

A first-use tutorial for the VIP Analysis software

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The software *VIP Analysis* supports decision-making in choice problems where a Decision Maker (DM) wishes to select an alternative from a set of several potential ones, accounting for multiple criteria at the same time. The underlying model is that of additive aggregation of value (or utility) functions, without needing to specify precise values for the model's scaling constants that (indirectly) reflect the importance of each criterion. *VIP Analysis* implements a methodology to deal with Variable Interdependent Parameters presented in:

Dias, L. C. & J. N. Clímaco, "Additive Aggregation with Variable Interdependent Parameters: the VIP Analysis Software", Journal of the Operational Research Society, Vol. 51, No. 9, pp. 1070-1082, 2000.

This tutorial concerns the Version 1.0 of the software.

INSTALLATION

V.I.P. Analysis runs on Windows 95/98 computers, as well as posterior Microsoft operating systems. The monitor should be at least VGA (640x480) with 16 colors. It occupies very little space on disk and has minimum requirements in terms of RAM. The program may run without a mouse, but becomes somewhat cumbersome to use. You should have a 2-button mouse to make the best use of this software. To access the on-line manual you must have a default browser installed (e.g. Microsoft Explorer or Netscape).

Unzip the file VIP1.zip to the folder where you want it to be located (e.g. the "Program Files" folder). The unzipped folder should contain the program (vip1.exe), a folder "Manual", this document (vip_tutorial.pdf), and an example input file (example.vip). No updates to the Windows registry or Start Menu are performed. The software is now ready to run.

GUIDED TOUR OF VIP ANALYSIS

Start the program `vip1.exe` (e.g. double-click on its icon) and choose the option **Open...** from menu **File** (you may either choose **File|Open...** or button ). Locate the file `example.vip` and press button **OK** (or press key **ENTER**).

The initial data appear on the program window (Figure 1). For convenience, in any moment you may change the size of the window or maximize it, drag the splitter to the right or left, and/or change the size of the cells displaying the data (using the controls ).

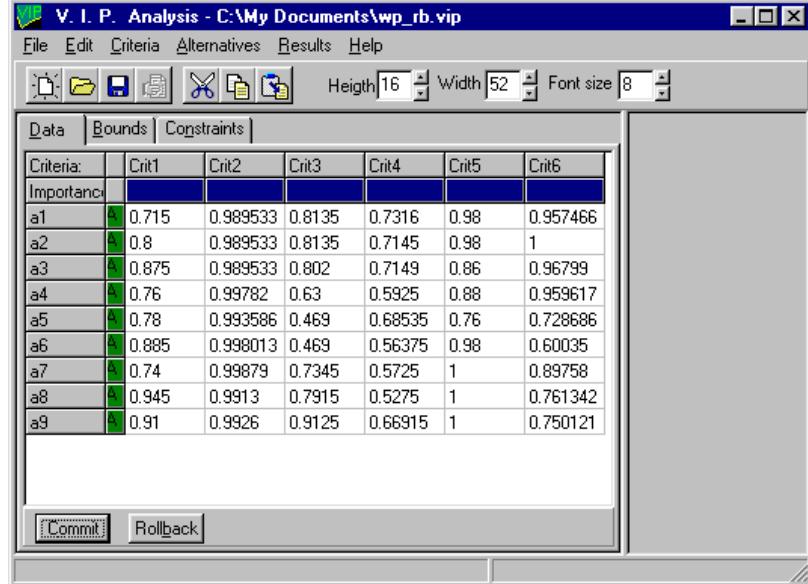


Figure 1: Single-criteria value for 9 alternatives according to six value functions

The data displayed on tab **Data** concern a situation analysed by Keeney and Nair in the 70s. We follow this study as reported by Roy and Bouyssou, who consider an additive aggregation model.¹ This decision situation concerned the choice of a location for a nuclear plant, faced by the Washington Public Power Supply System. There are nine potential sites (a_1 to a_9) and six criteria: impact on human health ($crit1$); loss of salmon ($crit2$); impact on other species ($crit3$); impact on economy ($crit4$); aesthetics ($crit5$); cost ($crit6$). The table on tab **Data** indicates the value of each alternative according to each of six criteria ($v_j(a_i)$, $i=1,\dots,9$, $j=1,\dots,6$). For instance, alternative a_1 is valued at 0.715 according to the first criterion ($v_1(a_1)=0.715$), being the worst alternative according that criterion (although it is the best one according to the fourth criterion, with $v_4(a_1)=0.7316$).

According to the additive model, the overall value of each alternative is given by

$$V(a_i) = k_1 v_1(a_i) + k_2 v_2(a_i) + \dots + k_6 v_6(a_i),$$

¹ B. Roy and D. Bouyssou. *Aide multicritère à la décision: méthodes et cas*. Economica: Paris, 1993.

where the parameters k_1, \dots, k_6 are denoted scaling constants and reflect the relative weight of the six value functions. More precisely, they reflect trade-offs among the six value functions. These values are normalised such that $k_1 + k_2 + \dots + k_6 = 1$ and $k_1, \dots, k_6 \geq 0$. The analysts started by asking some questions to the DMs and inferred from their answers the following order for the scaling constants:

$$k_6 > k_1 > k_2 > k_4 > k_5 > k_3.$$

Then, they continued asking questions to the DM to obtain precise values for these parameters.

The current status of the data reflect the intermediate stage where the analysts have inferred an order for the scaling constants, but have not yet tried to obtain more precise information. The table on the **Bounds** tab (Figure 2) shows that no bounds for the parameters were fixed, apart from the natural bounds that no scaling constant may be negative nor higher than 1.

	Data	Bounds	Constraints			
	Crit1	Crit2	Crit3	Crit4	Crit5	Crit6
LowerB	0	0	0	0	0	0
UpperB	1	1	1	1	1	1

Figure 2: Lower and upper bounds for the scaling constants.

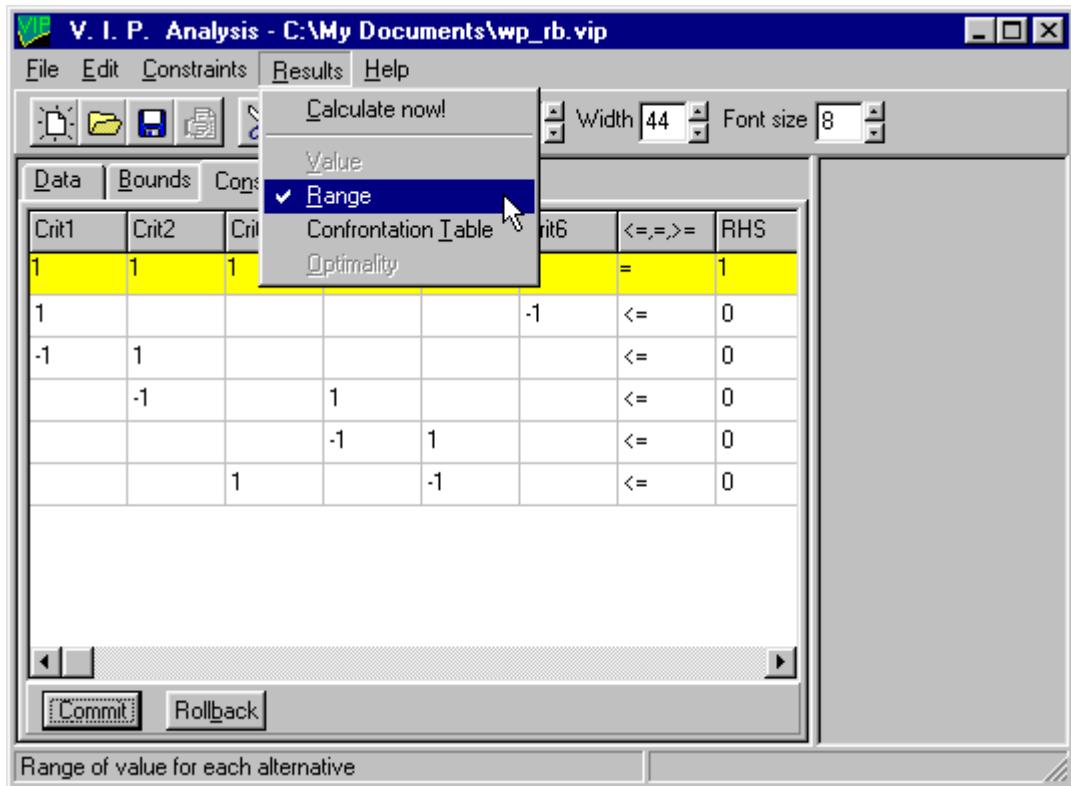


Figure 3: Additional constraints for the scaling constants.

The table that can be seen on the **Constraints** tab (Figure 3) shows the normalisation constraint ($k_1 + k_2 + \dots + k_6 = 1$) plus five additional constraints in five consecutive lines (from top to bottom: $k_1 - k_6 \leq 0$, $(-k_1) + k_2 \leq 0$; $(-k_2) + k_4 \leq 0$; $(-k_4) + k_5 \leq 0$; and $k_3 - k_5 \leq 0$). Together, these five constraints define the order $k_6 \geq k_1 \geq k_2 \geq k_4 \geq k_5 \geq k_3$.

Hence, every possible combination of positive values for the scaling constants satisfying those constraints are considered equally acceptable for the moment. The role of VIP Analysis is now to discover which results (and conclusions) can be drawn considering this set of acceptable parameters.

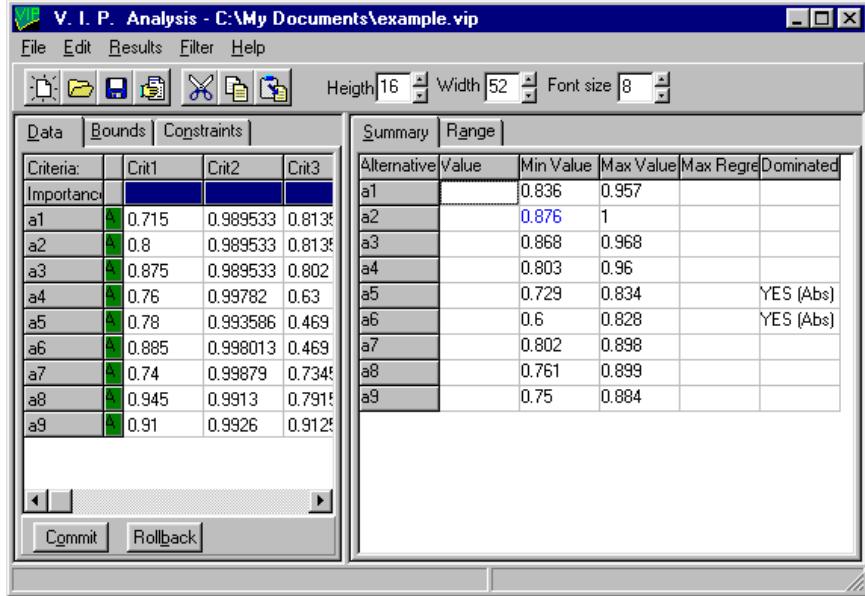


Figure 4: Summary of results.

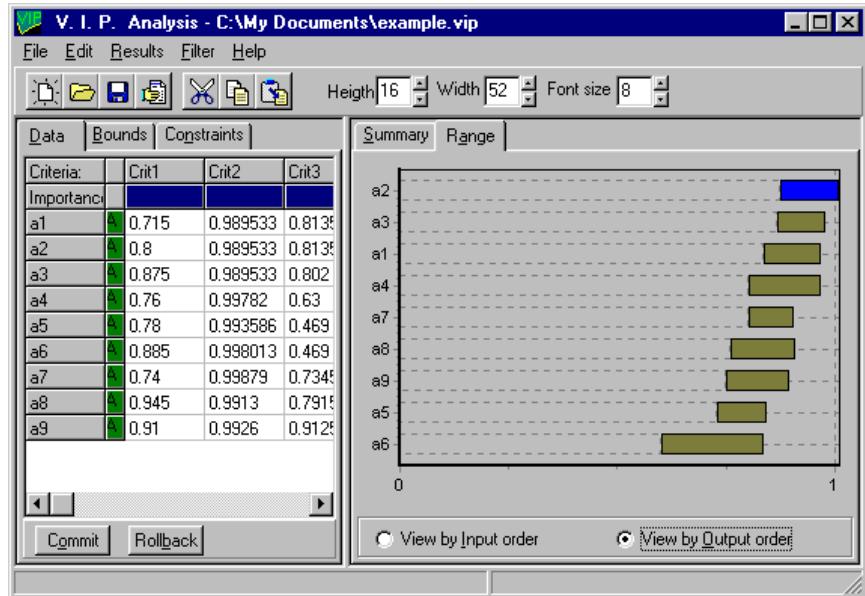


Figure 5: Range of value for the alternatives sorted by minimum value.

As a first approach, VIP Analysis will compute the range of value for each alternative, i.e. the minimum and maximum global value that each alternative may have, subject to the constraints on the scaling constants k_1, \dots, k_6 . Choose the option **Range** from the **Results** menu (Figure 3) to indicate this result is to be calculated and then choose the option **Calculate now!** From the same menu. The right part of the VIP Analysis window will then show the outputs (Figure 4 and Figure 5). Figure 4 indicates that alternatives a_5 and a_6 are *absolutely dominated* because their maximum value

is less than the minimum value of a_1 . Hence, whatever the value for the scaling constants k_1, \dots, k_6 , the alternatives a_5 and a_6 are considered worse than a_1 . The ranges may be seen graphically (Figure 5) either by input order (a_1, a_2 , etc.) or by output order (sorted by their minimum value). The results show that a_2 and a_3 are the best according to the minimum value rule.

The software offers the possibility of filtering the set of alternatives, based on their minimum value, maximum regret or on the possibility of being dominated. In this case, suppose the DM would pretend to focus on the alternatives with value always higher than 0.8. Choosing the option **by Min Value** of menu **Filter** allows to mark some alternatives as inactive (Figure 6). The inactive alternatives are not deleted, so that they may be reactivated later. In this case, the marked alternatives are a_5, a_6, a_8 and a_9 , which appear with a red mark on the left part of the VIP Analysis window, while they are omitted from the results presented on the right part of the window (Figure 7)

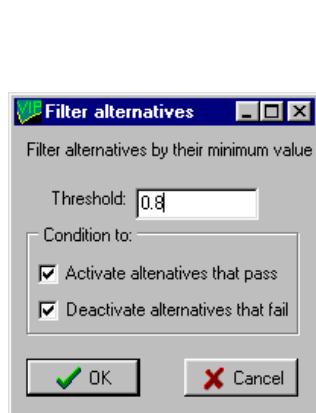


Figure 6: Filter.

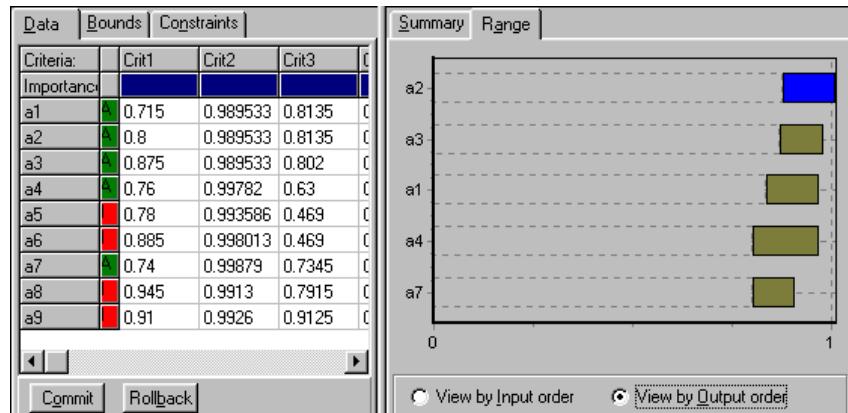


Figure 7: After filtering.

Another result that VIP Analysis can compute is the Pairwise Confrontation Table, which indicates the maximum advantage (difference of value) of each alternative over each other one. To perform this, choose the **Confrontation Table** option from the **Results menu** and then choose the option **Calculate now!** from the same menu. The right part of the VIP Analysis window will then show the table under tab **Confrontation** (Figure 8).

	a1	a2	a3	a4	a7
a1		-0.018	-0.004	0.061	0.06
a2	0.064		0.032	0.08	0.102
a3	0.085	0.021		0.065	0.103
a4	0.024	-0.024	-0.008		0.062
a7	-0.009	-0.051	-0.04	0.021	
Max Regret	0.085	0.021	0.032	0.08	0.103

Tolerance: x10 /10
k=[0 0 0 0 0 1]. [Tight: 2 3 4 5]

Figure 8: Pairwise confrontation table.

The negative cells are marked in red colour indicating that the alternative corresponding to the respective row is *dominated* by the one corresponding to the respective column. Indeed, if the maximum advantage (difference of value) is negative, then this means that the row-alternative value is always lower than the column-alternative value for any values of k_1, \dots, k_6 respecting the imposed constraints. By considering only the constraints $k_6 \geq k_1 \geq k_2 \geq k_4 \geq k_5 \geq k_3$, it is possible to extract some interesting conclusions about a_2 and a_3 : they are the only non-dominated ones and they are the best two in terms of minimum value and maximum regret.² These alternatives happened to be the two with highest value in the original study.

When the user selects a cell, the program displays the value of the scaling constants that optimise it, as well as the inequalities that are binding at that optimum (these are the constraints that might lead to a different optimum if they were changed). For instance, for the selected cell (a_2, a_3) , the maximum advantage favourable to a_2 is 0.032, which occurs when $k_6 = 1$ and all other scaling constants are null. If the DM finds this unacceptable, then he/she can add further constraints. For instance, the DM may try to answer some questions regarding trade-offs among the criteria. Suppose that his/her answers imply the following constraints to add to the existing ones, using the option **Insert** from menu **Constraints** (Figure 9):

- one unit of value in $v_3(\cdot)$ is worth 0.06 units of value in $v_2(\cdot)$ $\Rightarrow -0.06 k_2 + k_3 = 0$;
- one unit of value in $v_4(\cdot)$ is worth 0.26 units of value in $v_6(\cdot)$ $\Rightarrow k_4 - 0.26 k_6 = 0$;
- one unit of value in $v_5(\cdot)$ is worth 0.15 units of value in $v_6(\cdot)$ $\Rightarrow k_5 - 0.15 k_6 = 0$.

Constraints							
Crit1	Crit2	Crit3	Crit4	Crit5	Crit6	$\leq, =, \geq$	RHS
1	1	1	1	1	1	=	1
1					-1	\leq	0
-1	1					\leq	0
	-1		1			\leq	0
		-1	1			\leq	0
		1		-1		\leq	0
-0.06	1					=	0
		1			-0.26	=	0
			1	-0.15		=	0

Commit **Rollback**

Figure 9: New set of constraints.

After confirming the changes (button **Commit**), the option **Optimality** from the **Results** menu becomes available, since the parameter space can now be illustrated in two dimensions. Choosing

² Maximum regret is the maximum disadvantage of an alternative when compared with any other alternative. It corresponds to the maximum value in each column, which is depicted graphically under tab **Max regret** (not illustrated here).

that option and then the option **Calculate now!** from the same menu produces new results. You can check that a_2 and a_3 are still the best in terms of minimum values (tab **Ranges**) and the ranges have become narrower, which is due to the fact that introducing constraints excludes some combinations of parameter values and corresponding results that were previously deemed acceptable. You can also check that a_2 and a_3 are the only non-dominated ones (tab **Confrontation**). A new tab **Optimality** appears with a graphical representation of the region in the parameter space where each alternative is the best. To observe figure 10 in your computer, perform the following actions:

- choose the tab **Optimality**;
- select the row relative to a_3 and use the right button of the mouse to select the option **Alternative at the bottom** from the pop-up menu;
- select the row relative to a_2 and use the right button of the mouse to select the option **Alternative at the top** from the pop-up menu;
- resize the window, if needed;
- click on a point in the green region;
- drag the **Tolerance** “trackbar” a little to the right, so that the tolerance becomes *0.1*.

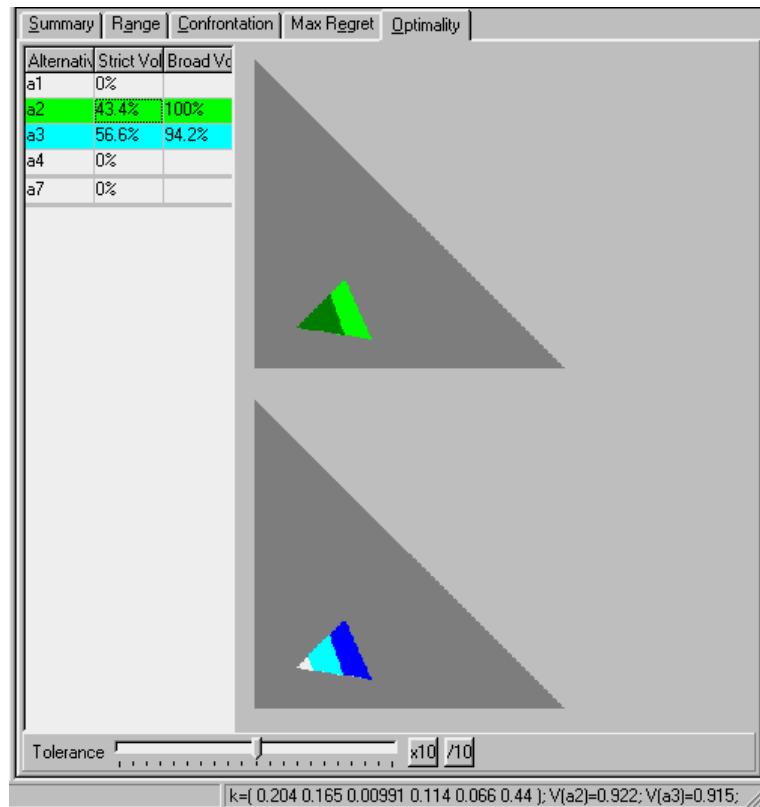


Figure 10: Optimality domains.

Figure 10 displays the “optimality domains” of the two selected alternatives, showing where each of the two is the best among the set of alternatives. We can see that the two domains are not very different in size. The combination of values for the scaling constants that appears at the bottom

$(k_1=0.204, k_2=0.165, \dots)$ corresponds to the point that was selected in the green region (you probably have selected a different one!). After that combination we can read the value of the two alternatives considering those parameter values (since we selected a point in the dark green region the value of a_2 is higher than the value of a_3 (the reverse occurs in the dark blue region). Note that the dark grey region corresponds to parameter values that violate some constraint(s).

The **Tolerance** control allows to tell the computer that a very small difference of value may be ignored. Setting the tolerance to 0.1, this means that a_2 is considered “quasi-optimal”, i.e. either better than all the remaining ones, or worse but by a difference less than the tolerance. The light green domain shows that a_2 is quasi-optimal for all the acceptable parameter values, whereas a_3 is quasi-optimal in a domain representing 94.4% of the acceptable combinations of parameter values. Notice how the relation between the relative volumes is inverted when comparing a_2 with a_3 . You may also observe how the domains of quasi-optimality change as the tolerance decreases or increases. For all these reasons, we believe that these interactive graphical displays are a powerful tool of analysis and learning.

CONCLUDING REMARK

The choice between a_2 and a_3 is still open. Perhaps the DM has learned enough to make an informed decision, or perhaps he/she is now capable of adding more constraints on the parameter values that will make a clear winner emerge. Or perhaps he/she has learned how to create a new alternative by combining the strengths of a_2 and a_3 . VIP Analysis intends to support the DM, and not to replace him/her. Whether you are an actual or prospective DM or analyst, or teacher or student, I hope you will find it valuable.