IDS Multicriteria Assessor Manual

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January 2007

1 INTRODUCTION

The purpose of this manual is to demonstrate how to use the main features of the IDS Multicriteria Assessor software, or IDS for short.

IDS is a general purpose multi-criteria decision support software developed on the basis of the Evidential Reasoning (ER) approach. More information about the ER approach can be found from the web site: www.e-ids.co.uk. More information about MCDM problems can be found in sources such as http://www.terry.uga.edu/mcdm/.

IDS is different from most other MCDM software packages in that it can handle different types of uncertainties, such as randomness, ambiguity and ignorance in an integrated framework. It uses belief decision matrices to preserve information structures in raw data and provides more informative outcomes. The following are some of the main features available in the IDS Multicriteria Assessor.

- There are two different interfaces for building and viewing an attribute hierarchy. One is in a drawing style and the other in the Windows Explorer style. For smaller models, you can use the Drawing style. For large models, it is better to use the Explorer view. The switch between the two views is by pressing the picture button in the IDS main window (see **Section 2.2.2** and **Figure 2.2**).

  In either style, there is a TreeView for displaying the attribute hierarchy and a ListView for all alternatives.

- There are different types of graphic displays for inspecting and reporting outcomes such as ranking and performance distributions.

- Guidance, supporting information and comments can be stored and retrieved whenever and wherever they are needed.

- The total number of attributes that can be used in an attribute hierarchy in this academic version is limited to 200, but there is no limit (except for computer space) in the corporate version of the software.

- Newly added alternatives can be assessed independently without affecting previous assessment results.

Using IDS for MCDM problem analysis includes the following 4 major tasks.

- Modelling
- Data input
- Result reporting
- Sensitivity analysis

The information synthesis is handled by the built-in ER algorithm automatically and you may not notice the calculation process. The following sections will describe how to use IDS for fulfilling the 4 tasks in detail. It is worth mentioning that **context sensitive help** can be activated by pressing F1 key in the keyboard whenever it is needed when working in IDS windows. Also it is not necessary to read the whole manual in order.

2 BUILD AN ATTRIBUTE HIERARCHY

2.1 Overview

This section describes how to model a MCDM problem using IDS. In IDS, the model building process is related to the common features of assessing alternative courses of action, or alternatives for short. It involves the following steps.

Step 1: Identify an attribute hierarchy for assessing alternatives. This step requires expert knowledge on alternatives to be assessed.

Step 2: Identify the types of BOTTOM level attributes. For example, is it qualitative or quantitative? Note that this step only applies to BOTTOM level attributes. Upper level attributes are always defined as qualitative in the program.

Step 3: For each QUANTITATIVE attribute, identify whether it is of probabilistic nature. If yes, mark the attribute as uncertain.

Step 4: For each quantitative attribute, identify the unit and range of possible values. For each qualitative attribute, define a set of grades to measure its performances.

Step 5: Define a value function for each attribute.

Step 6: Find out the relative importance of sub-attributes (children) to their upper level attribute (father) using either *Pairwise Comparison* or *Visual Scoring*.

For illustration purpose, a real life example, the selection of motorcycles, will be used to demonstrate the model building process in IDS. You can find the example in the installation folder, which is by default "C:\Program Files\IDS Ltd\IDS Multicriteria Assessor\Example\Motorcycle.ids".

The attributes to consider for selecting a motorcycle are described in **Figure 2.1**. A number given in brackets at the end of an attribute name in **Figure 2.1** is a weight assigned by a buyer, representing the relative importance of the attribute among a group of attributes sharing the same immediate upper level attribute. Different groups of attributes may use different scales for weight assignment. In the motorcycle example, one group uses 0 to 100 as its scale and another group uses 0 to 1 as its scale. It is not important what scale to use as long as a weight assigned to an attribute reflects the relative importance of the attribute in comparison with the other attributes in the same group.

Note that the attribute hierarchy constructed in **Figure 2.1** is independent of any specific model of motorcycles.
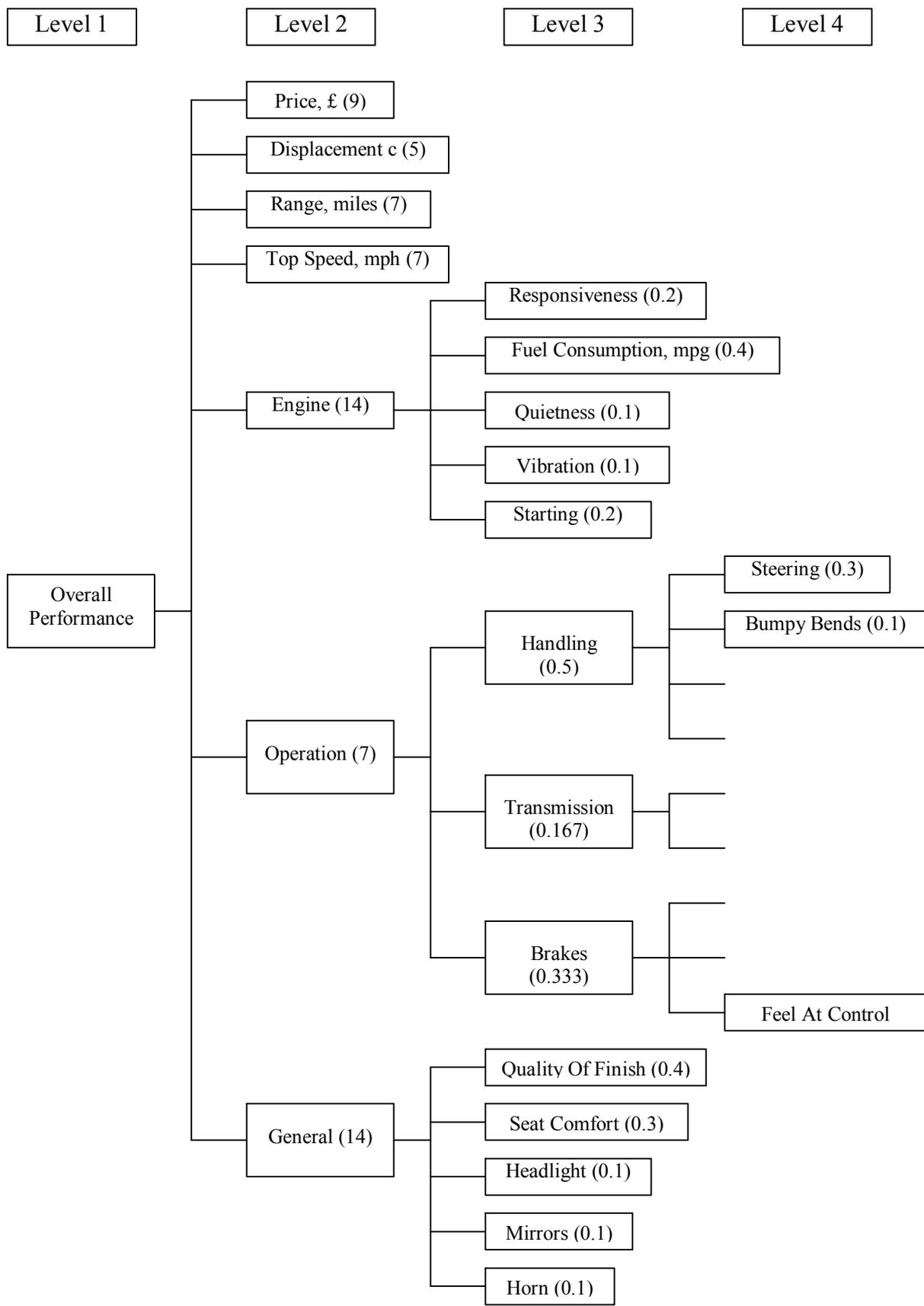
Figure 2.1   Attribute Hierarchy for Motorcycle Selection

2.2 Model a MCDM Problem Using IDS

2.2.1 Start IDS Multicriteria Assessor (IDS.exe) Application

From the Taskbar of your PC, select *Start -> All Programs -> IDS Multicriteria Assessor* program or double click the **IDS Multicriteria Assessor** shortcut on your Desktop if there is one. The programme "IDS.exe" can also be found in the directory C:\Program Files\IDS Ltd\IDS Multicriteria Assessor if you used the default settings to install the software.

By doing so, a window similar to **Figure 2.2** will open. There is only one alternative and one attribute initially. Note that in IDS all alternative boxes are marked yellow and all attribute boxes are marked blue.
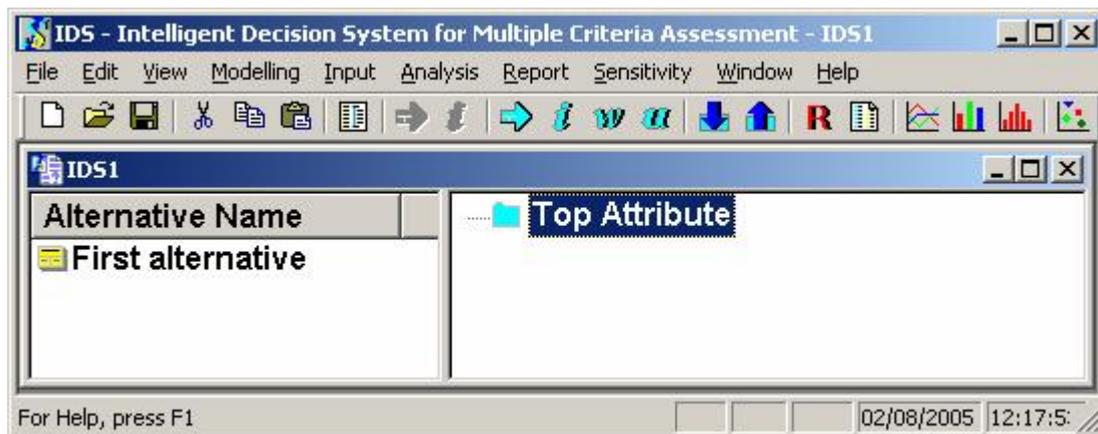
Figure 2.2   A New IDS Model Window

2.2.2 Insert Attributes

Left click the mouse (we simply use "click" in the manual to represent a left click) once anywhere on the top attribute, named Top Attribute by default, and then click the blue arrow on the Toolbar of IDS (**Figure 2.2**) to invoke the IDS *Insert Attributes* dialog window (**Figure 2.3**). From the window, select the *Insert right* radio button and then click the *Confirm* button once. Then select the *Insert below* radio button and click the *Confirm* button 6 times. Now you should have an attribute hierarchy with one top attribute and seven 2nd level attributes (**Figure 2.4**).
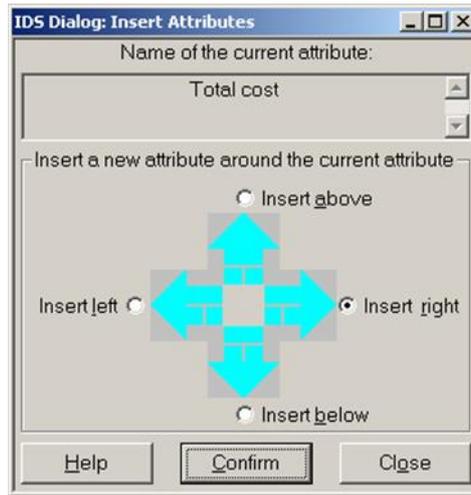
Figure 2.3   IDS Dialog: Insert Attributes

At the moment, each attribute is given a default name, Top Attribute, Attribute 1, Attribute 2, …, Attribute 7. They will be renamed later in **Section 2.2.3**.

If for any reason any attribute box needs to be deleted, it can be done by clicking anywhere on the box and then the *Cut* ✂ button on the Toolbar or by selecting the *Cut* command from the *Edit* menu of the main window. It is also recommended to save the model from time to time to avoid accidental loss of data.
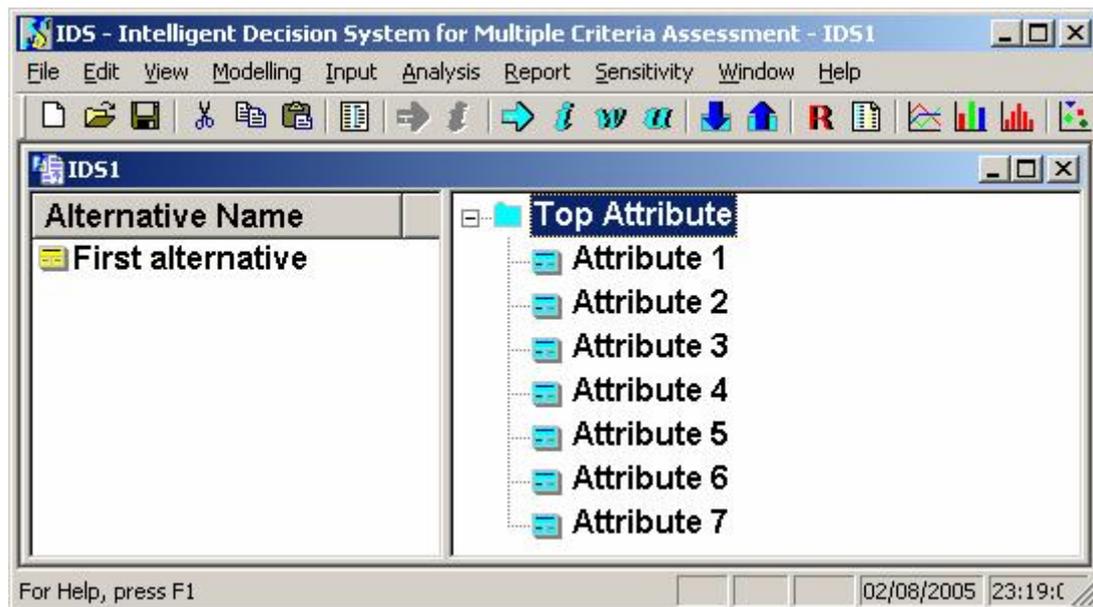
Figure 2.4   Attribute Hierarchy Skeleton

2.2.3   Define Top and Other Higher Level Attributes

Bottom level and higher level attributes are defined differently. To define a higher level attributes, such as the top one, select the attribute by clicking on the attribute box once (**Figure 2.4**) and then right click on the same box or click the 𝒊 icon (see

Figure 2.2) on the Toolbar. By doing so, the *IDS Dialog: Define An Attribute* window will appear (**Figure 2.5**).

You can use the dialog window to define the attribute by providing the information given in **Table 2.1**.

Table 2.1 Attribute Definition for *Top Attribute* or Higher Level Attributes

| Item	Information Requested	Values Provided	Comments
1	Attribute Name	*Overall Performance*	Type in the attribute name in this field. If you wish to provide more information about the attribute, you can click the *Describe* (**Figure 2.5**) button, which will invoke an interface for you to enter text information.
2	Attribute Type	*Qualitative*	Any higher level attribute (an attribute with child attributes in the hierarchy) is always defined as a *Qualitative* type, while a bottom level attribute can be either *Qualitative* or *Quantitative*.
3	Number of Grades:	*5*	When an attribute is defined as a *Qualitative* type, you may wish to specify the number of grades to be used for assessing the attribute. You may change the number at any time when necessary. The name of the grades can also be changed if necessary (see next item below).
4	Define Grades Now?	*Yes/No*	If you select *Yes*, you will see a window similar to (**Figure 2.6**). You can change the default grade names and also the utility/value score associated with each grade in the window. The higher the score, the more preferred the grade is.
			If you wish to provide explanations or standards for a grade, you can click on the grade name and then the *Define* button in the window (**Figure 2.6**). The grade definition you enter here will appear later to guide the assessment of an alternative on this attribute [refer to **Section 4.5** for details].
5	*Advanced* (button)		When the *Advanced* button is clicked (not applicable to the top attribute), the marked area (**Figure 2.7**) on the left side of the button will appear (see below). You may leave this button alone, which implies that the value function for this attribute is assumed to be linear by default.
6	*Rule* or *Utility* (button)		You may specify how the value/utility function of this attribute is related to that of its father attribute. You can choose either *Rule* or *Utility*. The difference is explained in **Section 2.3**.

Figure 2.5   Define A Qualitative Attribute
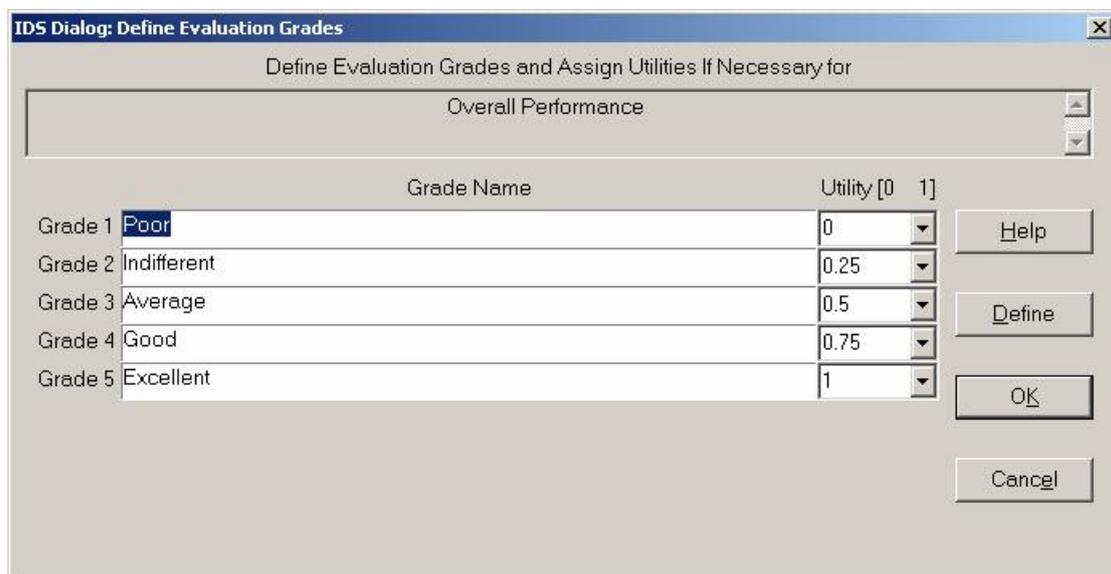
Figure 2.6   Define Evaluation Grades

2.2.4   Define A Bottom Level Attribute

When defining a bottom level attribute, you have the choice to define it either as a *Qualitative* type or *Quantitative* type.

2.2.4.1   Define Qualitative Attributes

Qualitative bottom level attributes are defined in the same way as defining the upper level attributes such as the *Overall Performance* attribute (**Table 2.1**).

2.2.4.2 Define Quantitative Attributes

To define a quantitative attribute, such as *Price*, involves the following steps:

- Select the attribute you wish to define by clicking on the attribute box, *Attribute* 1 (**Figure 2.4**)

- Right click on the box or click the 🔹 icon on the Toolbar (**Figure 2.4**) to open the *IDS Dialog: Define An Attribute* window

- From the dialogue window, click the *Quantitative* radio button (**Figure 2.7**)

- Use the dialog window to define the attribute by providing the information given in **Table 2.2**.

Follow similar procedures as above, the other quantitative attributes *Displacement*, *Range* and *Top Speed* can be defined by using the information provided in **Table 2.3**.
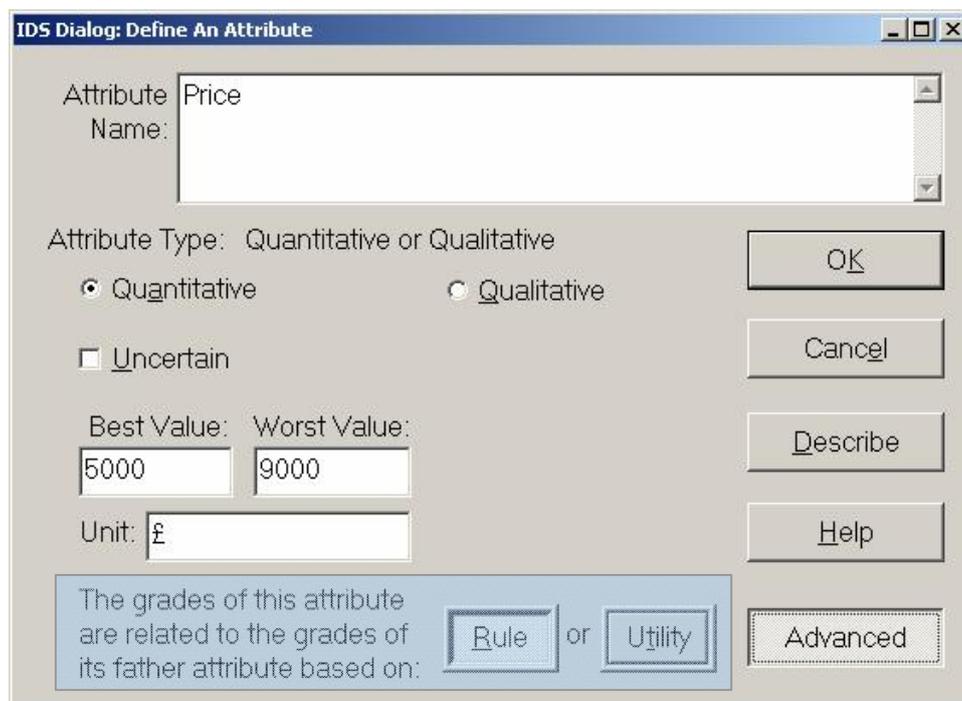
Figure 2.7   Define A Qualitative Attribute

2.2.5 Complete the Rest of the Model

By following the instructions detailed in the above four sections, other attributes can be added and defined. Save the built model by pressing the 💾 button on the toolbar, use a meaningful file name, such as MotorcycleSelection.ids. The file will be given an extension ".ids" and you will be able to open it by double clicking it later. The complete IDS model of the motorcycle selection problem looks like the one shown in **Figure 2.8.**

Table 2.2   Attribute Definition for Price

Item	Information Requested	Values Provided	Comments
1	Attribute Name	*Price*	You type in the attribute name in this field. If you wish to provide more information about the attribute name and its meaning, you can use the *Describe* (**Figure 2.5** or **Figure 2.7**) button to type in any explanation text.
2	Attribute Type	*Quantitative*	By nature the *Price* attribute is quantitative and assessed numerically. When an attribute is quantitative, it could be uncertain, such as random distribution or even unknown (partially or completely). For example, the fuel consumption rate of a motorcycle changes with weather and road conditions. Its user may states that 70% of the time it will be used on motorways and 30% on urban road. Therefore the *Fuel Consumption* attribute may be defined as uncertain by selecting the *Uncertain* radio button in the window.
3	Best value	*5000*	The lowest price you wish to pay or available for the product range.
4	Worst Value	*9000*	The highest price you wish to pay or available for the product range.
5	Unit	*£*	The unit for the attribute value, the *Best Value* or the *Worst Value*.
6	*Advanced* (button)		When the *Advanced* button is clicked, the marked area on the left side of the button will appear (see below). You may leave this button alone which implies that the value function for this attribute is assumed to be linear by default.
7	*Rule* or *Utility* (button)		You may specify how the value/utility function of this attribute is related to that of its father attribute. You can choose either *Rule* or *Utility*. The difference is explained in **Section 2.3**.

Figure 2.8   IDS Model of the Motorcycle Selection Problem

2.2.6   Import An Existing IDS Model

At times you may wish to incorporate previously saved IDS models (files with the extension .ids) into the current model. This happens when the old attribute hierarchy in the previous model can be used as a sub model of the current model.

To do so, you should click on the attribute where you wish to add the pre-built model, and then select from the menu bar of the main window *Modelling->Attribute->Add from IDS File* (**Figure 2.9**). You will then be asked to browse and add the IDS model file (**Figure 2.10**). As soon as you click the *Add* button (**Figure 2.10)**, the model will be inserted under the selected attribute. If you are not happy with position where the model is added, you can use the ✂ button to cut the unwanted attributes, or simply do not save and re-do the importing at a different location.
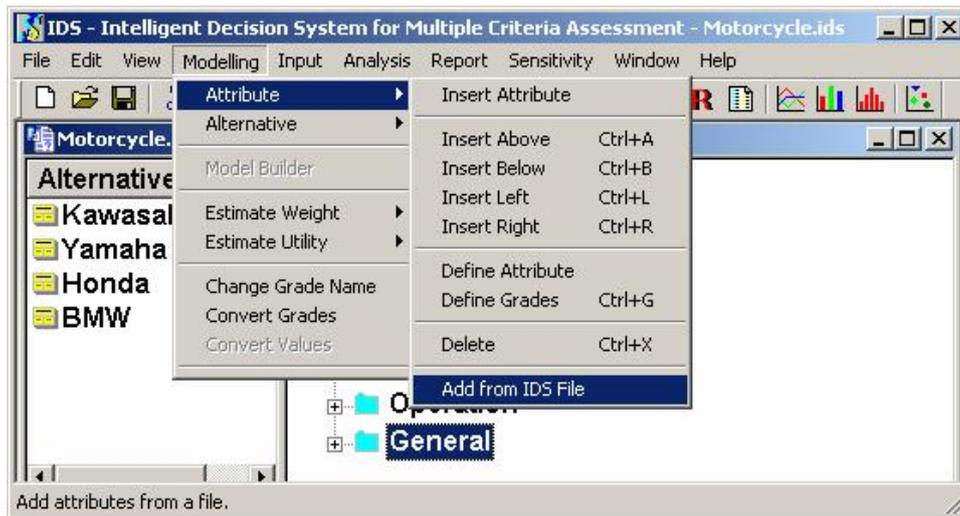
Figure 2.9   Import Previously Built IDS Multicriteria Assessor Model

Figure 2.10   Browse and Add the Existing IDS Model

2.3   Convert Values or Grades of Attributes

In the attribute definition dialog (**Figure 2.5** and **Figure 2.7**), you are asked whether the attribute to be defined is related to its father attribute based on rule or utility. This section will explain what the difference is between the two. It is an advanced feature of the IDS. You may skip answering the question if you are not sure how to handle it. By default, the IDS program will assume a linear value or utility function for each attribute.

2.3.1   Relate a Quantitative Attribute to Its Father Attribute

This sub section describes how to convert a quantitative attribute value to the grades of its father attribute. For qualitative attributes, it is described in the next sub section.

In the motorcycle selection problem, the *Overall Performance* of a motorcycle is determined by its 7 sub-attributes. The *Overall Performance* is assessed by 5 grades: *Excellent*, *Good*, *Average*, *Indifferent* and *Poor*. One of its sub-attributes, *Price* for example, is assessed numerically in pound sterling. You may ask how to relate *Price* to its father attribute *Overall Performance*, in another word, how to assess the *Overall Performance* as far as *Price* is concerned? There are two techniques to convert values of an attribute to its father's grades, one based on rules and the other on utilities or values.

2.3.1.1   Rule Based Approach

One way is to convert *Price* into the 5 grades used in its father attribute assessment. The decision makers is expected to provide equivalence **rules** to relate each evaluation grade of the *Overall Performance* to a particular *Price*. For example, according to the decision makers' knowledge, s/he may define the following rules:

Rule 1. If *Price* **is £5000**, then *Overall Performance* **is Excellent** as far as *Price* is concerned.

Rule 2. If *Price* **is £6500**, then *Overall Performance* **is Good** as far as Price is concerned.

Rule 3. If *Price* **is £7500**, then *Overall Performance* **is Average** as far as Price is concerned.

Rule 4. If *Price* **is £8500**, then *Overall Performance* **is Indifferent** as far as Price is concerned.

Rule 5. If *Price* **is £9000**, then *Overall Performance* **is Poor** as far as Price is concerned.

This is the so-called rule based approach. If you prefer to relate *Price* to *Overall Performance* by rules, then you should select the *Rule* button when defining the *Price* attribute using the dialog box shown in **Figure 2.7**. After the *Rule* button is selected, you can then select from the main menu of the IDS window *Modelling->Convert Values* to pop up the *IDS Dialog: Convert Child Attribute's Values* (or *Grades*) *to Its Father's Grades* (**Figure 2.11**). From this dialog, you can input the rules.

Figure 2.11   Convert Child Attribute's Value to Its Father Grades

2.3.1.2 Utility Based Approach

Another way is the so-called utility or value based approach. You can choose this method if you can express your preferences towards different attribute values by numbers in [0, 1], with 1 representing the most favourable and 0 the least. These numbers are normally referred to as **utilities** or **values, depending upon how they are generated**.
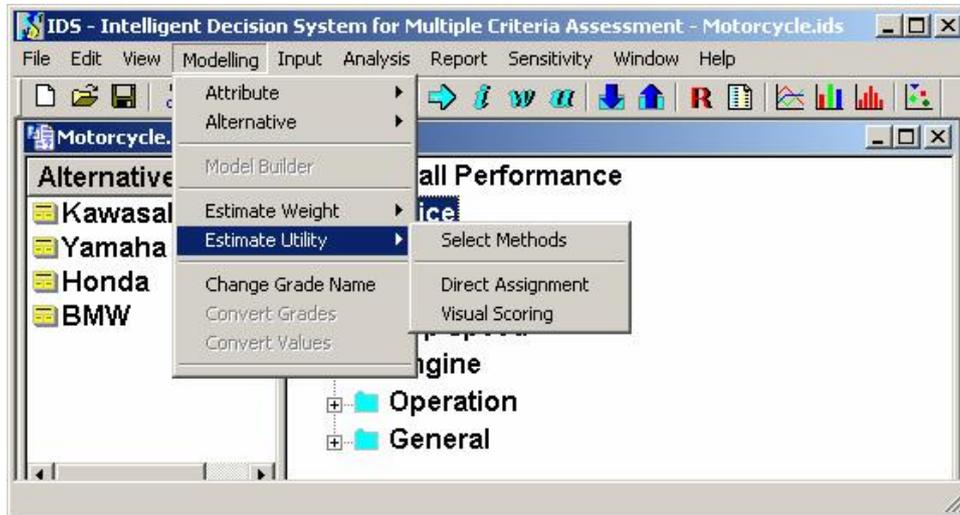
Figure 2.12   Use the Modelling Menu to Assign Attribute Utility

In the case of the *Price* attribute, suppose your preference is represented by **Table 2.5**. You can input the preference information in IDS as follows.

* Click the *Utility* option in the *Define An Attribute* dialog window (**Figure 2.7**)

* From the *Modelling* menu (**Figure 2.12**) select *Estimate Utility* then *Direct Assignment* or *Visual Scoring* to activate an IDS Dialog window similar to **Figure 2.13** if *Direct Assignment* is selected or **Figure 2.14** if *Visual Scoring* is selected

* Modify utilities/values and their corresponding attribute values as necessary from the dialog window shown in **Figure 2.13** (for *Direct Assignment*) or drag and drop the marked point on the utility/value function curve to the desired position (**Figure 2.14**) (for *Visual Scoring*).

*

Table 2.5   Utilities Assigned to the *Price* Attribute

Attribute Value (Price in £)	Utility (Preference degree)
9000	0.00
8500	0.25
7500	0.50
6500	0.75
5000	1.00

2.3.1.3 Let IDS Decide

If there is no rule or utility (preference) information available to convert the child attribute values to its father grades, IDS will use the rule based approach and assign the father grades to the range of the child attribute values in **equal distance**. For example, in the case of the *Price* attribute, IDS would relate *Poor* to £9000, *Indifferent* to £8000, *Average* to £7000, *Good* to £6000, and *Excellent* to £6000. Therefore if you are not sure whether to use rule based or utility base approach, you may answer *No* when you are asked whether to convert the values.

If you choose the utility based approach, IDS will also assign the initial utilities for you assuming a linear relationship between the utility range [0,1] and the attribute value range, [9000, 5000], for example in the case of the *Price* attribute. If it is acceptable, you need do nothing else. Otherwise you can use the dialog window shown in **Figure 2.13** to modify the values.

Figure 2.13   Assign Utilities/Values to Attribute Values by Direct Assignment
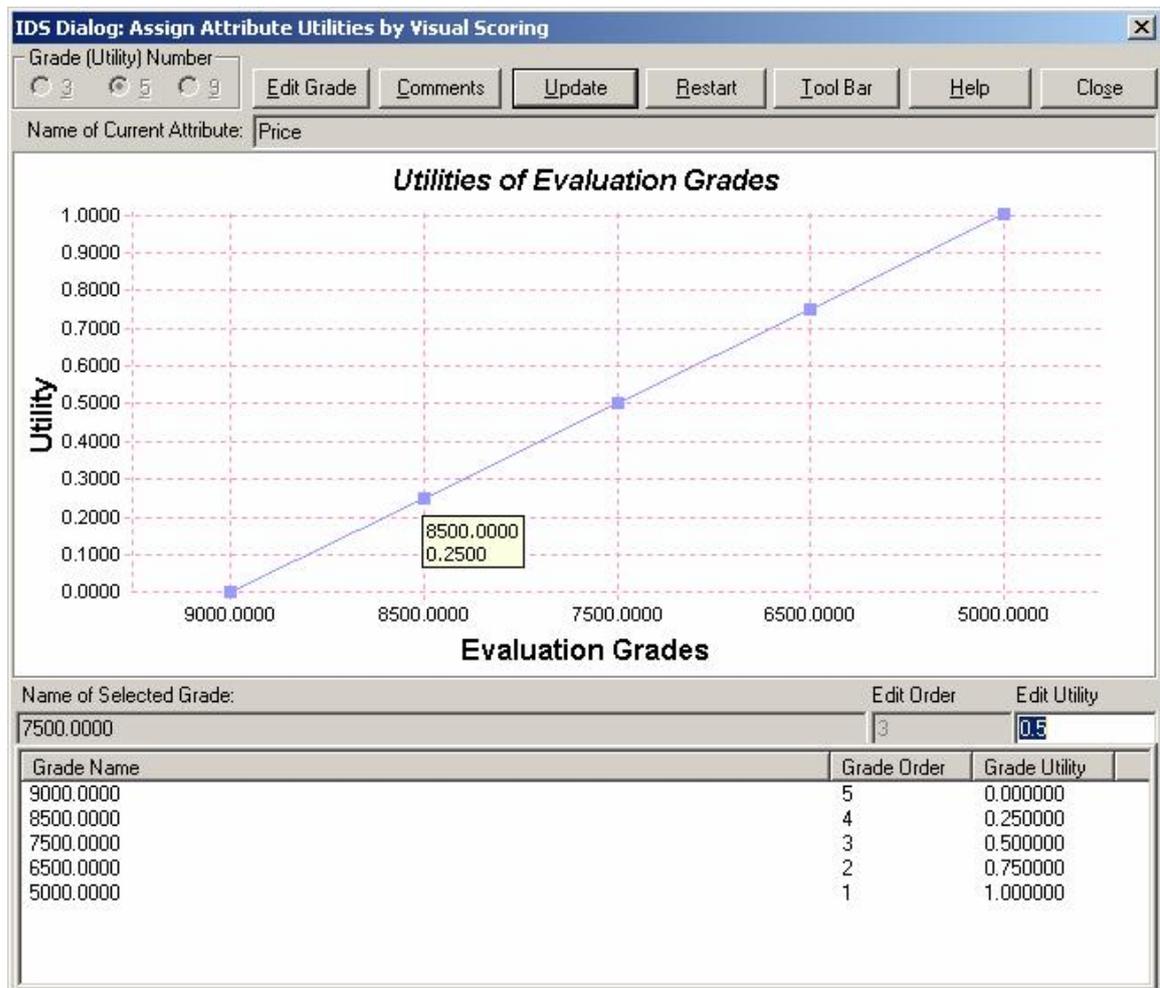
Figure 2.14   Assign Utilities/Values to Attribute Values by Visual Scoring

2.3.2   Relate a Qualitative Attribute to Its Father Attribute

If a child attribute is qualitative, IDS allows the attribute to be assessed using a different set of grades from its father's to facilitate data collection. When this is the case, we will demonstrate how the rule and utility based approaches can be applied to relate the grades of the child attribute to those of its father attribute.

2.3.2.1   Rule Based Approach

In the motorcycle selection problem, for example, if the *Engine* attribute is assessed by 6 grades {*Best, Very Good, Good, Average, Poor, Worst*}, to use the *rule* based approach, the decision maker should provide equivalence **rules** to relate each evaluation grade for assessing *Engine* to all the grades for *Overall Performance*. For example, according to the decision maker's knowledge, s/he may define the following 6 rules, one for each of the 6 grades of *Engine*:

> **Rule 1**.   If *Engine* **is the Worst**, then *Overall Performance* **is**
>
> > **0% Excellent**
> > **0% Good**
> > **0% Average**
> > **0% Indifferent**

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100% Poor

as far as *Engine* is concerned.

Rule 2. If ***Engine* is Poor**, then ***Overall Performance* is**

0% Excellent
0% Good
0% Average
80% Indifferent
20% Poor
as far as *Engine* is concerned.

Rule 3. If ***Engine* is Average**, then ***Overall Performance* is**

0% Excellent
0% Good
60% Average
40% Indifferent
0% Poor
as far as *Engine* is concerned.

Rule 4. If ***Engine* is Good**, then ***Overall Performance* is**

0% Excellent
40% Good
60% Average
0% Indifferent
0% Poor
as far as *Engine* is concerned.

Rule 5. If ***Engine* is Very Good**, then ***Overall Performance* is**

20% Excellent
80% Good
0% Average
0% Indifferent
0% Poor
as far as *Engine* is concerned.

Rule 6. If ***Engine* is Best**, then ***Overall Performance* is**

100% Excellent
0% Good
0% Average
0% Indifferent
0% Poor
as far as *Engine* is concerned.

To relate the grades of *Engine* to those of *Overall Performance* using the rules, follow the following steps:

- Click and then right click on the *Engine* attribute from the attribute hierarchy (**Figure 2.8**). When the attribute definition window similar to **Figure 2.5** is displayed, change the *Number of Grades* to 6,

- Click the *Advanced* button to reveal the *Rule* and *Utility* buttons,

- Click the *Rule* button. If you are asked "Do you want to change grade conversion rules?" we normally recommend you to answer *No*, but in this case you should answer *Yes*.

- If you are asked "Do you want to change grade conversion rules?" we normally recommend you to answer *No*, but in this case you should answer *Yes*. At this point, you will see a window shown in **Figure 15** for you to rename the grade names. Rename the 6 grades and then click OK.

- When asked whether to convert grades manually (**Figure 16**), answer *Yes* and the IDS Dialog window similar to **Figure 2.17** will be displayed. The window displays the program default conversion for **Rule 1**. You may modify it accordingly to the new rule above. When it is done and you click the **OK** button in the window, the current window will close and another similar window will pop up for you to view or modify another rule. The process continues until all the 6 rules are viewed or changed.

  If you wish to change the conversion at any time later, you can invoke the *IDS Dialog: Convert Child Grades to Father Grades* (**Figure 2.17)** by selecting *Modelling->Convert Grades* from the main menu of the IDS window.
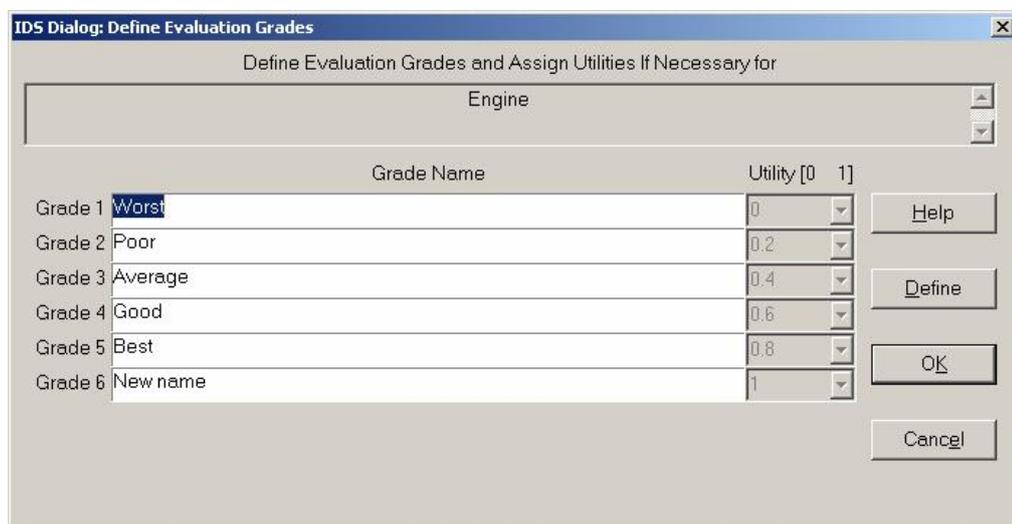
Figure 2.15 IDS Dialog for Defining Grades
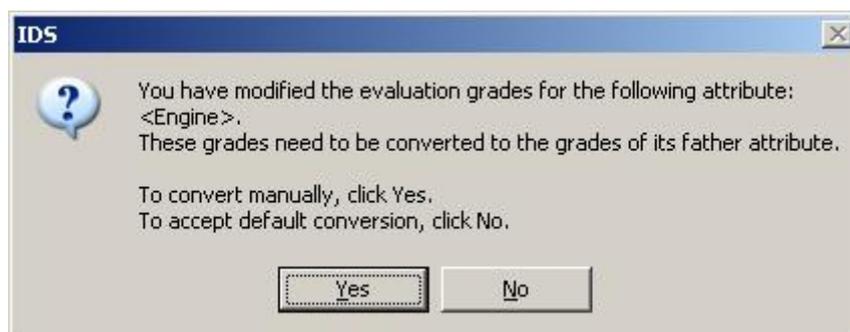
Figure 2.16 IDS Dialogue for Confirming Manual Grade Conversion

From the procedure shown above, we can see that it is better not to change the assessment grades frequently, especially the grades of those attributes at a high level in the attribute hierarchy.

Fortunately, if you have to change assessment grades for some attributes, IDS provides default conversion rules for you. The default conversion assumes that any set of assessment grades is equal distance distributed in the utility/value range [0,1], which is reasonable and most commonly used.

As mentioned earlier, the above conversion procedures are for illustration purpose and not really required in the motorcycle example. You can find the example in the installation folder.
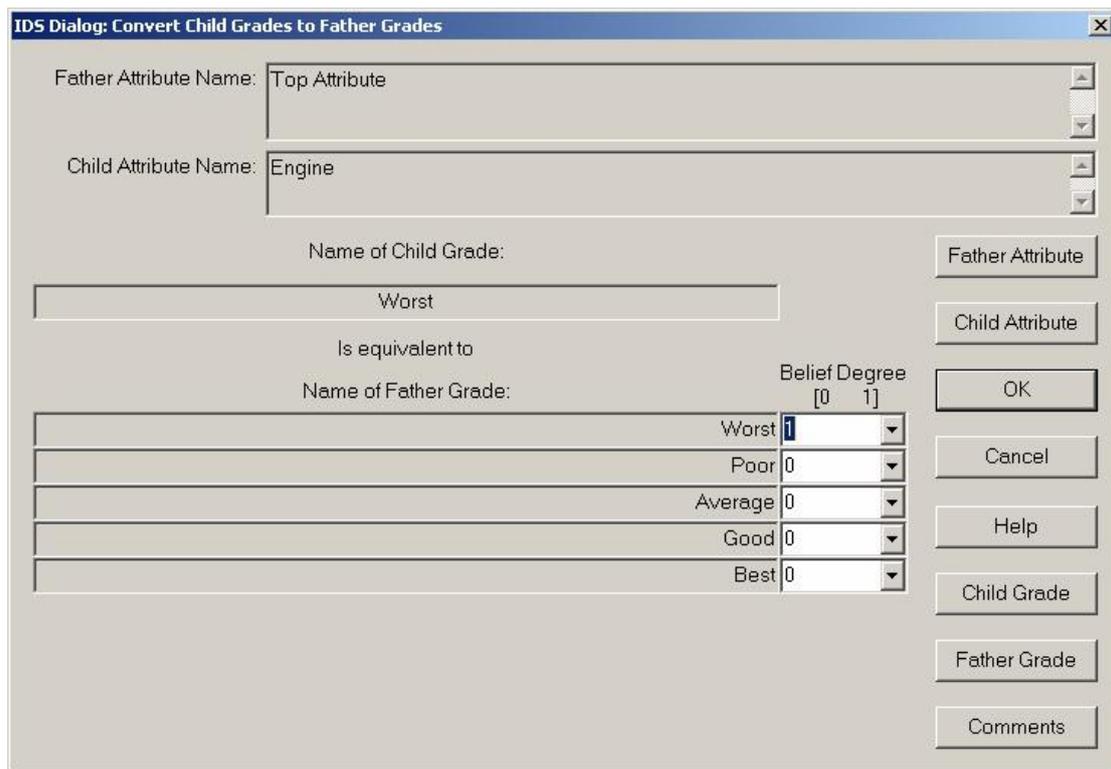
Figure 2.17   Covert Child Grade to Father Grade by Rules

2.3.2.2   Utility Based Approach

Another way is the so-called utility based approach. You can choose this method if you can express your preferences towards different grades by numbers in the utility/value space [0, 1], with 1 representing the most favourable and 0 the least. Again we use the *Engine* attribute as an example and assume it was assessed by 5 grades before and is now by 6 grades.

To use this method to conduct the grade conversion between *Engine* and its father attribute and between *Engine* and its children,

- Click and then right click on the *Engine* attribute from the attribute hierarchy (**Figure 2.8**). When the attribute definition window similar to **Figure 2.5** is displayed, change the *Number of Grades* to 6,

- Click the *Advanced* button (**Figure 2.7)** to show the *Rule* and *Utility* buttons,

- Click the *Utility* button. If you are asked "Do you want to estimate attribute utilities?" we normally recommend you to answer *No*, but in this case you should answer *Yes*.

- At this point, a dialog window shown in **Figure 2.18** will pop up for you to select a method to assign utility to each grade. You may select *Direct Assignment* or *Visual Scoring,* which will activate a window similar to **Figure 2.19** if *Direct Assignment* or **Figure 2.14** if *Visual Scoring* is selected. It basically gives you another chance to edit the utilities you have assigned to each assessment grade of *Engine*. You will not see the grade by grade conversion process as shown in the rule based approach. It is because by using the utility based approach, the father's grades and child's grades are all represented by utilities, which is in a common space of [0, 1]. It implies that the conversion is already implemented through the utility assignment and an conversion matrix is generated internally by IDS.

- If you wish to change the conversion of *Engine* at any time later, you can click on the *Engine* attribute box (**Figure 2.8**) and then select *Modelling->Estimate Utilities->Direct Assignment* or *Visual Scoring* from the main menu of the IDS window.

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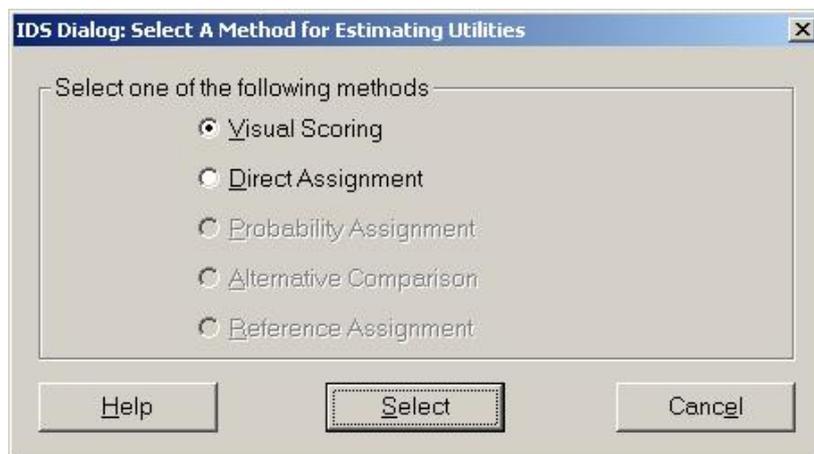
Figure 2.18   Covert Child Grade to Father Grade by Rules
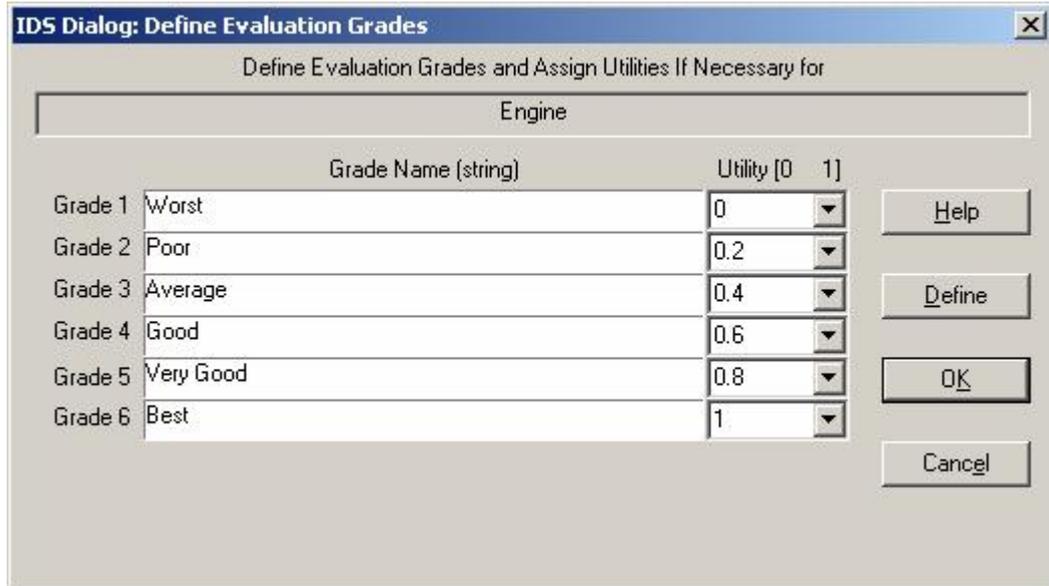
Figure 2.19   Define Evaluation Grades and Assign Utilities

3   ASSIGNING WEIGHTS

Having defined all attributes, the next task is to assign a weight to each attribute. A weight should reflect the relative importance of each child attribute to the evaluation of its father attribute. Therefore when assigning weights, each time you only need to look at a small group of attributes which share the same father attribute.

At the start, IDS automatically assigns a weight to every attribute, assuming that all attributes are equally important.

In the motorcycle selection problem, there are 7 groups of attributes as shown in **Table 3.1.** Different groups can use different scales for their weights.

Table 3.1   Weight Assigned to Each Attributes

Group	Father Attribute of the Group	Child Attributes in the Group with Weights in Brackets
1	Overall Performance	Price (9), Displacement (5), Range (7), Top Speed (7), Engine (14), Operation (7) and General (14)
2	Engine	Responsiveness (0.2), Fuel Consumption (0.4), Quietness (0.1), Vibration (0.1), Starting (0.2)
3	Operation	Handling (0.5), Transmission (0.167), Brakes (0.333)
4	General	Quality of Finish (0.4), Seat Comfort (0.3), Headlight (0.1), Mirrors (0.1), Horn (0.1)
5	Handling	Steering (0.3), Bump Bends (0.1), Manoeuvrability (0.4), Top Speed Stability (0.3)
6	Transmission	Clutch Operation (0.5), Gearbox Operation (0.5)
7	Brakes	Stopping Power (0.4), Braking Stability (0.3), Feel at Control (0.3)

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IDS provides two ways to help you to assign weights systematically: visual scoring and pairwise comparison.

3.1   Visual Scoring

The first method is **Visual Scoring**. To use the method,

(1) Click any attribute of the group you wish to assign weights to (refer to **Figure 2.8**).

(2) Click the shortcut icon ⬚ (the w here stands for Weight) from the toolbar of the IDS main window, and then the *Visual Scoring* radio button and the *Select* button on the *IDS Dialog: Select A Method for Assigning Weights* **(Figure 3.1).** Alternatively, from *Modelling* menu of the IDS main window select *Estimate Weight* and then select <u>*Visual Scoring*</u>. This will invoke the dialog window shown in **Figure 3.2**.
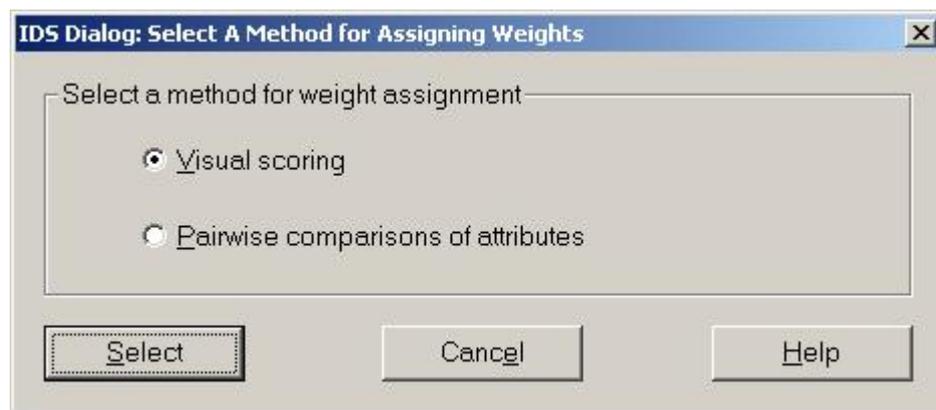
Figure 3.1   Select A Method for Assigning Weight

(3) In the dialog window shown in **Figure 3.2**, the weight of each attribute in the group is displayed graphically. The relative importance of each attribute is represented by the height of its column. To change the weight of an attribute, you can use a computer mouse to drag the top edge of its column up and down until it reaches the desired height. During the dragging process, the weights are displayed at the top of each column dynamically.

You can choose any of the 3 scales: [0, 1], [0, 10] or [0, 100] for assigning weights. You can also change scales at any time. When you change scales, the ratio of any two attribute weights will be maintained and the assessment results will not be affected.

You can also use a normalised scale. If weights are normalised, the total sum of the normalised weights in a group will be 1 if the scale [0, 1] is used, 10 or 100 if [0, 10] or [0, 100] is chosen respectively.

If you change any of the weights using the drag and drop function and the weights are not normalised, the rest of the weights will not change. If the weights are normalised, the rest of the weights in the group will also change automatically in order to keep the total sum at a fixed number, 1, 10, or 100. However, the ratio between any two will be maintained during the process.

At the bottom of the window (**Figure 3.2**), there is also a list view to list all attributes in a group and their weights. By clicking on any of the attribute name in the list, you can type in a weight value from the edit box just above the list. This is

a better way for assigning weights than the dragging and dropping graph bars if you want to assign weights precisely.

(4) When you are happy with weights assigned to all attributes in a group, you can click on the *Confirm Weights* button to accept the assigned weights. If you are not happy with all the changes you have made since last time you have pressed the *Confirm Weights* button or from when the window shown in Figure 3.2 was invoked, then you can press the *Restart* button to start from the previous weight setting again until you are happy with the new setting.
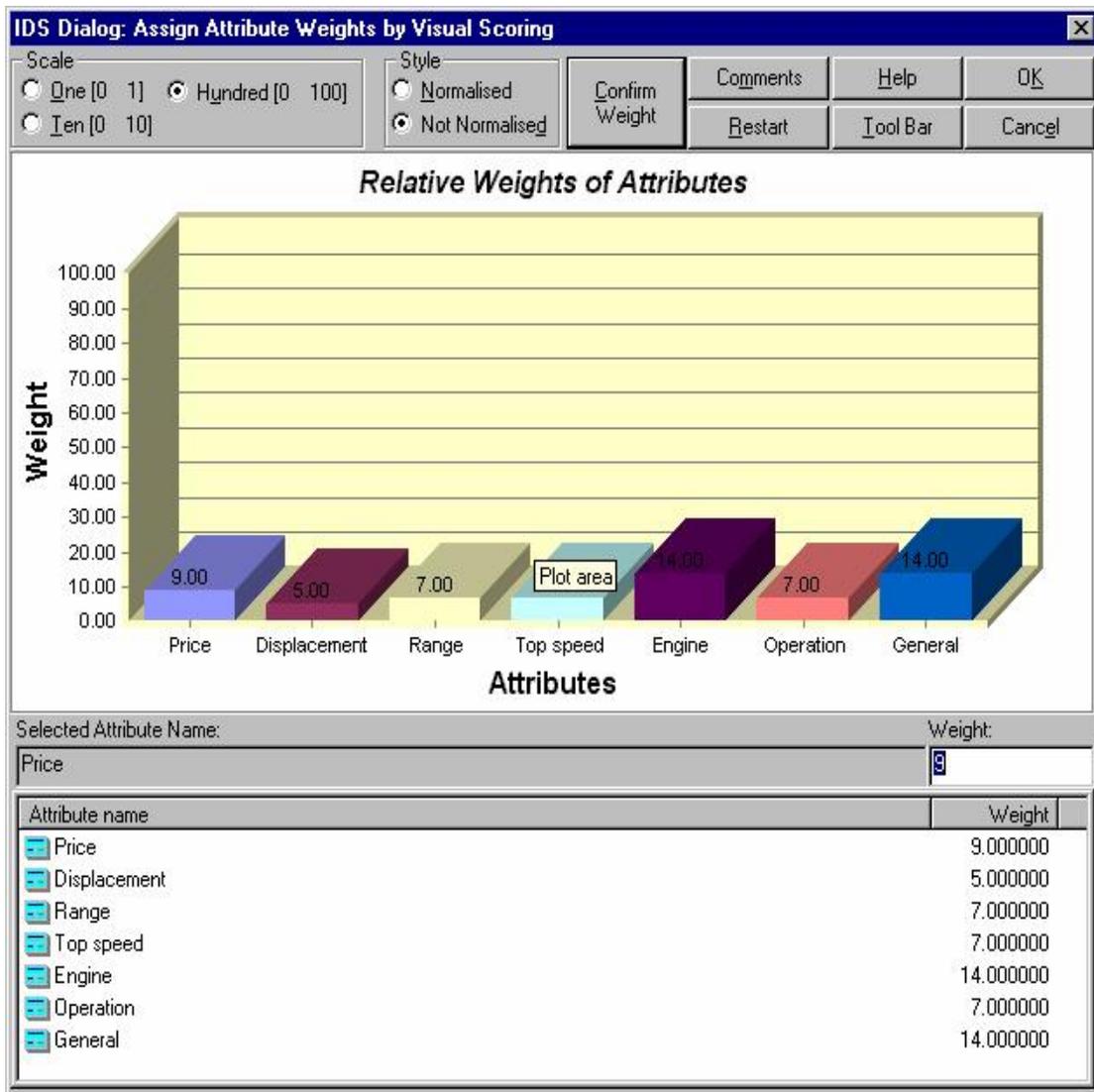
Figure 3.2   Assigning Attribute Weights by Visual Scoring

3.2   Pairwise Comparison

The second method is **Pairwise Comparison**. Users who know the AHP (Analytical Hierarchy Process) method may find this method familiar. To use this method,

(1) Click any attribute of a group you wish to assign weights to (refer to **Figure 2.8**).

(2) Click the shortcut icon ꝏ from the toolbar of the IDS main window, and then click the *Pairwise Comparison* radio button and then *Select* button on the *IDS*

Dialog: Select A Method for Assigning Weights **(Figure 3.1).** Alternatively, from the *Modelling* menu of the IDS main window select *Estimate Weight* and then *Pairwise Comparison*. This will activate the dialog window similar to **Figure 3.3.**
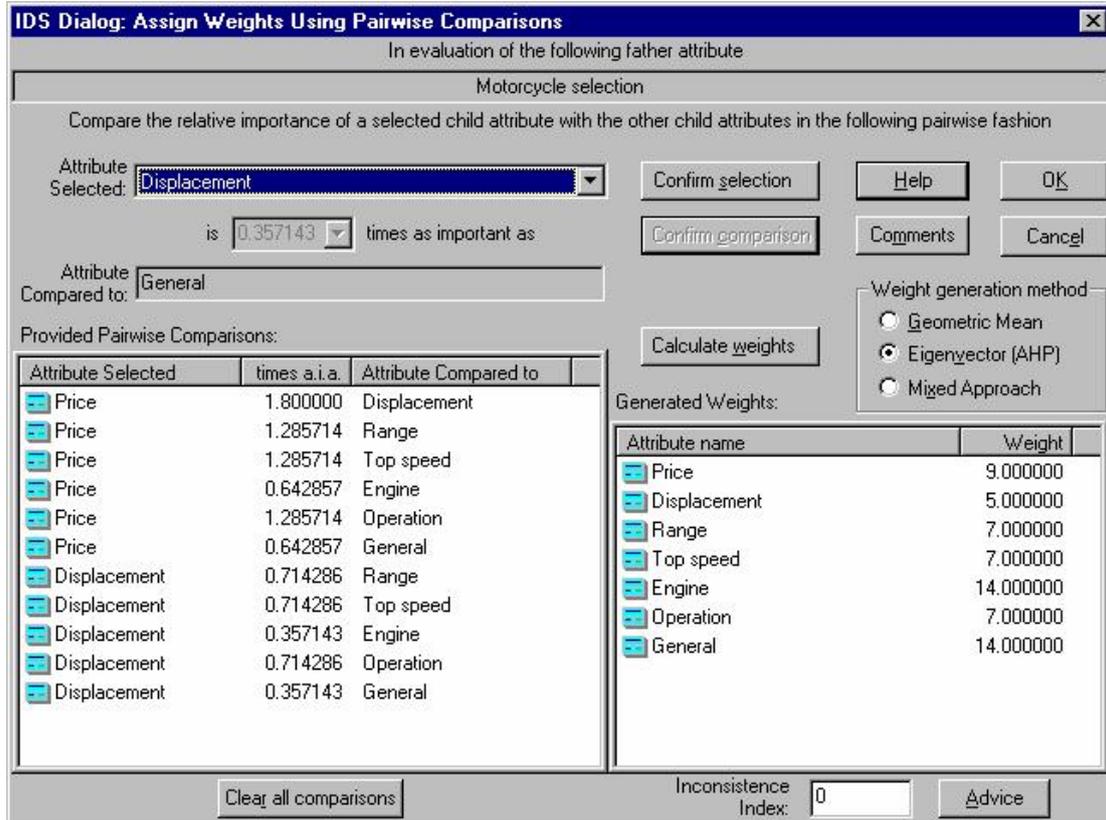
Figure 3.3   Assigning Attribute Weights by Pairwise Comparison

(3) In the dialog window shown in **Figure 3.3**, from the *Attribute Selected* drop down list, select an attribute (*Displacement* in the example of **Figure 3.3**) and then press the *Confirm selection* button. As soon as the button is pressed, the *Confirm comparison* button is enabled and so does the ratio drop down list on the left side of the *Confirm comparison* button. The ratio 0.357143 in the example of **Figure 3.3** can be edited and indicates that *Displacement* is 0.357143 times as important as the *General* attribute. *General* is the attribute name shown below the ratio drop down list in the field *Attribute Compared to*. If you are happy with the ratio displayed in the ratio drop down list, you should click the *Confirm comparison* button to save the change and move to the next pairwise comparison. The attribute name in the *Attribute Compared to* field changes each time you press the *Confirm comparison* button until all attributes in the group have been compared with *Displacement* once. When it is done, the results will be added to the list displayed in the left bottom pane of the window (**Figure 3.3**). Next, you may choose another attribute from the *Attribute Selected* drop down list and repeat the above process until all possible pairs in the group are compared. In total there are $(N^2 - N)/2$ possible pairs.

It is not compulsory to compare all the $(N^2 - N)/2$ pairs. The minimum requirement is that you should at least compare one attribute with the rest of the attributes in the group once. For example, if you choose *Price*, you should compare at lease the following 6 pairs (*Price, Displacement*), (*Price, Range*), (*Price, Top Speed*), (*Price, Engine*), (*Price, Operation*), and (*Price, General*).

If you provide only minimum information, IDS will work out the relative importance of all the pairs. If you provide more information than minimum, then IDS will use the redundant information for consistency test. The inconsistence index is displayed at the bottom on the same window (**Figure 3.3**). More information about the inconsistence index is discussed below.

(4) The results for the compared pairs are listed in the left bottom pane of the window shown in **Figure 3.3**. If you are not happy with any of the results, you can use the process stated above to make changes. Once you are happy with the comparison, you can click the *Calculate weights* button. The calculated weights are displayed in the bottom right pane of the window shown in **Figure 3.3**.

There are 3 methods to calculate weights from pairwise comparisons: Geometric Mean, Eigenvector and Mixed Approach. You can use any of them. The Mixed Approach takes the average of the weights generated by both Geometric Mean and Eigenvector methods. The detailed description of the two methods is out of the scope of the manual and could be found in the latest books on multiple criteria decision analysis.

Below the weight pane, the inconsistence index is also displayed. If all comparisons are completely consistent, the inconsistence index will be zero and vice versa. In this case, the weights generated using any of the three methods will be the same. This will happen if only minimum information is used, that is only one attribute is selected to compare with all other attributes and only these comparisons are used to generate weights, as discussed in point (3) above. If the inconsistence index is

- less than 0.01, the comparisons can be regarded sufficiently consistent. In this case, the weights generated using the three methods should be very similar. If the inconsistence index is

- less than 0.1 but larger than 0.01, the comparisons can be regarded reasonably consistent. In this case, the weights generated using the three methods may be slightly different. You could choose the weights generated using one of the three methods that you prefer. If the inconsistence index is

- larger than 0.1, the comparisons may involve considerable inconsistency. If the weights generated using the three methods are noticeably different, then the comparisons may need to be modified. If this is not possible, the mixed approach could be used to generate a set of average weights.

3.3 Visual Scoring vs Pairwise Comparison

The pairwise comparison method is sometimes called AHP (Analytical Hierarchy Process) method because it is the core element of the AHP method. Pairwise comparison is more complicated than the visual scoring method and may not necessarily produce a better set of weights. For this reason, we recommend to use visual scoring, especially for beginners. For people who know AHP very well, pairwise comparison provides an alternative way for generating weights.

4 USING IDS MODEL FOR DATA COLLECTION

4.1 Overview

In a multicriteria analysis, an alternative needs to be assessed on each attributes in the bottom level of the attribute hierarchy. This section describes how to collect and record assessment information for each alternative on each bottom level attribute and how to record uncertainties in assessment.

4.2 Add and Define an Alternative

To use the model for assessing an alternative, you need to add and define an alternative. It is easy to add an alternative. You first click anywhere in the left pane of the IDS Multicriteria Assessor main window (**Figure 2.2**), and then click the ⇨ command button on the toolbar. A new alternative will be added with a default name *Alternative n*.

When you first use the model, there is an alternative already in the left pane of the main window with a name *First Alternative*. You may rename it and use it.

To define an alternative in most cases is simply to rename the alternative. To define it, you need to click on the alternative box and then right click it. You will see a dialog box similar to one shown in **Figure 4.1**. You can then change the name in the space provided. If you wish to provide more detailed description about this alternative, you can do so by clicking the *Describe* button in the same window.

Figure 4.1   Define An Alternative

To input and record assessment information, click the alternative box (in the left pane) once to select it and double click on the bottom level attributes, one at a time to input assessment information and all information you enter (as explained in the next section) will be associated with this alternative. The alternative will remain selected as long as you do not click on any other alternatives. If you have navigated away from this alternative, you should navigate back by clicking it again once before you enter any information for it.

You should also save your work from time to time.

4.3 Data Input for Quantitative Attributes without Uncertainty

To record assessment information in the IDS model, first you need to make sure the targeted alternative is highlighted. If not, you can click it once to highlight it.

If an attribute is defined as *Quantitative* (refer to **Table 2.2**), double clicking on it will activate a dialog window similar to **Figure 4.2**. For example, the *Price* for *Yamaha* is £5199. You simply type the price in the space provided in the window.
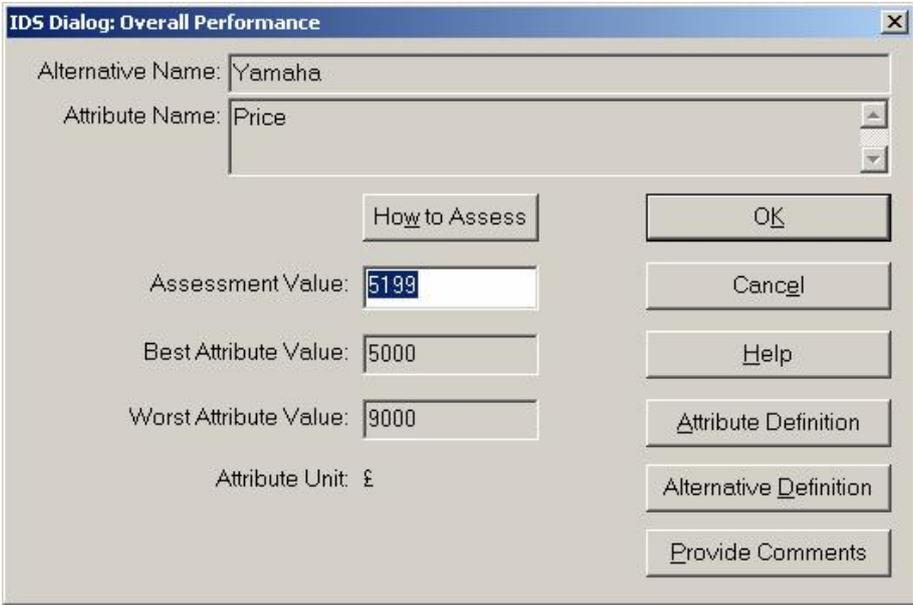
Figure 4.2   Input Assessment Data for Quantitative Attributes

4.4 Data Input for Quantitative Attributes with Uncertainty

If an attribute is defined as *Quantitative* with uncertainty (**Table 2.2**), double clicking on it will activate a dialog window similar to **Figure 4.3**. For example, the fuel consumption rate of a motorcycle measured by miles per gallon changes with weather and road conditions. If its user states that 70% of the time it will run on motorways and 30% on urban streets, you should enter 2 in the field "*The Number of Possible Values*" in **Figure 4.3**, one for motorways and the other for urban streets. The maximum number of possible values the current version of IDS can handle is 20. If you wish to use a number larger than 20, please email us at info@e-ids.co.uk.

Other buttons in this window are mainly used for providing help and other information to assist the assessment. Details on the function of each button in this window are given in **Table 4.1**.
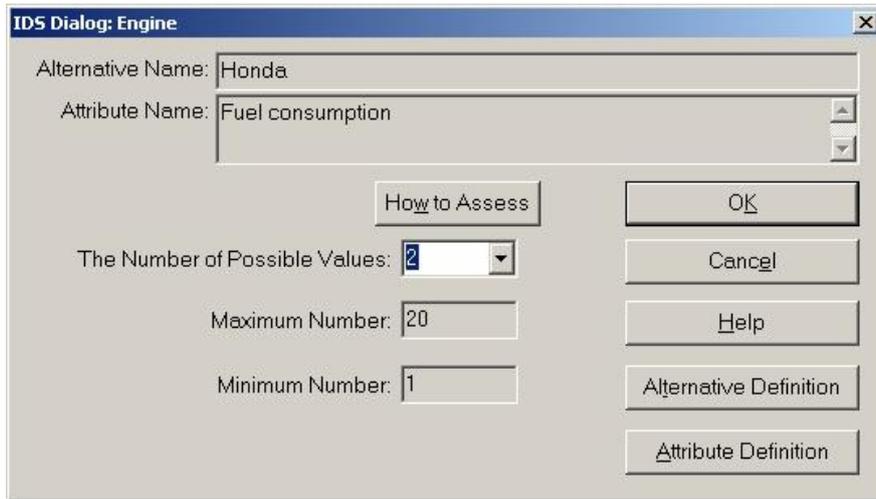
Figure 4.3   Input Assessment Information for Quantitative Attributes with Uncertainty (Step 1)

After you have entered a number for *The Number of Possible Values*, click the *OK* button and you will then be prompted to enter the values and their associated probabilities in a window similar to the one shown in **Figure 4.4**.

Table 4.1   Input Assessment Information for Quantitative

Attributes with Uncertainty

Item	Information Requested	Values Provided	Comments
1	How to Assess	N/A	Press this button to get some help on how to assess this attribute.
2	The Number of Possible Values	2	An integer is required. You may use any number from 1 to 20.
3	Help	N/A	Press this button to get some help on how to use this dialog window.
4	Attribute Definition	N/A	Press this button to find out more information about this attribute. The information is stored at the model building stage (refer to Item 1 of **Table 2.1** or **Table 2.2**)
5	Alternative Definition	N/A	Press this button to find out more about this alternative. The information is stored when you defined the alternative earlier (refer to **Section 4.2**).
6	Provide Comments (for **Figure 4.4**)	If you wish to explain the assessment you made, you may enter it here.	The information entered may help other people to understand how the assessment is made.

Figure 4.4   Input Assessment Information for Quantitative Attributes with Uncertainty (Step 2)

To input assessment information, depending on the figure you entered earlier, you need to provide the same number of values in the *Possible Value* column and the probability associated with each of the values in the *Belief Degree* column. For the motorcycle *Honda*, the *Fuel consumption* rate is 43 and 31 miles/gallon on motorways and urban streets respectively. For the buyer who uses the motorcycle mainly on motorways (70%), then the assessment data entered should be similar to those shown in **Figure 4.4**.

The values you enter must be between the *Best Attribute Value* and the *Worst Attribute Value*. The total belief degrees should be 1 or less. If the total is less than 1, it means that some of the information is missing (incomplete). Although the program can accept and process such incomplete information, you are encouraged to identify as much information as possible to reduce uncertainties in the overall assessment results.

For details on how to use each of the buttons in this window, refer to **Table 4.1**.

4.5   Input Assessment Information for Qualitative Attributes

If an attribute is defined as the *Qualitative* type, double clicking it will bring a dialog window similar to **Figure 4.5**.

The figures displayed in the *Grade Name* column are defined in the modelling stage (refer to Item 4 in **Table 2.1**).

To input your assessment of the selected alternative on the attribute, you only need to tick one or more grades and provide each grade with a belief degree in the *Belief Degree* [0, 1] column. You may select a figure from the dropdown list or type in your own figure.

Note that the total belief degrees (subjective probability) should be 1 or less. If the total is less than 1, it means that some of the information is missing (incomplete). Although the program can accept and process such incomplete information, you are

encouraged to identify as much information as possible to reduce uncertainties in the final results.
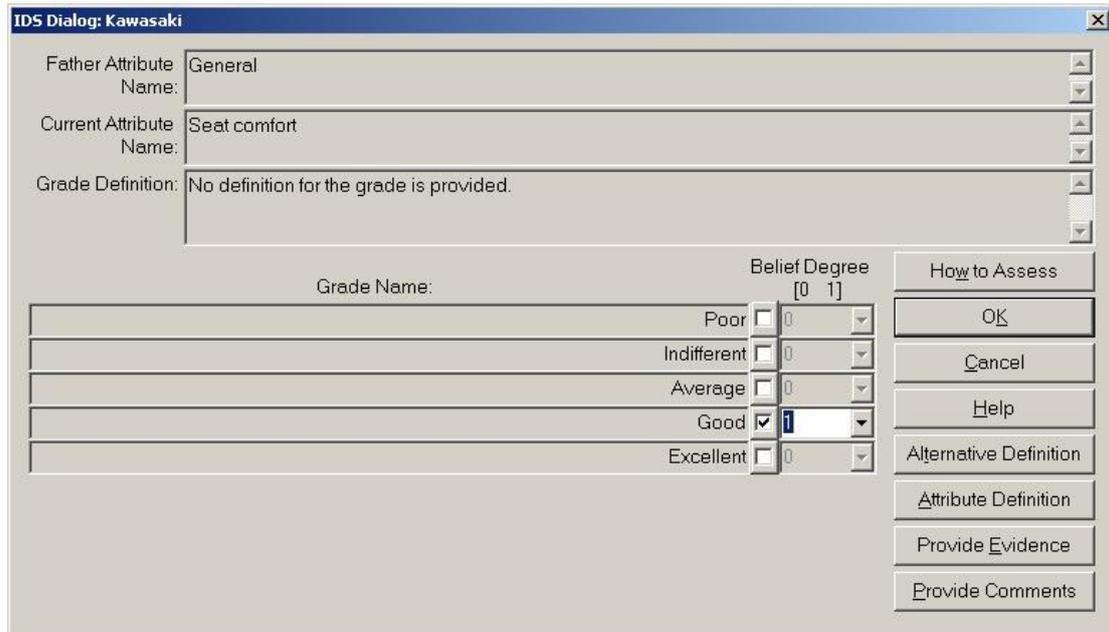
Figure 4.5   Input Assessment Information for Qualitative Attributes
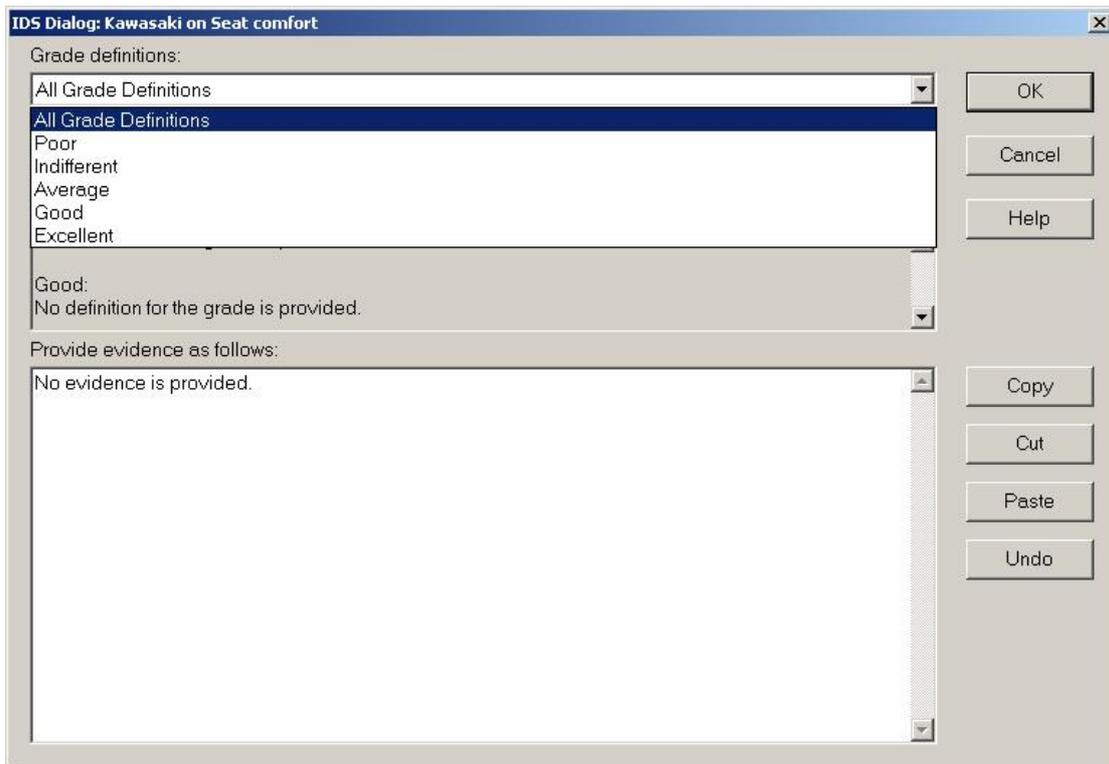
Figure 4.6   Provide evidence When Input Assessment Information for Qualitative Attributes

For details on how to use each of the buttons in this window (**Figure 4.5**) refer to **Table 4.2**.

Table 4.2   Input Assessment Information for Qualitative Attributes with Uncertainty

Item	Info Requested	Values Provided	Comments
1	Grade Definition:	N/A	Depending on which grade name the cursor is in the *Grade Name* column, the *Grade Definition* display area will display more information about the grade. Such information acts as assessment standards to help reduce inconsistency in subjective judgements. The information is entered earlier in the model building process (See Item 4 in **Table 2.1**).
2	How to Assess	N/A	Press this button to get some help on how to assess this attribute.
4	Help	N/A	Press this button to get some help on how to use this dialog window.
5	Attribute Definition	N/A	Press this button to find out more information about this attribute. The information is stored at the model building stage (refer to Item 1 of **Table 2.1** or **Table 2.2**)
6	Alternative Definition	N/A	Press this button to find out more about this alternative. The information is stored when you defined the alternative earlier (refer to **Section 4.2**).
6	Provide Evidence	If you wish to record evidence used to assess an alternative related to the attribute, you may press this button to activate a window shown in **Figure 4.6** and enter the information in the space provided. To help you make consistent judgements, the grade definitions are displayed in the upper pane of the window. You may choose from the dropdown list to display the definition for one grade at a time.	The information entered may help to convince people that the grades and their associated belief degrees you entered in the window shown in **Figure 4.5** are based on evidence and are compared with assessment standards for each grade.
7	Provide Comments	If you wish to explain the assessment you made, you may enter it here.	The information entered may help other people to understand how the assessment is made.

5 VIEW RESULTS WITH IDS MULTICRITERIA ASSESSOR

Once assessment information for all bottom level attributes is collected, the overall performance and the performance for higher level attributes are then calculated by IDS Multicriteria Assessor using the Evidential Reasoning (ER) approach automatically. For each attribute, the computed performance information includes not only an indicative score, but also a performance distribution and uncertainty associated with the assessment.

You may view the assessment information for any selected alternatives on any selected attributes in the attribute hierarchy at any time – even when you have not gathered information for some of the bottom level attributes. In this case the missing information will be shown in the assessment as uncertainty in terms of performance score range (**Figure 5.2**).

There are a number of graphic interfaces for viewing results. In this section, we will demonstrate how to use the interfaces to view a few commonly used graphics.

5.1 View Performance Scores on Top and Sub Attributes

Performance scores of alternatives on attributes are often used for ranking purposes. If you wish to compare and rank alternatives, IDS provides a very simple interface to view performance scores on the top or any sub attributes as follows:

1. Click anywhere in the alternative pane (left pane) of the IDS main window (**Figure 2.8**),

2. Click the top attribute or any attribute of interest to you in the attribute hierarchy once in the right pane, and

3. Click the ▉ button in the toolbar at the top of the window. The graph you see is similar to the one shown in **Figure 5.1** (for the *Overall Performance* attribute) or **Figure 5.2** (for the *Engine* attribute).

The results in **Figure 5.1** or **Figure 5.2** display the performance scores for all the alternatives on the selected attributes. Because there are some missing data in the assessment information, the graph provides a lower and upper bound of the performance scores, so that you know that the scores will be in the range marked in grey whatever the missing data turn out to be.

The table at the lower pane of the window displays the values plotted in the graph. You may hide the table by dragging down the dividing line just above the table.
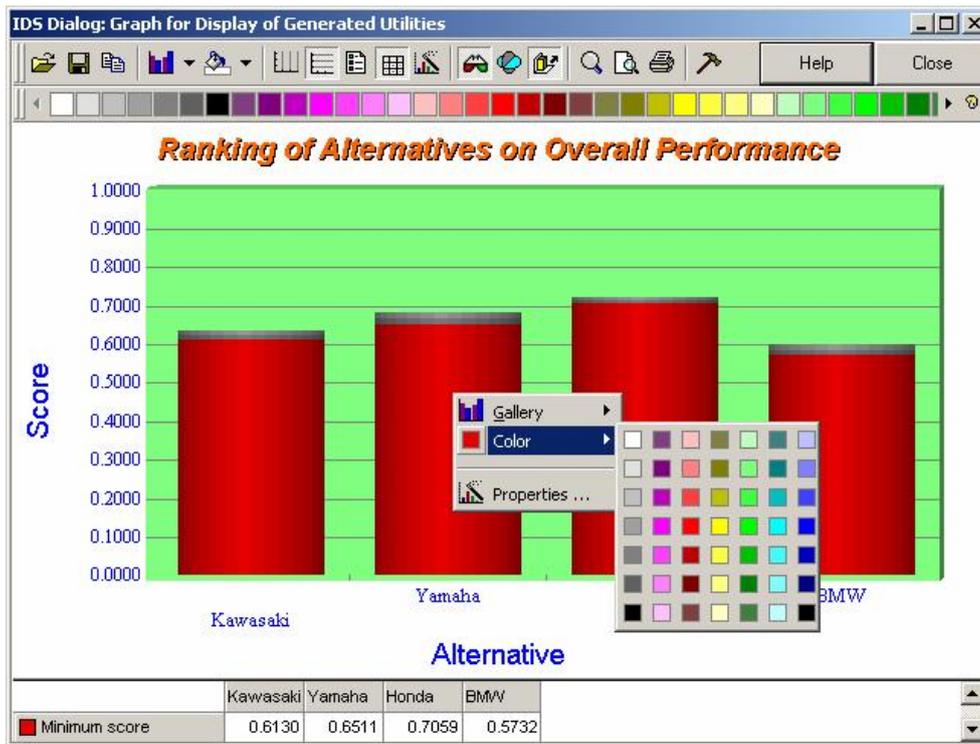
Figure 5.1   Performance Scores on Overall Performance
(Note that if you wish to change any colour in the figure, you can right click the colour and then select *Color* to pick up a desired colour from the provided colour pallet, as shown in **Figure 5.1)**
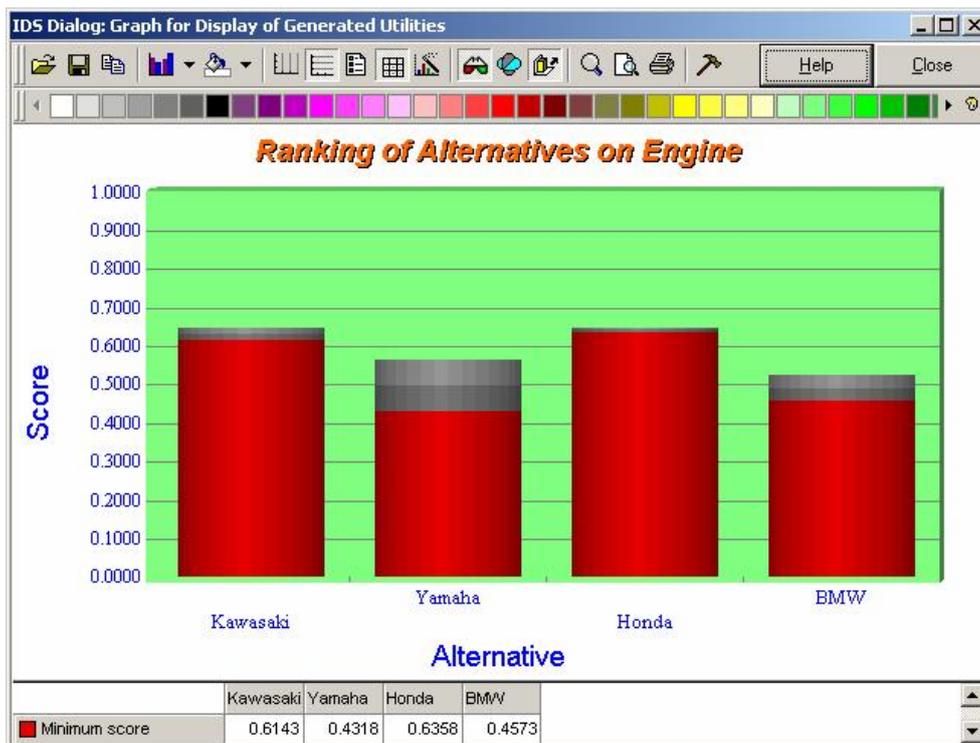

Figure 5.2   Performance Scores on Engine

5.2   Compare Selected Alternative on Any Selected Attributes

The previous section talked about viewing performance scores of all alternatives on ONE attribute. This section describes how to view the performance scores of any selected alternatives on a number of selected attributes. The steps are given below.

1. Click the ![button] button once in the toolbar of the main window (**Figure 2.8**). This will bring the graphic window similar to **Figure 5.3**.

    This window displays all the performance scores of all the alternatives on the top attribute and its immediate child attributes. If there are uncertainties in the estimates, the lower and upper bound will not be displayed. Instead the average of the lower and upper bound is calculated and displayed.

    If the legend is not shown in the graph, you may right click any blank area on the graph to display the pop up menu and select the *Legend box* to display it.

    If the data displayed on the graph look crowded, you may wish not to display them. You can do so by right clicking anywhere on the graph except the data columns (so that the changes will be applied to all alternatives, not just the selected one), and then from the pop up menu selecting the *Properties....* This will bring up the chart property window, as shown in **Figure 5.4**. Select the *Series* tab if it is not already selected. Make sure that *<<All Series>>* is displayed in the drop down list and then un-check the *Show points labels* option.
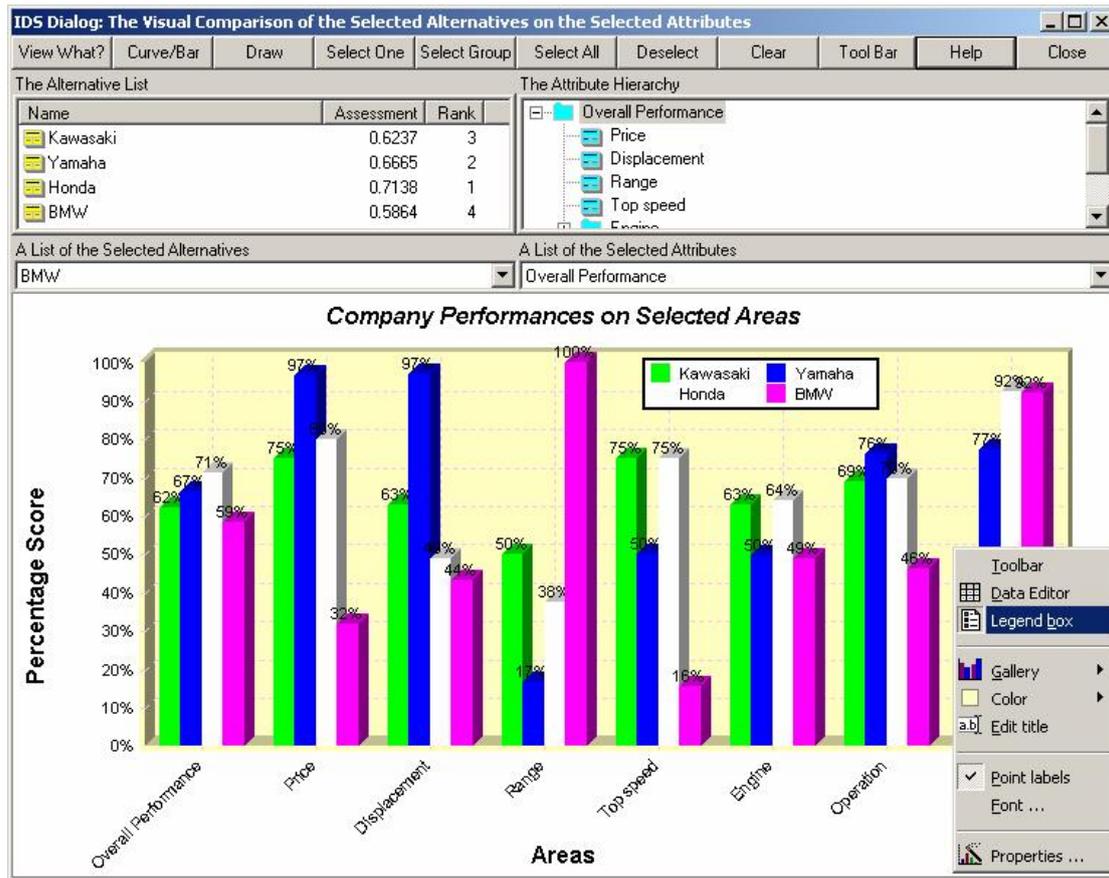

Figure 5.3   Compare Selected Alternatives on Selected Attributes

36
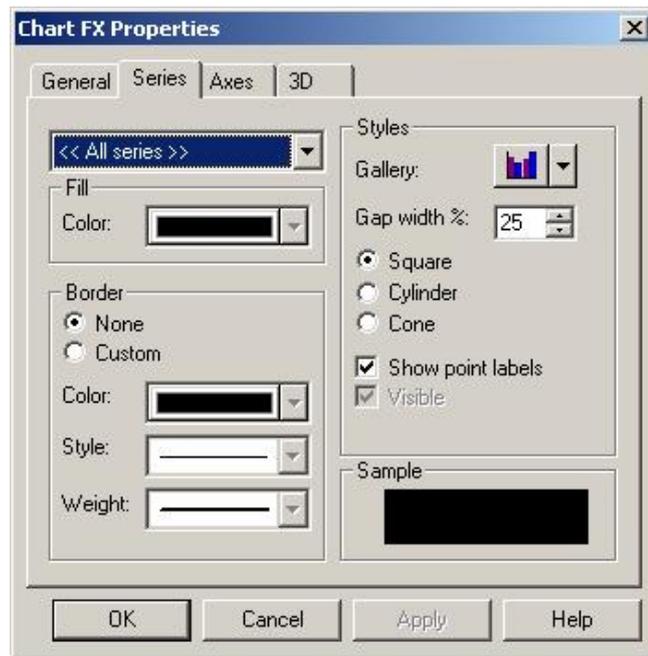
Figure 5.4　Handling Graphs Using the Graph Property Window

2. If you wish to add or remove an alternative from the display, you can click on the alternative listed in the upper left pane or the *A List of Selected Alternatives:* dropdown list (**Figure 5.3**), click the button *Select One* or *Deselect* respectively, and then click the *Draw* button to redraw the picture.

   By clicking the arrow in the *A List of the Selected Alternatives* dropdown list (**Figure 5.3**), you can view which alternatives are selected for the display.

3. If you wish to add or remove an attribute from the display, you can click on the attribute listed in the upper right pane or the *A List of Selected Attributes:* dropdown list (**Figure 5.3**), click the button *Select One* or *Deselect* respectively, and then click the *Draw* button to redraw the picture.

   If you wish to select a group of attributes, you can use the *Select Group* button. Clicking the button will add the selected attribute and all the attributes sharing the same father attribute.

   By clicking the arrow in the *A List of the Selected Attributes* dropdown list, you can view which attributes are selected for the display.

4. You may use the *Clear* button to deselect all the alternatives and attributes.

5. You may use the *Select All* button to select all the alternatives and attributes.

6. You may click the *Toolbar* button to show the graphic editing tool box to change the appearance of the picture.

5.3　View Performance Diversity Information

Performance diversity information for any alternatives on any attributes is uniquely provided by the IDS Multicriteria Assessor due to the adoption of the Evidential Reasoning approach for information aggregation. The distributed performance information of alternatives on bottom level attributes is preserved and propagated to the top level attribute in the aggregation process. The distributed information provides a panoramic view on the diversity of an alternative's performance.

5.3.1　View Performance Diversity Information for One Alternative

To view the performance diversity information for one alternative on any attribute, do the following.

1. Click once on the alternative you are interested in, for example, BMW, in the left pane of the IDS main window (**Figure 2.8**),

2. Click once on the attribute you are interested in, for example, *Overall Performance*, in the right pane of the window, and

3. Click the 📊 button in the toolbar at the top of the window. The graph you will see is similar to the one shown in **Figure 5.5**.
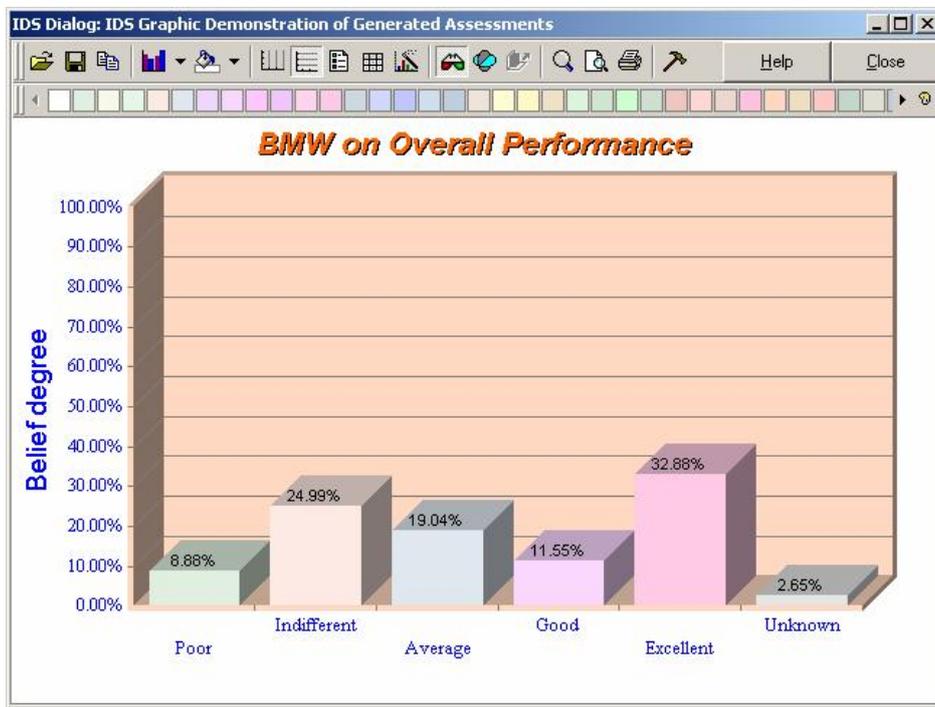
Figure 5.5　Display Performance Diversity of An Alternative

The information displayed in **Figure 5.5** provides more information than just an average performance score. This picture reveals the distribution of the overall strengths and weaknesses of the alternative. You may also search where those weak areas and strong areas locate (see **Section 5.3.3**). Such information can help the decision maker to make a more informed choice.

5.3.2   View Performance Diversity Information for Selected Alternatives

To view performance diversity information for all or selected alternatives on any attribute, do the following.

1. Click once on the attribute you are interested in, for example, the *Overall Performance*, in the right pane of the IDS main window (**Figure 5.6**),

2. Select from the menu bar of the main window *Report -> Graph Belief Degree ->Alternatives* (**Figure 5.6**). This will generate a graph shown in **Figure 5.7**.
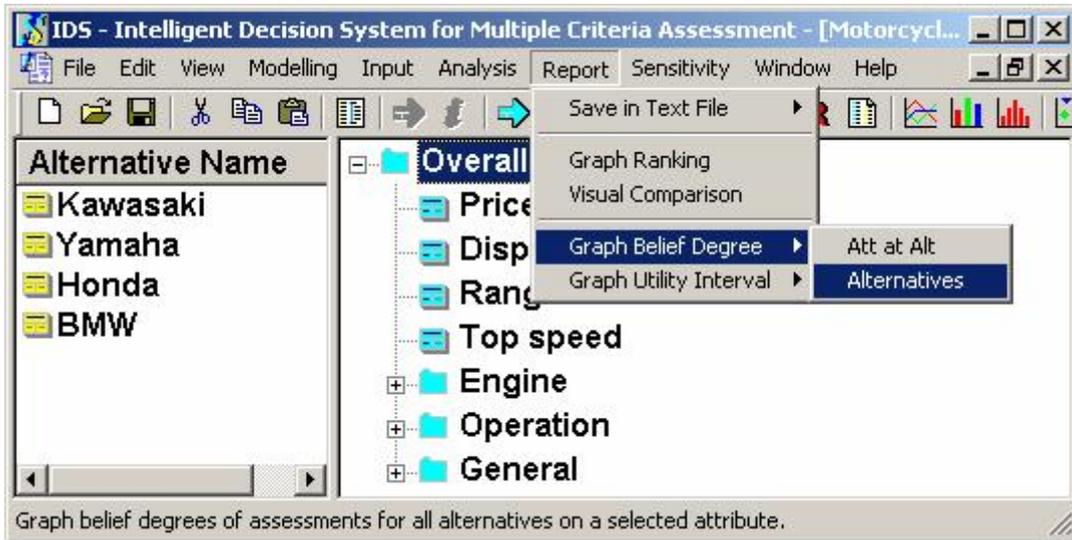

Figure 5.6   Menu Selection for Comparing Performance Diversity of All Alternatives on A Selected Attribute
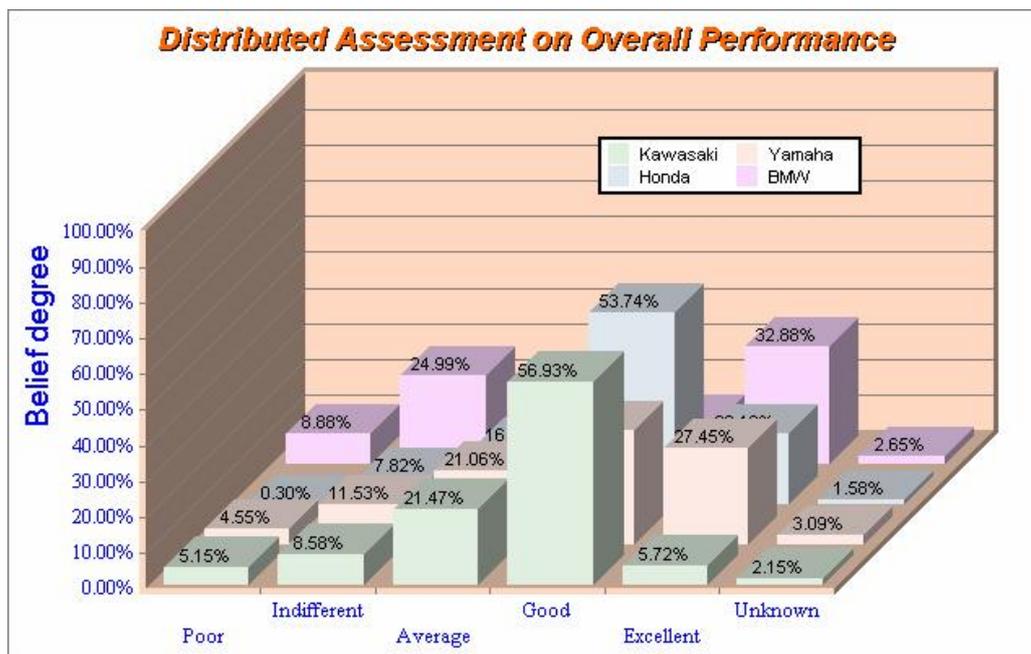

Figure 5.7   Compare Performance Diversity of All Alternatives on An Attribute

Note that this type of graph can only be plotted for qualitative attributes. The labels of the X-axis in the picture are the grades defined at the attribute definition stage (refer to Item 4 of **Table 2.1**).

The picture in **Figure 5.7** displays the diversity information for all the alternatives. There is a legend box to help you identify which is which. If the legend box is not shown, you can right click on any blank area in the picture and then select *Legend box* from the pop up menu (**Figure 5.3**). You may also drag the legend box to where you want it to be located.

If you wish to exclude some of the alternatives from the display, you may right click the unwanted alternative and then select *Properties…* from the pop up menu (**Figure 5.3**). This will bring the following window as shown in **Figure 5.8**. From the Series tab of the window, you need to make sure that the unwanted alternative name is displayed in the drop down list of the window and then un-tick the *Visible* option, as highlighted in **Figure 5.8**.

The chart property window also provides many other functions for you to change the appearance of the picture. You can edit all pictures through their property windows.
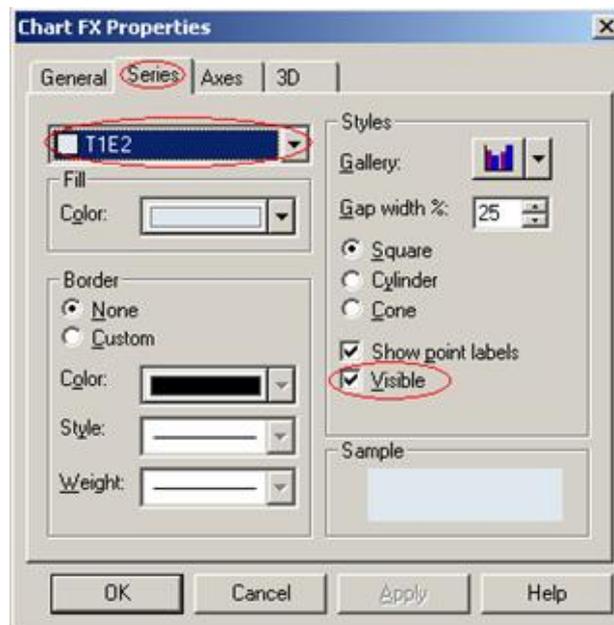
Figure 4.8   Compare All Alternatives' Total Cost Estimates

5.3.3   Search Strengths and Weaknesses for Selected Alternatives

To search strengths and weaknesses for selected alternatives, do the following.

1. Click the ⬈ button once in the toolbar of the main window (**Figure 5.6**). This will invoke the graphic window similar to **Figure 5.3**.

2. If you wish to add or remove an alternative from the search, you can click on the alternative listed in the upper left pane or the *A List of Selected Alternatives:* dropdown list (**Figure 5.3**), click the button *Select One* or *Deselect* respectively.

By clicking the arrow in the *A List of the Selected Alternatives* dropdown list (**Figure 5.3**), you can view which alternatives are selected for the search.

3. Click on the *View What?* button at the top of the window (**Figure 5.3**), so that the window similar to the one shown in **Figure 5. 9** will be displayed. Click the last radio button to specify that you want to view for the selected alternatives on all the attributes which have scored either more or less than a specified score. When you have made the selection, click the *View* button. For example, if you specify to *View any attributes better that 0.5 each for all the selected alternatives*, and Honda and BMW are the selected alternatives, you will see a picture similar to the one shown in **Figure 5.10**.

5.3.4   Compare Differences and Similarities between Two Alternatives

To search and compare differences and similarities between two alternatives, do the following.

1. Click the ⬜ button once in the toolbar of the main window (**Figure 5.6**). This will invoke the graphic window similar to **Figure 5.3**.

2. Add or remove alternatives by clicking on the alternative listed in the upper left pane or the *A List of Selected Alternatives:* dropdown list (**Figure 5.3**), and clicking the button *Select One* or *Deselect* respectively. Check that only two alternatives are selected by clicking the arrow in the *A List of the Selected Alternatives:* dropdown list (**Figure 5.3**). If not, use the *Select One* or *Deselect* button to add or remove alternatives from the selected list.

3. Click on the *View What?* button at the top of the Window (**Figure 5.3**), so that the window similar to the one shown in **Figure 5. 9** will be displayed. You may specify what you want to view by clicking the third radio button. You may specify whether you what to see the differences or similarities between the two and by how much. When you have made your selection, click the *View* button. The selection in **Figure 5.9** will display all areas where Yamaha and BMW are scored very differently, with at least 50% between the scores in each area (attribute). The outcome of the search is shown in **Figure 5.11**.
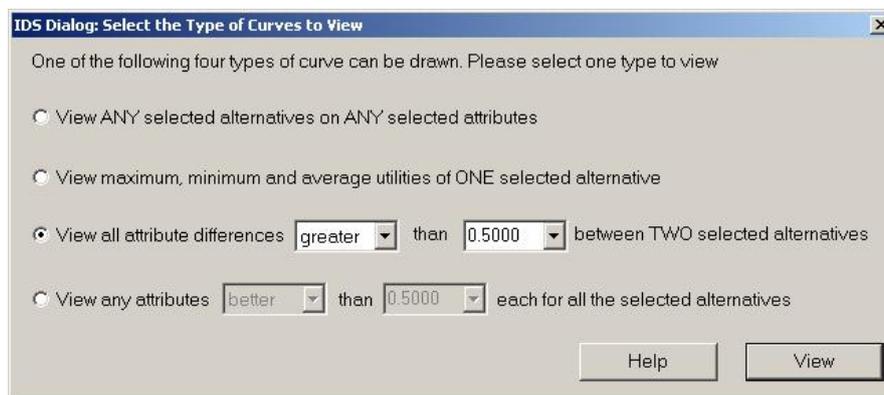

**Figure 5.9   Search and Compare Differences and Similarities between Two Alternatives**
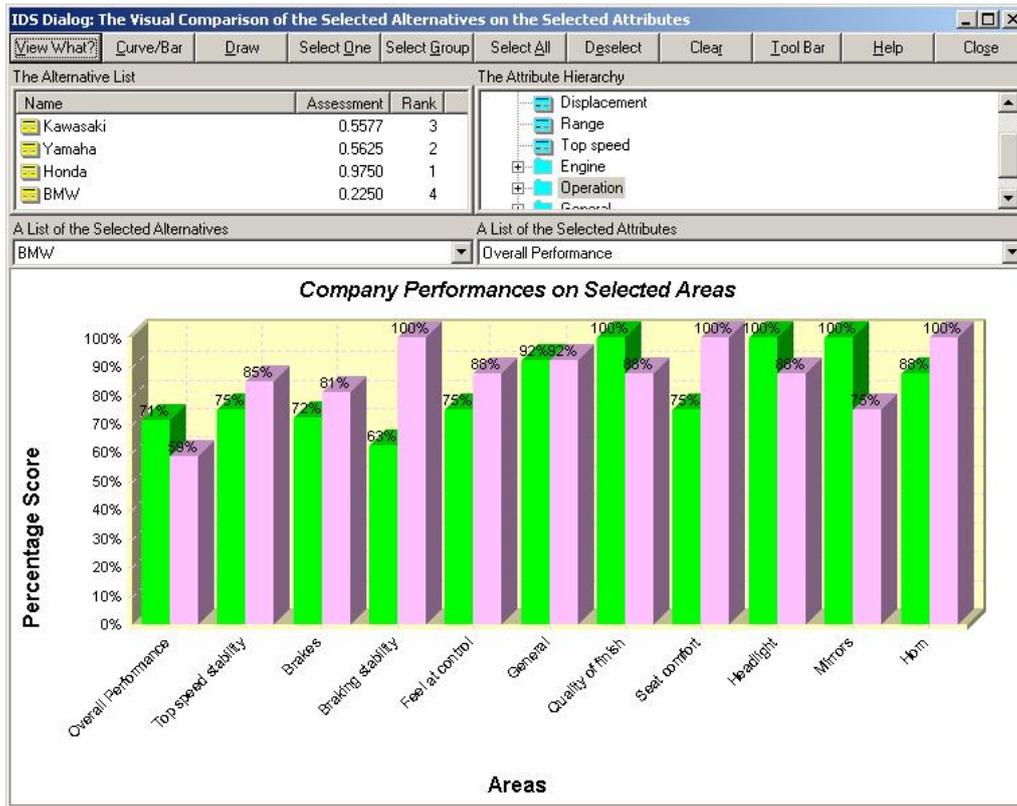
Figure 5.10   Search Outcomes Showing All Attributes Scored Higher than 50% for Both Honda and BMW
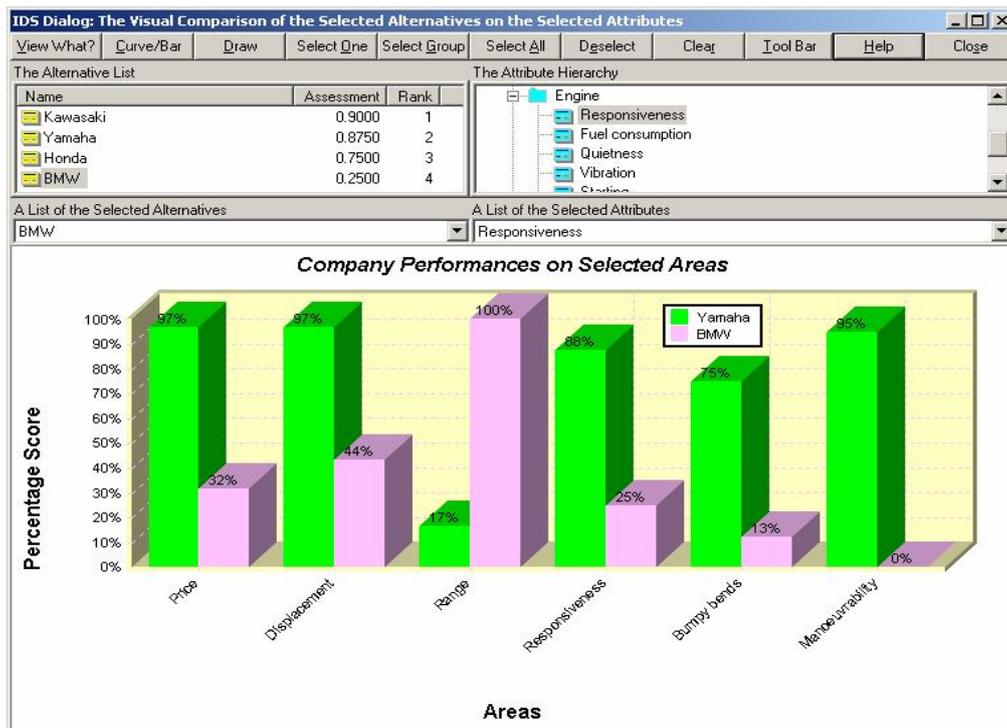

Figure 5.11   Search Outcomes Showing Major Differences between Yamaha and BMW

6   SENSITIVITY ANALYSIS

Decision maker are often interested in examining how changes in attribute weights and alternative performances on an attribute affect the overall ranking of alternatives. This is the purpose of sensitivity analysis.

When there is missing information in alternative assessments, the score ranges generated by the ER approach, such as the ones shown in **Figure 5.1** and **Figure 5.2**, are the outcomes of a kind of global sensitivity analysis carried out on the possible ranges of missing information.

On top of score ranges, IDS also provide 3 other types of sensitivity analysis: *Chang Weight*, *Change Input Data* and *Trade-Off Analysis*. They are described below.

6.1   Sensitivity Analysis on Change of Weight

To conduct sensitivity analysis on change of weight, do the following.

1. Click once on the attribute you are interested in changing its weight, for example, *Engine*, in the right pane of the IDS main window (**Figure 6.1**),

2. Select from the menu bar of the main window *Sensitivity -> Change Weight* (**Figure 6.1**). This will invoke a graphic window shown in **Figure 6.2**.
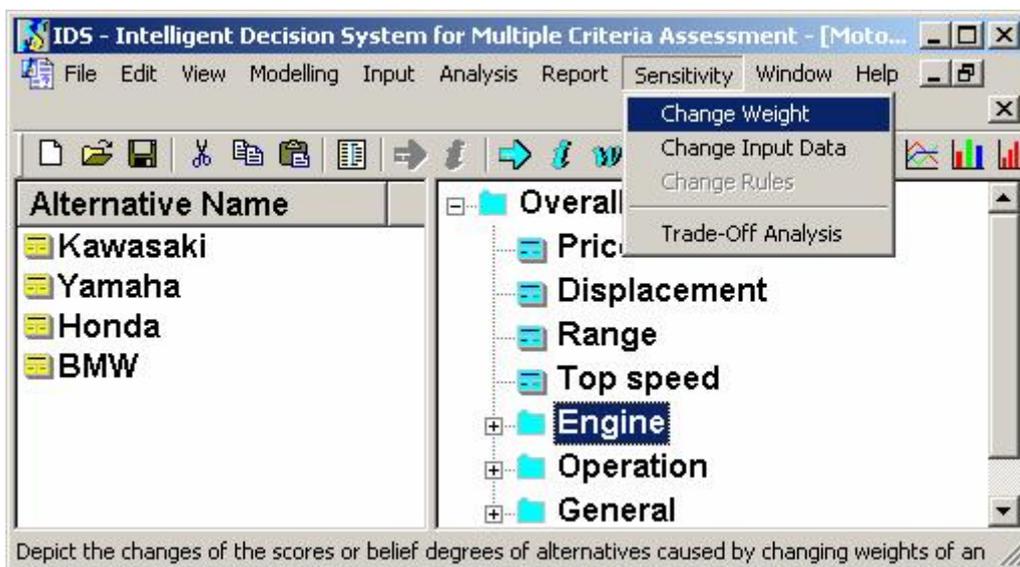
**Figure 6.1   Menu Selection for Sensitivity Analysis**

3. To see the effect of changing the weight for *Engine*, you need only to drag and drop the bar corresponding to the *Engine*'s weight in the lower left pane of the window (**Figure 6.2**) to the desired height. The scores of all the alternatives on *Overall Performance* change accordingly and are dynamically updated in the lower right pane of the window.

Figure 6.2   Ranking Sensitivity Analysis on Change of Weight

There are various options in this window to allow you to select alternatives and attributes. You can also choose weights of other attributes to change and use different types of graph for the analysis. The details are described below.

6.1.1   Select Alternatives to View Ranking

If you are only interested in the ranking of a number of alternatives, you may add or remove alternatives displayed in the lower right pane of the window by clicking on the alternatives listed in the upper left pane or the *A List of the Selected Alternatives:* dropdown list (**Figure 6.5**), and then clicking the button *Select One* or *Deselect One* respectively. Check that the alternatives listed in the *A List of the Selected Alternatives:* dropdown list are what you are interested in.

6.1.2   Select Attributes on Which to Rank Alternatives

If you wish to add or remove attributes in the lower right pane of the window, so that you can examine the rankings of the selected alternatives on these attributes, you should first make sure the radio button (on the right) *Click this button if you want to Select attributes on which to rank alternatives* is selected. Then you can click on the attributes listed in the upper right pane or the *A List of the Selected Attributes:* dropdown list (**Figure 6.2**), and click the button *Select One* or *Deselect* respectively.

6.1.3 Select Attributes for Changing Weights

If you wish to add or remove attributes in the lower left pane of the window, so that you can change weights for the attributes, you should first make sure the radio button (on the left) *Click this button if you want to select attributes for Changing weights* is selected. Then you can double click on the attribute you wish to select from the upper right pane (**Figure 6.2**). As soon as you double click on the attribute, the weights for the attribute and the other attributes in its group, which share the same father attribute, will be displayed in the lower left pane of the window. You may use the mouse to drag and drop the edge of the bars to change the weights of the attributes and see the effects of the changes in the lower right pane.

The weights displayed can be normalised. Click the *Normalise* button to get the weights normalised and click on the button again to cancel the normalisation.

6.1.4 Select Different Types of Sensitivity Analysis Graphs

There are three types of graphs for you to choose from: *Ranking*, *Belief Degree* and *Rank Change*. By default, the *Ranking* type (shown as in **Figure 6.2**) is displayed. If you click the *Rank Change* button at the top of the window, the graph type will change to the one shown in **Figure 6.3**. If you click the *Belief Degree* button at the top of the window, the graph type will change to the one shown in **Figure 6.4**.
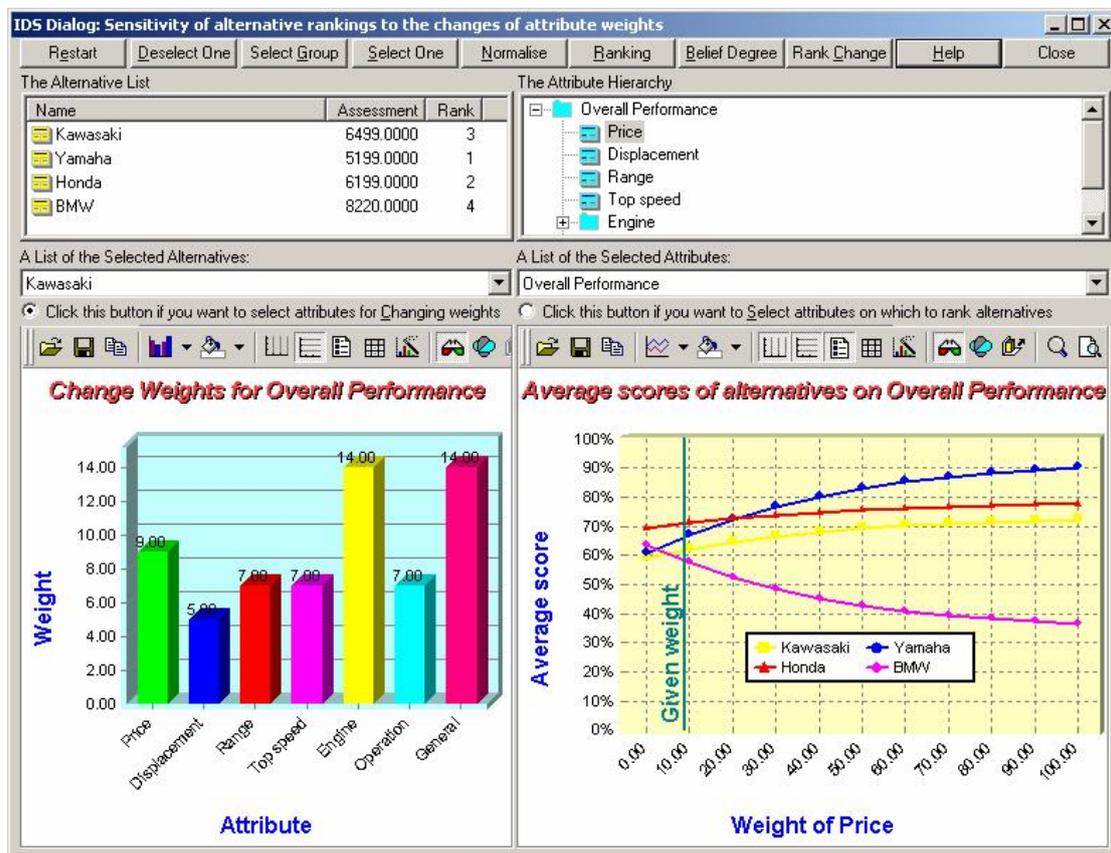

**Figure 6.3   Rank Change Sensitivity Analysis on Change of Weight**
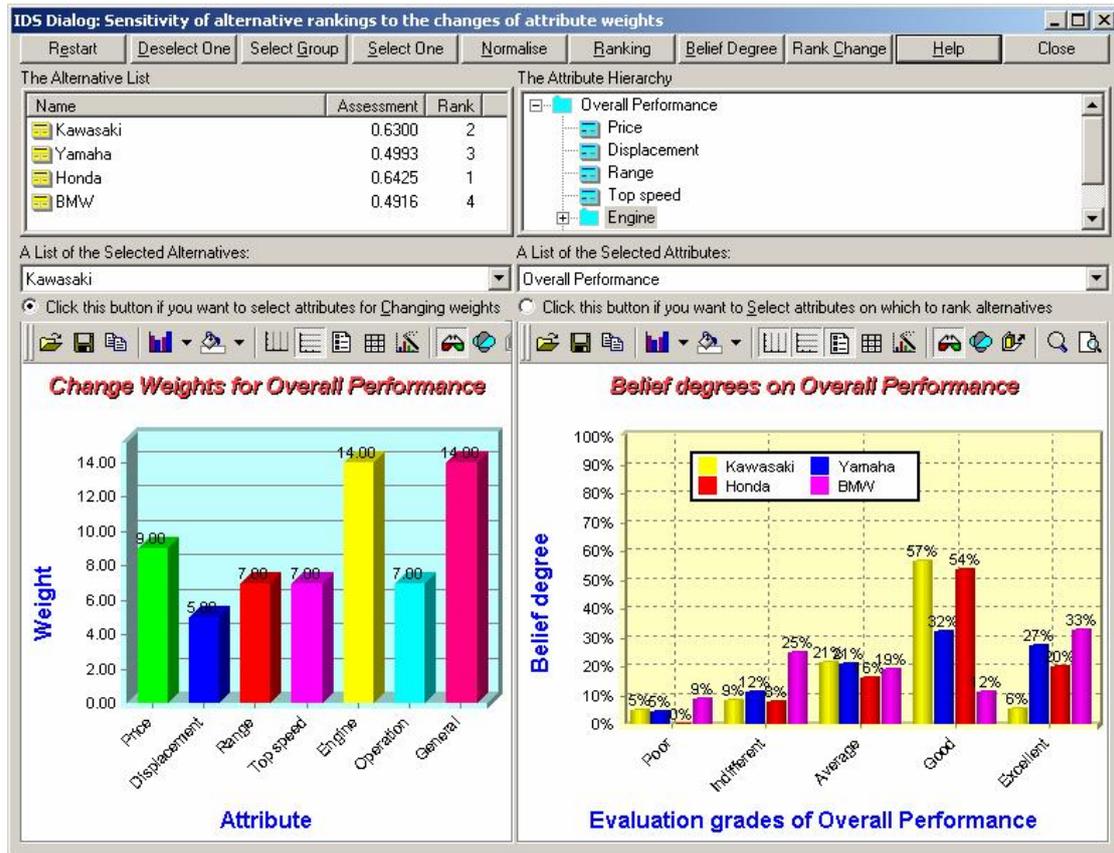
Figure 6.4   Belief Degree Sensitivity Analysis on Change of Weight

You may choose any type of the graphs according to your requirement. All graphs will respond dynamically to any changes you make to the attribute weights displayed in the lower left pane. Note that the ER approach is a nonlinear aggregation method and the nonlinearity is shown in **Figure 6.3**.

6.2   Sensitivity Analysis on Change of Input Data

To conduct sensitivity analysis on change of input data, do the following.

1. Click once on an alternative, for example *Honda*, in the left pane of the IDS main window (**Figure 6.1**) to select it.

2. Click once on the attribute in the right pane of the IDS main window (**Figure 6.1**) on which you wish to change the assessment data for the selected alternative. The attributes have to be at the bottom level of the hierarchy, for example, *Quietness*, in the right pane of the IDS main window (**Figure 6.1**),

3. Select from the menu bar of the main window *Sensitivity -> Change Input Data* (**Figure 6.1**). This will generate a graph shown in **Figure 6.5**.

4. To see the effect of changing the assessment data for the selected alternative on the selected attribute, you need only to change the assessment input by

dragging and dropping the bars (from the top edge or zero level if the belief degree is 0.00 and the bar is not shown) corresponding to the belief degrees of the assessment grades for the attribute if it is of a qualitative type (**Figure 6.5**) or the attribute value if it is of a quantitative type (**Figure 6.6**). The scores of all the alternatives on the selected attribute change accordingly and are dynamically updated in the lower right pane of the window.
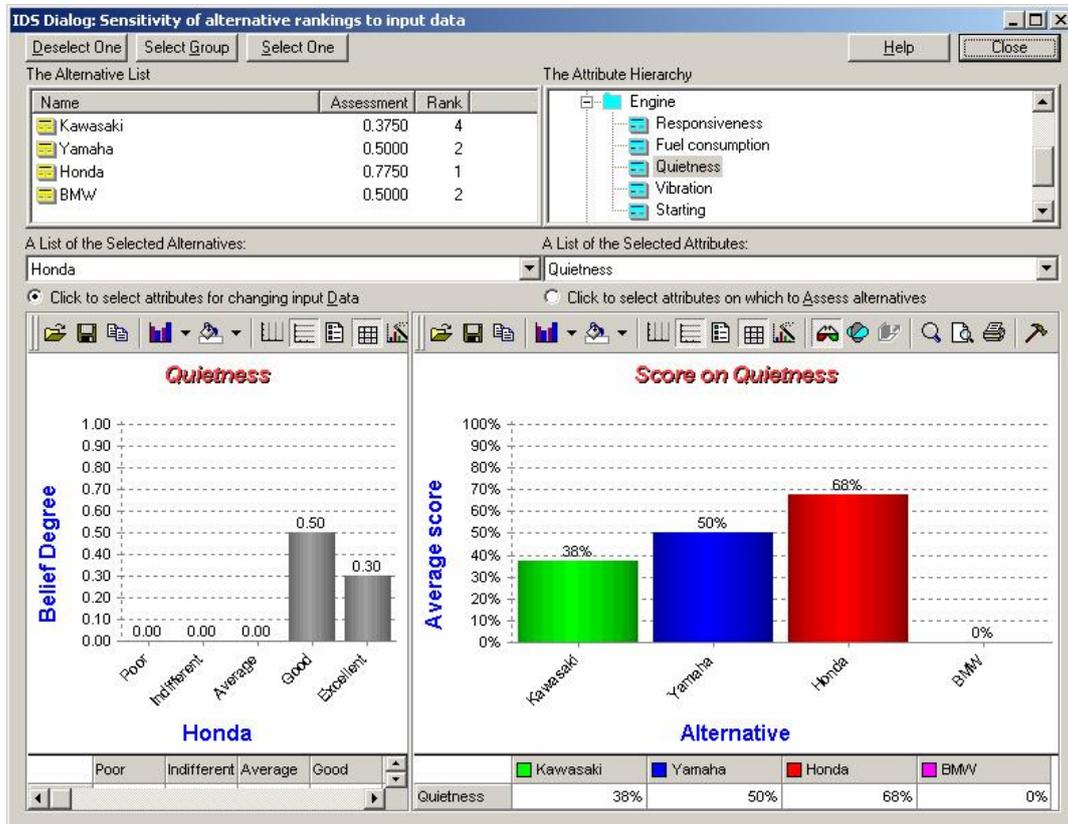

Figure 6.5   Ranking Sensitivity Analysis on Change of Input Data for Qualitative Attributes
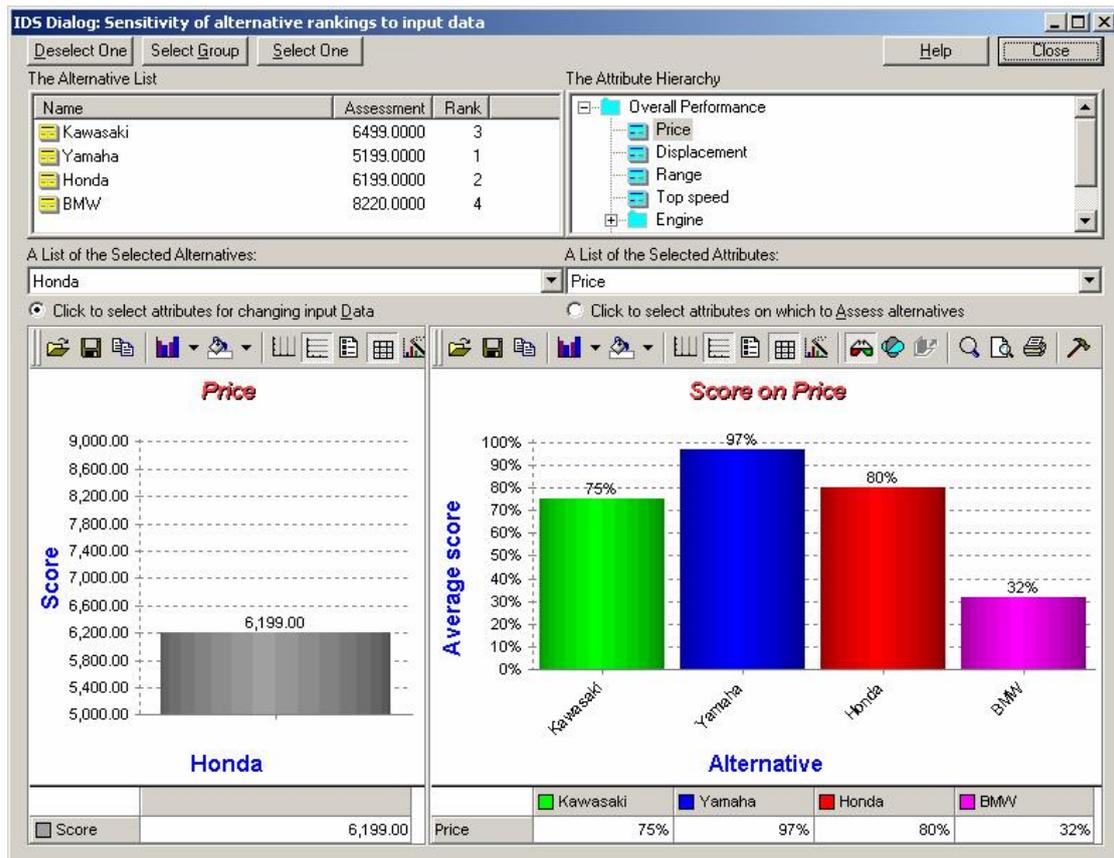
**Figure 6.6   Ranking Sensitivity Analysis on Change of
Input Data for Quantitative Attributes**

There are various options in this window to allow you to select any alternative and any bottom level attribute for changing input data through the lower left pane of the window (**Figure 6.5** or **Figure 6.6**). You can also choose any attribute or a number of attributes from different levels in the hierarchy on which to view the ranking changes simultaneously.

6.2.1   Select Alternatives to View Ranking

If you are only interested in the ranking of a number of alternatives, you may add or remove alternatives displayed in the lower right pane of the window by clicking on the alternatives listed in the upper left pane or the *A List of the Selected Alternatives:* dropdown list (**Figure 6.5**), and then clicking the button *Select One* or *Deselect One* respectively. Check that the alternatives listed in the *A List of the Selected Alternatives:* dropdown list are what you are interested in.

6.2.2   Select Attributes on Which to Rank Alternatives

If you wish to add or remove attributes in the lower right pane of the window, so that you can examine the rankings of the alternatives on these attributes, you should first make sure the radio button (on the right) *Click to Select attributes on which to Assess alternatives* is selected. Then you can click on the attributes listed in the upper right pane or the *A List of the Selected Attributes:* dropdown list (**Figure 6.5**), and click the button *Select One* or *Deselect One* respectively.

6.2.3 Change Selection of Attribute for Changing Input Data

From the window shown in **Figure 6.5**, you may select any bottom level attribute for changing input data for a selected alternative. Changing the selection of an alternative is discussed in the next section.

If you wish to change the assessment information for the attribute currently displayed in the lower left pane of the window, you should first make sure that the radio button (on the left) *Click to Select attributes for Changing input Data* is selected. Then you can double click on the attribute you wish to select from the upper right pane (**Figure 6.5**). As soon as you double click on the attribute, the assessment information for the selected alternative on the attribute will be displayed in the lower left pane of the window. You may use the mouse to drag and drop the edge of the bars to change the input data and see the effects of the changes in the lower right pane.

6.2.4 Change Selection of Alternative for Changing Input Data

To change the selection of alternative for changing input data on the selected attribute is simple. You need only to click once on the bar corresponding to the alternative in which you are interested in the lower right pane of the window (**Figure 6.5**). If the alternative is not shown in the pane, you may follow the instruction described in **Section 6.2.1** to add it on in the lower right pane of the window.

6.3 Trade-Off Analysis

Trade off analysis is to compare all alternatives on two attributes, usually one cost related attribute and the other benefit related attribute. Therefore, the trade-off analysis is sometimes called cost-benefit analysis. The picture will visually display any best value options and worst value options.

To conduct the analysis, do the fowling:

1. Click once on an attribute in any level of the attribute hierarchy, for example *Price*, in the right pane of the IDS main window (**Figure 6.1**).

2. Click once on another attribute in the hierarchy.

3. Click the ⬚ button from the toolbar of the main window (**Figure 6.1**). This will invoke the graphic window shown in **Figure 6.7**.

Note that the attribute selected first (in step 1) will be on the X-axis in the graph and the second attribute on the Y-axis.
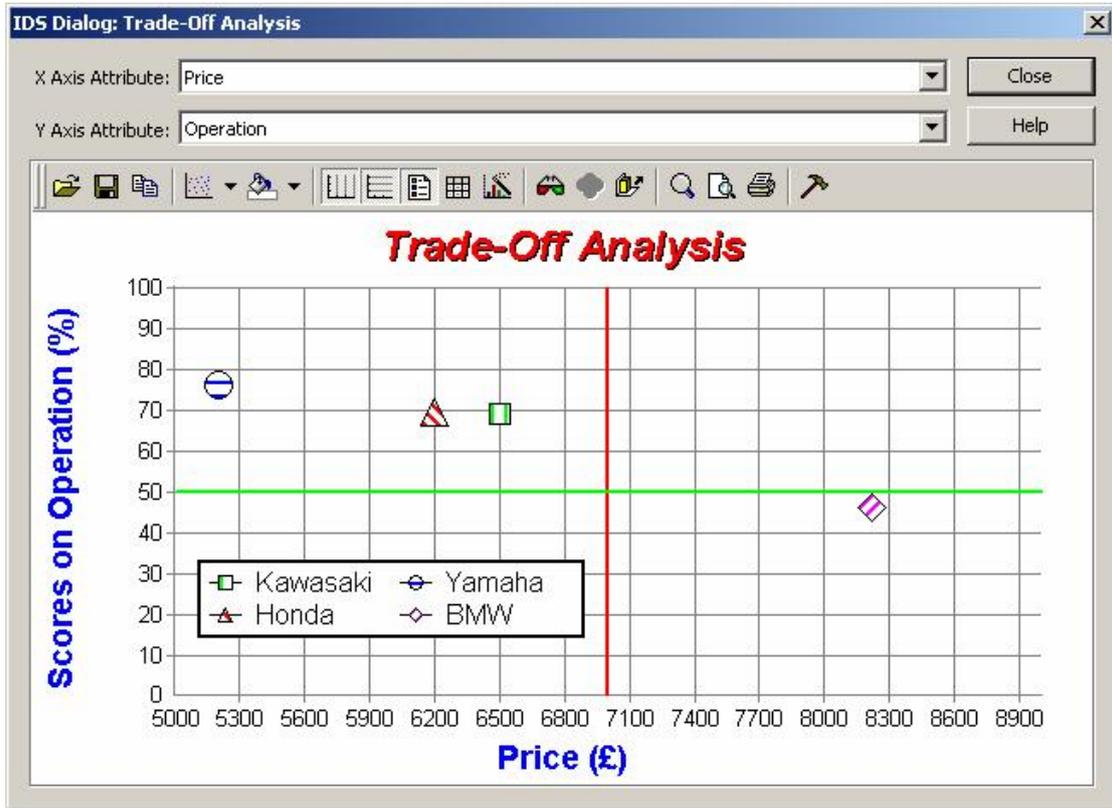
Figure 6.7   Trade-Off Analysis

7   ADVANCED FUNCTIONS

This section describes several other functions in IDS which may help you save time and effort during modelling, data collection and data output processes. Although they are called advanced functions, they are not necessarily difficult to learn.

7.1   Compare Results Using Different Models

Experts may do their estimates separately in their own computers. They may use the same cost model (including hierarchy and attribute definitions). They may also use different models. How to compare the estimates made by different experts side by side? We will look at two cases below.

7.1.1   Compare Results Using the Same Model Structure

If you have two or more IDS Multicriteria Assessor files (with extension .ids) and they have the same model structure, you can import the alternatives from one file to another file. To do it, you need to

1. Open the .ids files and make sure that all alternative names in different files are different from each other. If they are the same, the data may be over-written by the imported file;

2. **Click once on any of the alternatives listed in the left pane. If you leave the cursor in the right pane on any of the attributes, the view of the alternative list will not be updated automatically after importing. However, you may manually update the view by clicking any alternative and then clicking the 🔅 icon in the toolbar.**

3. Select from the menu bar in the program main window *Input -> Add Data from IDS File*, and then from the window similar to **Figure 2.9** browse and select the file you wish to import. Once you have selected the file and press the *Add* button, the alternatives in the selected file will be added to the current window,

4. Save the file in another name from the menu bar in the program main window *File->Save As…*

7.1.2   Compare Results Using Different Model Structures

If the models in different files are completely different, the data in the two files can not be compared directly. It makes sense to only compare things with some similarity.

If you have two or more .ids files and they have different model structures to certain degrees, you may still be able to import the alternatives in one file to another by following the steps in the previous section. The importing function will import the alternatives and their data on the attributes that are common to both models. **Therefore you should always import the alternatives of a more detailed model -- a model with more sub attributes, into a less detailed model. This is because the attribute hierarchy of the less detailed model is common to both models.**

When importing, you should make sure that the *Best Value* and *Worst Value* are the same for the common quantitative attributes in both the current .ids file (container file) and the imported .ids file.

7.2   Save the Model and Data in Text File

If you wish to save the model and the assessment information for an alternative in text format, you can do so by

1. Clicking the alternative you want to save from the left pane of the program main window,

2. Clicking from the menu of the window *Report->Save in Text File -> Alternative* (**Figure 7.1**). This will bring a window similar to the one shown in **Figure 7.2**,

If you wish to save only the model structure (the hierarchy), you can select the second radio button and then clicking the *Start Saving* button (**Figure 7.2**). If you wish to save the data for the selected alternative, you can select the first radio button, and then from the enabled list below, select what you want to save.

The text may not be in the exact format you want and you may need to edit them for your reporting purposes.

You may also save all the alternative estimates on one selected attribute by clicking the *Report->Save in Text File -> Attribute* (**Figure 7.1**) menu in the program main window.
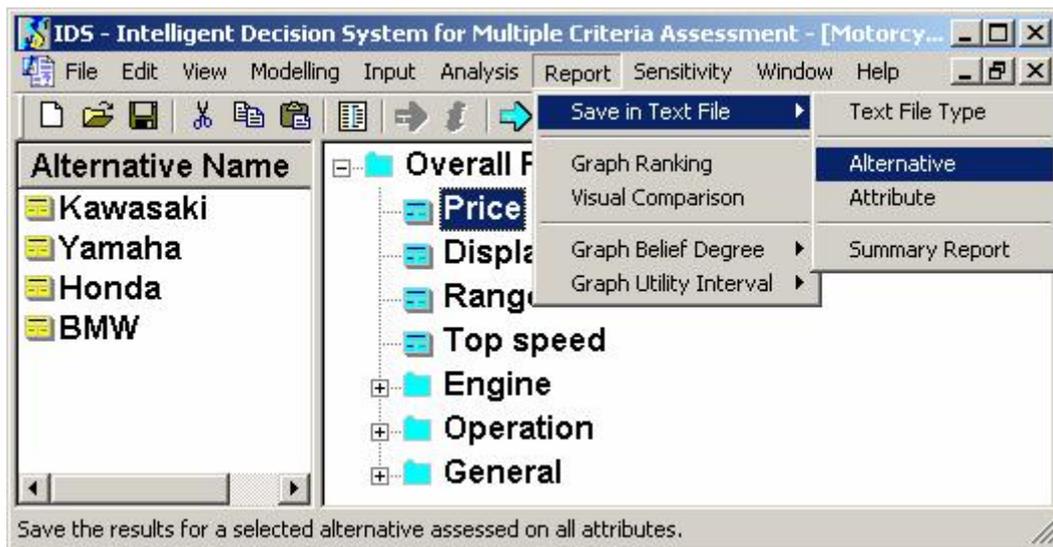

**Figure 7.1   Menu Selection for Saving Model and Data in Text File**
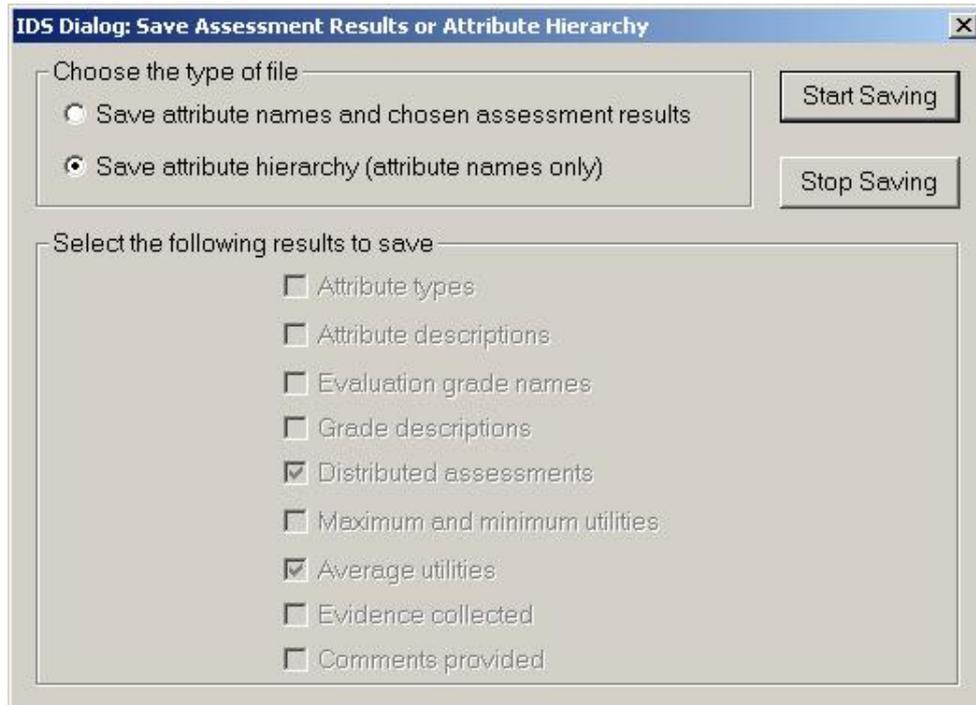
Figure 7.2   Save the Model in Text Format

7.3   Import or Copy Graphs

7.3.1   Copy Graphs to Other Documents
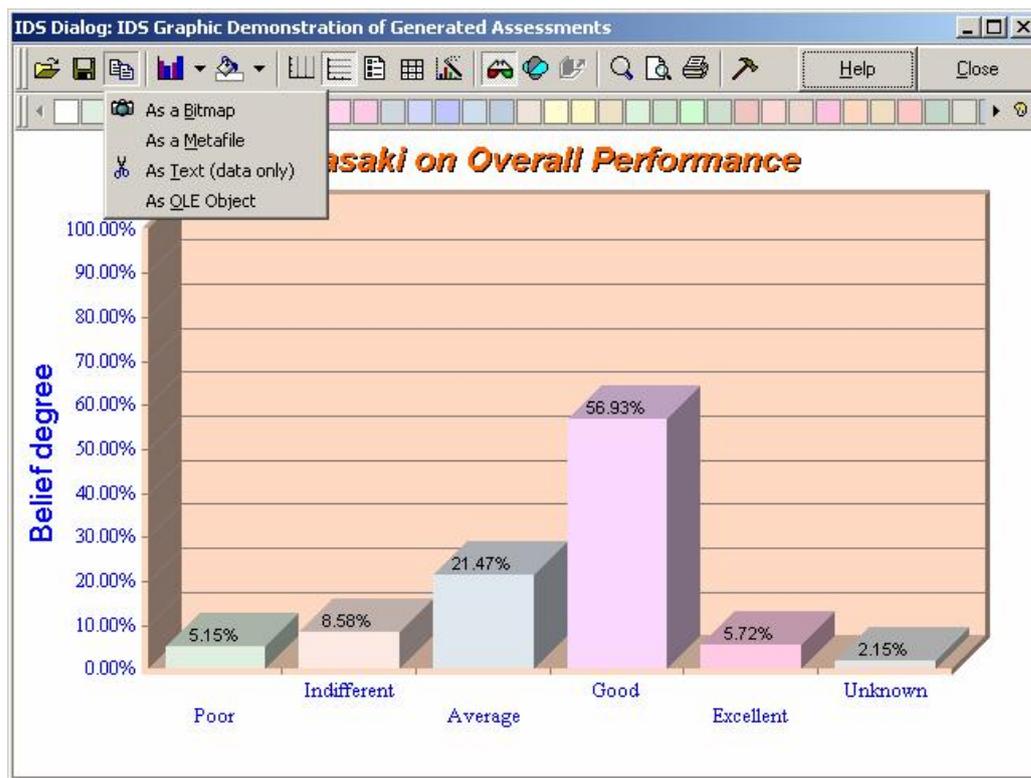
Figure 7.3   Copy a Graph and Graph Toolbar

If you wish to use a graph in presentations or reports, you can left click the [icon] button in the graph toolbar at the top of the graph window (as shown in **Figure 7.3**), from the pop up menu select *As a Bitmap* (or *As a Metafile*), and then paste it into your power point or word documents**.**

7.3.2 Change Colours

If you wish to change any colour in a graph, you can right click the colour you want to change, from the pop up menu select *Color* and then pick up a desired colour from the provided colour pallet, as shown in **Figure 5.2.**

7.3.3 Change Font

If you wish to change any font in a graph, you can right click the text for which you want to change the font, from the pop up menu select *Font…* and then pick up a desired font from the provided font changing window.

7.3.4 Change Graph Titles, Titles for X-Axis and Y-Axis

If you wish to change the text in a graph titles and the titles for X-Axis or Y-Axis, you can right click the title you want to change, from the pop up menu select *Edit Title* and then type the text you want in the space provided.

7.3.5 Change the Appearance of a Graph

If you wish to change any part of the Graph Titles, you can right click the place you want to change, from the pop up menu select *Properties*…and then use the provided chart properties window to make the change (**Figure 5.4** and **Figure 5.8**).

You can also use the graph toolbar at the top of the graph window to change the style of the graph, add or remove gridlines, switch between 3-D and 2-D, and print the graph.

7.4 Aggregating A Group of Alternatives

To aggregate the assessments of several alternatives, you need to create a Group alternative by following the steps below.

You can create a group alternative by clicking in the alternative pane and then the *Modelling -> Alternative -> Create Group Assessment* menus (**Figure 7.4)**. This will activate a window similar to **Figure 7.5**.

You can select and deselect any alternatives to form the group alternative. You may also change the weight of any of the alternatives selected. The dropdown list in the window will display which alternatives are included in the group.

For the aggregated group alternative, the belief degrees associated with the grades or the value of each bottom level attribute are the weighted average of the belief degrees or the values of the alternatives in the group on the attribute.
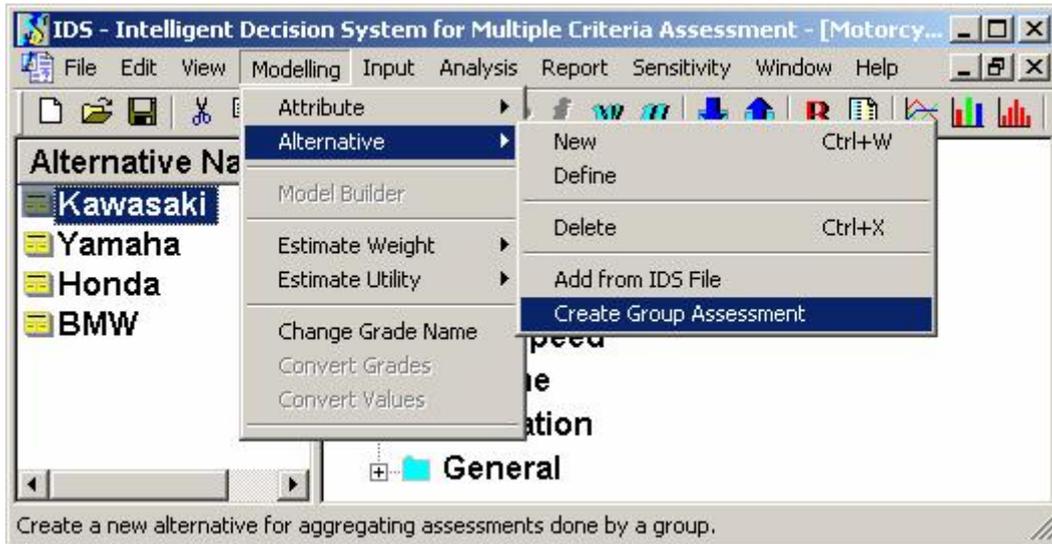
Figure 7.4   Menu for Generate a Group Alternative
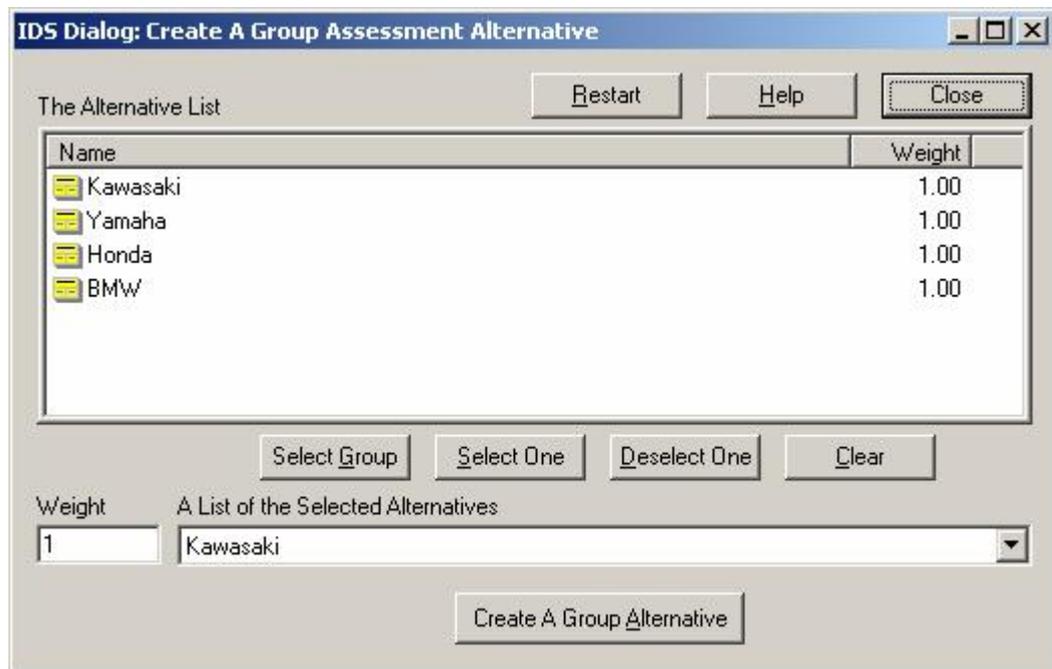
Figure 7.5   Windows for Generating a Group Alternative

APPENDIX COMPARE ER APPROACH WITH AHP

People who know AHP method often ask what are the differences between the ER approach and the AHP method. Although both ER and AHP use hierarchical structure to model a MADA problem, ER differs from AHP in the following ways.

1. In the ER framework, alternatives are not in the hierarchical structure, while in AHP all alternatives consist of the bottom level of the hierarchy.

2. ER approach uses a belief decision matrix to model a MADA problem. Each element of the matrix is a distributed assessment in forms of the belief structure. In a conventional decision matrix, each of its element is a single number. In AHP, the decision matrix becomes a pairwise comparison matrix with each element describing the relative importance of an attribute over another attribute or the relative preference of an alternative over another alternative.

3. ER uses the Evidential Reasoning approach to aggregate the distributed assessments of the lower level attributes to higher level attributes progressively.

4. AHP and many other methods based on the additive value/utility function approach that requires the attributes of a MCDM problem to satisfy the additive preferential independence condition. Such a condition limits the scale of MCDM problems those methods can handle. ER approach does not require such a condition and can handle large scale MADM problems. There is no limit on the number of attributes in the IDS hierarchy or on the number of alternatives to be assessed. For example, IDS has been used for conducting organisational self-assessment, which includes 3 levels of criteria. There are 9 criteria in level 1, 32 in level 2, and 210 in level 3. IDS can handle it easily with a 256 MB RAM PC. It would be a daunting task for AHP.

5. IDS can assess newly added alternatives independently. Because IDS calculates a ranking score for an alternative independently, when new alternatives are presented to IDS, IDS does not need to re-evaluate the previously assessed alternatives. AHP, on the other hand, is based on pairwise comparisons. When new alternatives are presented to AHP, the assessments done on the old alternatives have to be abandoned. A new assessment procedure has to be started taking into account all the old and newly added alternatives.

6. IDS produces consistent rankings after new alternatives are added into the assessment procedure. It is known that the use of AHP may lead to problems like rank reversal, that is, the introduction of new alternatives for assessment may cause the unexpected and irrational change of the rankings of the current alternatives.

7. In addition to generate a score for each alternative, IDS produces a distributed assessment. The distributed assessment gives the decision maker an idea of the diversity of the performance of an alternative.

8. IDS can handle mixed information with uncertainties in the same ER framework. The mixed information includes deterministic, random, qualitative and incomplete or missing data for some attributes.

9. IDS also uses the pairwise comparison method as one of its weighting elicitation methods.