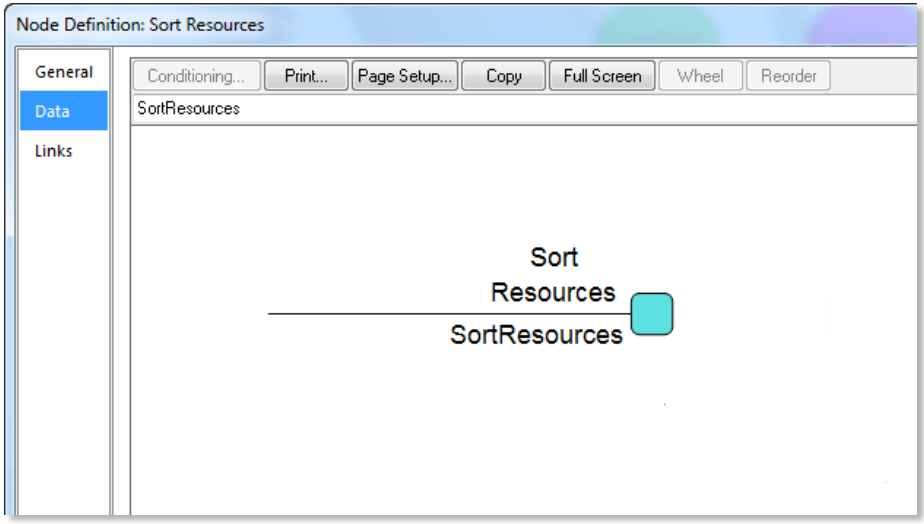


Figure 3-11. Node Definition Data for the Sort Resources Macro Node

SortResources is the name of the update macro.

Note: Calculation macros must be VBA Subs without any parameters. If you need to pass parameters to your macro, just add one or more DPL Export nodes and have the macro check the values of the cells to which those nodes are linked. The macro name is case sensitive.

⇨ Click OK to close the Node Definition dialog. Your model should now look similar to Figure 3-12.

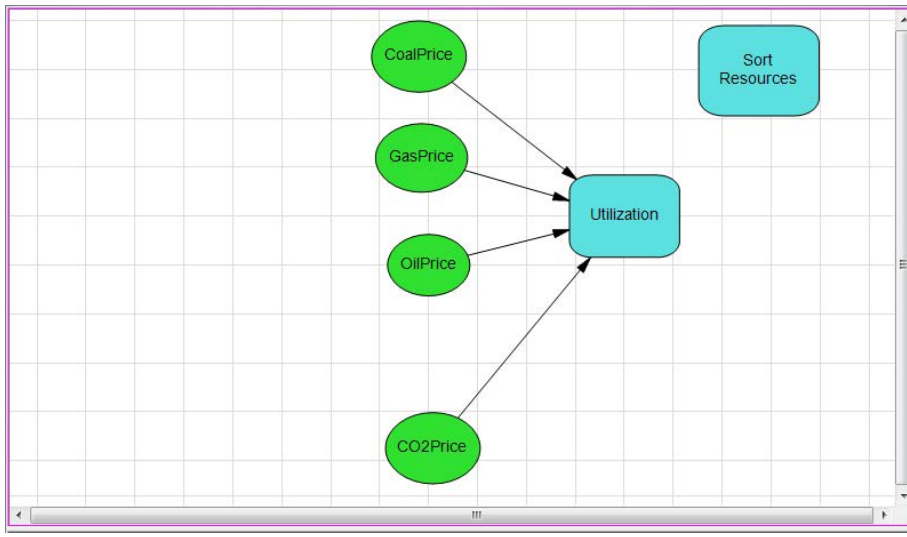


Figure 3-12. Influence Diagram with Sort Resources Macro Node

You are now ready to run the model.

⇨ In the Home | Run group, make sure Risk Profile is checked and uncheck Policy Tree.

⇨ Click Home | Run | Decision Analysis.

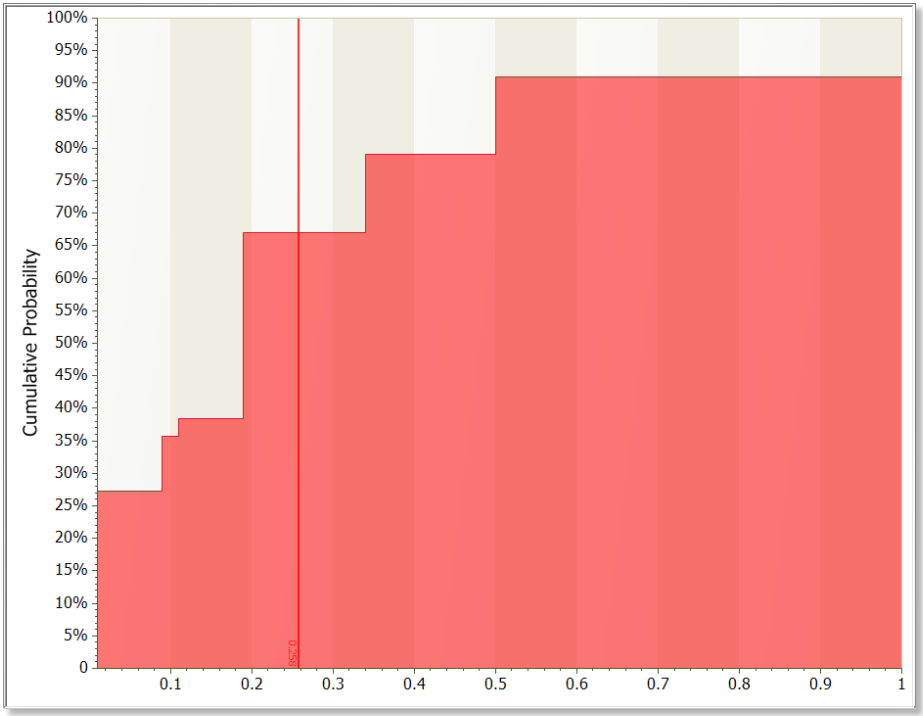


Figure 3-13. Risk Profile

The risk profile in Figure 3-13 shows a broad range of outcomes. You can run a tornado diagram to see which of the chance nodes is contributing the most uncertainty.

⇨ Drop-down the Home | Sensitivity | Tornado split button and select Base Case from the list.

⇨ Click OK to accept the default Low/Nominal/High assignments.

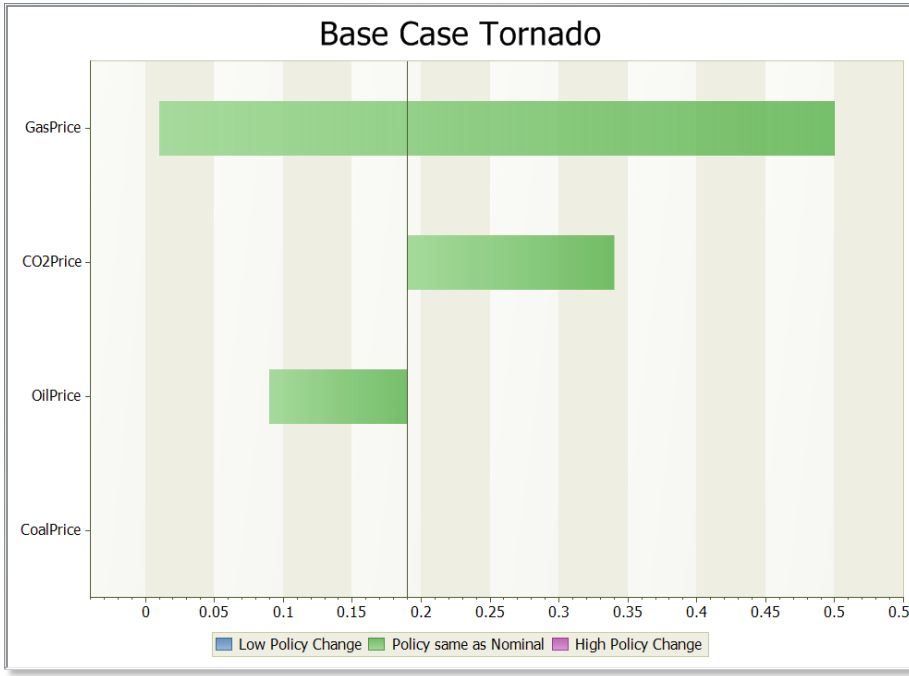


Figure 3-14. Tornado Diagram

Figure 3-14 indicates that GasPrice is the most sensitive variable, which is what you expect since you're running a gas-fired plant, but CO2 and Oil prices are also significant. Coal price is not sensitive. As it is modeled, the risk in the dispatch cost of a coal plant is primarily driven by CO2 emissions.

4 Multiple Experts

4.1 Why Use Multiple Experts?

Decision analysis requires the assessment of probability distributions using data, expert judgment, or most often, a combination of these. Probability distributions are defined by the DPL analyst, but to acquire the necessary knowledge and/or data, the analyst often needs to consult experts, and different experts often have different opinions. For chance nodes with two states (also known as binomial chance events), DPL provides a built-in capability to aggregate probability assessments from several experts. This chapter explains and demonstrates how this multiple experts feature works.

For purposes of this chapter, the quantity being assessed (a probability of a particular event occurring) will be called a **likelihood** to avoid confusion with the other probabilities involved in the calculations.

Probability assessments are often difficult, and experts may have significantly differing views. Given a variety of experts and their assessments, the analyst would like to come up with some sort of weighted average likelihood to use in the analysis. One possibility is to simply apply weights to each expert and compute a straightforward weighted average. However, this method does not directly incorporate any measure of the degree of confidence in each expert's assessment. It also does not capture the overlap of knowledge across experts.

DPL's aggregation method uses data provided by the analyst to calculate the weights and the overall expected likelihood. The weights used by DPL are determined by the reliability of the expert (measured by the assessments the expert provides) and the amount of shared information among the experts (measured by an overlap factor). DPL's method is simple and quick to use.

4.2 Overview of DPL's Multiple Experts Feature

Through a process of careful questioning, a distribution of likelihoods is extracted from each expert. To use DPL's multiple experts feature, each

expert must provide his/her assessment of the 10th, 50th, and 90th percentiles for the likelihood in question. The analyst ranks the experts from most "reliable" to least, and enters the 10-50-90 percentile values (referred to as fractiles) from the distribution for each expert.

An overlap factor is also required for all experts entered after the first (most reliable) expert. This quantity represents the amount of shared information the experts are believed to have.

DPL approximates each expert's distribution as a Beta distribution, and computes an expected value of the weighted average of all the distributions.

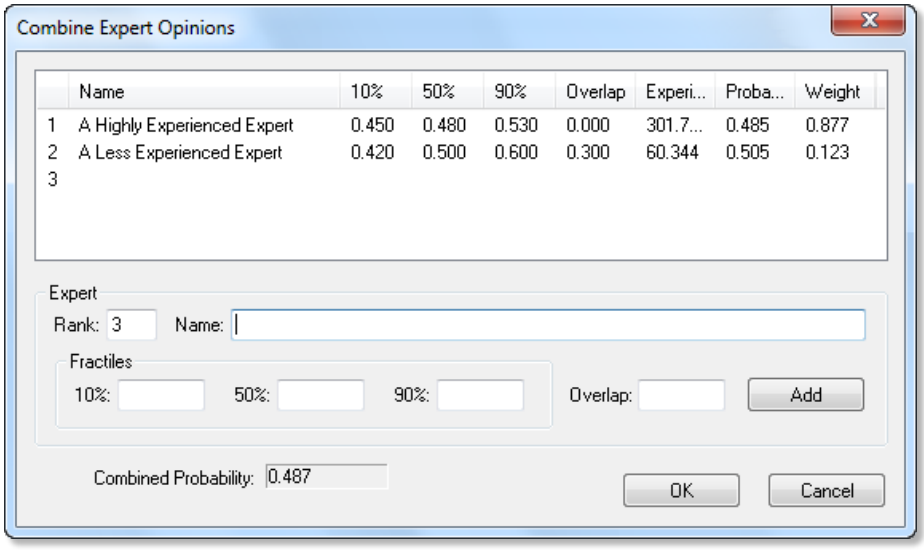


Figure 4-1. DPL Dialog for Combining Expert Opinions

Look at the top row of the Combine Expert Opinions dialog in Figure 4-1. The following headings appear: Name, 10%, 50%, 90%, Overlap, Experience, Probability, and Weight. Each of these is a quantity used to calculate the overall likelihood of the event. The fractiles and overlap factors are entered by the analyst, and the other quantities are calculated by DPL.

In Figure 4-1, a highly experienced expert and a less experienced expert have each assessed likelihoods for an uncertain event. The less experienced expert has provided a wider range around his or her 50% (median) point estimate. The combined probability for the two experts is 0.4875.

The subsections below provide descriptions of each quantity in this dialog. The last section of this chapter provides a brief tutorial on using DPL's Multiple Experts feature.

4.2.1 The Overlap Factor

The overlap factor is provided by the analyst. It is a number between zero and one, representing the fraction of the information provided by that expert that overlaps the information already represented by other experts. For example, if two academic experts are entered who are in the same department, have read the same books, and have attended the same seminars, the second one entered may have an overlap factor close to 1. An overlap factor of zero implies that the expert with zero overlap has only information or data that is entirely unknown to other experts; this is not typically the case.

Determining the overlap factors is a challenge left to the analyst. It is important to consider using overlap factors in order to avoid over-representing any one source of information.

4.2.2 The Experience Index

The experience index is calculated by DPL. This number represents the amount of information in each expert's assessment, and is based on the 10-50-90 fractiles.

This quantity is most easily explained by the "colored balls in an urn" model of the Beta distribution. Suppose the quantity being assessed is the probability that you will pick a red ball from an urn with an unknown percentage of red balls. An expert draws n balls from the urn, where n is different for each expert. Based on the size of the sample drawn (n) and the portion of the balls drawn that are red, the expert constructs his or her own distribution of the likelihood of drawing a red ball. As n increases, the accuracy of the expected value of the likelihood increases.

In DPL, the quantity *n* is labeled the experience index. Note that *n* is determined by the distribution, rather than the distribution being determined by *n*. It is an estimate of the total "n" (or alpha plus beta) in a Beta distribution that approximately corresponds to the fractiles. The precise formula for the experience index is:

$$n = \frac{E(p) - E(p^2)}{E(p^2) - (E(p))^2}$$

where *p* represents the probability (likelihood) being assessed, and *E(x)* is the expected value of *x*.

4.2.3 The Probability

The probability column contains the expected value of the likelihood of the event for each expert, calculated from the 10-50-90 fractiles.

4.2.4 The Weight

The weights for all experts should add up to 1. The weight is based on the overlap factor and the experience index. First, each expert's experience index is adjusted by subtracting off the amount of overlap (multiplying by 1 – overlap factor). Then the weight for the *k*th expert represents the fraction of all total experience that is attributable to that expert, that is:

$$w_k = \frac{n_k}{\sum n_i}$$

where n_i is the adjusted experience index of the *i*th expert.

4.2.5 Ranking

The experts should be ranked in order of reliability, and entered in this order, with the most reliable entered first. This way the overlap factor will apply to the less reliable experts. If the experience indices are not in descending order when all data has been entered, DPL will put up a warning box. See Figure 4-2.

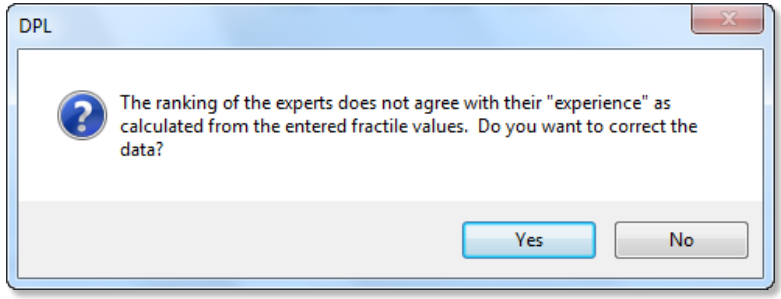


Figure 4-2. DPL Warning About Expert Rankings

In general, more reliable experts should have higher experience indices. DPL is checking to make sure the entries are what you intended.

If an expert believed by the analyst to be less experienced has a very high experience index, it may be that this expert is not well calibrated and has provided 10-50-90 fractiles that are closer together than they should be given his/her knowledge. The analyst must exercise judgement to ensure that the opinion of an overconfident expert is not overweighted.

4.3 Tutorial: Using Multiple Experts to Assess Early Product Approval

Suppose you are a decision analyst at a firm that is preparing to launch an exciting new product early next year. Plans are in place for an expensive product launch, including millions of dollars in advertising and promotions and a large kickoff meeting for the global sales team. Government regulators were on track to approve the product at the end of the calendar year, so the product launch has long been scheduled for the first quarter of the next year. You've done an extensive DPL analysis of decisions surrounding the product launch, but the launch timing was never in question.

You just received a call with new information. Because of the national election in November, there are rumors that the regulators in your industry are going to speed up approvals during the summer and fall, which could lead to your product being approved and launched a few months early (i.e., only a few months from now). If this happens, the promotional events and other pre-launch investments may need to be accelerated at significant

cost. You need to adjust your DPL analyses accordingly, and the NPV of the product will change.

You decide to consult a few external and internal experts to better understand the likelihood that the product will be approved (and launched) in the current calendar year, so that you can incorporate this new uncertainty into your models.

- ⇨ Start DPL 8 Enterprise (if it isn't already open).
- ⇨ If necessary, save your previous Workspace and close it.
- ⇨ Select File | New to open a blank Workspace.
- ⇨ Create a discrete chance node named Early Product Approval.
- ⇨ Modify the default outcomes so that the node has two outcomes: Yes and No, as in Figure 4-3.

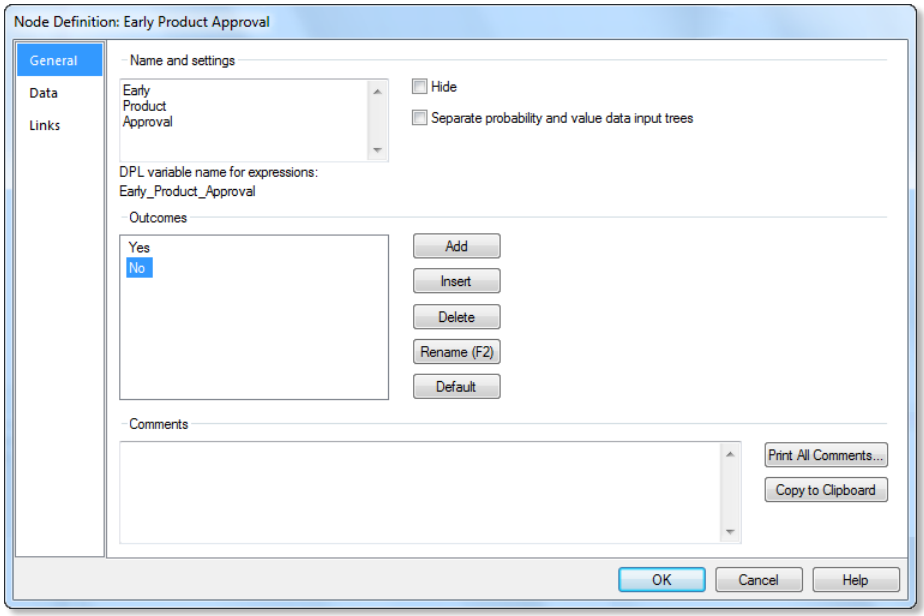


Figure 4-3. Chance Node Definition with Two States

- ⇨ Click the Data tab and delete any probabilities remaining on the Yes and No branches.
- ⇨ The dialog should look like Figure 4-4. Note that the Multiple Experts button is enabled.

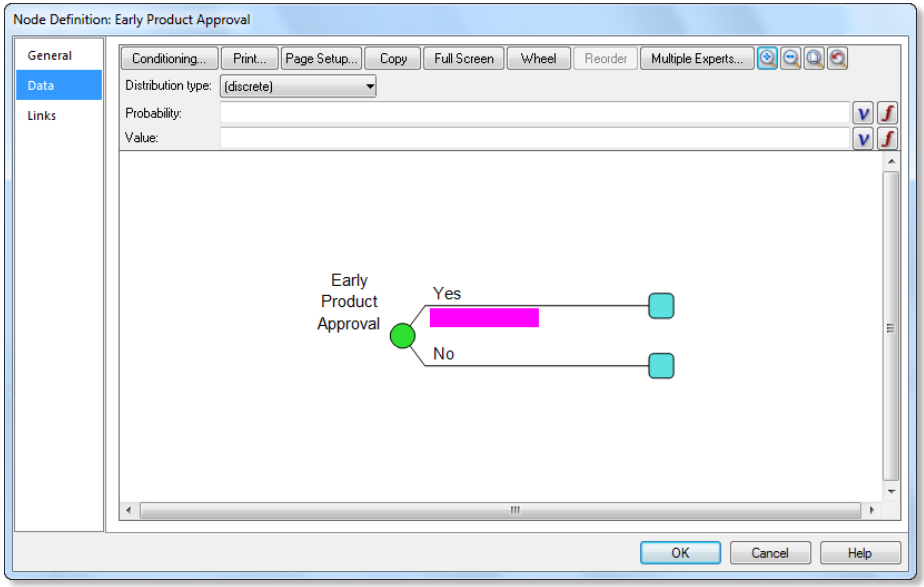


Figure 4-4. Node Data with Multiple Experts Enabled

⇨ Click the Multiple Experts button. The Combine Expert Opinions dialog appears.

You will enter data for the three experts you interviewed about the likelihood of early product approval.

⇨ In the Name edit box for the first expert, enter Government Consultant.

⇨ Click in the three Fractiles edit boxes, and enter the values 0.28, 0.33, and 0.39.

⇨ Leave the overlap blank (it will default to zero since this is the first expert).

⇨ Click the Add button. The dialog should look like Figure 4-5.

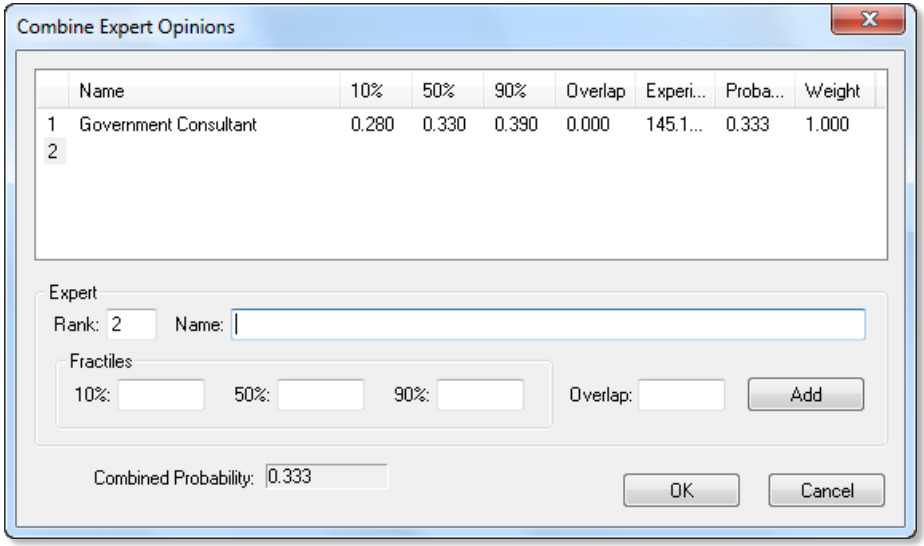


Figure 4-5. Combine Expert Opinions Dialog with First Expert's Data Entered

Note that DPL has calculated the experience index to be about 145 for this expert; this is analogous to saying the expert has about 145 observations from which to draw conclusions, which seems reasonable given the context. DPL has also calculated a weighted likelihood of 0.333 for this expert.

DPL prompts you to enter the second (rank 2) expert.

- ⇨ For the rank 2 expert, enter the name In-house Expert. Enter the following fractiles: 0.2, 0.28, 0.4.
- ⇨ Enter 0.2 for the overlap. You believe that your in-house expert (a former government regulator) has about 20% overlap, i.e., 80% "new" information compared with the government consultant.
- ⇨ Click the Add button. DPL updates the calculations.
- ⇨ Before examining results, add the third expert, named Third Opinion. The fractiles are: 0.15, 0.25, and 0.5 and the overlap is 0.5.
- ⇨ Click the Add button. The final results are shown in Figure 4-6.

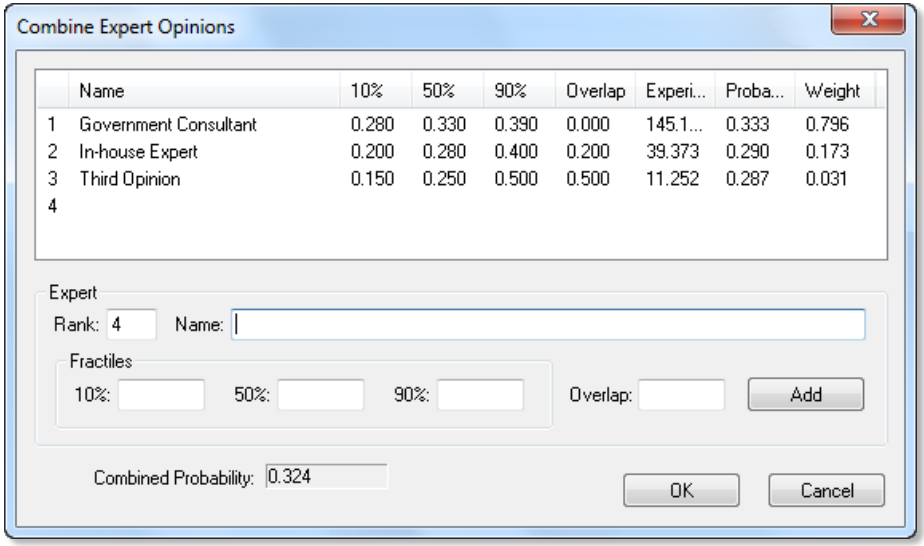


Figure 4-6. Final Combined Expert Opinions

DPL has calculated that the In-house expert has an experience factor of about 39. The Third Opinion expert has an experience factor of only about 11.

The weights applied to the three experts are calculated and shown in the far right column. The government consultant's assessment gets nearly 80% of the weight, while the other two experts get about 17% and 3%, respectively. The overall combined probability (likelihood) is 0.324. You decide to use this probability in your analysis, and to also conduct sensitivity analysis to see how decision sensitive it is.

⇨ Click OK to accept the probability as it is.

As shown in Figure 4-7, DPL has applied the combined probability to this chance node, and noted that it comes from the Multiple Experts feature. You can proceed to use this node in your model as you would use any other two-state chance node.

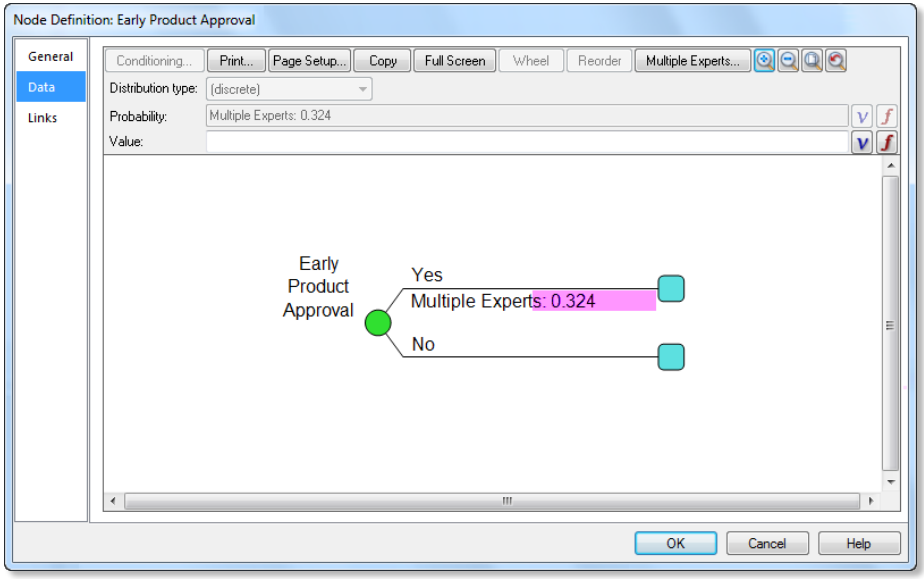


Figure 4-7. Node Data with Multiple Experts Data Defined

Note: As shown in Figure 4-7, when multiple experts data is in place, you can no longer enter probabilities directly. In order to remove the multiple experts data from the node, you would need to go back into the Multiple Experts dialog and delete each expert. To do this, you select each expert by clicking on his/her number in the far left column and then click Delete. When there are no experts remaining in the dialog, click OK and the node will be cleared of the multiple expert's data.

5 DPL Developer API

5.1 Overview

DPL Enterprise includes an Application Programming Interface (API), which is an interface for controlling DPL from other programs. DPL's API can be used to automate repetitive tasks, such as updating and running several models. It can also be used to leverage DPL's decision analysis engine in programs meant for use by persons not familiar with DPL or even decision analysis.

Although using the DPL API requires some programming ability, common tasks can be accomplished with only a few commands and do not require specialist software development expertise. If you have written Excel macros in Visual Basic for Applications (VBA), then you should have no trouble learning to use the DPL API.

Most uses of the API involve creating one or more template Workspace files as part of the development process. At runtime, the client application controlling DPL supplies specific data and runs analyses to produce results. These results can then be displayed to the user either by DPL or by the client application.

The DPL API uses Automation (also called OLE Automation) as the underlying technology for exposing capabilities to client programs. Automation makes it easy to control DPL from current versions of Microsoft Office. Future versions of the DPL API may employ other technologies.

The DPL API can be used with any language that supports Automation, including the .NET family of languages. Code examples in this chapter are written in VBA.

5.2 Controlling DPL from Visual Basic

In this section, you will create a Visual Basic program that opens a DPL Workspace file and runs a Decision Analysis. In what follows, we assume

the client is Visual Basic for Applications (VBA) in Microsoft Excel 2010, but the process is similar in any VB or VBA client environment.

5.2.1 Running a Decision Analysis

Before you can use DPL objects in a program, you need to register DPL as a server. You do this by running DPL with the /Register switch.

- ⇨ Select Start | Run from Windows.
- ⇨ Browse for DPL8.exe (normally in C:\Program Files (x86)\Syncopation\DPL8).
- ⇨ Add " /Register" (without quotes) after the path name and click OK.

DPL's splash screen will be visible for a second or so as DPL registers itself with the system. You are now ready to begin using the DPL API.

You will start with a blank Excel workbook.

- ⇨ Start Microsoft Excel.
- ⇨ Click Developer | Code | Visual Basic.
- ⇨ Select Insert | Module.
- ⇨ Type the code below into the editor window.

```
Sub RunWildcat()    Dim oDPLApp As Object, oDPLWS
As Object        Set oDPLApp =
CreateObject("DPL.Application")    oDPLApp.Show =
1    Call oDPLApp.OpenWorkspace("C:\Wildcat.da")
Set oDPLWS = oDPLApp.Workspace
oDPLWS.RunDecisionAnalysisEnd Sub
```

You will need to change "C:\Wildcat.da" to the actual location of that example file on your computer ("C:\Program Files (x86)\Syncopation\DPL8\Examples\Wildcat.da" if you used the default installation location when installing DPL).

- ⇨ Start DPL.
- ⇨ Return to the Visual Basic Editor.
- ⇨ Make sure the cursor is in the Sub RunWildCat.
- ⇨ Press F5 to run your Sub.

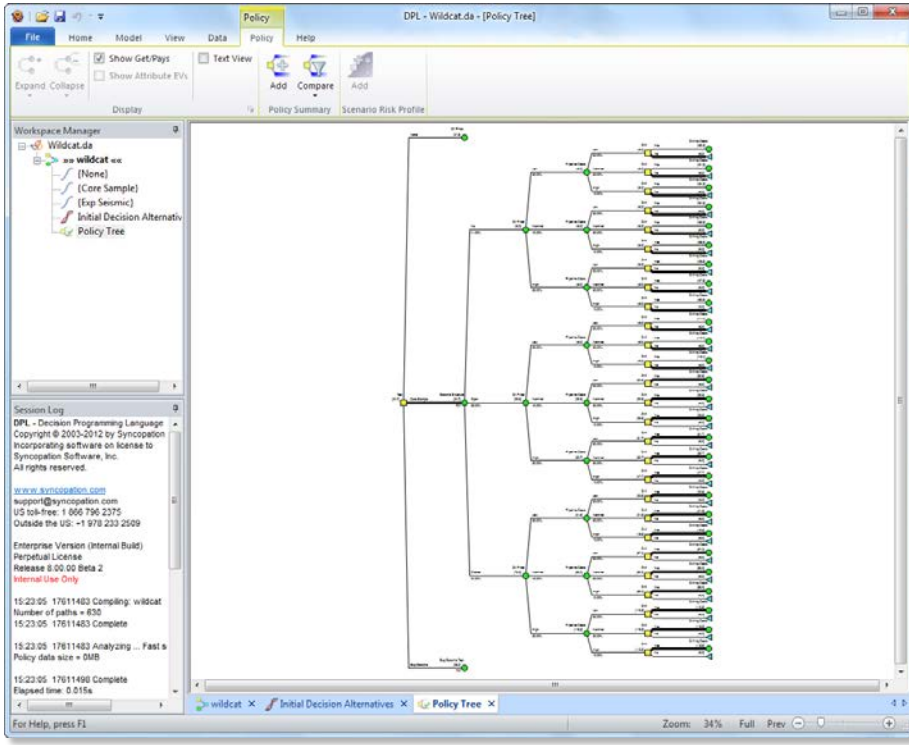


Figure 5-1. Wildcat Policy Tree™

Note: if you run your macro before starting DPL, the CreateObject function will create an invisible instance of DPL. You can make such an instance visible using the Show property of DPLApplication (in the example above, the line "oDPLApp.Show = 1" was included just in case).

In the above, you ran a Decision Analysis without specifying any options. In the DPL API, run options are properties of the DPLWorkspace object (oDPLWS).

⇨ Insert the two lines below before the RunDecisionAnalysis line.

```
    oDPLWS.PolicyTree = 0
oDPLWS.InitialDecisionAlternatives = 1
```

⇨ Press F5 to run the Sub again.

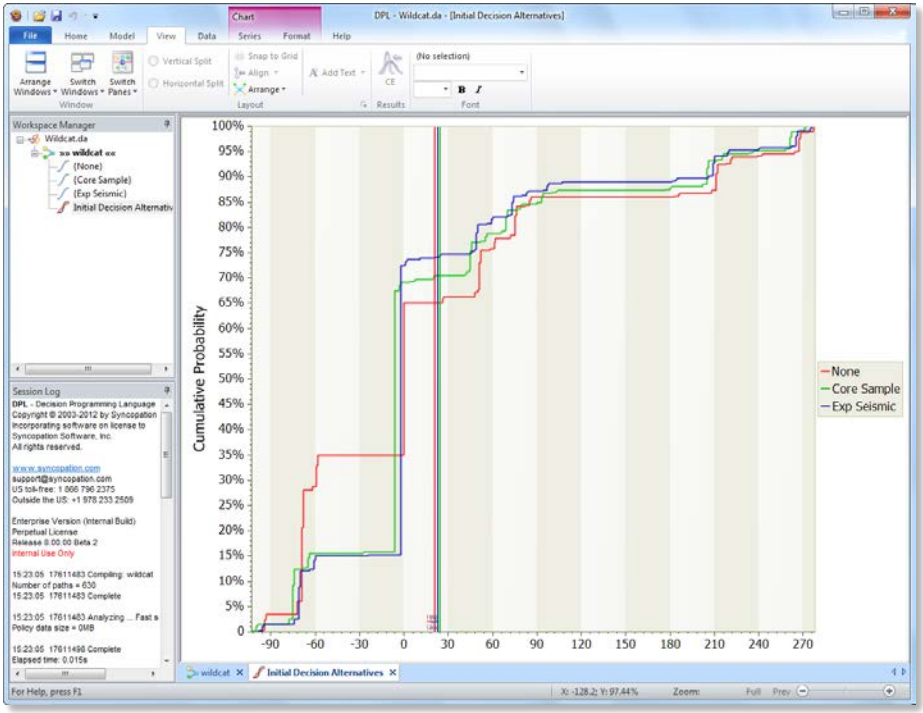


Figure 5-2. Wildcat Risk Profile

Lastly, you'll use the API to make a "what-if" change to the model to look at a non-optimal alternative of the Test decision. To do that you'll use branch control on the Test decision in the decision tree.

⇨ Add these lines to your Sub, replacing the two you previously added.

```
    oDPLWS.PolicyTree = 1    Dim oDPLModel as
Object    Set oDPLModel = oDPLWS.MainModel    Dim
oDPLNode as Object    Set oDPLNode =
oDPLModel.Nodes("Test")    Dim oDPLTreeNode as
Object    Set oDPLTreeNode = oDPLNode.TreeNodes(1)
oDPLTreeNode.BranchControl = 0
oDPLModel.ClearMemory
```

⇨ Press F5 to run the Sub again.

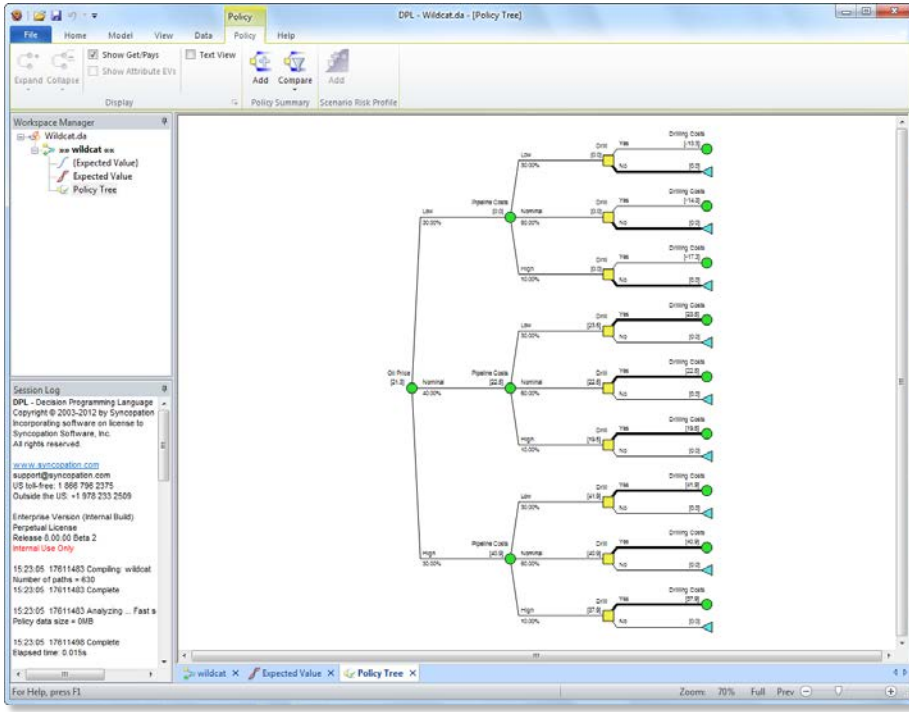


Figure 5-3. Wildcat Policy Tree™ with Test Controlled

5.2.2 Adding a Type Library Reference

If you would like DPL's object types (DPLApplication, DPLWorkspace, etc.) to be known to your development environment, you can add a reference to the DPL API type library. Doing so has the benefit that your development environment can check syntax and provide lists of properties/methods. Adding a reference is not required, and the examples in this chapter do not assume that it has been done (in particular, they declare variables as type Object rather than as a specific DPL object type).

The type information is contained in the main DPL executable (DPL8.exe). To add a reference from Excel VBA, go to the Visual Basic Editor and follow these instructions:

- ⇨ Select Tools | References....
- ⇨ Click Browse...
- ⇨ Change Files of Type to be Executable Files.

- ⇨ Find your DPL executable. (C:\Program Files (x86)\Syncopation\DPL8\DPL8.exe if you installed in the default location).
- ⇨ Click Open.
- ⇨ Scroll down in the Available Reference list to find "DPL 1.0 Type Library"
- ⇨ Check the checkbox next to it if it isn't already.
- ⇨ Click OK.

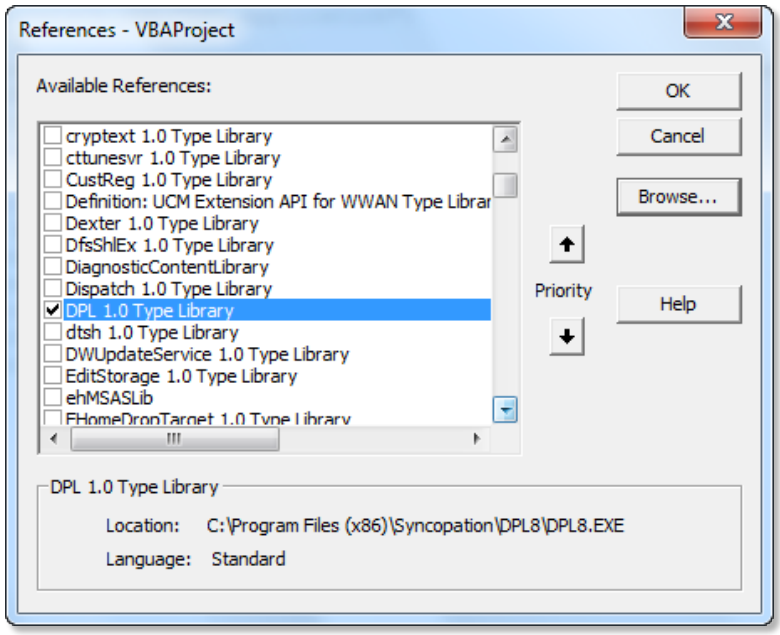


Figure 5-4. Type Libary References

With the type library reference, you can use DPL types in your code, as in the following example. Note that you still need to Dim the application as Object (not as DPLApplication).

```
Sub RunWildcatTypes()    Dim DPLApp As Object
Set DPLApp = CreateObject("DPL.Application")
DPLApp.OpenWorkspace ("C:\Wildcat.da")    Dim WS
As DPLWorkspace    Set WS = DPLApp.Workspace
Dim Model As DPLModel    Set Model = WS.MainModel
Dim Node As DPLNode    Set Node =
```

```
Model.Nodes("Test")    Dim TreeNode As DPLTreeNode
Set TreeNode = Node.TreeNodes(1)
TreeNode.BranchControl = 0    Model.ClearMemory
WS.RunDecisionAnalysisEnd Sub
```

Test the Type Library now.

- ⇨ Enter the new Sub into Module1.
- ⇨ Change the path from "C:\Wildcat.da" to where the file is on your computer.
- ⇨ Press F5 to run it.
- ⇨ Note: if you place your cursor next to the WS on the last line of the Sub and type ".", Excel provides you with a list of Methods and Properties of a DPLWorkspace.

5.3 API Objects and Types

DPL's API provides several objects which allow you to manipulate the application, its documents and their data. The figure below shows the hierarchical relationships of the DPL API objects.

```
DPLApplication (1 per running instance of DPL)
      →DPLWorkspace (1)       →DPLModel (0 or
more)             →DPLNode (0 or more)
            →DPLTreeNode (0 or more)
      →DPLResult (0 or more)
```

Figure 5-5. DPL API Objects

5.3.1 The DPLApplication Object

The Application object represents a running instance of DPL. It is the starting point for any conversation with the DPL API.

The methods of the Application object correspond to activities that effect the whole application and not just individual windows (e.g., Models, Risk Profile Charts, etc). Most methods in the Application object correspond to commands in the File menu.

The code below obtains a reference to a DPLApplication object.

```
Dim oDPLApp As ObjectSet oDPLApp =
CreateObject("DPL.Application")
```

5.3.2 The DPLWorkspace Object

The DPLWorkspace object corresponds to a DPL Workspace (.DA) file. Only one Workspace file can be loaded at a time. DPL creates a blank Workspace when it starts. The currently loaded Workspace can be accessed using the Workspace property of the DPLApplication object.

```
Dim oDPLWS As ObjectSet oDPLWS = oDPLApp.Workspace
```

5.3.3 DPLModel Objects

DPLModel objects correspond to components of a DPL Workspace that can be run or evaluated, including Models, Programs and Commands.

```
Dim oDPLModel as Object, oDPLModel2 as ObjectSet
oDPLModel = oDPLWS.MainModelSet oDPLModel2 =
oDPLWS.Models("Another Model")
```

A DPLModel object can be any of the types shown in Table 5-1 below (see the Type property).

ID	Hex value (decimal value)	Description
ID_DOC_TYPE_IDDT	0x0001 (1)	Model (influence diagram and decision tree)
ID_DOC_TYPE_PROGRAM	0x0002 (2)	Program not run directly
ID_DOC_TYPE_DRIVER_PROGRAM	0x0004 (4)	Runnable program
ID_DOC_TYPE_COMMAND	0x0005 (5)	Command

Table 5-1. DPLModel Types

5.3.4 DPLNode Objects

DPLNode objects correspond to nodes in a DPL influence diagram. A DPLNode object is returned by the Nodes property (collection) of a DPLModel object.

```
Dim oDPLNode1 as ObjectSet oDPLNode1 =
oDPLModel.Nodes("Revenue")
```

5.3.5 DPLTreeNode Objects

DPLTreeNode objects correspond to nodes in a DPL decision tree. Each decision tree node is an instance of an influence diagram node of type

Decision, Chance or Controlled. A DPLTreeNode object is returned by the TreeNodes property (collection) of a DPLNode object.

```
Dim oDPLTreeNode1 as ObjectSet oDPLTreeNode1 =
oDPLNode1.TreeNodes(1)
```

5.3.6 DPLResult Objects

DPLResult objects correspond to components of a DPL Workspace that are the result of analyses, such as Policy Trees™, Risk Profile Charts, Rainbow Diagrams, etc.

```
Dim oDPLResult as ObjectSet oDPLResult =
oDPLWS.Results("Expected Value")
```

A DPLResult object can be any of the types shown in Table 5-2 below (see the Type property).

ID	Hex value (decimal value)	Description
ID_DOC_TYPE_ENDPOINTS	0x0010 (16)	Endpoints
ID_DOC_TYPE_RISK_PROFILE	0x0020 (32)	Risk Profile chart
ID_DOC_TYPE_DECPOLICY	0x0021 (33)	Policy Tree™
ID_DOC_TYPE_POLICYSUM	0x0022 (34)	Policy Summary™
ID_DOC_TYPE_SENS	0x0023 (35)	Rainbow diagram (one-way)
ID_DOC_TYPE_TWOWAY_SENS	0x0024 (36)	Rainbow diagram (two-way)
ID_DOC_TYPE_VAL_COMP	0x0025 (37)	Value tornado diagram
ID_DOC_TYPE_NOM_COMP	0x0026 (38)	Base case tornado diagram
ID_DOC_TYPE_EVENT_COMP	0x0027 (39)	Event tornado diagram
ID_DOC_TYPE_VOIC	0x0028 (40)	Value of info/control chart
ID_DOC_TYPE_CORR	0x0029 (41)	Value correlations chart
ID_DOC_TYPE_OPTION_VALUE	0x002A (42)	Option value chart

Table 5-2. DPLResult Types

5.3.7 Parameter Data Types

The DPL API uses the five data types described below. Examples of how to declare them in VB and C/C++ are given after each description. Note that in VB one can also use Variants for any type. The Variant subtypes (VT_*) are shown in the comments.

Object: An OLE Automation IDispatch pointer.
```
Dim o as Object
'VB VT_DISPATCH   LPDISPATCH lpDispatch;  // C/C++
```

Double: A double precision floating point number, which can take values in the range of 2.2250738585072014e-308 to 1.7976931348623158e+308.
```
Dim d as Double   'VB VT_R8   double d;          //
C/C++
```

Long: A 32-bit signed integer, which can take values in the range of -2147483648 to 2147483647.
```
Dim i as Long     'VB VT_I4
int i;            // C/C++
```

Bool: A Long value interpreted to be boolean (zero for false, nonzero for true).
```
Dim b as Long     'VB VT_I4   BOOL b;           //
C/C++
```

String: An OLE Automation BSTR string.
```
Dim s as String
'VB VT_BSTR _bstr_t s;        // C/C++
```

5.4 API Reference

This section documents the properties and methods of each type of object in the DPL API.

The syntax for properties is:

property_name : type[DPL Type Library type].

The property declaration is followed by a parenthetic comment indicating whether the property is read-only or read/write.

The syntax for methods is:

method_name(param1 : param1 type, param2 : param2 type, …)

5.4.1 DPLApplication Properties

DisplayRunStatus : Bool (read/write)

Controls whether or not DPL displays the run status dialog when running an analysis. The default is false if DPL was started by Automation, true otherwise.

ErrorsToLog : Long (read/write)

Controls the display of error and warning messages that would normally be displayed in message boxes. Must be one of the following:

0 Display interactively with message boxes 1 Print in session log 2 Both

LastError : String (read-only)

A string describing the last error (or warning) from DPL, whether or not that error was displayed. In most cases, the string in LastError will be the same as the description property of the VB Err object.

```
      On Error GoTo OnErr     ... 'code that
results in an errorOnErr:     MsgBox
Err.Description   MsgBox oDPLApp.LastError 'same
as above
```

LogFile : String (read/write)

The path of a text file for the session log. Log messages will be printed both to the Session Log window and the specified file.

The file will be opened immediately and will stay open until the DPL Application instance is released. Any existing file of the same name will be overwritten. To close the file explicitly, set LogFile to "" (an empty string).

Options(Name : String) : Long (read/write)

Reserved for future use. There are no DPLApplication named options at this time.

PostRunExcelMacro : String (read/write)

Contains the name of an Excel macro that DPL should run at the end of an analysis. Using this property with the RunAsynchronous property, you can

have your client program start a DPL analysis and return to an idle state, then you can have DPL pass control back to the client after the analysis. With this technique, you can run a DPL analysis from a VBA macro in an Excel workbook which is itself linked to DPL and will be used in the analysis. See the DrugDevelopmentRunButton example files.

ReleaseNumber : Long (read-only)

The DPL release number as an integer. For example, DPL release 8.01.02 would return the integer 80102.

RunAsynchronous : Bool (read/write)

When this property is true, calls to DPL "Run" methods will return immediately. When false (the default), they will return when the analysis is complete. You can use this method to "kick off" a run in a situation where the results will be examined interactively by the user, or you can use it in conjunction with the PostRunExcelMacro to take back control after the analysis (if the client is Excel).

Show : Long (read/write)

The current state of the DPL main window. Set this property to maximize, minimize, show or hide DPL's main window. The appropriate values are those of the Windows API ShowWindow command, a few of which are listed below. Consult the Windows API documentation for details.

SW_HIDE	0	SW_SHOWNORMAL	1
SW_SHOWMINIMIZED	2	SW_SHOWMAXIMIZED	3

If DPL is started by Automation (e.g., by using CreateObject("DPL.Application") in VBA) when no instance of DPL is running, DPL's main window will initially be hidden.

Workspace : Object[DPLWorkspace] (read-only)

This method returns a DPLWorkspace object corresponding to the currently loaded DPL Workspace file. If no Workspace is loaded, DPL will throw an exception.

5.4.2 DPLApplication Methods

CloseWorkspace()

Closes the current Workspace file without prompting.

Exit(Code : Long)

Terminates the DPL Application returning Code to the system (e.g., use Exit(0) for "normal" termination). Note that the call is asynchronous, so DPL may still be running when the method returns.

NewWorkspace()

Creates a new, blank Workspace file. If a Workspace was previously loaded, it is closed.

OpenWorkspace(Path : String)

Opens the Workspace file indicated by Path.

SaveWorkspace()

Saves the Workspace file using the current file name and path. The Workspace file must be named otherwise DPL will throw an exception.

SaveWorkspaceAs(Path : String)

Saves the Workspace file to Path.

Warning(message : String)

Causes DPL to display a message box containing message.

WriteToLog(message : String), WriteLnToLog(message : String)

Writes message to the session log. WriteLnToLog appends a new line, so that the next log message will start in the first column of the following line. To send a multi-line message to the session log, include carriage return / linefeed pairs ("\r\n" in C/C++, Chr$(13)+Chr$(10) in VB).

5.4.3 DPLWorkspace Properties

Distribution : Long (read/write)

The type of risk profile(s) DPL should generate in the next run. Must be one of the following:

0 No distribution 1 Objective function 2 Objective function and all attributes 3 All attributes 4 One attribute

If the value is 4, DistributionIndex should be set to the index of the desired attribute.

DistributionGraphFormat : Long (read/write)

Controls how the risk profile generated in a Monte Carlo simulation run is displayed.

0 Cumulative 1 Histogram

This has no effect on risk profiles generated in Decision Analysis runs, which are always displayed in Cumulative form.

DistributionIndex : Long (read/write)

The index of the attribute for which a risk profile should be generated in the next run. Ignored unless Distribution is set to 4.

DistributionIntervals : Long (read/write)

The number of distribution intervals DPL should use for the risk profiles generated in the next run. Must be between 0 and 10000. Default is 500.

For Monte Carlo simulation runs, this property can be set to -1, indicating that DPL should store all samples and do no aggregation.

EvaluationMethod : Long (read/write)

The evaluation method DPL should use in the next run. Must be one of the following:

0 Fast sequence evaluation 1 Full enumeration
2 Discrete Tree Simulation

FatPolicy : Bool (read/write)

True if DPL should produce Fat Policy™ (i.e., rolled-back expected values for all attributes) in the next run. Ignored if there is only one attribute.

InitialDecisionAlternatives : Bool (read/write)

True if DPL should generate a risk profile chart showing initial decision alternatives in the next run. Ignored if the tree doesn't start with a decision or if it starts with a decision having more than eight alternatives.

MainModel : Object[DPLModel] (read-only)

An object reference to the main model of the currently loaded Workspace file. Returns Null if no Workspace is loaded or the current Workspace has no main model.

```
Dim oDPLModel As ObjectSet oDPLModel =
oDPLApp.MainModel
```

Note that this property is read-only. To change the main model, use the Models property to obtain an object reference to the model you want to make main, then call its MakeMain property.

Models(Name : String) : Object[DPLModel] (read-only)

An object reference to the model with title Name. Returns Null if there is no model (DPL Model or Program window) with title Name in the Workspace. The example below displays the type of a model named "Bob".

```
Dim oDPLModel As ObjectSet oDPLModel =
oDPLApp.Model("Bob")If oDPLModel Is Nothing Then
      MsgBox "Sorry, no Bob in the Workspace"Else
      MsgBox "Bob is type " +
Str(oDPLModel.Type)End If
```

Options(Name : String) : Long (read/write)

Used to set various options not having their own properties. Currently the following options are recognized:

DecimalPlaces OutputScaling ZeroEquivalent ProbsAsPercents (Bool) DecimalPlacesProbs

These control display as per the similarly named options in File | Options | Outputs.

PolicyLevels : Long (read/write)

The number of policy levels DPL should include in the Policy Tree™ in the next run. Default is all levels. A value of 1 is treated as 2, since the Policy Tree™ requires two or more levels.

PolicySummary : Bool (read/write)

True if DPL should generate a Policy Summary™ in the next run.

PolicyTree : Bool (read/write)

True if DPL should generate a Policy Tree™ in the next run.

RecordEndpoints : Bool (read/write)

True if DPL should record endpoints in the next run. Requires that the evaluation method be full enumeration otherwise it is ignored.

Results(Name : String) : Object[DPLResult] (read-only)

An object reference to the result with title Name. Returns Null if no Workspace is loaded or there is no result with the title Name in the Workspace. See the Model property for an example.

SamplesInitial : Long (read/write)

The initial number of samples for a Monte Carlo simulation run or a Decision Analysis run using discrete tree simulation evaluation method.

SamplesRestart : Long (read/write)

The minimum number of samples following each decision in a Monte Carlo simulation run or a Decision Analysis run using discrete tree simulation evaluation method. Has no effect if the model does not contain decisions.

TimeSeriesFromAtt : Long (read/write)

The index of the first attribute to be displayed in the next Time Series Percentiles run. Note that the first attribute has index 1 (not 0).

TimeSeriesInitialPeriod : Long (read/write)

The number displayed for the first attribute on the x-axis in the Time Series Percentiles graph. For example, if each attribute represents cash flow in a given year, and the first attribute corresponds to 2010, you would set this property to 2010.

TimeSeriesNumPeriods : Long (read/write)

The number of time periods (attributes) to be displayed in the next Time Series Percentiles run. For example, if there are five attributes corresponding to years 2014-2018, you would use:

```
oDPLWS.TimeSeriesFromAtt =
1oDPLWS.TimeSeriesNumPeriods =
5oDPLWS.TimeSeriesInitialPeriod =
2014oDPLWS.RunTimeSeries
```

Title : String (read-only)

The file name of the Workspace (e.g., "Wildcat.da"). This property is read-only; use the DPLApplication method SaveWorkspaceAs() to rename the Workspace.

ValueCorrelations : Long (read/write)

True if DPL should generate a Value Correlations chart in the next Decision Analysis or Monte Carlo run. For a Decision Analysis, Value Correlations require that the evaluation method be full enumeration.

ValueOfInfoControl : Bool (read/write)

True if DPL should generate an Expected Value of Perfect Information/Control chart in the next Decision Analysis run. Ignored if the number of PolicyLevels is not the maximum for the decision tree.

5.4.4 DPLWorkspace Methods

CreateProgram(Data : String, Name : String, Driver : Bool)

Creates a DPL Program in the current Workspace with the DPL code contained in Data and the title Name. Driver should be True if the program can be run directly, or False if the program is intended as an include file to

be referenced by another program or a Model. The example below creates and runs a simple program.

```
Dim Data As StringData = "chance c.{lo,hi} = {0.5}
= 1,2;" _      & "sequence: " _      & "gamble on c
and get c"oDPLApp.CreateProgram(Data, "C", 1)Dim
oDPLModel as ObjectSet oDPLModel =
oDPLApp.Model("C")oDPLModel.MakeMainoDPLWS.RunDeci
sionAnalysis
```

This method is convenient for small programs, such as those supplying data used to initialize nodes in a template influence diagram. However for large programs, writing a .dpl file to disk and calling ImportProgram is more efficient.

ImportProgram(Path : String, Name : String, Driver : Bool)

Imports the program (.dpl source file) specified by Path into the current Workspace and gives it the title Name. Driver should be true if the program can be run directly, or false if the program is intended as an include file to be referenced by another Program or a Model.

RunDecisionAnalysis()

Runs a Decision Analysis. To specify run options, use the following properties: EvaluationMethod, Distribution, DistributionIndex, InitialDecisionAlternatives, ValueCorrelations, PolicyTree, PolicyLevels, FatPolicy, PolicySummary, ValueOfInfoControl. These properties have the same meanings and defaults as in the Home | Run group.

The example below runs a Decision Analysis generating a Risk Profile but no Policy Tree™.

```
oDPLWS.Distribution = 1oDPLWS.PolicyTree =
0oDPLWS.RunDecisionAnalysis
```

RunMonteCarloSimulation()

Runs a Monte Carlo simulation. To specify run options, use the following properties: SamplesInitial, SamplesRestart, Distribution, InitialDecisionAlternatives, DistributionIntervals, DistributionGraphFormat, ValueCorrelations, PolicySummary, PolicyLevels, PolicyTree. These properties have the same meanings and defaults as in the Home | Run group.

RunOptionValue()

Runs an Option Value analysis. DPL will use the default decision alternatives as specified in Node Definition General. Or you may specify defaults by using the DPLNode DefaultState property before the run.

RunTimeSeries()

Runs a Time Series analysis. See the TimeSeriesNumPeriods property for an example.

RunTornado(type : Long, option : Long)

Runs a tornado diagram. The type of tornado is determined by the type and option parameters. The valid combinations are shown below in Table 5-3.

type	opt	Tornado Type
37	0	Value
38	0	Base Case
38	1	Initial Decision Alternatives
39	0	Event (Deterministic)
39	1	Event (Probabilistic)

Table 5-3. Tornado Types

Note that 37, 38 and 39 correspond to the DPLResult Type values of the charts produced by the run. The example below runs a Base Case Tornado.

```
oDPLWS.RunTornado(38, 0)
```

UpdateAllResults()

This method refreshes all output (DPLResult) windows. This may be necessary after changing options that effect display.

```
oDPLWS.Options("DecimalPlaces") =
1oDPLWS.UpdateAllResults
```

5.4.5 DPLModel Properties

EvalResultEV : Double (read-only)

The expected value (EV) results of the most recent Decision Analysis run.

EvalResultCE : Double (read-only)

The certain equivalent (CE) results of the most recent Decision Analysis run.

EvalResultsValid : Long (read-only)

Indicates whether evaluation results (e.g., EvalResultEV) exist. The value will be 0-2 with the following meanings.

0 Results not valid 1 Results valid from a Decision Analysis run 2 Results valid from a Monte Carlo simulation run

IncludeEnd : String (read/write)

See IncludeStart.

IncludeStart : String (read/write)

Used to set the name of the includes (DPL Programs) referenced by the Model. IncludeStart corresponds to the "DPL Program for Data Definitions" in the Model Links dialog; IncludeEnd corresponds to "DPL Calculation Program".

Nodes(Name : String) : Object[DPLNode] (read-only)

Used to obtain an object reference to a node (DPLNode) in the model with title or variable name Name. See the DPLNode property VariableName for an explanation of node titles and variable names. Returns Null if no such node exists in the DPLModel.

```
    Dim oModel As Object    Dim oNode As Object
Set oModel = WS.MainModel    Set oNode =
oModel.Nodes("Test")
```

Options(Name : String) : Long (read/write)

Reserved for future use. There are no DPLModel named options at this time.

Title : String (read/write)

The title of this DPLModel object, as displayed in the Workspace Manager.

Type : Long (read-only)

The type of this DPLModel object. See Table 1 for a list of DPLModel types.

5.4.6 DPLModel Methods

Delete()

Deletes the associated document from the Workspace.

MakeMain()

Makes this document the main model, that is, the document that will be run in the next analysis. This DPLModel must be of type Model (influence diagram / decision tree) or a driver program. If the model is not of one of these types, DPL throws an exception.

ClearMemory()

Deletes compile structures and removes any volatile (unrenamed) outputs associated with this model. Same as Home | Run | Clear Mem.

If you run an analysis and then modify the model, you will need to issue a ClearMemory command to force the model to be recompiled.

5.4.7 DPLNode Properties

DefaultState : Long (read/write)

The default state of this node as set in the General tab of the Node Definition dialog and as used by Base Case tornadoes and Option Value charts. The first state has index 0. The value -1 indicates there is no default.

```
Dim oDPLNode as ObjectSet oDPLNode =
oDPLModel.Nodes("Drill")oDPLNode.DefaultState = 1
      'No
```

Name : String (read/write)

The title or name of the node. Note that this string will include carriage return/linefeed pairs if the node name is on more than one line. If there are instances of this node in the decision tree, their names will be changed as well. A node name can contain characters not valid in a DPL variable name, such as punctuation and whitespace. Use the VariableName property to get the name as sanitized for use in expressions.

Probabilities(Index : Long) : String (read/write)

The probabilities of the node. The individual probabilities are indexed as they appear in the Data tab (or Probabilities tab if separately conditioned) of the Node Definition dialog, with the topmost branch being index 0. The probabilities are stored as strings even if they are constant numbers.

SensHigh : Double (read/write)

See SensLow.

SensLow : Double (read/write)

SensLow and SensHigh are the Low and High values used for each bar in Value tornado diagrams. They can only be set for unconditioned, constant value nodes.

```
Dim oDPLNode1 as Object, oDPLNode2 as ObjectSet
oDPLNode1 = oDPLModel.Nodes("Sales")Set oDPLNode2
= oDPLModel.Nodes("Costs")oDPLNode1.SensLow =
1.3oDPLNode1.SensHigh = 1.9oDPLNode2.SensLow =
0.7oDPLNode2.SensHigh = 1.1oDPLWS.RunTornado(37,
0)
```

TreeNodes(Index : Long) : Object[DPLTreeNode]

Used to obtain an object reference to a decision tree node (DPLTreeNode) in the model which is an instance of this influence diagram node (DPLNode). If there is only one instance of this node in the decision tree, it will have index 1. If there are several instances, the instance number is

shown in the title bar of the Node Definition dialog when you double-click on a node in the decision tree.

Type : Long (read-only)

The type of this node. The type is one of the following:

0 Decision 1 Chance 2 Controlled 3 Value

Values(Index : Long) : String (read/write)

The values of the node. The individual values are indexed as they appear in the Data tab (or Values tab if separately conditioned) of the Node Definition dialog, with the topmost branch being index 0. The values are stored as strings even if they are constant numbers.

```
Dim oDPLNode1 as ObjectSet oDPLNode1 =
oDPLModel.Nodes("Costs")'Costs is a three-state
chance nodeoDPLNode1.Values(0) =
"10"oDPLNode1.Values(1) = "12"oDPLNode1.Values(2)
= "15"
```

VariableName : String (read-only)

The variable name of the node for use in expressions. If the node name is a valid identifier (that is, it begins with a letter and consists of letters, numbers and underscores) then the variable name is simply the node name. If not, the variable name is the node name with invalid characters replaced with underscores ('_'). For example, if the node name is "R&D Costs", the variable name is "R_D_Costs".

5.4.8 DPLTreeNode Properties

BranchBlock : String (read/write)

Used to block (temporarily remove from consideration) certain branches of a decision node. The format of the string is a comma separated list of ones and zeroes, one for each decision alternative. A zero indicates that that alternative is blocked.

```
Dim oDPLNode1 as ObjectDim oDPLTreeNode1 as
ObjectSet oDPLNode1 = oDPLModel.Nodes("Invest")Set
oDPLTreeNode1 = oDPLNode1.TreeNodes(1)'Block the
```

```
second of three
alternativesoDPLTreeNode1.BranchBlock = "1,0,1"
```

Set BranchBlock to an empty string ("") to unblock all branches.

Note that changing the BranchBlock state of a tree node will overwrite the BranchControl state and vice versa. If you use this method on a TreeNode that is not a decision node, DPL throws an exception.

BranchControl : Long (read/write)

Used to temporarily control a decision or chance node to a given state. Zero corresponds to the first state. The value -1 indicates that the tree node is not controlled.

```
'Control the node to its first
stateoDPLTreeNode1.BranchControl = 0
```

Note that changing the BranchControl state of a tree node will overwrite the BranchBlock state and vice versa.

Name : String (read/write)

The name of the tree node. Note that this string will include carriage return/linefeed pairs if the name is on more than one line. Changing the name of a tree node does not change the name of the influence diagram node of which it is an instance.

Type : Long (read-only)

The type of this tree node. The types are the same as those of influence diagram nodes (see Type in DPLNode). Only decision and chance nodes appear in the decision tree.

5.4.9 DPLResult Properties

Options(Name : String) : Long (read/write)

Reserved for future use. There are no DPLResult named options at this time.

Title : String (read/write)

The title of this DPLResult object, excluding the type prefix. For example, a Risk Profile Chart might have the title "Expected Value".

Type : Long (read-only)

The type of this DPLResult object. See Table 5-2 for a list of DPLResult types.

5.4.10 DPLResult Methods

CopyPicture(Long : format)

Copies a picture of the associated window to the Windows clipboard. If format is 0, the picture is a bitmap; if it is 1, the picture is a metafile.

Delete()

Deletes the associated document from the Workspace.

Export(Path : String)

Exports the associated document to the comma separated value (CSV) or XML file in Path. The format is determined by the file extension of Path, which must be either ".CSV" or ".XML".

ReduceDist(Index : Long, Name : String, NumStates : Long, Format : Long)

Reduces a distribution to a chance node. This method is only valid for Risk Profile charts. Index indicates which of the risk profile datasets displayed in the chart should be reduced, the first one being index 0.

The node will be called Name and will have NumStates outcomes. The output is determined by the Format parameter:

1 DPL session log 2 Windows clipboard 3 Both

6 DPL User Function Libraries

6.1 Overview

One way to extend the functionality of DPL is to create a Windows DLL with functions to be called from your DPL models. A DPL DLL can also serve as a way to interface DPL with other programs, such as software packages performing detailed economic calculations for specific industry verticals. Calling a function in a DPL DLL involves very little overhead, so a DLL can be attractive in situations where runtime performance is critical.

Implementing a DPL DLL requires technical expertise and significant effort, so before starting such a project you should consider whether more high-level mechanisms such as running Excel macros, database initialization links or the DPL Developer API would better meet your needs.

6.2 Technical Considerations

A DPL user function library must have a file extension of .DLL. Each library may contain one or more user functions in addition to the standard functions required by the Windows DLL mechanism. There is no limit to the number of libraries that may be in use during a DPL session. A library is loaded the first time it is encountered during the compilation of a DPL model, program or command procedure. A library is released by Windows only when all DPL sessions that have referenced the library are terminated. At the time a library is loaded, it must reside in the current directory or in a directory included in the PATH environment variable.

Though a library can behave as a full Windows application, it is recommended that a library constrain itself to providing computational functions suitable for execution during a DPL analysis.

User functions are divided into two categories: functions called implicitly by DPL, and functions called explicitly by DPL programs and command procedures. Implicitly called functions are optional. When a library is loaded, DPL checks for the presence of certain predefined function entry points. At various times during a DPL session, these entry points are called, such as when an analysis is starting or ending. Explicitly called functions

are referenced by expressions in DPL models, which are then executed when the expressions are evaluated.

User functions may be written in any language that complies with the requirements of a native Windows DLL. The examples used in this specification (including the sample code) have been prepared for use with the Microsoft Visual Studio C++ compiler.

All functions receive at least one parameter, which is the number of additional parameters passed to the function. This will allow for future expansion of the parameter list for each function. A function can check that the number of parameters received are correct and terminate via the error call-back function if it is not (parameter mismatches will generally result in a crash). Alternatively, a library may check the DPL version number supplied with the load function to ascertain whether the number of parameters for subsequent calls will be correct.

User functions may call certain DPL functions as part of their execution. When a library is loaded, it is passed a list of function entry points in DPL. These functions provide access to DPL features, such as writing to the DPL Log or accumulating distribution data.

All definitions required to interface with DPL are provided in an include file called dpluserf.h. This file should be included in the DLL source after windows.h and any required C language include files. A Zip file containing the sample code and these include files can be obtained from Syncopation support.

6.3 Implicit Functions

6.3.1 Load Library

This function is called the first time a DPL session compiles a program or command procedure that references a DLL. Note that each DPL session that references a DLL will call the load function. If a DLL cannot operate with more than one session at a time (e.g., because of its use of static storage), it must reject the load attempt by calling the DPL error function.

This function is passed a list of entry points within DPL that may be used to perform various services during subsequent library function calls. A function definition macro for the load function is provided in the dpluserf.h include file. Another include file, load.h, is also provided for validating and saving the entry point list (see the sample code).

Typical functions performed by the load function include:

- Saving the list of DPL function entry points
- Writing a sign-on/copyright message to the DPL Log
- Verifying that the library is not already active
- Opening files that will be used during subsequent processing
- Allocating global memory and other Windows objects
- Creating a window to provide a custom interface to the user
- Controlling sequence optimization during subsequent analyses

Name:

load

Parameters:

1. Integer number of parameters (= 3)
2. Pointer to an array of pointers to functions
3. Integer number of elements in the array of parameter 2
4. Integer DPL version number (e.g., 0x00080000 => Release 8.0)

Returns:

0 : Fast sequence evaluation is not allowed in this library
1 : Fast sequence evaluation is allowed

Fast sequence evaluation (the fastest exact evaluation method) should not be allowed if the library requires that all decision tree paths be executed during a decision analysis; e.g., if the library matches each call to data obtained from a disk file. This function should not return if the load is to be aborted (call the error function instead as defined below).

6.3.2 Unload Library

This function is called when a DPL session that previously called the library's load function is terminated. The library is not released until all DPL sessions that have referenced the library are terminated. Libraries that need to perform termination processing before being released by Windows should maintain a count of the active sessions connected to the library and perform final processing when the count reaches zero.

Typical functions performed by the unload function include:

- Closing open files
- Deallocating global memory and other Windows objects
- Destroying any windows created by the library

Name:
unload

Parameters:
1. Integer number of parameters (= 0)

Returns:
(None)

6.3.3 Begin Analysis

This function is called prior to beginning an analysis of a compiled DPL program. Analyses result from executing any of the Run menu functions. Performing a tornado diagram or rainbow diagram will result in multiple analyses.

The function should prepare the library for subsequent function calls during an analysis. Typical functions performed by the begin analysis function include:

- Initializing variables used during an analysis
- Opening or repositioning files for endpoint input or output
- Allocating temporary memory and other Windows objects

Name:
begin_analysis

Parameters:
1. Integer number of parameters (= 0)

Returns:
(None)

6.3.4 End Analysis

This function is called after an analysis has completed.

Typical functions performed by the end analysis function include:

- Closing open files
- Deallocating temporary memory and other Windows objects

Name:
end_analysis

Parameters:
1. Integer number of parameters (= 0)

Returns:
(None)

6.3.5 Reset (error recovery)

This function is called during DPL error processing. The cause of the error may or may not relate directly to the library and may or may not have occurred during an analysis. The library should perform whatever recovery processing is required to guarantee that it is prepared to receive subsequent function calls.

Typical functions performed by the reset function include:

- Calling the end_analysis function, if appropriate
- Deleting output files

Name:
reset

Parameters:
1. Integer number of parameters (= 0)

Returns:
(None)

6.3.6 Window Functions

This function is called whenever DPL needs to disable all DPL windows or enable all DPL windows. This function must be implemented by libraries that create their own windows.

Name:
window_functions

Parameters:
1. Integer number of parameters (= 2)
2. Integer indicating the required window function
3. Window handle

Returns:

An integer (BOOL) indicating whether the window handle parameter matches a window owned by the library

Consider the follow code fragment:

```
#include "dpluserf.h"
BOOL CALLBACK WINDOW_FUNCTIONS( int function, HWND hWnd )
{
switch( function ) {
case WF_ENABLE:
     if( hLibWnd )
          EnableWindow( hLibWnd, TRUE );
     break;
case WF_DISABLE:
     if( hLibWnd )
          EnableWindow( hLibWnd, FALSE );
     break;
case WF_ROTATE:
     return( hWnd == hLibWnd );
     }
return( YES );
}
```

Here, it is assumed that the library has created a window and saved its handle in the variable, hLibWnd. For the enable and disable functions, the window is enabled or disabled if the window handle is valid. Note that the window handle parameter is ignored and the function always returns 1, defined as YES. For the rotate function, the window handle parameter is compared with the library window handle and the result of the comparison is returned.

6.4 Explicit Functions

Explicit functions are the functions you write and call from your DPL models.

Explicit functions behave in much the same way as DPL built-in functions: they are coded in DPL expressions, receive numbers and strings as parameters, and return a double precision floating point number.

An explicit function is referenced in a DPL expression by coding the name of the library, optionally followed by a period and the function entry point name, then a parenthesized argument list. The library name may not include a path specification. At the time the library is loaded, it must exist either in the current directory or in a directory in the current path.

If a period and function entry point name do not follow the library name, the default entry name, calculate, will be used. The argument list consists of from 0 to 127 expressions or strings separated by commas. The following are all valid explicit function references:

```
mylib()
mylib.calculate( 1, x+y )
mylib.filename( "c:\\dpl\\test.dat" )
```

All functions should begin with the following line:

```
extern "C" double CALLBACK name( int num_parms, double
argument[], int num_args )
```

where name is the name of the function. This provides the following required definitions:

- The routine observes the appropriate calling convention
- The function returns a double precision floating point number
- The function accepts three parameters:
    1. The number of parameters (= 2)
    2. A pointer to an array of double precision floating point numbers
    3. The integer number of elements in the array specified by parameter #2.

Although an explicit function reference is coded in DPL with separate arguments, the library function always receives three parameters. The parameters passed by the explicit function are placed into the array accessed by the second parameter above. For example:

```
mylib(1,2,3,4)
```

would result in three parameters being passed to the library:

1. The number of additional parameters (always 2)
2. A pointer to an array of four elements containing the numbers 1, 2, 3, and 4
3. The number 4 (the number of elements in the array)

An empty explicit function reference argument list, such as mylib`()` above, would still result in three parameters; however, the second parameter would be a null pointer and the third parameter would be zero.

String pointers are passed to the library as specially encoded floating point numbers. An attempt to use one of these numbers in ordinary arithmetic will result in a floating point math error. The include file dpluserf.h contains two macros for dealing with these numbers:

```
IS_STRING_ARG( p )
```

This macro tests a double precision floating point number to see if it is a string argument pointer. It evaluates to one (TRUE) if the number is a string pointer and a zero (FALSE) if it is not.

```
STRING_ARG( p )
```

This macro returns the string argument pointer encoded in the double precision floating point number.

The follow code fragment illustrates the use of the string macros.

```
if (IS_STRING_ARG(argument[0])) {
        int len = strlen(STRING_ARG(argument[0]));
        ...
} else
        (*DPL_functions.error)( "Not a string!" );
```

The parameter count, the argument count, and the IS_STRING_ARG macro may be used to perform parameter validation by a library function.

The values in the array parameter are passed by value. This means that any changes made to them within the function will not affect values in the DPL model (i.e., the array parameter entries may be used as local variables). Strings pointed to by string argument pointers should not be modified. Doing so may cause unpredictable results.

All explicit functions must return a valid double precision floating point number. This number will be used to complete expression evaluation at the point where the function reference occurred within the DPL model.

If all explicit function reference arguments are constants, a call will be performed to the function only once at compile-time. Otherwise, a call will be performed each time the containing expression is evaluated and one or more arguments have changed in value unless the library's load function indicated that no optimizations should be performed. In this case, a call will be made each time the containing expression is evaluated whether or not any arguments have changed in value.

6.5 DPL Callback Functions

When a library is loaded, the load function will be passed a list of call-back function pointers from within DPL, should the load function be defined by the library. This list should be saved for use by the library during subsequent function calls. The include file dpluserf.h defines this list and allocates storage for it. This file also contains a macro to assist in defining the load function. Another include file, load.h, may be included at the beginning of the load function to validate and copy the call-back function pointers. The function pointers may then be used to call DPL to perform various services. For example:

```
#include "dpluserf.h"

LOAD_FUNCTION
{
#include "load.h"
(*DPL_functions.write_to_log)( "Sample User Library\n" );
return( YES );
}
```

Here, LOAD_FUNCTION is a macro from the load.h include file that defines the load function entry point and declares its parameter list.

Call back functions provide access to DPL functions (e.g., writing to the DPL Log) and to functions that are difficult to perform in a DLL (e.g., loading a resource or performing formatted input and output). Call-back functions are invoked using the following syntax:

```
(*DPL_functions.name)( argument_list )
```

where name represents the name of the call_back function and argument_list represents the list of required arguments.

6.5.1 Error

This function writes the message argument to the DPL Log and terminates the calling function. The calling function does not receive control again after issuing the call. As part of error processing, DPL will call the library's reset function.

Name:

Error

Arguments:

1. Pointer to char (message)

Returns:
(Does not return)

6.5.2 Move from left-to-right (with count)

This function moves the source argument to the destination argument starting with the left-most bytes of the source and destination arguments. The number of bytes moved is provided by the count argument.

Name:
movlrc

Arguments:
1. Pointer to char (the destination)
2. Pointer to char (the source)
3. Integer byte count

Returns:
(None)

6.5.3 Move from right-to-left (with count)

This function moves the source argument to the destination argument starting with the right-most bytes of the source and destination arguments. The number of bytes moved is provided by the count argument. This function is useful when moving a string to the right to provide space on the left.

Name:
movrlc

Arguments:
1. Pointer to char (the destination)
2. Pointer to char (the source)
3. Integer byte count

Returns:
(None)

6.5.4 Compare from left-to-right (with count)

This function compares the source argument to the destination argument starting with the left-most bytes of the source and destination arguments. The number of bytes compared is provided by the count argument.

Name:

cmplrc

Arguments:

1. Pointer to char (the destination)
2. Pointer to char (the source)
3. Integer byte count

Returns:

0 : Arguments are not equal
1 : Arguments are equal

6.5.5 Write to DPL Log

This function writes the message argument to the DPL Log.

Name:

write_to_log

Arguments:

1. Pointer to char (message)

Returns:

(None)

6.5.6 Capture DPL Distribution Accumulation

This function provides DPL with the address of an alternative function for accumulating distributions during an analysis. The function must accept two double precision floating point arguments: a probability (y-axis value) and an outcome value (x-axis value). This function must respond to the call by calling the accum_dist call-back function, as appropriate.

Name:

capture_dist

Arguments:

1. Pointer to a function accepting two double precision floating point numbers

Returns:

(None)

6.5.7 Accumulate DPL Distribution

This function should be called by the function argument of the capture_dist function after it is called by DPL to accumulate distribution data. This function is generally used to accumulate distributions on other than the normal outcome (tree endpoint) probability/value pairs of a decision analysis.

For example, assume the library embodies an endpoint value model that involves cashflows for a number of periods. Assume further that each time the library is called to calculate an endpoint value, the cashflows for each period are computed and saved in static storage. If the library captures the distribution accumulation, it will receive a call to accumulate distributions for each endpoint. At that time, it may call the accum_dist call-back function once for each time period passing two arguments:

- The current probability times the cash flow for the period (y-axis)
- The number of the period (x-axis)

For each call, the cashflow increment will be added to the total for the period. In this way, a distribution will be accumulated of expected cashflow for each period.

Name:

accum_dist

Arguments:

1. Double precision floating point number (y-axis value)
2. Double precision floating point number (x-axis value)

Returns:
(None)

6.5.8 Get Analysis Outcome

This function may be called after completing an analysis to obtain the expected value and certain equivalent of the run. The function returns a structure containing room for both values; however, the field for certain equivalent will be meaningful only if the model contained a utility function specification. The structure is defined in the include file dpluserf.h.

Name:
get_outcome

Arguments:
(None)

Returns:
An outcome structure containing the expected value and certain equivalent of a DPL analysis. (see dpluserf.h)

6.6 Code Examples

The sample problem involves a decision between two loan alternatives. The first alternative has possibly higher interest rates but lower loan costs than the second. The object is to minimize the amount paid on the load according to the following formula:

```
amount paid = costs + principal * (1 + rate) ^ time
```

where costs is the cost of the loan, principal is the amount of the loan, rate is the interest rate per period, and time is the number of periods. The principal and time values are constant throughout a decision analysis (although the user may perform a sensitivity analysis on them). The costs will depend on the loan decision while the rate will depend both on the loan decision and on a general uncertainty on interest rates.

While the sample is implemented as a DPL program for conciseness, the procedure is the same for a graphical model.

The DPL program file: SAMPLE.DPL

```
decision loan.{a,b};
chance rate.{high, med, low} | loan =
     {.10, .85, .05},   // loan.a
     {.20, .79, .01};   // loan.b
value loan_costs | loan = 1000, 500;
value rate | rate = .12, .09, .08;
value principal = 50000;
value time = 30;

sequence:

get sample.init( principal, time ) then
decide about loan then
gamble on rate and
pay sample( loan_costs, rate )
```

The value function described above will be implemented in the user library sample.dll. The library contains two explicit entry points:

- Init – used to set the principal and time values for an entire analysis
- Calculate – used to form an endpoint value (called implicitly)

Since the values for principal and time do not change during a run, it would be inefficient to pass them to the value function at each endpoint. In this particular example, there are only two "constant" values. However, some problems may involve hundreds of similar terms. Consequently, these values are passed to the library at the beginning of each run (the library will also receive a begin_analysis call at this time but this call cannot pass any arguments to the library). The values are passed at the beginning of the sequence section by the line

```
get sample.init( principal, time ) then
```

Because the init function returns a value of zero, this line has no effect on the results of the analysis. Also, because the values are set in the sequence section, sensitivity analyses may be performed on principal and time.

The two values that depend on the sequence of events, loan_costs and rate, are passed to the value model by the line

```
pay sample( loan_costs, rate )
```

The library's calculate function will then calculate the value function and return the result.

Since DPL is unaware of the relationships among events and values in a value model supplied by a user library, care must be exercised if DPL is allowed to perform sequence optimizations. The sample program above will

operate correctly with sequence optimizations enabled since all value model variables are passed at tree endpoints. The following code fragment would also operate correctly:

```
decide about loan and
pay loan_costs then
gamble on rate and
pay sample( rate )
```

Here, it is assumed that the library's calculate function no longer includes the loan costs. In general, it is good practice to promote portions of the value function as far up the tree as possible to assist DPL's optimizations. Because loan_costs could be separated from the value function (it appeared as an expression term; i.e., connected to the rest of the function by plus or minus), it could be promoted without problem.

Assume, however, that the loan time was uncertain and the sequence section was as follows:

```
decide about loan and
pay loan_costs then
gamble on time then
gamble on rate and
pay sample( rate, time )
```

The following code fragment would be incorrect:

```
decide about loan and
pay loan_costs then
gamble on time and
get sample.time( time ) then
gamble on rate and
pay sample( rate )
```

Here, the library function time would save the value of time for the subsequent calculate call and return a value of zero. In this case, time is not separable and should not be promoted (it is not a separate term of the value function). This sequence would be evaluated correctly, however, if the library's load function suppressed sequence optimization.

When implementing a value function in a user library, it is safest to suppress sequence optimization at the library's load call. If sequence optimization is desired, it must be verified that the policy produced employing optimization is the same as that produced without optimization.

The following sample file can be used with the sample.dpl file defined earlier:

Library source file: SAMPLE.CPP

```
////////////////////////////////////////////////
// SAMPLE DPL USER FUNCTION LIBRARY
////////////////////////////////////////////////

#include "windows.h"
#include "math.h"
#include "dpluserf.h"

static struct constants {
   double principal, time;
} c;

////////////////////////////////////////////////
// WINDOWS LIBRARY INITIALIZATION
extern "C" BOOL CALLBACK LibMain(HANDLE hInstance,
  WORD wDataSeg, WORD cbHeap,LPSTR lpszCmdLine)
{
        return YES;
}

////////////////////////////////////////////////
// WINDOWS LIBRARY TERMINATION
extern "C" VOID CALLBACK WEP( int nParameter ) {}

////////////////////////////////////////////////
// LOAD-TIME INITIALIZATION
extern "C" LOAD_FUNCTION
{
        #include "load.h"

        (*DPL_functions.write_to_log)( "Sample DPL User Function
Library\n" );

        // enable sequence optimizations
        return( YES );
}

////////////////////////////////////////////////
// GET THE CONSTANT PARAMETERS
extern "C" double CALLBACK INIT( int num_parms,
   double argument[], int num_args )
{
        if ( num_args != 2 )
```

```
                (*DPL_functions.error)( "Function \"init\"
requires two arguments" );

        // save a copy of the constants
        c = *(struct constants *)argument;

        return(0.0);
}

////////////////////////////////////////////////
// CALCULATE THE VALUE MODEL

#define loan_costs          argument[0]
#define rate                argument[1]

extern "C" double CALLBACK CALCULATE( int num_parms,
   double argument[], int num_args )
{
        if ( num_args != 2 )
                (*DPL_functions.error)( "Function \"CALCULATE\"
requires two arguments" );

        return loan_costs + c.principal * pow( 1.0 + rate,
c.time );
}
```

The above code is a simple example of what a library can add to an analysis. The input is validated in both init and calculate. The init function stores the time and principle for later use by the calculate function, which returns the total loan payment to DPL.

The functions LibMain and WEP are required to support Windows DLL initiation and termination (see the Windows SDK documentation for a detailed description of the process of constructing a DLL).

The degree of parameter validation performed by a user library is left to the discretion of the library developer. The sample code checks only that the number of arguments passed to the functions init and calculate are correct. The library could also have verified that the total number of parameters and the type of each argument were correct. Full parameter validation for the init function might be:

```
if( num_parms != 2 )
   (*DPL_functions.error)( "Incorrect number of parameters" );
if( num_args != 2 )
   (*DPL_functions.error)( "Function \"init\" requires two
arguments" );
```

```
if( IS_STRING_ARG( loan_costs ) || loan_costs < 0.0
        || loan_costs > c.principal )
   (*DPL_functions.error)( "Invalid \"loan_costs\"" );
if( IS_STRING_ARG( rate ) || rate <= 0.0 || rate > 1.0 )
   (*DPL_functions.error)( "Invalid \"rate\"" );
```

Since the sample problem contains only four paths, this degree of validation would have no effect on run time. For larger trees, the impact on run time could be excessive. If the library developer is also the author of the models which will use the library, minimal validation may be sufficient.

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