Brogiolo Francisco

Project work

Supplier problem

FAZIOLI PIANOFORTI

PROBLEM STATEMENT

Fazioli produces pianos with a high standard of quality

However, the consumers have become more exigent and each year expect higher levels of performance of the new pianos

Therefore an analysis has been carried out by the experts of the company to determine which suppliers are to be replaced by new ones of higher quality:

Analysis of the main Raw Materials

Wood

Strong and supple wood is used to make the framework

The current quality is not bad but can be substantially improved

Metal

Metal is used for many parts, including the cast iron plate

The quality of this material can be improved just a little

High tensile steel

High tensile steel wire is used for the strings

Currently it is impossible to improve its quality

3 New wood suppliers are needed (they supply long fibers of spruce and maple wood)

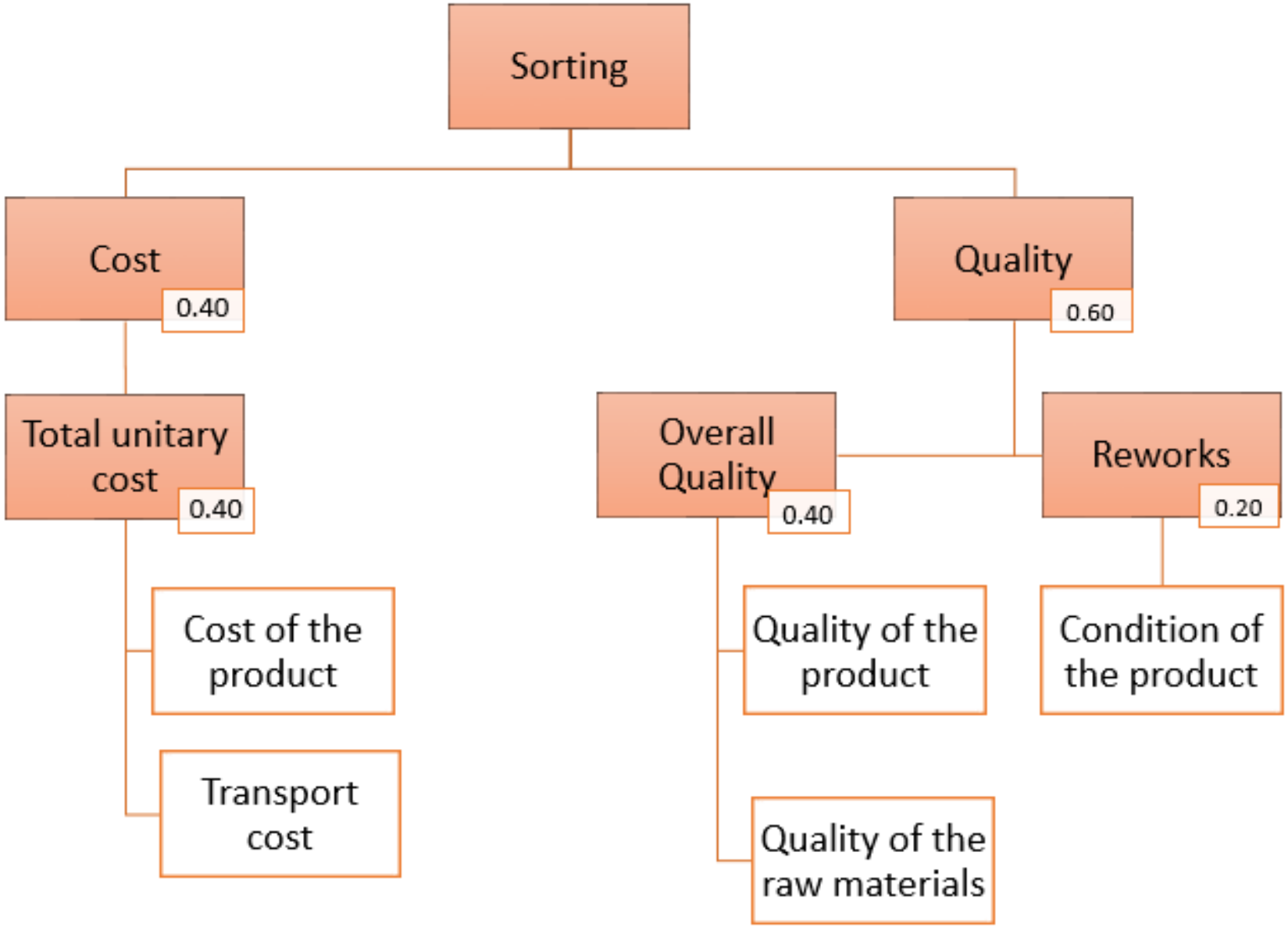
At least one must be from Italy, since the company has many clients in this country, and it is good for the brand to foster the national production

Possible situations:

-One Italian company belongs to the three best suppliers. No problem.

-No Italian company present in the three best suppliers. In this case we would add to the list the best acceptable Italian supplier (raising to 4 new suppliers) to satisfy the brand requirements.

Structure of the model for sorting



Criteria for sorting

Total unitary cost

Total unitary cost = Cost of the product per unit + Unitary transport cost

Cost of the product per unit: given in the dataset.

Unitary transport cost: As the pianos are produced with a high amount of wood, the units transported are on average 5000, so this cost is calculated by “Transport cost”/5000.

Overall Quality

As a combination of the quality of the product Q and the quality of the raw materials RM, as shown on Tables “A”.

Reworks

It is given in the data as Condition of the product. It is critical because not always the company can make the rework, raisig the cost and delaying the production process, which would make it even longer than what it originally is, generating some problems with clients if the product is not finished by the established date.

Overall Quality

For the piano manofacturing the importance of Q and RM is the same.

Q: quality of the product	
1	Poor
2	Sufficient
3	Good
4	Very good

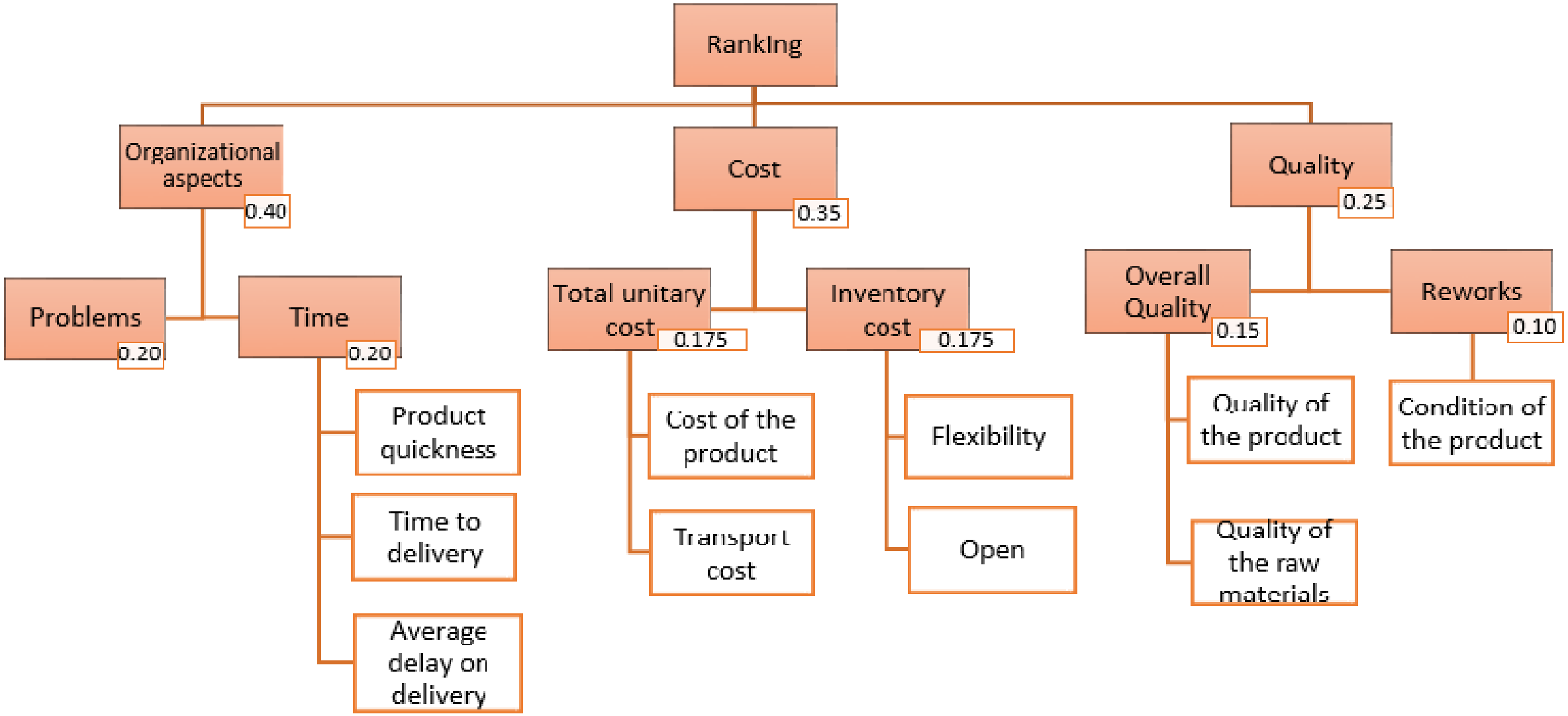
RM: quality of the raw materials	
1	Poor
2	Sufficient
3	Good
4	Optimal

1: Worst case
6: Best case

		Q			
		P	**S**	**G**	**VG**
RM	**P**	1	1	1	1
	S	1	2	3	4
	G	1	3	4	5
	O	1	4	5	6

Tables “A”

Structure of the model for ranking



Criteria for ranking

Problems

It is an important aspect and can affect the duration of the production of a piano, which is very long by itself and should not be further delayed by some problem.

Time

Is period of time from the order to the moment in which the product arrives. It is important because it adds time to the whole process (it means more time that the customer will have to wait to obtain the product).

Time = Time of product delivery + Delivery delay + Production quickness.

Inventory cost

It depends on the flexibility and open months. A flexible supplier and that works every month would allow the company to reduce the inventory to the minimum all the time by having the chance of no ordering when the demand decreases, and order more if it increases. It is not a negligible expense because the wood must be protected to don't lose its quality until it is used to the production. Final scale explained in "Tables B".

Total unitary cost, Overall quality and Rework (as for sorting)

Inventory cost

The importance for both data is the same, with the exception that a no flexible supplier is penalized.

F: Flexibility on the amount of lots	
1	Flexible
2	Sometimes flexible
3	No flexible

Open: when the supplier works	
1	Every month
2	Eleven months
3	Ten months

1: Best case
6: Worst case

		F		
		1	**2**	**3**
Open	**1**	1	2	4
	2	2	3	5
	3	3	4	6

Tables “B”

Parameters for sorting

	Used scale	b1	Indifference threshold	Preference threshold	Veto threshold	b2	Indifference threshold	Preference threshold	Veto threshold
Total unitary cost	0.404-0.126	0.300	-	0.010	0.160	0.210	-	0.010	0.160
Overall Quality	1-6	2	-	-	4	4	-	-	3
Reworks	4-1	3	-	-	2	2	-	-	2

Parameters for ranking

	Used scale	Indifference threshold	Preference threshold	Veto threshold
Total unitary cost	0.404-0.126	-	0.010	0.200
Overall Quality	1-6	-	-	4
Reworks	4-1	-	-	3
Problems	1-3	-	-	-
Time	8-37	2	3	23
Inventory cost	5-1	-	-	4

Results for sorting

MCDA-ULaval :: Multi-Criteria Decision Analysis - C:\Fran\Facu\Quantitative\Electre\Project work\Project.mcda

File Edit Project Performance table Result Scenarios Language Help

Project : Sorting - Result : <1.Sorting model, Performances, *, Ø>

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::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                RESULT <1.Sorting model, Performances, *, Ø>
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
Statistics :
<min,max>        #        %
<1,2>            2        9,5238%
<1,3>            2        9,5238%
<2,2>            8        38,0952%
<2,3>            9        42,8571%


ACTION     Pessimist (pseudo-conjunctive)          Optimist (pseudo-disjunctive)
  A1                      C2 Intermediate                    C3 Acceptable
  A2                         C1 Rejection                    C3 Acceptable
  A3                      C2 Intermediate                    C3 Acceptable
  A4                      C2 Intermediate                    C3 Acceptable
  B1                         C1 Rejection                    C3 Acceptable
  B2                         C1 Rejection                 C2 Intermediate
  B3                         C1 Rejection                 C2 Intermediate
  C1                      C2 Intermediate                    C3 Acceptable
  C2                      C2 Intermediate                    C3 Acceptable
  C3                      C2 Intermediate                    C3 Acceptable
  D1                      C2 Intermediate                 C2 Intermediate
  D2                      C2 Intermediate                 C2 Intermediate
  D3                      C2 Intermediate                 C2 Intermediate
  D4                      C2 Intermediate                 C2 Intermediate
  E1                      C2 Intermediate                 C2 Intermediate
  E2                      C2 Intermediate                 C2 Intermediate
  E3                      C2 Intermediate                 C2 Intermediate
  E4                      C2 Intermediate                 C2 Intermediate
  F1                      C2 Intermediate                    C3 Acceptable
  F2                      C2 Intermediate                    C3 Acceptable
  F3                      C2 Intermediate                    C3 Acceptable

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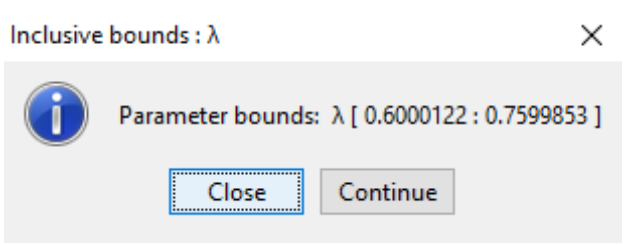
```

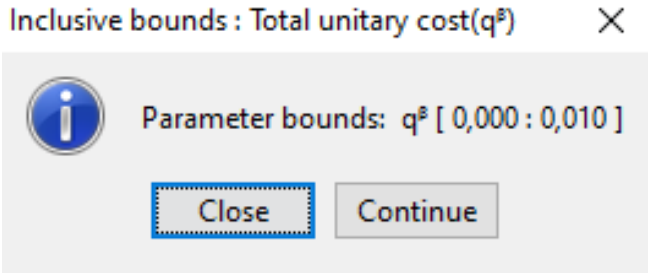
We can see that there are no actions accepted by the two procedures. There are 9 actions that are intermediate for the pessimistic procedure and accepted for the optimistic procedure. We should focus on them on the RA to see if they have a tendency to be accepted or to be intermediate. These candidates are: A1, A3, A4, C1, C2, C3, F1, F2 and F3.

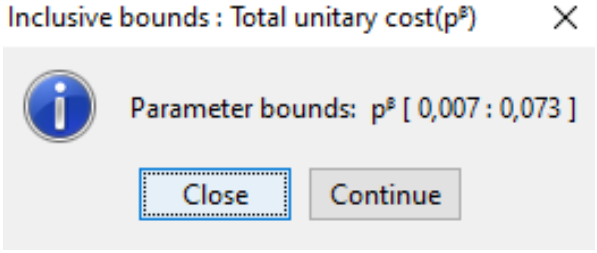
Stability analysis

A1, A3, A4, C1, C2, C3, F1, F2 and F3 are intermediate for the pessimistic procedure and acceptable by the optimistic one. No acceptable candidate by both the procedures

Bounds for parameters		Original value
Lamda	0.60-0.76	0.65
q of cost	0-0.01	0
p of cost	0.007-0.07	0.01
K cost	0.36-0.49	0.4
K quality	0.36-0.49	0.4
K rework	0.01-0.29	0.2







Robustness analysis with one change at a time

		Result	Cost 0.35	Cost 0.5	Quality 0.35	Quality 0.50	Rework 0.3	Conclusion?
1	A1	**I-A**	I	A	A	I	A	I-A->A
2	A3	**I-A**	I	A	A	I	A	I-A->A
3	A4	**I-A**	I	I-A	I-A	I	I	I-A
4	C1	**I-A**	I	I-A	I-A	I	I	I-A
5	C2	**I-A**	I	I-A	I-A	I	I	I-A
6	C3	**I-A**	I	I-A	I-A	I	I	I-A
7	F1	**I-A**	I-A	I	I	I-A	I	I-A
8	F2	**I-A**	I-A	I	I	I-A	I	I-A
9	F3	**I-A**	A	I	I	A	A	I-A->A
10	D3	**I**	A	I	I	A	A	I->A
11	D4	**I**	A	I	I	A	A	I->A

I-A = intermediate for pessimistic and acceptable for optimistic
I = intermediate for pessimistic and for optimistic
A = Accepted by both the procedures

Scenario analysis (1/2)

PARAMETER	RANGE	PACE	Number of steps	Total analysis
Lamda	0.6 to 0.75	0.05	4	256
K cost	0.35 to 0.5		4	
K quality	0.35 to 0.5		4	
K rework	0.15 to 0.3		4	

Decision configuration : 1.Sorting model
Performance table : Performances
Alternative subset : *
Sub-Configuration : Ø
Scenario Parameters:

λ Min: 0.6 Max: 0.75 # Divisions: 3
k(Total unitary cost) Min: 0.35 Max: 0.5 # Divisions: 3
k(Overall Quality) Min: 0.35 Max: 0.5 # Divisions: 3
k(Rework) Min: 0.15 Max: 0.3 # Divisions: 3

	D1	D2	D3	D4	D5	D6	D7	TOTAL
Times	146	31	18	31	19	10	1	256
%	57.0%	12.1%	7.0%	12.1%	7.4%	3.9%	0.4%	100%

-D1 is the original result
-I neglect D6 and D7 because they appear almost never and with a lot of simultanious changes

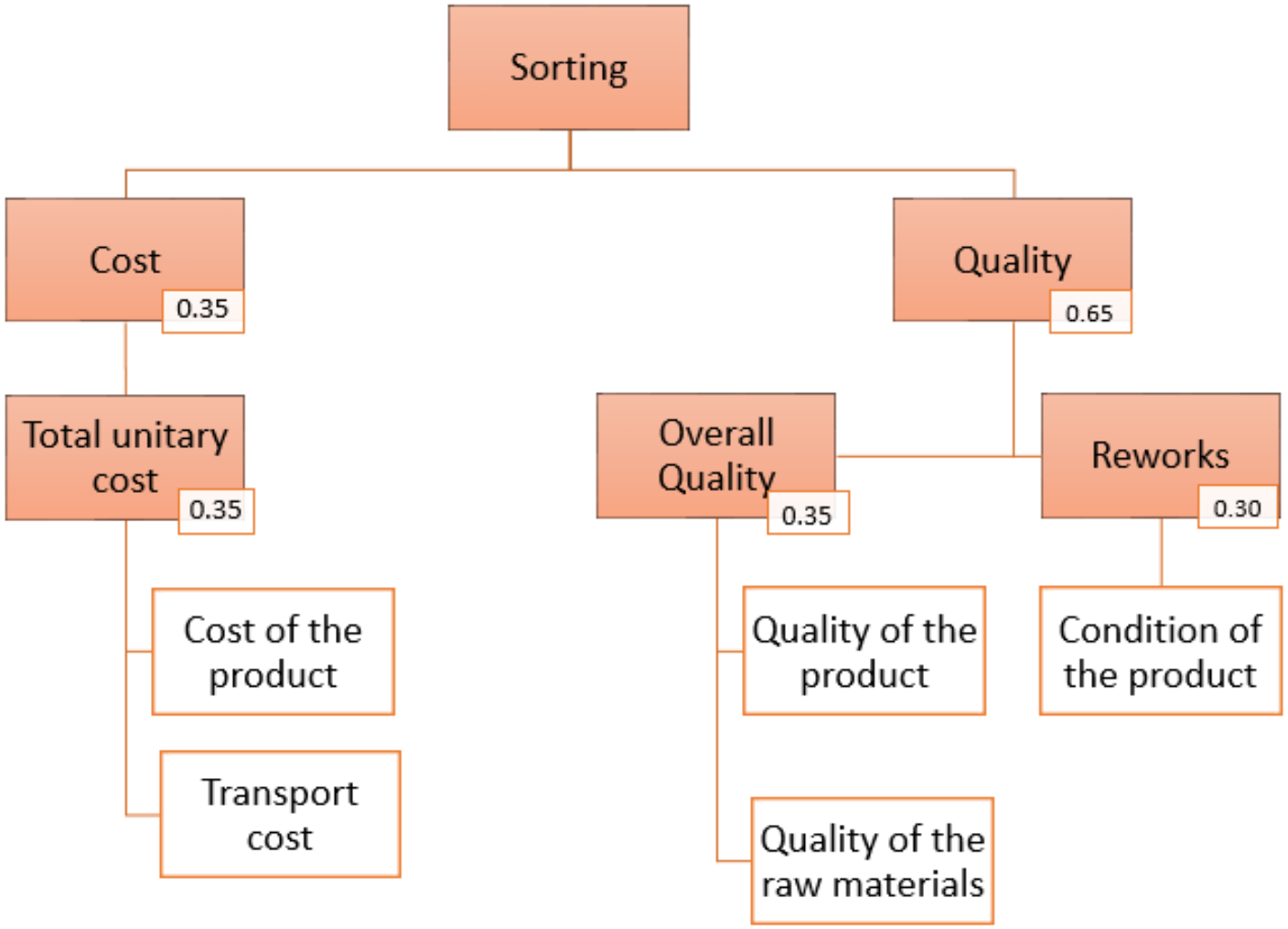
Scenario analysis (2/2)

Result(D1)		D2	D3	D4	D5	Conclusion
A1	**I-A**	A	I-A	I-I	A	**I-A->A**
A3	**I-A**	A	I-A	I-I	A	**I-A->A**
A4	**I-A**	I-A	I-A	I-I	I-I	**I-A**
C1	**I-A**	I-A	I-A	I-I	I-I	**I-A**
C2	**I-A**	I-A	I-A	I-I	I-I	**I-A**
C3	**I-A**	I-A	I-A	I-I	I-I	**I-A**
F1	**I-A**	I-I	I-A	I-A	I-I	**I-A**
F2	**I-A**	I-I	I-A	I-A	I-I	**I-A**
F3	**I-A**	I-I	I-A	A	A	**I-A->A**
D3	**I-I**	I-I	I-I	A	A	**I->A**
D4	**I-I**	I-I	I-I	A	A	**I->A**

I-A = intermediate for pessimistic and acceptable for optimistic
I = intermediate for pessimistic and for optimistic
A = Accepted by both the procedures

Variance of the model for sorting

As the bounds for the criterion rework were suggesting a lack of impact of that criterion, I would like to analyse the model with the following weights:



Results

Project : Sorting - Result : <2.Sorting model, Performances, *, Ø>

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               RESULT <2.Sorting model, Performances, *, Ø>
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Statistics :
<min,max>       #       %
<1,1>           1       4,7619%
<1,2>           1       4,7619%
<2,2>           14      66,6667%
<3,3>           5       23,8095%


ACTION    Pessimist (pseudo-conjunctive)          Optimist (pseudo-disjunctive)
  A1                        C3 Acceptable                   C3 Acceptable
  A2                      C2 Intermediate                 C2 Intermediate
  A3                        C3 Acceptable                   C3 Acceptable
  A4                      C2 Intermediate                 C2 Intermediate
  B1                         C1 Rejection                 C2 Intermediate
  B2                      C2 Intermediate                 C2 Intermediate
  B3                         C1 Rejection                    C1 Rejection
  C1                      C2 Intermediate                 C2 Intermediate
  C2                      C2 Intermediate                 C2 Intermediate
  C3                      C2 Intermediate                 C2 Intermediate
  D1                      C2 Intermediate                 C2 Intermediate
  D2                      C2 Intermediate                 C2 Intermediate
  D3                        C3 Acceptable                   C3 Acceptable
  D4                        C3 Acceptable                   C3 Acceptable
  E1                      C2 Intermediate                 C2 Intermediate
  E2                      C2 Intermediate                 C2 Intermediate
  E3                      C2 Intermediate                 C2 Intermediate
  E4                      C2 Intermediate                 C2 Intermediate
  F1                      C2 Intermediate                 C2 Intermediate
  F2                      C2 Intermediate                 C2 Intermediate
  F3                        C3 Acceptable                   C3 Acceptable
```
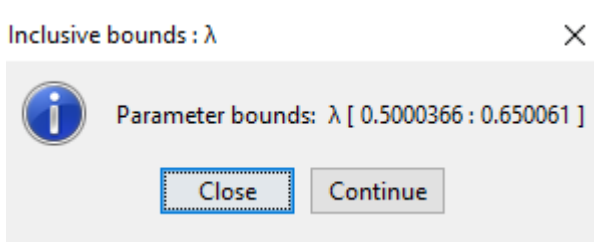
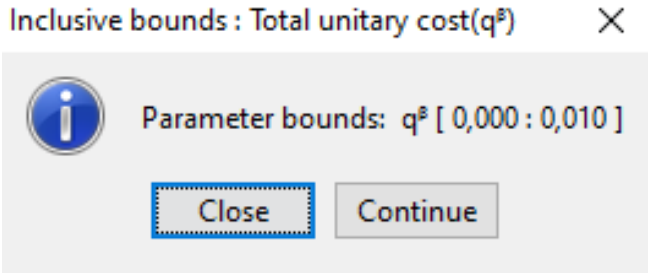

A1, A3,F3, D3 and D4 are acceptable

Stability analysis

Bounds for parameters		Original value
Lamda	0.50-0.65	0.65
q of cost	0-0.01	0
p of cost	0.00-0.16	0.01
K cost	0.35	0.35
K quality	0.35	0.35
K rework	0.30-0.35	0.3





The bounds for the weights are very limited, but as it is already a modified model, it is acceptable.

Robustness analysis with one change at a time

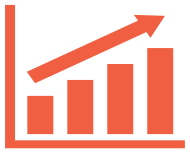
Candidate	Result	Cost 0.34	Cost 0.36	Q. 0.34	Q 0.36	λ 0.66	λ 0.71	Conclusion
A1	A	I	A	A	I	I-A	I-A	A
A3	A	I	A	A	I	I-A	I-A	A
A4	I	I	I-A	I-A	I	I-A	I-A	I
C1	I	I	I-A	I-A	I	I-A	I-A	I
C2	I	I	I-A	I-A	I	I-A	I-A	I
C3	I	I	I-A	I-A	I	I-A	R-A	I
F1	I	I-A	I	I	I	I-A	I-A	I
F2	I	I-A	I	I	I	I-A	I-A	I
F3	A	A	I	I	A	I-A	I-A	A
D3	A	A	I	I	A	I	I	A
D4	A	A	I	I	A	I	I	A

CONCLUSIONS

Suppliers A1, A3, D3, D4 and F3 are acceptable, but...

A1 and A3 have a low level of Quality (2 out of 6), that is not good enough to be consistent with the problem formulation

A variance of the model is proposed to obtain suppliers with better quality



Variance of the original model for sorting

→Some suppliers with not good enough quality were accepted (A1 and A3 with an overall quality of 2 out of 6)

	Used scale	b1	Indifference threshold	Preference threshold	Veto threshold	b2	Indifference threshold	Preference threshold	Veto threshold
Total unitary cost	0.404-0.126	0.300	-	0.010	0.160	0.210	-	0.010	0.160
Overall Quality	1-6	2→3	-	-	4	4→5	-	-	4
Reworks	4-1	3	-	-	2	2	-	-	2

Results for sorting with the changed model

Project : Sorting - Result : <3.Sorting model, Performances, *, Ø>

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::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
              RESULT <3.Sorting model, Performances, *, Ø>
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
Statistics :
<min,max>       #       %
<1,1>           1       4,7619%
<1,2>           5       23,8095%
<1,3>           4       19,0476%
<2,2>           5       23,8095%
<2,3>           6       28,5714%


ACTION     Pessimist (pseudo-conjunctive)          Optimist (pseudo-disjunctive)
  A1                        C1 Rejection                      C3 Acceptable
  A2                        C1 Rejection                      C3 Acceptable
  A3                        C1 Rejection                      C3 Acceptable
  A4                     C2 Intermediate                      C3 Acceptable
  B1                        C1 Rejection                   C2 Intermediate
  B2                        C1 Rejection                   C2 Intermediate
  B3                        C1 Rejection                      C1 Rejection
  C1                        C1 Rejection                      C3 Acceptable
  C2                     C2 Intermediate                      C3 Acceptable
  C3                     C2 Intermediate                      C3 Acceptable
  D1                     C2 Intermediate                   C2 Intermediate
  D2                        C1 Rejection                   C2 Intermediate
  D3                     C2 Intermediate                   C2 Intermediate
  D4                     C2 Intermediate                   C2 Intermediate
  E1                        C1 Rejection                   C2 Intermediate
  E2                     C2 Intermediate                   C2 Intermediate
  E3                     C2 Intermediate                   C2 Intermediate
  E4                        C1 Rejection                   C2 Intermediate
  F1                     C2 Intermediate                      C3 Acceptable
  F2                     C2 Intermediate                      C3 Acceptable
  F3                     C2 Intermediate                      C3 Acceptable

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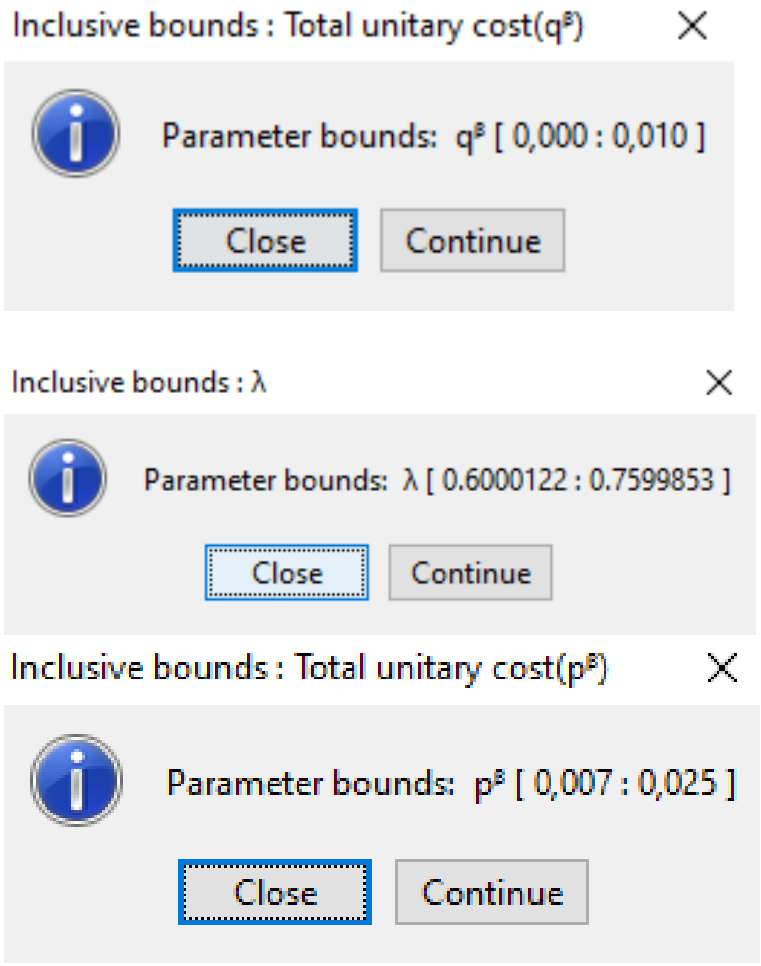
	Result
A4	I-A
C2	I-A
C3	I-A
D1	I
D3	I
D4	I
E2	I
E3	I
F1	I-A
F2	I-A
F3	I-A

We can see that there are no suppliers accepted by the two procedures. There are 6 actions that are intermediate for the pessimistic procedure and accepted for the optimistic procedures, that are: A4, C2, C3, F1, F2 and F3. 5 others are Intermediate and will be further analyzed as well, that are: D1, D3, D4, E2 and E3. The other 10 suppliers resulted rejected by one or both the procedures.

Stability analysis

Bounds for parameters		Original value
Lamda	0.60-0.76	0.65
q of cost	0-0.01	0
p of cost	0.007-0.025	0.01
Weights K		
K cost	0.36-0.49	0.4
K quality	0.36-0.49	0.4
K rework	0.01-0.29	0.2



Robustness analysis with one change at a time

	Result	Cost 0.35	Cost 0.5	Quality .35	Quality 0.50	Rework 0.30	Conclusion
A4	I-A	I	I-A	I-A	I	I	I-A
C2	I-A	I	I-A	I-A	I	I	I-A
C3	I-A	I	I-A	I-A	I	I	I-A
D1	I	I	I	I	I	I	I
D3	I	I	I	I	I	I	I
D4	I	I	I	I	I	I	I
E2	I	I	I	I	I	I	I
E3	I	I	I	I	I	I	I
F1	I-A	I-A	I	I	I-A	I	I-A
F2	I-A	I-A	I	I	I-A	I	I-A
F3	I-A	A	I	I	A	A	I->A

I-A = intermediate for pessimistic and acceptable for optimistic
I = intermediate for pessimistic and for optimistic
A = Accepted by both the procedures

Scenario analysis (1/2)

PARAMETER	RANGE	PACE	Number of steps	Total analysis
Lamda	0.6 to 0.75	0.05	4	256
K cost	0.35 to 0.5		4	
K quality	0.35 to 0.5		4	
K rework	0.15 to 0.3		4	

Decision configuration : 1.Sorting model
Performance table : Performances
Alternative subset : *
Sub-Configuration : Ø
Scenario Parameters:

λ Min: 0.6 Max: 0.75 # Divisions: 3
k(Total unitary cost) Min: 0.35 Max: 0.5 # Divisions: 3
k(Overall Quality) Min: 0.35 Max: 0.5 # Divisions: 3
k(Rework) Min: 0.15 Max: 0.3 # Divisions: 3

	D1	D2	D3	D4	D5	D6	D7	TOTAL
Times	146	31	18	31	19	10	1	256
%	57.0%	12.1%	7.0%	12.1%	7.4%	3.9%	0.4%	100%

-D1 is the original result
-I neglect D6 and D7 because they appear almost never and with a lot of simultanious changes

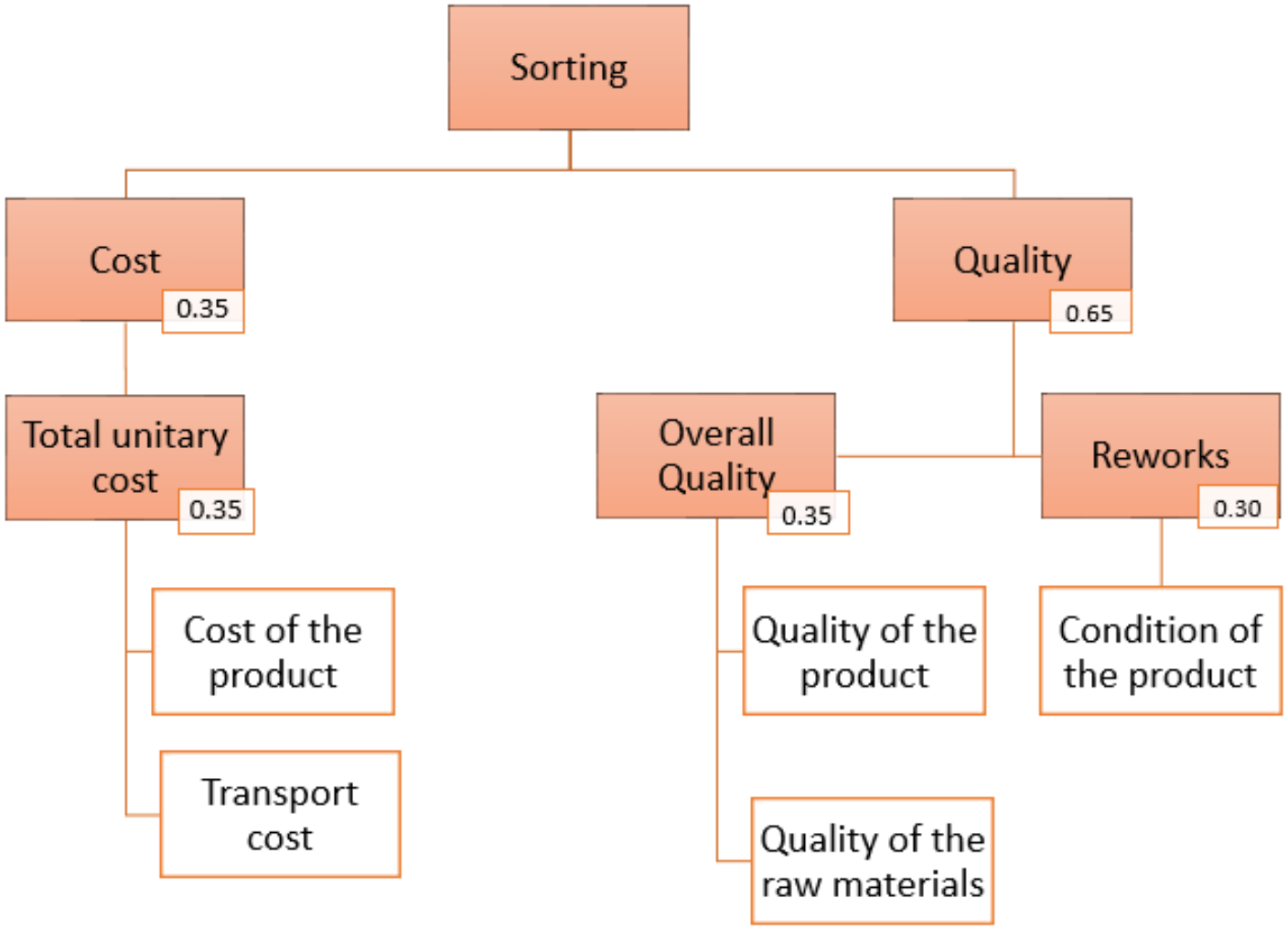
Scenario analysis (2/2)

	Result D1	D2	D3	D4	D5	Conclusion
A4	I-A	I-A	I-A	I	I	I-A
C2	I-A	I-A	I-A	I	I	I-A
C3	I-A	I-A	I-A	I	I	I-A
D1	I	I	I	I	I	I
D3	I	I	I	I	I	I
D4	I	I	I	I	I	I
E2	I	I	I	I	I	I
E3	I	I	R-I	I	I	I
F1	I-A	I	I-A	I-A	I	I-A
F2	I-A	I	I-A	I-A	I	I-A
F3	I-A	I	I-A	A	A	I-A>A

I-A = intermediate for pessimistic and acceptable for optimistic
I = intermediate for pessimistic and for optimistic
A = Accepted by both the procedures

Variance of the model

As the bounds for the criterion rework were suggesting a lack of impact of that criterion, I would like to analyse the model with the following weights:



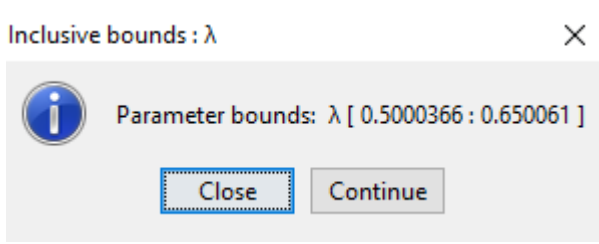
Results

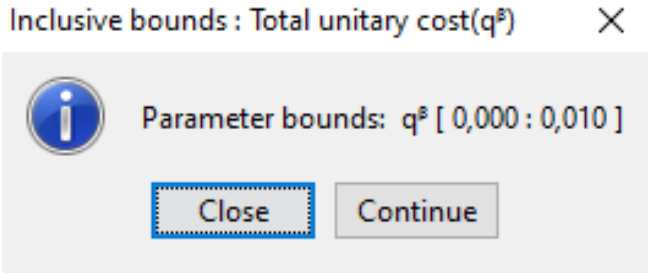
Candidate	Result
A4	I
C2	I
C3	I
D1	I
D3	I
D4	I
E2	I
E3	I
F1	I
F2	I
F3	A

Only F3 is acceptable

Stability analysis

Bounds for parameters		Original value
Lamda	0.50-0.65	0.65
q of cost	0-0.01	0
p of cost	0.00-0.16	0.01
K cost	0.35	0.35
K quality	0.35	0.35
K rework	0.30-0.35	0.3





→The bounds are not robust for the weights:

Analysis second model

Candidate	Result	Cost 0.34	Cost 0.36	Q. 0.34	Q 0.36	λ 0.66-0.7	λ 0.71-0.8	Conclusion
A4	I	I	I-A	I-A	I	I-A	I-A	I->I-A
C2	I	I	I-A	I-A	I	I-A	I-A	I->I-A
C3	I	I	I-A	I-A	I	I-A	R-A	I->I-A
D1	I	I	I	I	I	I	I	I
D3	I	I	I	I	I	I	I	I
D4	I	I	I	I	I	I	I	I
E2	I	I	I	I	I	I	I-A	I
E3	I	I	I	I	I	I	I-A	I
F1	I	I-A	I	I	I-A	I-A	I-A	I->I-A
F2	I	I-A	I	I	I-A	I-A	I-A	I->I-A
F3	A	A	I	I	A	I-A	I-A	A

Original result of the first model

→The conclusions are similar!

CONCLUSIONS

A totally acceptable supplier is not present because no one has optimal performances in the criteria “Total unitary cost”, “Overall quality” and “Rework” at the same time.
Therefore, suppliers A4, C2, C3, F1, F2 and F3, that are the ones with a tendency to the acceptable category, will be evaluated with the ranking model to obtain the best three suppliers.

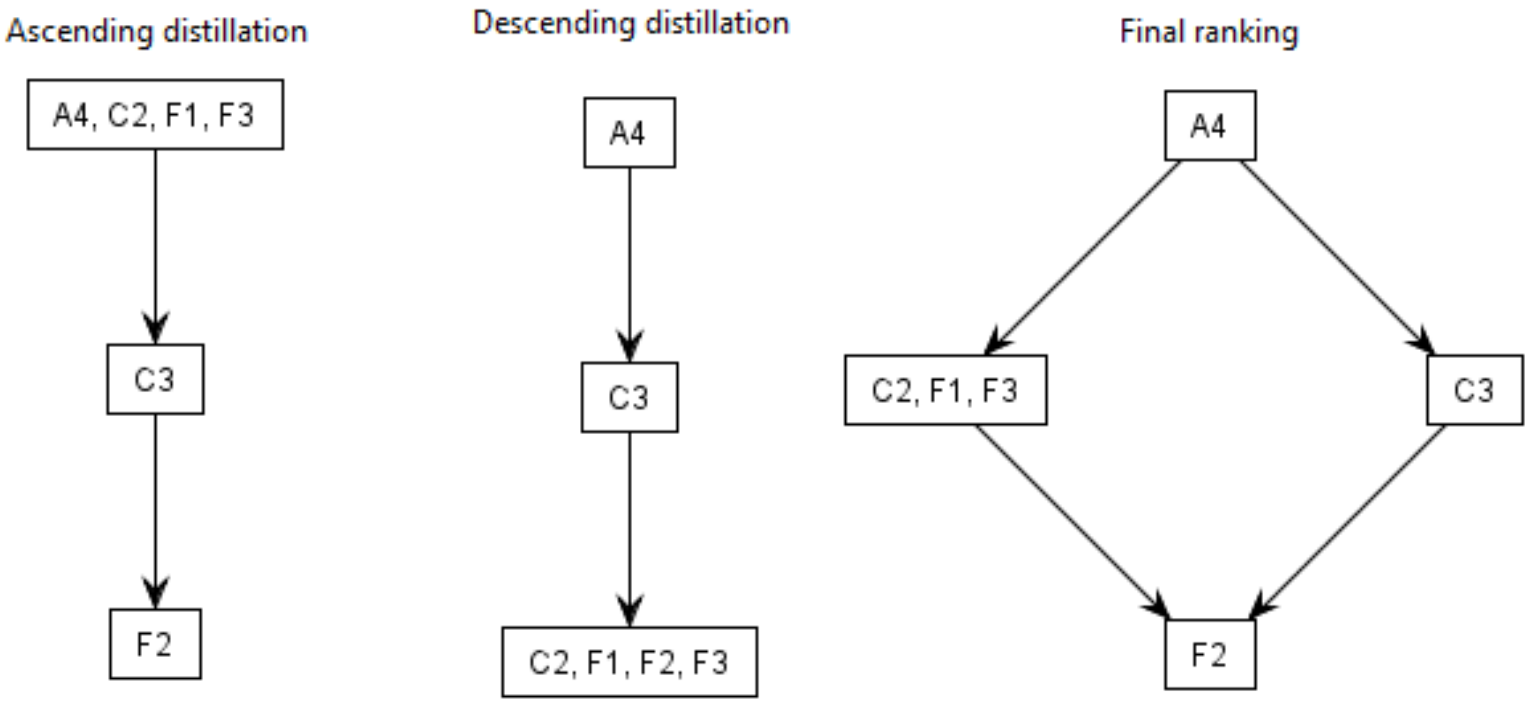
Suppliers and performances for ranking

Supplier	Tot. Cost	Overall Q	Rew	Pbs.	Time	Inv. Cost
A4	0.144	3	3	3	10	2
C2	0.135	3	3	3	9	4
C3	0.146	4	4	2	11	3
F1	0.292	6	3	3	36	5
F2	0.283	6	3	2	37	5
F3	0.302	6	2	2	37	3
Min	0.135	3	2	2	9	2
Max	0.302	6	4	3	37	5
Direction	MIN	MAX	MIN	MAX	MIN	MIN

Updated parameters for ranking

	Used scale	Indifference threshold	Preference threshold	Veto threshold
Total unitary cost	0.302-0.135	-	0.010	0.15
Overall Quality	3-6 (Scale:1-6)	-	-	3
Reworks	4-2(Scale:1-4)	-	-	2
Problems	2-3(Scale:1-3)	-	-	-
Time	9-37	2	3	23
Inventory cost	5-2(Scale:5-1)	-	-	3

Result for ranking



Stability analysis

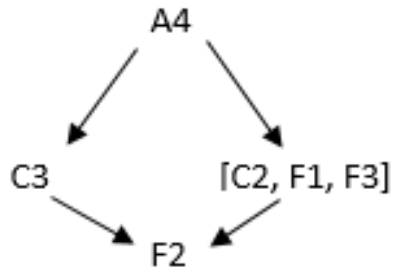
Bounds for parameters		Original value
q Total cost	0-0.008	0
p Total cost	0-0.02	0.01
v Total cost	0.21-Infinity	0.15
v Inv. Cost	2-Infinity	3
v Rework	2-2	2
v Quality	2-4	3
q Time	2-3	2
p Time	2-22	3
v Time	4-Infinity	23

Bounds for parameters		Original value
α	0.22-0.49	0.03
β	-0.24-0.08	-0.015
K total cost	0.13-0.21	0.175
K inv. Cost	0.15-0.24	0.175
K rework	0.04-0.14	0.1
K quality	0.12-0.24	0.15
K prob	0.11-0.27	0.2
K time	0-0.53	0.2

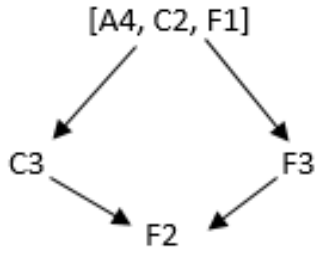
→The bounds are acceptable

Robustness analysis (changing one weight at a time)

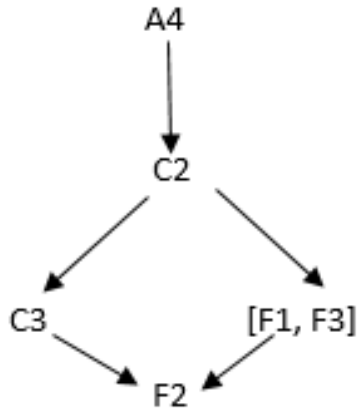
RESULT



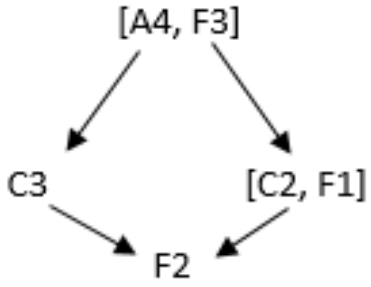
-Problems=0.28



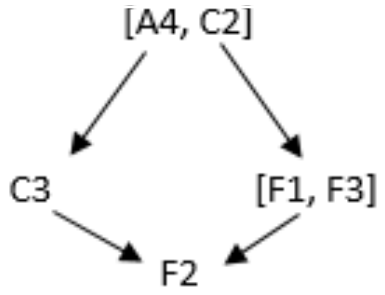
-Quality=0.11



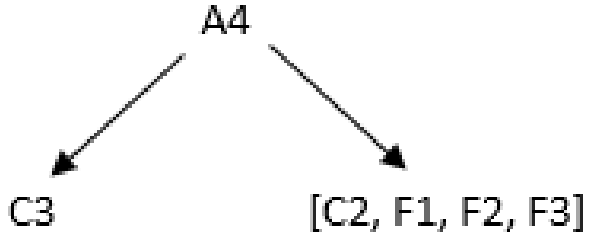
-Inventory cost=0.25
-Total cost=0.12



-Inventory cost=0.14
-Rework=0.15
-Total cost=0.22



-Problems=0.11
-Quality=0.24



Robustness analysis

The result is robust enough because it is confirmed that A4 is the best supplier, F2 is the worst one, and the difficult comparability of C3, and the indifference between F1 and F3.

C2 seems an interesting candidate to be selected.

However, the third supplier to select is not clear.

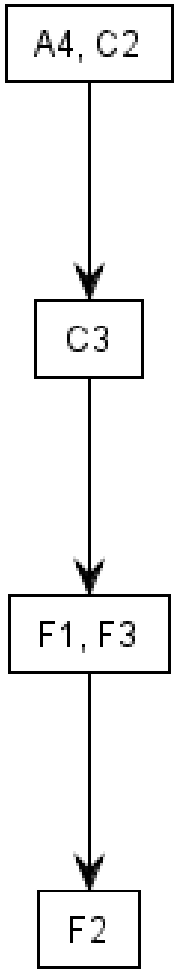
It was suggested to change the veto thresholds for the criteria Overall Quality and Rework because they were not so consistent with the size of the scale. This variation and its results are presented below:

Parameters

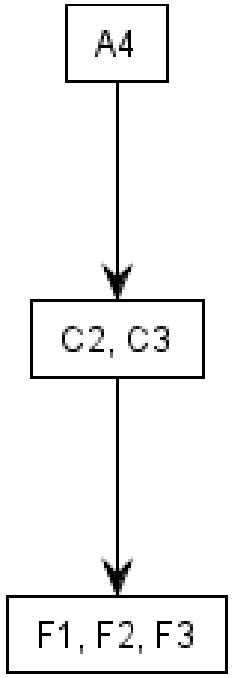
	Used scale	Indifference threshold	Preference threshold	Veto threshold
Total unitary cost	0.302-0.135	-	0.010	0.15
Overall Quality	3-6 (Scale:1-6)	-	-	3→4
Reworks	4-2(Scale:1-4)	-	-	2→3
Problems	2-3(Scale:1-3)	-	-	-
Time	9-37	2	3	23
Inventory cost	5-2(Scale:5-1)	-	-	3

Result

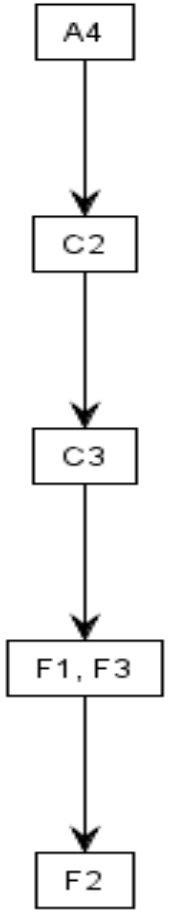
· Ascending distillation



Descending distillation



Final ranking



Stability analysis

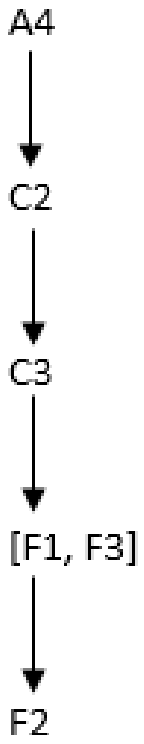
Bounds for parameters		Original value
q Total cost	0-0.008	0
p Total cost	0-0.02	0.01
v Total cost	0.21-Infinity	0.15
v Inv. Cost	2-Infinity	3
v Rework	3-Infinity	3
v Quality	4-Infinity	4
q Time	2-3	2
p Time	2-22	3
v Time	4-Infinity	23

Bounds for parameters		Original value
α	0.22-0.40	0.03
β	-0.22: -0.040	-0.015
K total cost	0.15-0.22	0.175
K inv. Cost	0.15-0.24	0.175
K rework	0.04-0.14	0.1
K quality	0.12-0.23	0.15
K prob	0.12-0.24	0.2
K time	0-0.46	0.2

→The bounds are acceptable

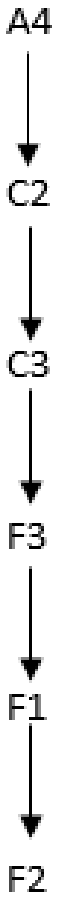
Robustness analysis (changing one weight at a time)

RESULT

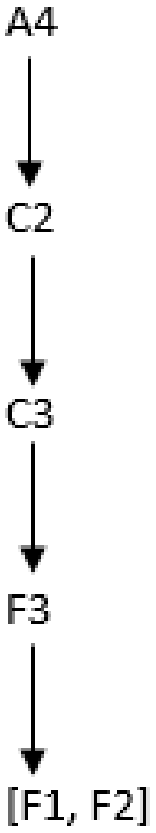


For the following changes one partial graph changed but the result was the same:
Total cost =0.23; Inventory cost = 0.13
Rework = 0.15; Problems = 0.25
Overall quality =0.11

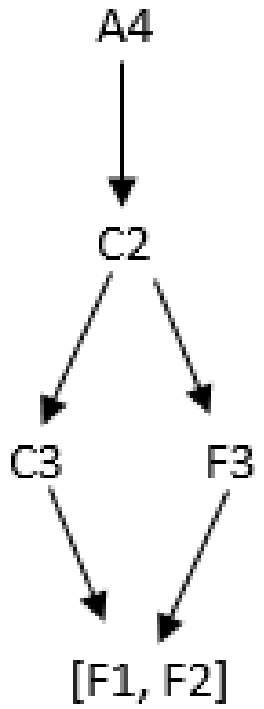
-Inventory cost=0.25
-Total cost=0.12



-Problems=0.11



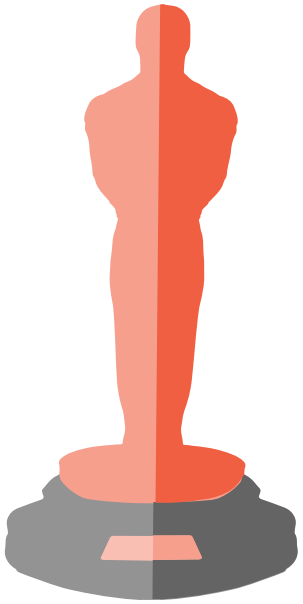
-Quality=0.24

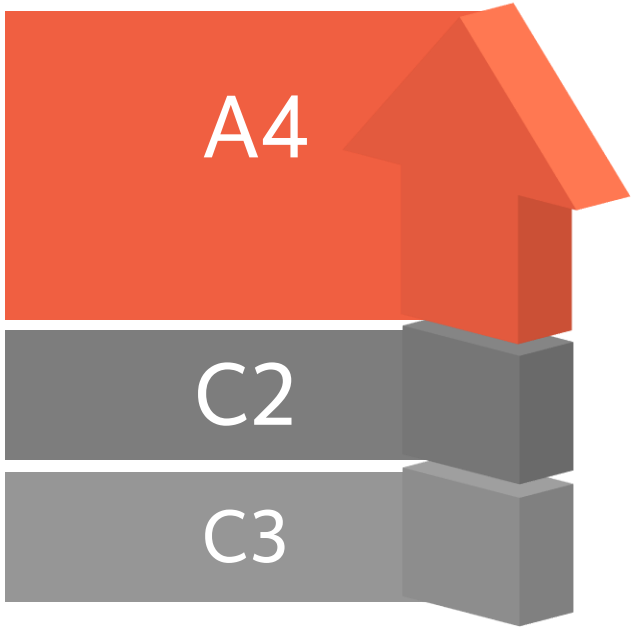


Robustness analysis and final decision

The result is very robust because the sequence A4-C2-C3-F3-F2 is always confirmed. (The result is exactly the same for some changes). The indifference of F1 and F3 is sometimes not confirmed. Now the incomparability of C3 doesn’s exist.

This result and robustness analysis allow us to take the final decision of the three suppliers:





← The brand constraint of having one italian supplier is satisfied since A4 is from Italy.

Thank you for your time and support for the project and during the course!