Ευρωπαϊκή Ένωση
Ευρωπαϊκό Κοινωνικό Ταμείο
ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ
ΕΚΠΑΙΔΕΥΣΗ ΚΑΙ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗ
επένδυση στην κοινωνία της γνώσης
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ & ΘΡΗΣΚΕΥΜΑΤΩΝ, ΠΟΛΙΤΙΣΜΟΥ & ΑΘΛΗΤΙΣΜΟΥ
ΕΙΔΙΚΗ ΥΠΗΡΕΣΙΑ ΔΙΑΧΕΙΡΙΣΗΣ
ΕΣΠΑ 2007-2013
πρόγραμμα για την ανάπτυξη
ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

ΘΑΛΗΣ – Πανεπιστήμιο Πειραιά
Μεθοδολογικές προσεγγίσεις για τη μελέτη της ευστάθειας σε προβλήματα λήψης αποφάσεων με πολλαπλά κριτήρια

Δ18 – Διοργάνωση workshops

Π18.6 – Έκθεση 6ου Επιστημονικού Workshop

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ
ΠΟΛΥΤΕΧΝΕΙΟ ΚΡΗΤΗΣ
ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

Στοιχεία παραδοτέου

Δράση: Δ18 – Διοργάνωση workshops

Τίτλος παραδοτέου: Π18.6 – Έκθεση 6ου Επιστημονικού Workshop

Τύπος παραδοτέου: I - PP

Έκδοση: 01

Ημερομηνία: 25 Ιουνίου 2015

Υπεύθυνος σύνταξης: Καθηγητής Κωνσταντίνος Ζοπουνίδης

Ομάδας σύνταξης: Καθηγητής Νικόλαος Ματσατσίνης
Αναπληρωτής Καθηγητής Μιχάλης Δούμπος
Επίκουρος Καθηγητής Παύλος Δελιάς
Professor Alexis Tsoukias
Δημήτριος Νίκλης, MSc

Περιεχόμενα

<u>Συντομογραφίες Παραδοτέου</u>

ΣΕ: Συντονιστής Έργου

ΥΕΟ: Υπεύθυνος Ερευνητικής Ομάδας

ΚΕΟ: Κύρια Ερευνητική Ομάδα

ΟΕΣ: Ομάδα Εξωτερικών Συνεργατών

ΟΕ: Ομάδα Έργου

ΥΔΠΕ: Υπεύθυνος Διασφάλισης Ποιότητας Έργου

ΕΥΔ: Επιστημονικός Υπεύθυνος Δράσης

ΟΕΜ: Ομάδα Εμπειρογνωμόνων

ΠΑΠΕΙ ή UNIPI: Πανεπιστήμιο Πειραιά

ΠΚ ή TUC: Πολυτεχνείο Κρήτης

ΕΜΠ ή NTUA: Εθνικό Μετσόβιο Πολυτεχνείο

1 Γενικά

1.1 Γενικά στοιχεία δράσης

Η δράση Δ18 αφορά τη διοργάνωση μιας σειράς επιστημονικών συναντήσεων εργασίας (workshops) και εντάσσεται στο σύνολο των δράσεων δημοσιότητας του έργου. Τα workshops οργανώνονται από τις ερευνητικές ομάδες των ιδρυμάτων που συμμετέχουν στην υλοποίηση του έργου και είναι ανοικτά για το κοινό, δεδομένου ότι απευθύνονται σε ερευνητές, υποψήφιους διδάκτορες, μεταπτυχιακούς φοιτητές, κ.λπ. που εργάζονται ή σκοπεύουν να ασχοληθούν με το ευρύτερο αντικείμενο της πολυκριτήριας ανάλυσης.

Στα πλαίσια των επιστημονικών αυτών συναντήσεων παρουσιάζεται όχι μόνο η τρέχουσα έρευνα που έχει πραγματοποιηθεί στα πλαίσια του έργου και αφορά τη μελέτη της ευστάθειας σε προβλήματα λήψης αποφάσεων με πολλαπλά κριτήρια, αλλά και το γενικότερο αντικείμενο της πολυκριτήριας ανάλυσης αποφάσεων.

Πιο συγκεκριμένα, οι στόχοι των επιστημονικών workshops είναι:

- η παρουσίαση των τρέχουσας ερευνητικής προσπάθειας που αφορά τη μελέτη της ευστάθειας στην πολυκριτήρια ανάλυση αποφάσεων,
- η παρουσίαση της γενικότερης θεωρίας και των πρακτικών εφαρμογών της πολυκριτήριας ανάλυσης αποφάσεων,
- η διάδοση του επιστημονικού αντικειμένου της πολυκριτηρίας ανάλυσης αποφάσεων και
- η δικτύωση και η ανταλλαγή απόψεων ανάμεσα σε επιχειρησιακούς ερευνητές και στελέχη επιχειρήσεων και οργανισμών που ασχολούνται με το συγκεκριμένο αντικείμενο.

Σύμφωνα με το πλάνο υλοποίησης, στα πλαίσια του συγκεκριμένου έργου πρόκειται να πραγματοποιηθούν 6 επιστημονικές συναντήσεις εργασίας (workshops), οι οποίες κατανέμονται σε 2 ανά έτος και 2 ανά ερευνητική ομάδα. Η γενική εποπτεία των συναντήσεων θα γίνεται από τη Μικτή Επιτροπή Συντονισμού του Έργου (βλ. δράση Δ21), στην οποία συμμετέχουν οι υπεύθυνοι των 3 ερευνητικών ομάδων. Πιο συγκεκριμένα, η Μικτή Επιτροπή Συντονισμού του Έργου αποτελείται από τους:

1. Καθηγητή Ιωάννη Σίσκο (συντονιστή έργου και υπεύθυνου της ερευνητικής ομάδας του ΠΑΠΕΙ)
2. Καθηγητή Κωνσταντίνο Ζοπουνίδη (υπεύθυνου της ερευνητικής ομάδας του ΠΚ)
3. Καθηγητή Ιωάννη Ψαρρά (υπεύθυνου της ερευνητικής ομάδας του ΕΜΠ)

Δεδομένου ότι η επιτροπή αυτή έχει ως στόχο τη συνολική παρακολούθηση υλοποίησης του έργου, η συνεισφορά της στη συγκεκριμένη δράση επικεντρώνεται στο συντονισμό με τις υπόλοιπες ενέργειες του έργου και τη συνεργασία με τον εκάστοτε διοργανωτή του επιστημονικού workshop.

1.2 Γενικά στοιχεία παραδοτέου

Το συγκεκριμένο παραδοτέο αφορά το 6ο Επιστημονικό Workshop του έργου που πραγματοποιήθηκε στα Χανιά, στις 6 Ιουνίου 2015. Σύμφωνα με το χρονοδιάγραμμα υλοποίησης του έργου (λαμβάνοντας υπόψη και την παράταση που έχει υποβληθεί), τη χρονική στιγμή διεξαγωγής του workshop έχουν ολοκληρωθεί:

1. Οι βιβλιογραφικές δράσεις του ερευνητικού προγράμματος:
    - Δ1: Βιβλιογραφική ανασκόπηση ανάλυσης ευστάθειας σε αναλυτικές-συνθετικές διαδικασίες
    - Δ5: Βιβλιογραφική ανασκόπηση προσεγγίσεων τεχνικής νοημοσύνης για την ανάλυση ευστάθειας πολυκριτήριων προβλημάτων
    - Δ9: Βιβλιογραφική ανασκόπηση ανάλυσης ευστάθειας σε προβλήματα πολυστοχικού προγραμματισμού
2. Η ανάπτυξη μέτρων αξιολόγησης της ευστάθειας:
    - Δ2: Ανάπτυξη μέτρων αξιολόγησης ευστάθειας σε αναλυτικές-συνθετικές διαδικασίες
    - Δ6: Ανάπτυξη μέτρων αξιολόγησης ευστάθειας σε προβλήματα ταξινόμησης
    - Δ10: Ανάπτυξη μέτρων αξιολόγησης μέτρων ευστάθειας σε προβλήματα πολυστοχικού προγραμματισμού
3. Η πειραματική αξιολόγηση των μέτρων ευστάθειας:
    - Δ3: Πειραματική αξιολόγηση μέτρων ευστάθειας σε αναλυτικές-συνθετικές διαδικασίες
    - Δ7: Πειραματική αξιολόγηση προσεγγίσεων τεχνικής νοημοσύνης για την ανάλυση ευστάθειας πολυκριτήριων προβλημάτων
    - Δ11: Πειραματική αξιολόγηση μέτρων ευστάθειας σε προβλήματα πολυστοχικού προγραμματισμού
4. Οι εφαρμογές των μεθοδολογιών μέτρησης και βελτίωσης της ευστάθειας:
    - Δ4: Εφαρμογές ανάλυσης ευστάθειας σε αναλυτικές-συνθετικές διαδικασίες
    - Δ8: Εφαρμογές προσεγγίσεων τεχνικής νοημοσύνης για την ανάλυση ευστάθειας πολυκριτήριων προβλημάτων
    - Δ12: Εφαρμογές ανάλυσης ευστάθειας σε προβλήματα πολυστοχικού προγραμματισμού

Επιπλέον, οι ερευνητικές ομάδες που συμμετέχουν στο πρόγραμμα βρίσκονται στο στάδιο της ανάπτυξης του λογισμικού και της υπολογιστικής υλοποίησης των μέτρων ευστάθειας (δράσεις Δ13 και Δ14) με βάση τα αποτελέσματα των προηγούμενων δράσεων.

Στα πλαίσια του 6ου Επιστημονικού Workshop του έργου πραγματοποιήθηκε παρουσίαση των μέχρι σήμερα αποτελεσμάτων από όλες τις ομάδες που συμμετέχουν στο πρόγραμμα δίνοντας έμφαση στις δράσεις που έχουν ολοκληρωθεί έως τώρα αλλά και τις προδιαγραφές των συστημάτων υποστήριξης αποφάσεων που πρόκειται να αναπτυχθούν στα πλαίσια αυτού του έργου και βρίσκονται σε στάδιο υλοποίησης. Στο παραδοτέο αυτό δίνονται:

- Γενικές πληροφορίες για τη δράση (τόπος, χρόνος διεξαγωγής, συμμετέχοντες, κ.λπ.)
- Συνοδευτικό υλικό της δράσης (αφίσα, δελτίο τύπου, παρουσιάσεις, κ.λπ.)
- Άλλο πρόσθετο υλικό (φωτογραφίες, κ.λπ.)

Επίσης, θα πρέπει να σημειωθεί ότι στα πλαίσια της συγκεκριμένης δράσης δίνεται για άλλη μια φορά η δυνατότητα συνάντησης των μελών των ερευνητικών ομάδων, γεγονός που είναι ιδιαίτερα σημαντικό σε ένα έργο που έχει ως βασικό αντικείμενο τη συνεργασία ερευνητικών ομάδων. Επίσης, η συγκεκριμένη δράση έχει και έναν χαρακτήρα προβολής των αποτελεσμάτων του έργου σε επιστήμονες και φοιτητές που δραστηριοποιούνται στον χώρο της πολυκριτήριας ανάλυσης αποφάσεων.

2 Υλοποίηση

2.1 Γενικές πληροφορίες workshop

Το 6ο Επιστημονικό Workshop με διακριτικό τίτλο "Robust MCDA» (ακρωνύμιο του έργου) πραγματοποιήθηκε στις 6 Ιουνίου 2015 στο Πολυτεχνείο Κρήτης. Το workshop διοργανώθηκε από την ερευνητική ομάδα του Πολυτεχνείου Κρήτης, στην οποία συμμετέχει και ο μετακαλούμενος ερευνητής της αλλοδαπής.

Για τις ανάγκες διοργάνωσης του workshop προετοιμάστηκε κατάλληλο ενημερωτικό υλικό (αφίσα, φυλλάδιο), το οποίο παρουσιάζεται στα Παραρτήματα Α-Β της παρούσας έκθεσης.

Όπως παρουσιάζεται αναλυτικά στην επόμενη παράγραφο, το workshop περιλαμβάνει 3 ενότητες:

1. Υλοποίηση αλγορίθμων μέτρησης και ανάλυσης ευστάθειας σε συστήματα υποστήριξης αποφάσεων.
2. Πρόσφατες εξελίξεις στο πρόβλημα της διαχείρισης της ευστάθειας σε προβλήματα πολυκριτήριας ανάλυσης.
3. Εφαρμογές αλγορίθμων μέτρησης και ανάλυσης ευστάθειας σε πραγματικά προβλήματα από τους χώρους της βελτιστοποίησης χαρτοφυλακίου, της ενεργειακής διαχείρισης και της λήψης πολιτικών αποφάσεων.

2.2 Απολογισμός workshop

Στο workshop συμμετείχαν και οι 3 ερευνητικές ομάδες του έργου, καθώς και σημαντικός αριθμός νέων επιχειρησιακών ερευνητών. Πιο συγκεκριμένα, δόθηκε η δυνατότητα συμμετοχής στους μεταπτυχιακούς φοιτητές του ΠΜΣ της Σχολής Μηχανικών Παραγωγής & Διοίκησης του Πολυτεχνείου Κρήτης, οι διδάσκονται αντίστοιχα μαθήματα (π.χ. Πολυκριτήρια Συστήματα Αποφάσεων, Χρηματοοικονομικές Αποφάσεις και Πολυκριτήρια Ανάλυση).

Επιπρόσθετα, θα πρέπει να σημειωθεί ότι το workshop διοργανώθηκε ακριβώς μετά την πραγματοποίηση της 4th International Symposium and 26th National Conference on Operational Research, το οποίο πραγματοποιήθηκε στα Χανιά στις 4-5 Ιουνίου 2015 και στο οποίο συμμετείχαν αρκετοί ερευνητές του έργου. Έτσι, το workshop προβλήθηκε στους συμμετέχοντες του συνεδρίου, αρκετοί από τους οποίους ανταποκρίθηκαν θετικά.

Ο Πίνακας 2.1 παρουσιάζει τα μέλη της ΚΕΟ και της ΟΕΣ του έργου που συμμετείχαν στο 5ο Επιστημονικό Workshop. Το Workshop παρακολούθησαν επίσης μεταπτυχιακοί φοιτητές, υποψήφιοι διδάκτορες και ερευνητές του Πολυτεχνείου Κρήτης. Συνολικά, ο αριθμός των συμμετεχόντων ανήρθε σε 40 άτομα περίπου.

Συνοπτικά, το πρόγραμμα του 5ου Επιστημονικού Workshop έχει ως εξής:

Σάββατο 6 Ιουνίου 2015

10:00 – 10:30: Προσέλευση και καλωσόρισμα από τους Διοργανωτές Καθ. Ν. Ματσατσίνη, Κ. Ζοπουνίδη, τον Αναπλ. Καθ. Μ. Δούμπο και τον Συντονιστή του έργου Καθ. Ι. Σίσκο

10:30 – 11:30 Towards the development of a modular DSS supporting robustness analysis in MCDA – E. Grigoroudis, N. Tsotsolas, N. Christodoulakis, and Y. Politis

11:30 – 12:30: Exploiting robustness analysis for triggering interactive feedbacks in MINORA and MIIDAS systems – Y. Siskos, A. Spyridakos, D. Yannacopoulos, and N. Tsotsolas

12:30 – 13:30: Regularized estimation for preference disaggregation in multiple criteria decision making – M. Doumpos and C. Zopounidis

13:30 – 14:30: Διάλειμμα

14:30 – 15:30 Robust portfolio optimization: A categorized bibliographic review – P. Xidonas, H. Doukas, G. Mavrotas, J. Psarras, and N. Matsatsinis

15:30 – 16:30: Robustness analysis approaches in political decision making – Y. Siskos, N. Tsotsolas, and S. Alexopoulos

16:30 – 17:00 Διάλειμμα

17:00 – 18:00 Foresight of innovative energy technologies through a linguistic multicriteria approach – J. Psarras, H. Doukas, and A.G. Papadopoulou

18:00 – 18:30 Στρογγυλό τραπέζι – Κλείσιμο του workshop

Πίνακας 2.1: Συμμετέχοντες στο 6ο επιστημονικό workshop

Ομάδα	Ερευνητές
Ερευνητική ομάδα Πανεπιστημίου Πειραιά	Ιωάννης Σίσκος (Καθηγητής/ΠΑΠΕΙ) Ευάγγελος Γρηγορούδης (Αν. Καθηγητής/Πολ. Κρήτης) Ιωάννης Πολίτης (Μεταδιδάκτορας/ΠΑΠΕΙ)
Ερευνητική ομάδα Πολυτεχνείου Κρήτης	Κωνσταντίνος Ζοπουνίδης (Καθηγητής/Πολ. Κρήτης) Νικόλαος Ματσατσίνης (Καθηγητής/Πολ/ Κρήτης) Μιχάλης Δούμπος (Αν. Καθηγητής/Πολ. Κρήτης) Δημήτρης Νίκλης (Υπ. Διδάκτορας/Πολ. Κρήτης)
Ερευνητική ομάδα Εθνικού Μετσόβιου Πολυτεχνείου	Ιώαννης Ψαρράς (Καθηγητής, ΕΜΠ)

Στο Παράρτημα Γ της συγκεκριμένης έκθεσης δίνονται οι παρουσιάσεις που χρησιμοποιήθηκαν σε όλη τη διάρκεια του workshop συνάντησης, σύμφωνα με το προηγούμενο πρόγραμμα.

Παράρτημα Α: Αφίσα workshop

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

ΠΟΛΥΤΕΧΝΕΙΟ ΚΡΗΤΗΣ

ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

6ο Επιστημονικό Workshop
Robust MCDA

ΠΡΟΓΡΑΜΜΑ ΘΑΛΗΣ

Μεθοδολογικές προσεγγίσεις για τη μελέτη της ευστάθειας σε προβλήματα λήψης αποφάσεων με πολλαπλά κριτήρια

6 Ιουνίου 2015
Σχολή Μηχανικών Παραγωγής & Διοίκησης
Πολυτεχνειούπολη, Κουνουπιδιανά, 73100 Χανιά

ΔΙΟΡΓΑΝΩΣΗ
Σχολή Μηχανικών Παραγωγής και Διοίκησης
Εργαστήριο Σχεδιασμού και Ανάπτυξης Συστημάτων Υποστήριξης Αποφάσεων
Πολυτεχνείο Κρήτης

Ευρωπαϊκή Ένωση
Ευρωπαϊκό Κοινωνικό Ταμείο
ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ
ΕΚΠΑΙΔΕΥΣΗ ΚΑΙ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗ
επένδυση στην κοινωνία της γνώσης
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ & ΘΡΗΣΚΕΥΜΑΤΩΝ, ΠΟΛΙΤΙΣΜΟΥ & ΑΘΛΗΤΙΣΜΟΥ
ΕΙΔΙΚΗ ΥΠΗΡΕΣΙΑ ΔΙΑΧΕΙΡΙΣΗΣ
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης
ΕΣΠΑ 2007-2013
ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ

Παράρτημα Β: Φυλλάδιο workshop

ΠΟΛΥΤΕΧΝΕΙΟ ΚΡΗΤΗΣ

6ο Επιστημονικό Workshop

Robust MCDA

ΠΡΟΓΡΑΜΜΑ ΘΑΛΗΣ

Μεθοδολογικές προσεγγίσεις για τη μελέτη της ευστάθειας σε προβλήματα λήψης αποφάσεων με πολλαπλά κριτήρια

6 Ιουνίου 2015

Πολυτεχνείο Κρήτης

ΔΙΟΡΓΑΝΩΣΗ

Σχολή Μηχανικών Παραγωγής και Διοίκησης

Πολυτεχνείο Κρήτης

ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΕΚΠΑΙΔΕΥΣΗ ΚΑΙ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗ

ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ ΚΑΙ ΘΡΗΣΚΕΥΜΑΤΩΝ ΕΙΔΙΚΗ ΥΠΗΡΕΣΙΑ ΔΙΑΧΕΙΡΙΣΗΣ

ΕΣΠΑ 2007-2013

Ευρωπαϊκή Ένωση

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Ερευνητικές Ομάδες

Πανεπιστήμιο Πειραιώς

Σίσκος, Ι.	Πανεπιστήμιο Πειραιώς
Γιαννακόπουλος, Δ.	ΤΕΙ Πειραιώς
Γρηγορούδης, Ε.	Πολυτεχνείο Κρήτης
Bouyssou, D.	Université Paris Dauphine
Hurson, C.	Université de Rouen
Σπυριδάκος, Α.	ΤΕΙ Πειραιώς
Τσότσολας, Ν.	Πανεπιστήμιο Πειραιώς
Πολίτης, Ι.	Πανεπιστήμιο Πειραιώς
Χριστοδουλάκης, Ν.	Πανεπιστήμιο Πειραιώς
Μουριάδου, Γ.	Πανεπιστήμιο Πειραιώς

Πολυτεχνείο Κρήτης

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Δούμπος, Μ.	Πολυτεχνείο Κρήτης
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Δελιάς, Π.	ΤΕΙ Καβάλας
Μαναρώλης, Ε.	Πολυτεχνείο Κρήτης
Νίκλης, Δ.	Πολυτεχνείο Κρήτης

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Ασκούνης, Δ.	Εθνικό Μετσόβιο Πολυτεχνείο
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Σίσκος, Ε.	Εθνικό Μετσόβιο Πολυτεχνείο

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http://www.robust-mcda-project.eu/

Συμμετέχοντα Ιδρύματα

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ΠΟΛΥΤΕΧΝΕΙΟ ΚΡΗΤΗΣ

ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΕΚΠΑΙΔΕΥΣΗ ΚΑΙ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗ

ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ ΚΑΙ ΘΡΗΣΚΕΥΜΑΤΩΝ ΕΙΔΙΚΗ ΥΠΗΡΕΣΙΑ ΔΙΑΧΕΙΡΙΣΗΣ

ΕΣΠΑ 2007-2013

Ευρωπαϊκή Ένωση

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Πρόγραμμα ΘΑΛΗΣ

Το 6 ° **Επιστημονικό Workshop Robust MCDA** πραγματοποιείται στα πλαίσια του έργου ΘΑΛΗΣ με τίτλο «Μεθοδολογικές προσεγγίσεις για τη μελέτη της ευστάθειας σε προβλήματα λήψης αποφάσεων με πολλαπλά κριτήρια» και εντάσσεται στο σύνολο των δράσεων δημοσιότητας του έργου.

Το έργο αφορά στη μελέτη της ευστάθειας (robustness) σε προβλήματα λήψης αποφάσεων με πολλαπλά κριτήρια. Η έννοια της ευστάθειας αναφέρεται τόσο στη συμφωνία των παραδοχών και εκτιμήσεων που διαμορφώνουν ένα μοντέλο υποστήριξης αποφάσεων σε σχέση με τα πραγματικά χαρακτηριστικά του προβλήματος, όσο και στην ποιότητα των προτεινόμενων λύσεων σε σχέση με εναλλακτικά σενάρια για το πλαίσιο και το περιβάλλον της απόφασης.

Το αντικείμενο του έργου καλύπτει θέματα όπως:

- η ανάπτυξη διαδικασιών μέτρησης της ευστάθειας των αποτελεσμάτων και των παραμέτρων διαδικασιών πολυκριτήριας ανάλυσης,
- η μελέτη της ποιότητας των δεδομένων και της σχέσης τους με τα αποτελέσματα μιας πολυκριτήριας αξιολόγησης, και
- η ανάπτυξη μεθοδολογιών για τη διαμόρφωση λύσεων που παρουσιάζουν ευστάθεια σε μεταβολές των παραμέτρων ενός προβλήματος απόφασης και του περιβάλλοντός της.

Βασικός στόχος του έργου είναι η ανάπτυξη ενός ολοκληρωμένου θεωρητικού πλαισίου για τη μέτρηση της ευστάθειας των λύσεων που προκύπτουν από υπάρχουσες μεθοδολογίες, καθώς επίσης και η προώθηση της διεθνούς επιστημονικής έρευνας στο χώρο της επιχειρησιακής έρευνας και της πολυκριτήριας ανάλυσης.

Πρόσθετοι στόχοι του έργου αποτελούν

- η ανάπτυξη της συνεργασίας σε εθνικό και διεθνές επίπεδο σε θέματα πολυκριτήριας ανάλυσης αποφάσεων,
- η διάδοση της παραγόμενης επιστημονικής γνώσης και
- η πρακτική εφαρμογή των θεωρητικών αποτελεσμάτων της έρευνας.

Τέλος, θα πρέπει να σημειωθεί ότι στο πλαίσιο του έργου θα μελετηθεί ένα ευρύ πεδίο πρακτικών εφαρμογών από τους χώρους της περιβαλλοντικής και ενεργειακής διαχείρισης, της ανάλυσης οικονομικών και τεχνολογικών κινδύνων (διαχείριση επενδύσεων, χρηματοοικονομικός προγραμματισμός, βιομηχανική ασφάλεια, κ.ά.), της διοίκησης επιχειρήσεων (εφοδιαστική αλυσίδα, προγραμματισμός έργων, μάρκετινγκ, διοίκηση προσωπικού, κ.ά.), καθώς και των κατασκευών (κτήρια, μηχανολογικά & ηλεκτρολογικά/ηλεκτρονικά συστήματα). Σε όλα αυτά τα πεδία, η λήψη αποφάσεων χαρακτηρίζεται από την ύπαρξη πολλαπλών κριτηρίων και περιορισμών (τεχνολογικών και οικονομικών) και την αυξημένη αβεβαιότητα.

Στόχοι και Θέματα Workshop

Βασικός στόχος του Workshop είναι η παρουσίαση όχι μόνο της τρέχουσας έρευνας που έχει πραγματοποιηθεί στα πλαίσια του έργου και αφορά τη μελέτη της ευστάθειας σε προβλήματα λήψης αποφάσεων με πολλαπλά κριτήρια, αλλά και του γενικότερου αντικειμένου της πολυκριτήριας ανάλυσης αποφάσεων.

Πιο συγκεκριμένα, οι στόχοι του Workshops είναι:

- η παρουσίαση των τρέχουσας ερευνητικής προσπάθειας που αφορά τη μελέτη της ευστάθειας στην πολυκριτήρια ανάλυση αποφάσεων,
- η παρουσίαση της γενικότερης θεωρίας και των πρακτικών εφαρμογών της πολυκριτήριας ανάλυσης αποφάσεων,
- η διάδοση του επιστημονικού αντικειμένου της πολυκριτήριας ανάλυσης αποφάσεων και
- η δικτύωση και η ανταλλαγή απόψεων ανάμεσα σε επιχειρησιακούς ερευνητές και στελέχη επιχειρήσεων και οργανισμών που ασχολούνται με το συγκεκριμένο αντικείμενο.

Επίσης, στα πλαίσια της συγκεκριμένου workshop δίνεται η δυνατότητα συνάντησης των μελών των ερευνητικών ομάδων.

Το Workshop περιλαμβάνει 3 ενότητες:

1. Υλοποίηση αλγορίθμων μέτρησης και ανάλυσης ευστάθειας σε συστήματα υποστήριξης αποφάσεων.
2. Πρόσφατες εξελίξεις στο πρόβλημα της διαχείρισης της ευστάθειας σε προβλήματα πολυκριτήριας ανάλυσης.
3. Εφαρμογές αλγορίθμων μέτρησης και ανάλυσης ευστάθειας σε πραγματικά προβλήματα από τους χώρους της βελτιστοποίησης χαρτοφυλακίου, της ενεργειακής διαχείρισης και της λήψης πολιτικών αποφάσεων.

Τόπος και Χρόνος Διεξαγωγής

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Πολυτεχνείο Κρήτης
Πολυτεχνειούπολη
73100 Χανιά
6 Ιουνίου 2015

Συμμετοχή

Το επιστημονικό workshop είναι ανοικτό για το κοινό και στις εργασίες του μπορούν να συμμετέχει ελεύθερα χωρίς περιορισμό κάθε ενδιαφερόμενος.

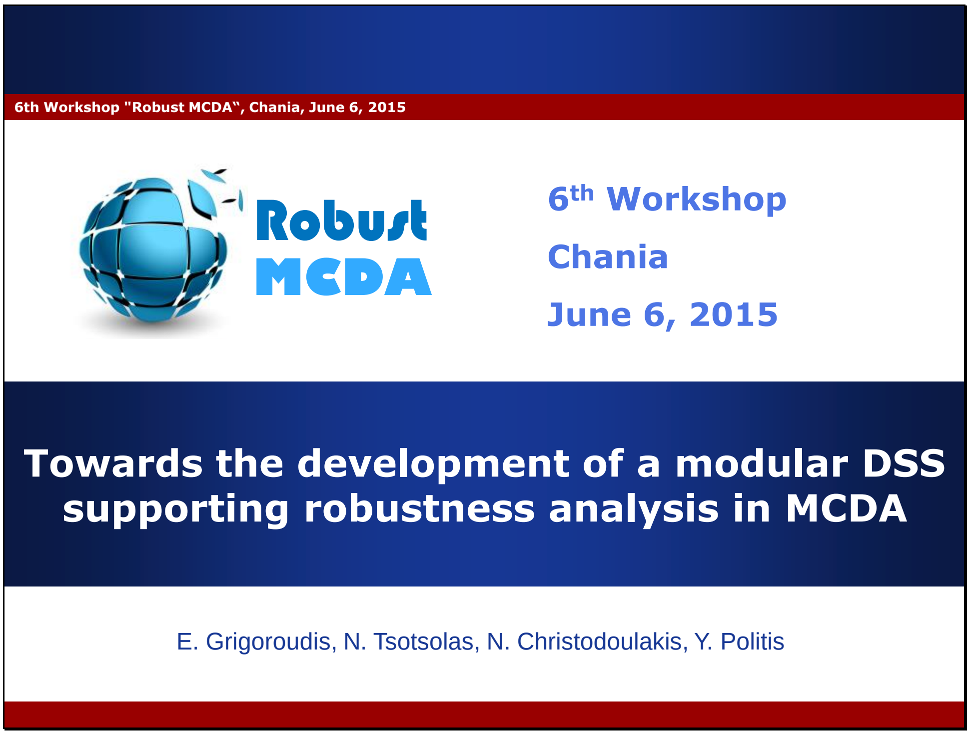
Πιο συγκεκριμένα, το επιστημονικό workshop απευθύνονται σε ερευνητές, υποψήφιους διδάκτορες, μεταπτυχιακούς φοιτητές, κ.λπ. που εργάζονται ή σκοπεύουν να ασχοληθούν με το ευρύτερο αντικείμενο της πολυκριτήριας ανάλυσης.

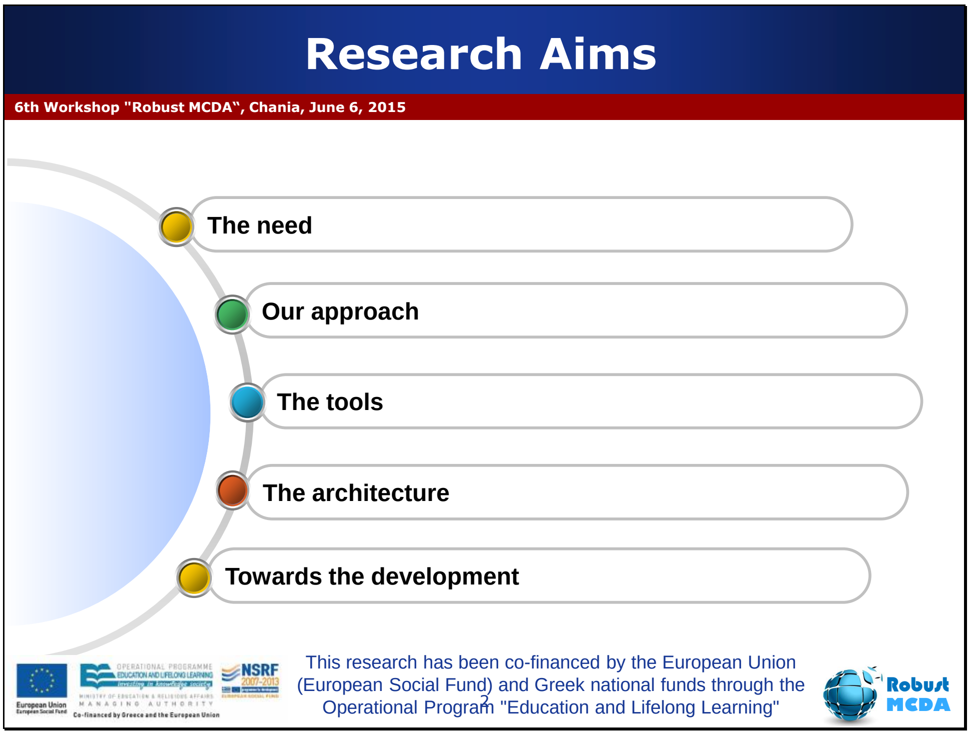
Πρόγραμμα Workshop

Σάββατο 6 Ιουνίου 2015	
10:00 – 10:30	Χαιρετισμοί
10:30 – 11:30	Towards the development of a modular DSS supporting robustness analysis in MCDA – E. Grigoroudis, N. Tsotsolas, and N. Christodoulakis
11:30 – 12:30	Exploiting robustness analysis for triggering interactive feedbacks in MINORA and MIIDAS systems – Y. Siskos, A. Spyridakos, D. Yannacopoulos, and N. Tsotsolas
12:30 – 13:30	Regularized estimation for preference disaggregation in multiple criteria decision making – M. Doumpos and C. Zopounidis
13:30 – 14:30	Διάλειμμα
14:30 – 15:30	Robust portfolio optimization: A categorized bibliographic review – P. Xidonas, H. Doukas, G. Mavrotas, J. Psarras, and N. Matsatsinis
15:30 – 16:30	Robustness analysis approaches in political decision making – Y. Siskos, N. Tsotsolas, and S. Alexopoulos
16:30 – 17:00	Διάλειμμα
17:00 – 18:00	Foresight of innovative energy technologies through a linguistic multicriteria approach – J. Psarras, H. Doukas, and A.G. Papadopoulou
18:00 – 18:30	Στρογγυλό τραπέζι - Κλείσιμο του workshop

Robust MCDA

Παράρτημα Γ: Παρουσιάσεις workshop





What we are building

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We are building a DSS dealing with robustness analysis in MCDA disaggregation – aggregation methods using a modular software framework.

Robustness analysis is an issue which should be tackled by DSSs as a mean to provide, in an understandable way, to the analyst and to the decision maker, a clear picture regarding reliability and stability of the accessed models and the produced results.

Three different approaches are found behind the word "*robustness*".

- Robust conclusion – valid in all or most pairs (version, procedure) – dealing with system values and gap from reality
- Robust solution – good in all or most cases– dealing with uncertainty of external environment and external factors
- Robust decision in dynamic context – keep open as many good plans as possible for the future – dealing with the unknown future

3

What we are building

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Based on the robustness measures the decision maker may accept or reject, or in some cases adapt the proposed decision model.

Various robustness analysis techniques are applied in several operational research methods and among others in the ones belonging to the MCDA family of methods.

One could find similar techniques when dealing with robustness analysis in different MCDA methods and consequently it should be rational to be able to reuse software modules when building the corresponding steps of a DSS.

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What we are building

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Why modular?

- DSS implement a **significant** number of algorithms to serve their role in supporting efficiently complex decision processes
- These algorithms supports several discrete steps:
  - data input
  - transformation
  - analysis
  - results
  - visualization of the results
- We are focus on these steps in a DSS that can be implemented by a flexible set of generic or less generic algorithms which can be built as articulated parts of the system

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The need

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Modular DSS because we need it to be:

- Of wide scope
- Adaptable
- Extensible
- Fast in development
- User friendly
- Interoperable

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The need

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Wide scope:

- Covering two robustness analysis approaches (Robust solution, Robust conclusion)
- Implementing several methods for robustness analysis (e.g. MAX-MIN Heuristic, Manas-Nedoma, Robust Ordinal Regression, Extreme Ranking) in MCDA disaggregation – aggregation approaches (e.g. Stochastic UTA, GRIP, SMAA)
- Calculate several robustness measures (ASI, Acceptability indices, confidence factors, extreme ranking indices, polyhedral capacity, etc)
- Visualize the robustness analysis using different ways

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The need

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Adaptable:

- Collaborate with other DSS or Information Systems
- Work in an environment with various data sources (data bases, data marts)
- Adapt the algorithms to new research findings
- Use well accepted standards in a transparent way

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The need

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Extensible:

- Support new processes or extend the existing ones
- Incorporate new algorithms
- Accept new forms of data schemas
- Produce new forms of data schemas

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The need

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Fast in development:

- Adopt a solid architecture scheme based on popular and fully supported standards
- Re-use code modules for repeated tasks
- Extended use of libraries for basic and common tasks
- Use a standard vocabulary

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The need

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User friendly:

- Provide the choice to use web-forms or files for data input
- Support the user to select the appropriate input file - Provide a list of alternative files-data set for input
- Propose pre-defined chains of modules for specific tasks – provide also alternative chains for the same task
- Provide lists with available outputs per task

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The need

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Interoperable:

- Fully open and transparent to the external world
- Use well-accepted standards for the description of the modules – entities
- Use of a very well defined and extensible vocabulary
- Adopt a stable and open framework for modular development

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Our Approach

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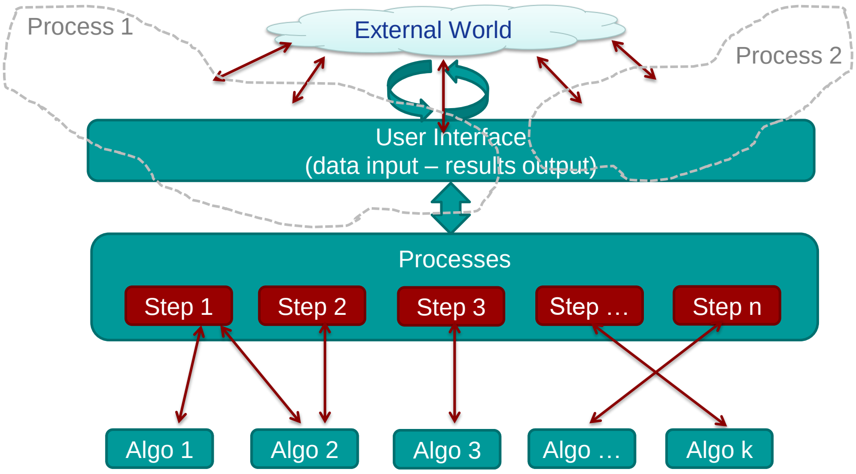
Why a modular approach instead of a layer approach?



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The tools

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A set of appropriate elements will be used to build this modular DSS:

- Elements from our already developed DSSs:
  - Stochastic UTA (TALOS)
  - MUSA-DSS
- XMCDA, a standardized XML vocabulary
- SOAP protocol for exchanging structured information
- A framework for modular development (OSGi or MEF)
- Libraries (such as Kappalab box for capacity calculation and integral manipulation on a finite setting)

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The tools

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XMCDA:

A data standard which allows to represent MultiCriteria Decision Analysis (MCDA) data elements in XML according to a clearly defined grammar.

XMCDA is an instance of UMCDA-ML, which is the Universal MultiCriteria Decision Analysis Modelling Language and which is one of the scientific initiatives inside the Decision Deck project. UMCDA-ML is intended to be a universal modelling language to express MCDA concepts and generic decision aid processes.

XMCDA focusses more particularly on MCDA concepts and data structures and is defined by an XML schema.

XMCDA allows the visualization of data structures in web browsers using XSLT files which performs a transformation of the XML data file into HTML.

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The tools

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XMCDA:

An XML schema sample of the XMCDA structure:

Consider the following example, where the set of alternatives $\{a_3,a_4\}$ is considered as a kernel of a graph.

```
<alternativesSet mcdaConcept="kernel" name="a kernel with two elements">
        <element>
                <alternativeID>a03</alternativeID>
        </element>
        <element>
                <alternativeID>a04</alternativeID>
        </element>
</alternativesSet>
```

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The tools

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XMCDA:

The Decision Deck project aims at collaboratively developing Open Source software tools implementing MCDA techniques which are meant to support complex decision aid processes. One of the main features of these software solutions are that they are interoperable in order to create a coherent ecosystem.

Currently the active developments apart from XMCDA are:

- diviz: a software for designing, executing and sharing MCDA methods, algorithms and experiments.
- XMCDA web services: distributed computational MCDA resources, using the XMCDA standard

The Decision Deck project is run by the Decision Deck Consortium, a French non profit association.

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The tools

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SOAP protocol:

SOAP, originally defined as Simple Object Access Protocol, is a protocol specification for exchanging structured information in the implementation of web services in computer networks. It relies on XML Information Set for its message format, and usually relies on other application layer protocols, most notably Hypertext Transfer Protocol (HTTP) or Simple Mail Transfer Protocol (SMTP), for message negotiation and transmission.

SOAP can form the foundation layer of a web services protocol stack, providing a basic messaging framework upon which web services can be built. This XML-based protocol consists of three parts: **an envelope**, which defines what is in the message and how to process it, **a set of encoding rules** for expressing instances of application-defined data-types, and a **convention** for representing procedure calls and responses.

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The tools

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OSGi:

The OSGi technology is a set of specifications that define a dynamic component system for Java. These specifications enable a development model where applications are (dynamically) composed of many different (reusable) components.

The OSGi specifications enable components to hide their implementations from other components while communicating through services, which are objects that are specifically shared between components. This simple model has far reaching effects for almost any aspect of the software development process.

An OSGI bundle is a package that encapsulates classes, resources, native files, etc. It can do nothing alone and is intended to be deployed inside an OSGI environment.

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The tools

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Managed Extensibility Framework - (MEF):

The Managed Extensibility Framework (MEF) is a composition layer for .NET that improves the flexibility, maintainability and testability of large applications. MEF can be used for third-party plugin extensibility, or it can bring the benefits of a loosely-coupled plugin-like architecture to regular applications.

Instead of explicit registration of available components, MEF provides a way to discover them implicitly, via *composition*. A MEF component, called a *part*, declaratively specifies both its dependencies (known as *imports*) and what capabilities (known as *exports*) it makes available. When a part is created, the MEF composition engine satisfies its imports with what is available from other parts.

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The tools

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MUSA -DSS:

The DSS was designed and developed for supporting the users of MUSA method at three different levels:

i. in benchmarking different post-optimality approaches (analytic and heuristic ones) for a given set of data

ii. in selecting the most appropriate parameters' values of the method

iii. in producing the full range of MUSA results

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1st Level: Benchmarking of Methods

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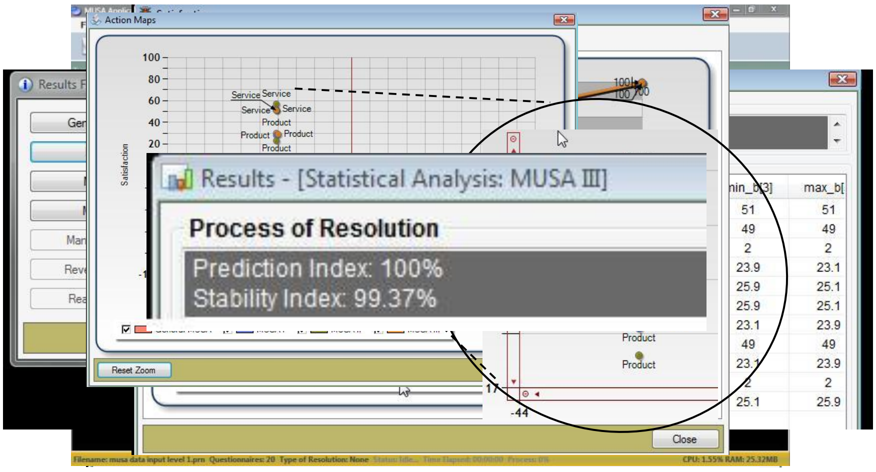
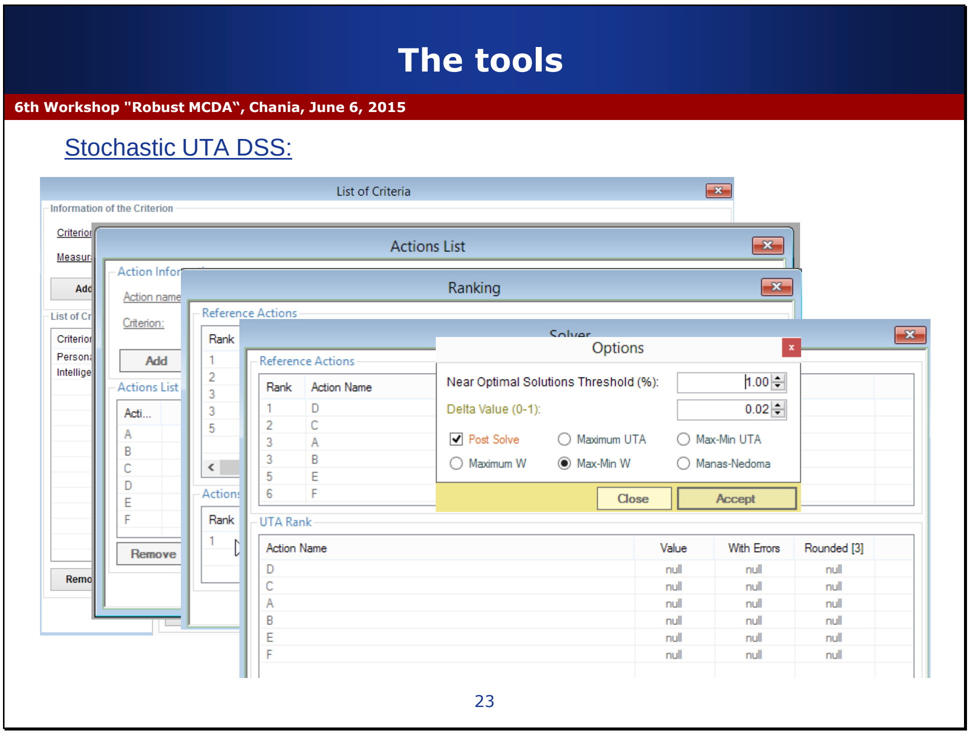


Indices OPL και ASI

1st Level

22


The tools
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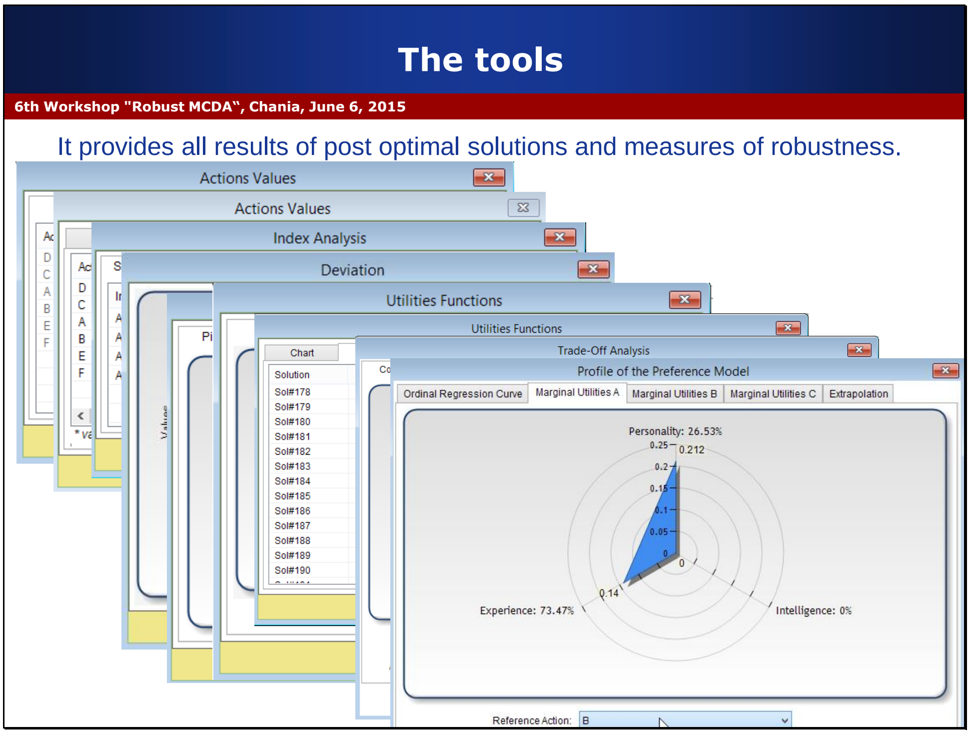
Stochastic UTA DSS:
List of Criteria
Actions List
Ranking
Solver
Options
Near Optimal Solutions Threshold (%):
1.00
Delta Value (0-1):
0.02
Post Solve
Maximum UTA
Max-Min UTA
Maximum W
Max-Min W
Manas-Nedoma
Close
Accept
Reference Actions
UTA Rank
Action Name
Value
With Errors
Rounded [3]
23


The tools
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It provides all results of post optimal solutions and measures of robustness.
Actions Values
Actions Values
Index Analysis
Deviation
Utilities Functions
Utilities Functions
Trade-Off Analysis
Profile of the Preference Model
Ordinal Regression Curve
Marginal Utilities A
Marginal Utilities B
Marginal Utilities C
Extrapolation
Personality: 26.53%
Experience: 73.47%
Intelligence: 0%
Reference Action:
B

The architecture

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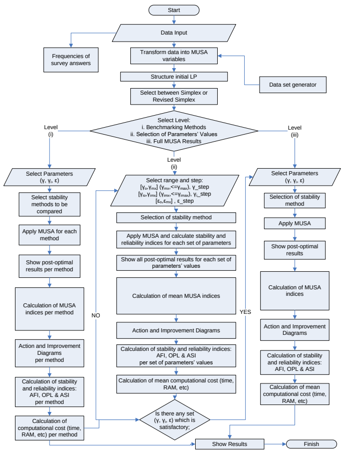
These two DSSs have built using reusable elements (subroutines, functions). The output of an element could be the input of the subsequent element and so on.



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The architecture

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Let's see for example the transformation of an existing module found in both DSSs:

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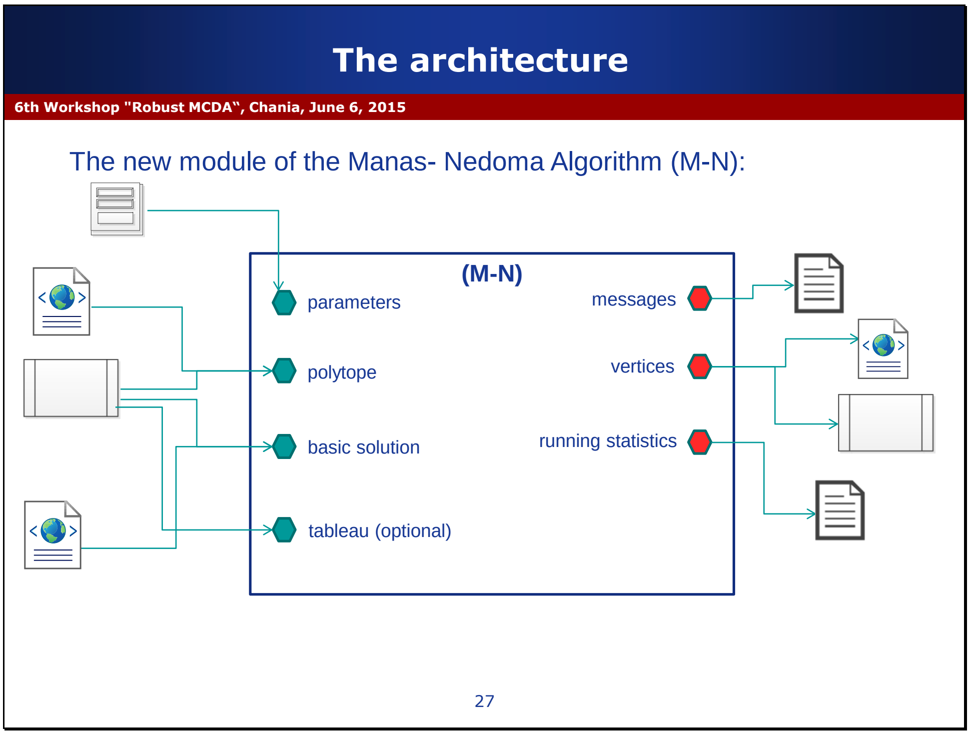
The architecture
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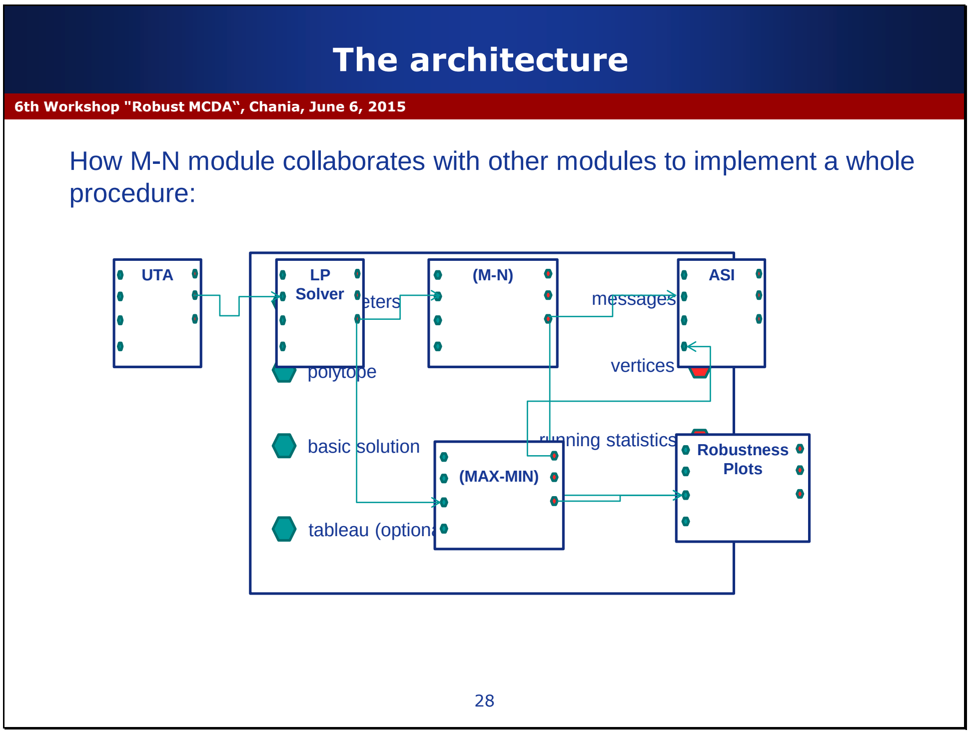
The new module of the Manas- Nedoma Algorithm (M-N):
(M-N)
parameters
polytope
basic solution
tableau (optional)
messages
vertices
running statistics
27


The architecture
6th Workshop "Robust MCDA", Chania, June 6, 2015
How M-N module collaborates with other modules to implement a whole procedure:
UTA
LP Solver
(M-N)
ASI
(MAX-MIN)
Robustness Plots
basic solution
vertices
messages
28

The architecture

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The basic modules to be developed at the first stage will be the following:

- Data input and transformation modules
  - ✓ Multicriteria performance table
  - ✓ Preferences (rankings, pairwise comparisons, constraints)
  - ✓ Models' parameters
- Analysis models modules
  - ✓ LP Solver
  - ✓ Stochastic UTA
  - ✓ SMAA (already under development in Stochastic UTA DSS)
  - ✓ GRIP
- Post-optimal analysis modules
  - ✓ ROR
  - ✓ Extreme ranking
  - ✓ Manas-Nedoma
  - ✓ Heuristic MAX-MIN

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The architecture

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- Robustness measures modules
  - ✓ ASI
  - ✓ Solutions' range
  - ✓ Visual display of the range
  - ✓ Hyper-polyedra (polytopes) volume
  - ✓ Acceptability indices
  - ✓ Confidence factors
  - ✓ Extreme ranking indices
  - ✓ Statistical indices

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Next Steps
6th Workshop "Robust MCDA", Chania, June 6, 2015
1
Develop the DSS shell based on XMCDA standards.
2
Transform the elements of the two DSS into modules compatible with XMCDA.
3
Add any necessary new modules – algorithms.
31


Next Steps
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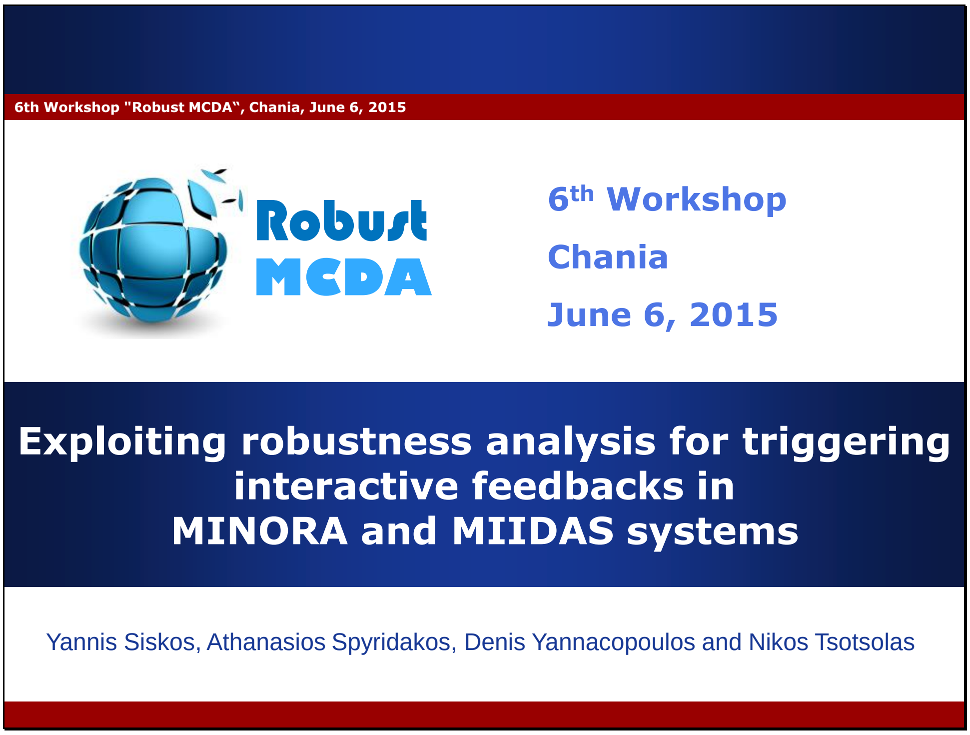
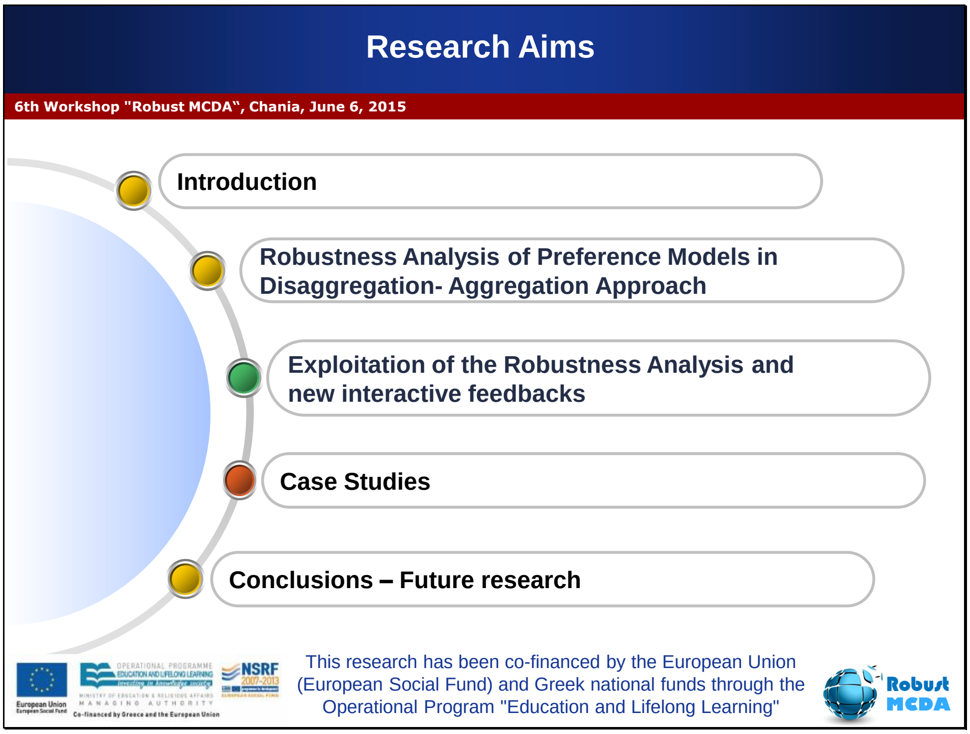
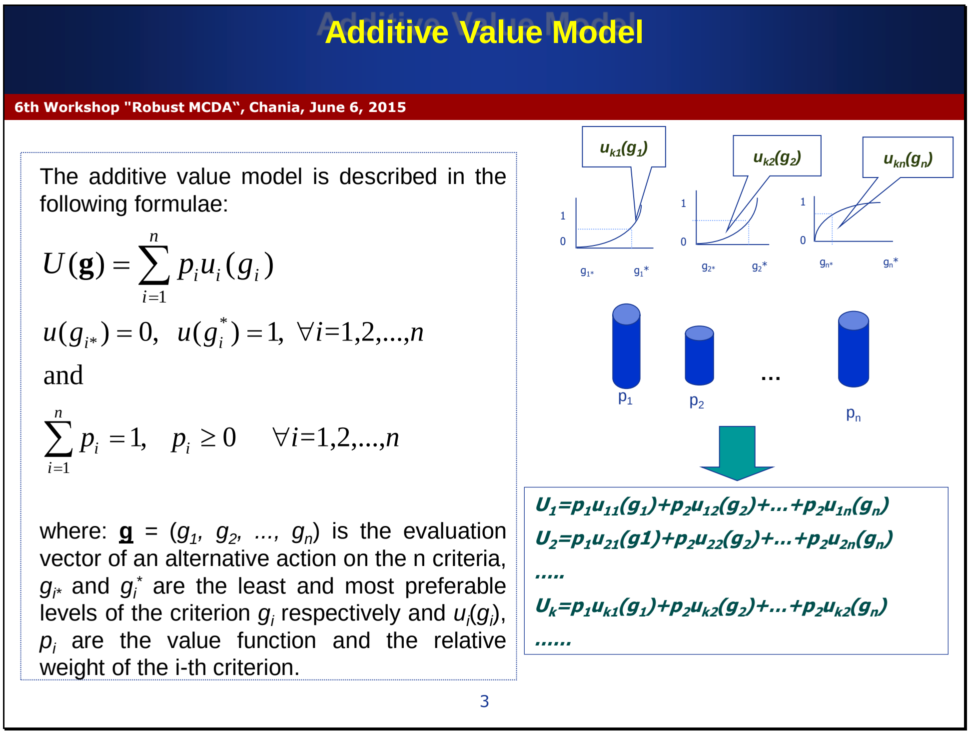
4
Incorporate the modules into the DSS shell.
5
Integrate two Group DSS (RACES & RAVI) into the DSS shell
6
Continue developing new modules for several MCDA methods.
32


6th Workshop "Robust MCDA", Chania, June 6, 2015
Robust MCDA
6th Workshop
Chania
June 6, 2015
Exploiting robustness analysis for triggering interactive feedbacks in MINORA and MIIDAS systems
Yannis Siskos, Athanasios Spyridakos, Denis Yannacopoulos and Nikos Tsotsolas


Research Aims
6th Workshop "Robust MCDA", Chania, June 6, 2015
Introduction
Robustness Analysis of Preference Models in Disaggregation- Aggregation Approach
Exploitation of the Robustness Analysis and new interactive feedbacks
Case Studies
Conclusions – Future research
This research has been co-financed by the European Union (European Social Fund) and Greek national funds through the Operational Program "Education and Lifelong Learning"
Robust MCDA



Additive Value Model
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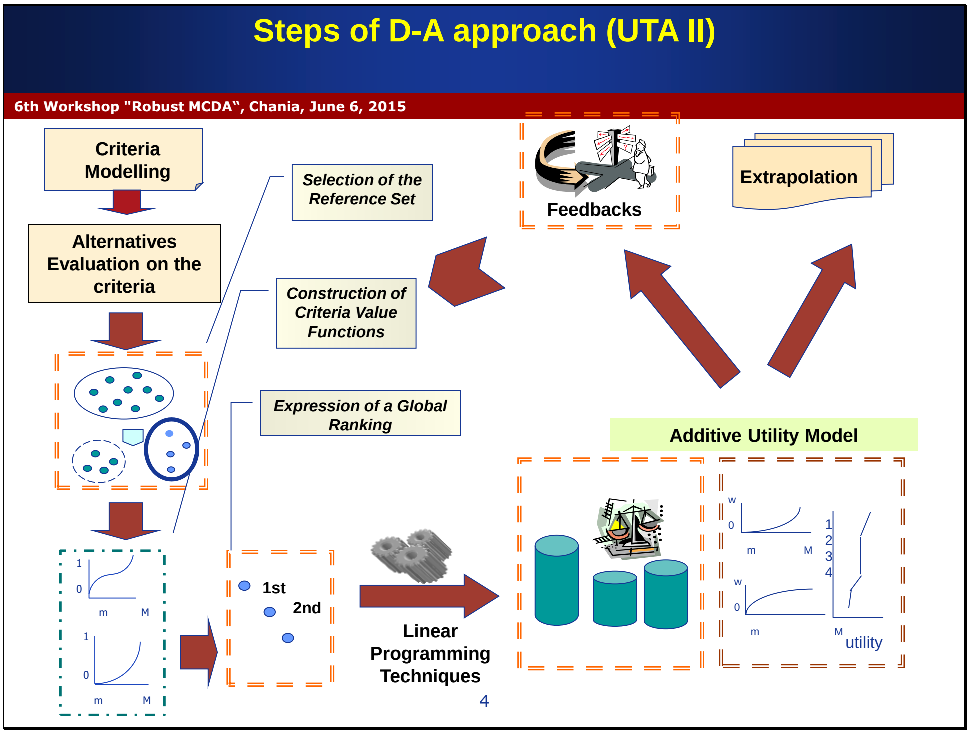
The additive value model is described in the following formulae:
$U(\mathbf{g}) = \sum_{i=1}^{n} p_i u_i(g_i)$
$u(g_{i*}) = 0, \ u(g_i^*) = 1, \ \forall i = 1,2,...,n$
and
$\sum_{i=1}^{n} p_i = 1, \ p_i \geq 0 \quad \forall i = 1,2,...,n$
where: $\mathbf{g}$ = (g_1, g_2, ..., g_n) is the evaluation vector of an alternative action on the n criteria, g_{i*} and g_i^* are the least and most preferable levels of the criterion g_i respectively and $u_i(g_i)$, p_i are the value function and the relative weight of the i-th criterion.
$u_{k1}(g_1)$
$u_{k2}(g_2)$
$u_{kn}(g_n)$
p_1
p_2
...
p_n
$U_1=p_1u_{11}(g_1)+p_2u_{12}(g_2)+...+p_2u_{1n}(g_n)$
$U_2=p_1u_{21}(g1)+p_2u_{22}(g_2)+...+p_2u_{2n}(g_n)$
.....
$U_k=p_1u_{k1}(g_1)+p_2u_{k2}(g_2)+...+p_2u_{k2}(g_n)$
......
3



Steps of D-A approach (UTA II)
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Criteria Modelling
Alternatives Evaluation on the criteria
Selection of the Reference Set
Construction of Criteria Value Functions
Expression of a Global Ranking
Feedbacks
Extrapolation
Additive Utility Model
1st
2nd
Linear Programming Techniques
utility
4

Solution of L.P.

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The estimation of the parameters of the value system in UTA may result to:

A. Only one solution (Robust). There is only one vector of the weights.

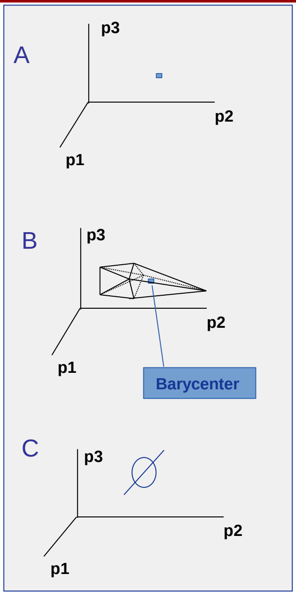
B. Infinite Solutions (Non Robust)

C. No Solutions, often in cases with extremely low structure.

Question?

In non robust cases which could be the vector of weights to work with ?

MINORA and MIIDAS systems (Siskos et al, 1993, 1999) proceed with Post Optimality Analysis. Solutions are estimated by maximising the weight of each criterion. The mean solution (barycenter) constitute the working vector of weights.



5

Robustness Analysis Concerns

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The presence of low robustness in the estimated preference model results to some crucial questions:

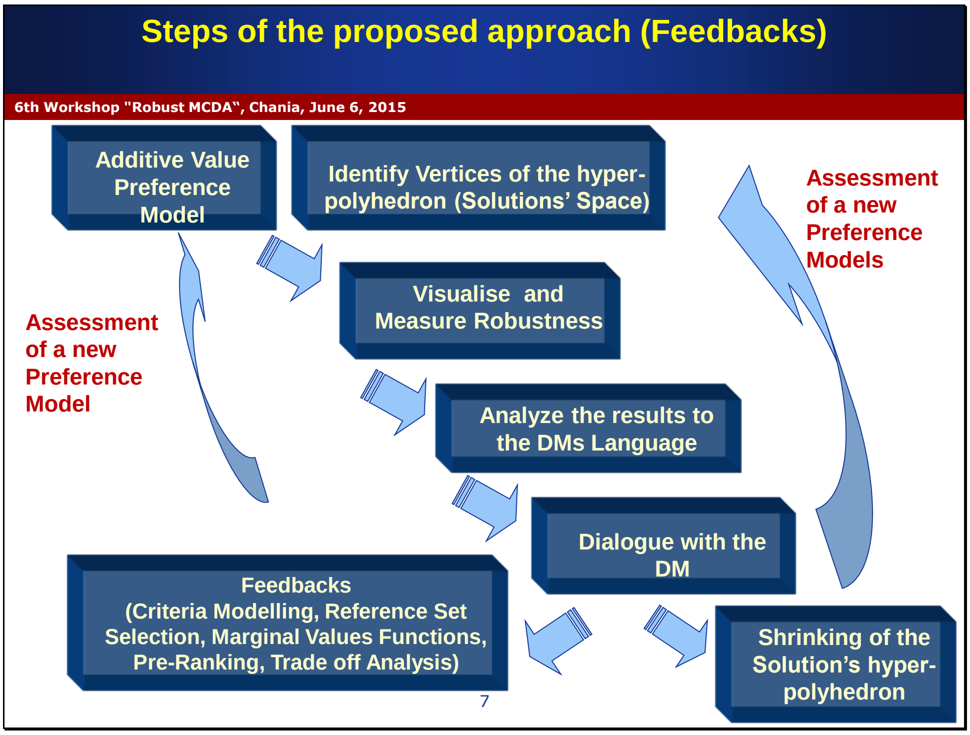
- How representative is the barycenter as far as the real preferences of the DM are concerned?
- Can be accepted a preference model with low robustness, while the criteria weights are varying in many cases in a wide range of values?
- Can be accepted a preference model where presents reversal of criteria importance into the estimated hyper-polyhedron?

The proposed Robustness Analysis of preference models aims to:

a) Explain the low robustness and increase the knowledge about the DMs' preference structures

b) Determine actions (Feedbacks) to be taken in order to increase the level of robustness

6



Robustness Indices

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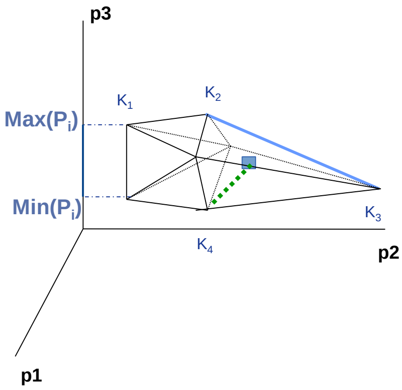
A. Minimum and maximum values of the criteria weights (Post Optimal Analysis)

$\mu_i = (\max(p_{ij}) - \min(p_{ij})),$
p_{ij} *the weight of the i criterion in the j vertice,*
$i = 1,2,\ldots,n, \quad j = 1,2,\ldots,m,$
n number of criteria and m number of vertices

B. The Average Stability Index (ASI)

$$ASI = 1 - \frac{\sum_{i=1}^{n} \sqrt{m\left(\sum_{j=1}^{m}(p_{ij})^2\right) - \left(\sum_{j=1}^{m} p_{ij}\right)^2}}{m\sqrt{(n-1)}}$$

(n= number of criteria and m number of vertices) (Grigoroudis & Siskos)



8

The RAVI Subsystem

(Robustness Analysis through Visual and Interactive Approaches)

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- Supports the Visualisation of n-dimensional spaces in 3d and 2d form
- Includes Links with MINORA and MIIDAS systems
- Supports Interactive feedbacks for the scrutiny of the hyper-polyhedra
- Aims:
  - Component in MINORA and MIIDAS systems.
  - Simple and easy way to present the Robustness of the assessed preference structures.
  - Acquire knowledge about preference models' structures and support the decision making process
  - Lead to more robust preference models through intervention on the preference models utilising addition preference information.
- Technology (.NET Platform, Windows Presentation Framwork, Visual C# and Libraries for Linear Algebra and 3D graphs)

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Robustness Analysis Tools

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- Visualisation of the Preference Models – Utilising 3d and 2d graphs for n – Dimensional Data
- "Dive" into the assessed preference models through tomographic approaches
- Examine the consequences on the preference models robustness for interventions
- Examine the capability to estimate a more robust preference models
- Estimate a more robust or a robust preference model.

Three new modules:

- Tomographical technique
- Shrinking the Hyper-polyhedron
- Prioritizations on the criteria

Crucial :

- The participation of the Decision Maker
- Focused and limited interventions.

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1st Case Study
Robustness Analysis and Feedbacks

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The Case Study: Job Evaluation

25 Alternatives Evaluated in 6 Criteria. 13 Alternatives selected in the Reference Set.

MIIDAS - Criteria, Alternatives, Multicriteria Table

Choices

Title ...... Job Evaluation

1,2 Pesonnel

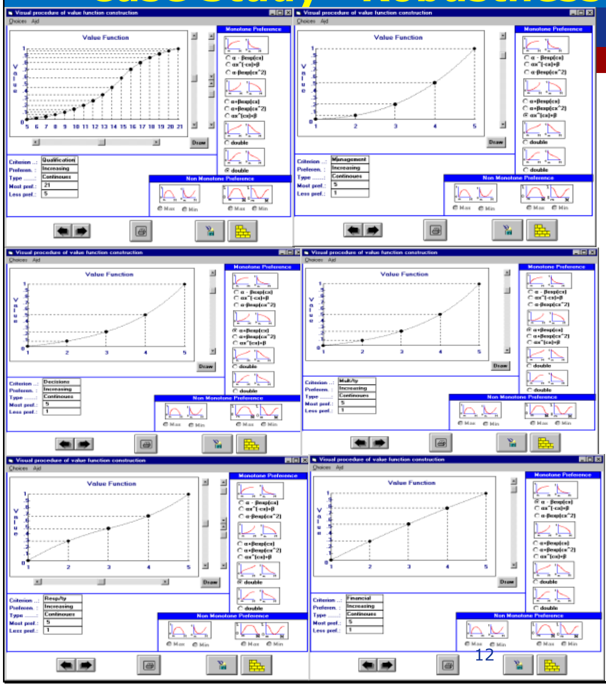
	1	2	3	4	5	6
Name	Qualificatio	Pesonnel	Decisions	Mult/ty	Responsibili	Budget
Preference	Increasing	Increasing	Increasing	Increasing	Increasing	Increasing
Less Pref.	5	1	1	1	1	1
Most Pref.	21	5	5	5	5	5
Type	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete

,3 Pesonnel

	Alternative	Qualificatio	Pesonnel	Decisions	Mult/ty	Responsibili	Budget
1	p-1	17	1	4	5	4	1
2	p-2	16	2	4	4	5	1
3	p-3	15	1	5	5	3	4
4	p-4	16	3	4	5	3	3
5	p-5	12	4	2	3	3	3
6	p-6	16	2	3	4	4	4
7	p-7	17	2	5	3	5	5
8	p-8	13	3	3	3	3	3
9	p-9	16	1	3	3	3	1
10	p-10	16	3	4	3	3	5
11	p-11	16	3	4	4	4	4

11

Case Study –Robustness Analysis and

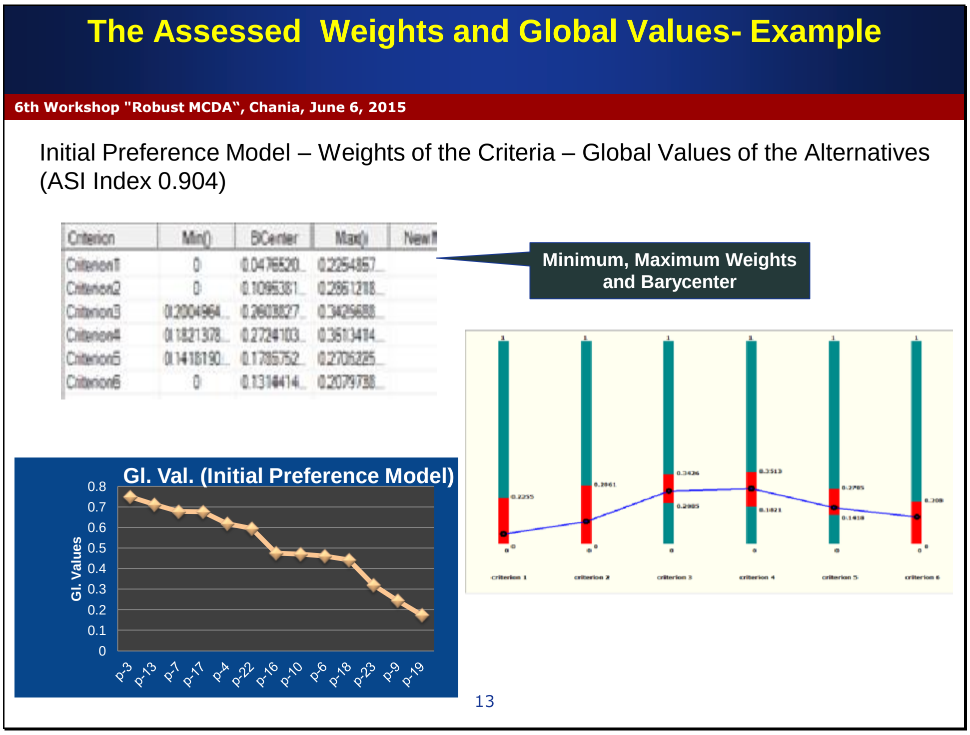


Marginal Value Functions

1	p-3	1
2	p-13	2
3	p-7	3
4	p-17	4
5	p-4	5
6	p-22	6
7	p-16	7
8	p-10	8
9	p-6	9
10	p-18	10
11	p-23	11
12	p-9	12
13	p-19	13

Ranking of the Reference Set

12


The Assessed Weights and Global Values- Example
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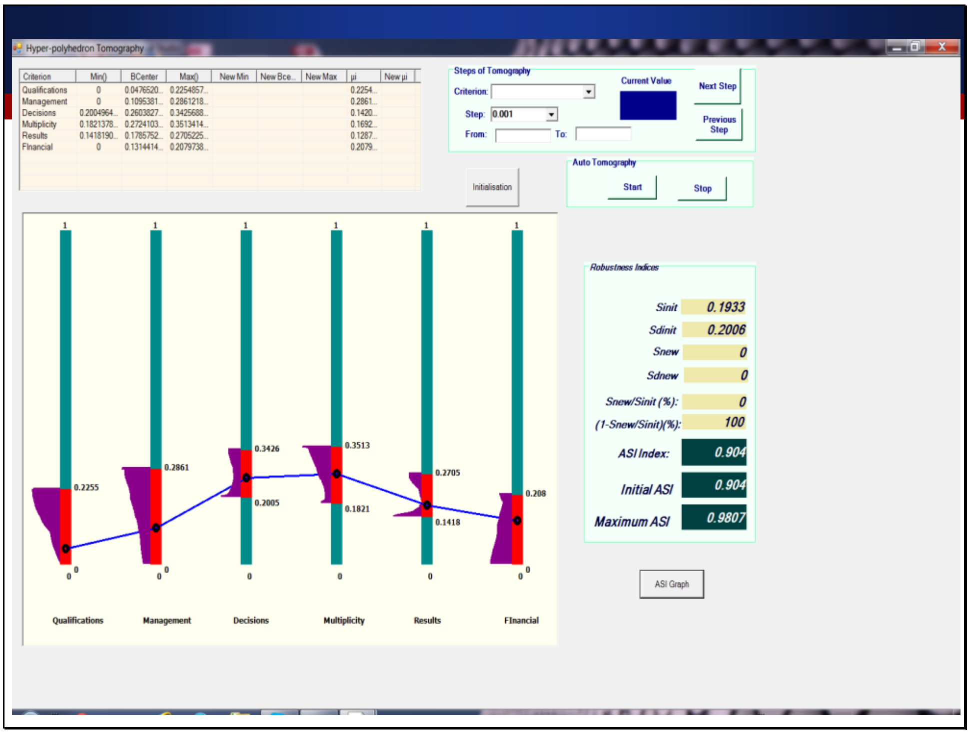
Initial Preference Model – Weights of the Criteria – Global Values of the Alternatives (ASI Index 0.904)
Criterion | Min() | BCenter | Max()
Criterion1 | 0 | 0.0476520.. | 0.2254857..
Criterion2 | 0 | 0.1095381.. | 0.2861218..
Criterion3 | 0.2004964.. | 0.2603827.. | 0.3425688..
Criterion4 | 0.1821378.. | 0.2724103.. | 0.3513414..
Criterion5 | 0.1418190.. | 0.1785752.. | 0.2705225..
Criterion6 | 0 | 0.1314414.. | 0.2079738..
Minimum, Maximum Weights and Barycenter
Gl. Val. (Initial Preference Model)
Gl. Values
p-3 p-13 p-7 p-17 p-4 p-22 p-16 p-10 p-6 p-18 p-23 p-9 p-19
13


Hyper-polyhedron Tomography
Steps of Tomography
Criterion:
Step: 0.001
From: To:
Current Value
Next Step
Previous Step
Auto Tomography
Start
Stop
Initialisation
Qualifications
Management
Decisions
Multiplicity
Results
Financial
Robustness Indices
Sinit 0.1933
Sdinit 0.2006
Snew 0
Sdnew 0
Snew/Sinit (%): 0
(1-Snew/Sinit)(%): 100
ASI Index: 0.904
Initial ASI 0.904
Maximum ASI 0.9807
ASI Graph

Tomographies of the Hyper-polyhedron

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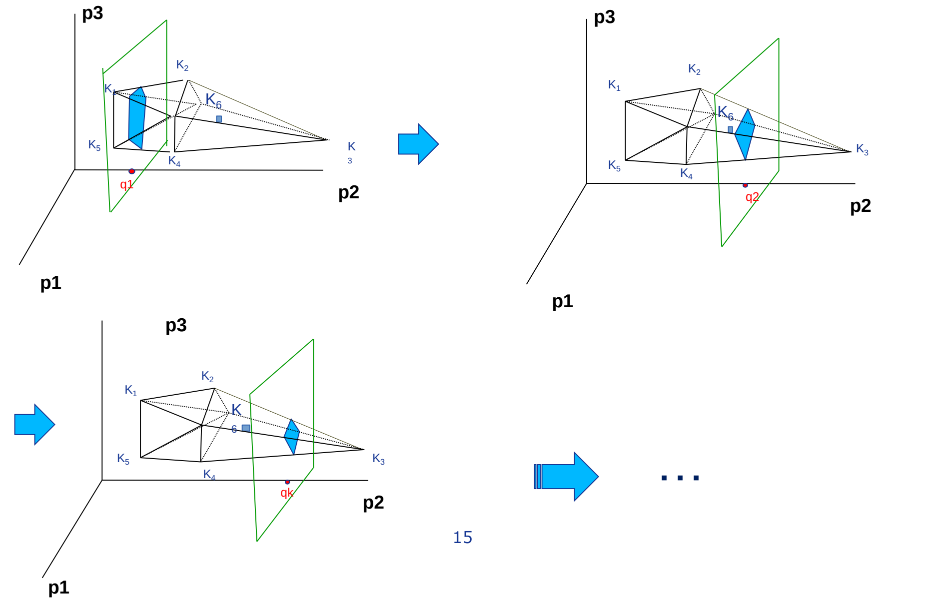

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Tomographical Approach

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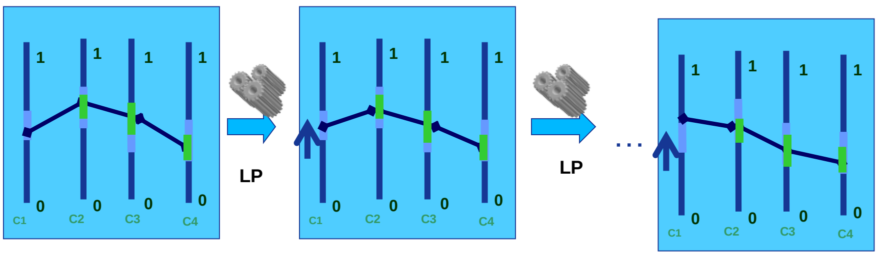
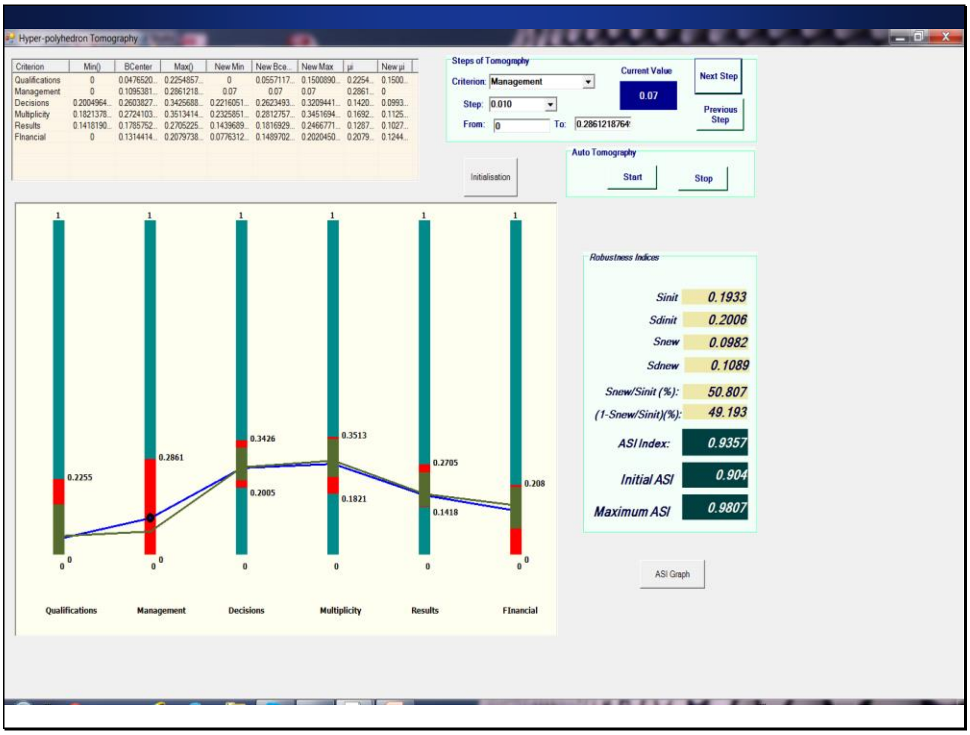
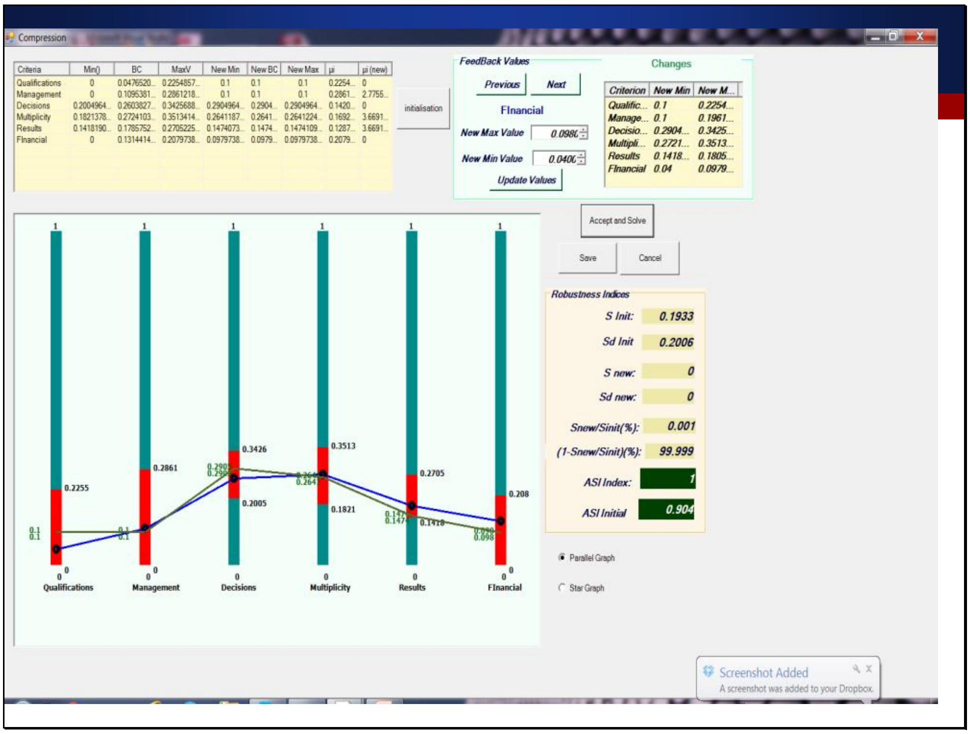
- For each criterion i starting with the P_{imin} value with a step (ex. 0.01) and until P_{imax} estimate the ranges of weights of the other criteria solving the Linear Programmes of Post Optimality Analysis including the new condition.
- Present the criteria weights in a parallel coordination graph in a controlled continuous base.
- Outcomes: Visualisation and identification of the impacts on the criteria weights for changes on the weight of the criterion i.



16


Hyper-polyhedron Tomography
Steps of Tomography
Criterion: Management
Step: 0.010
From: 0 To: 0.2861218764
Current Value
0.07
Next Step
Previous Step
Auto Tomography
Start
Stop
Initialisation
Robustness Indices
Sinit 0.1933
Sdinit 0.2006
Snew 0.0982
Sdnew 0.1089
Snew/Sinit (%): 50.807
(1-Snew/Sinit)(%): 49.193
ASI Index: 0.9357
Initial ASI 0.904
Maximum ASI 0.9807
ASI Graph
Qualifications
Management
Decisions
Multiplicity
Results
Financial


Compression
FeedBack Values
Previous
Next
Financial
New Max Value
New Min Value
Update Values
Changes
Accept and Solve
Save
Cancel
Robustness Indices
S Init: 0.1933
Sd Init 0.2006
S new: 0
Sd new: 0
Snew/Sinit(%): 0.001
(1-Snew/Sinit)(%): 99.999
ASI Index: 1
ASI Initial 0.904
Parallel Graph
Star Graph
Qualifications
Management
Decisions
Multiplicity
Results
Financial
Screenshot Added
A screenshot was added to your Dropbox.

Shrinking Weights Tolerance- Global Values with the new Barycenters

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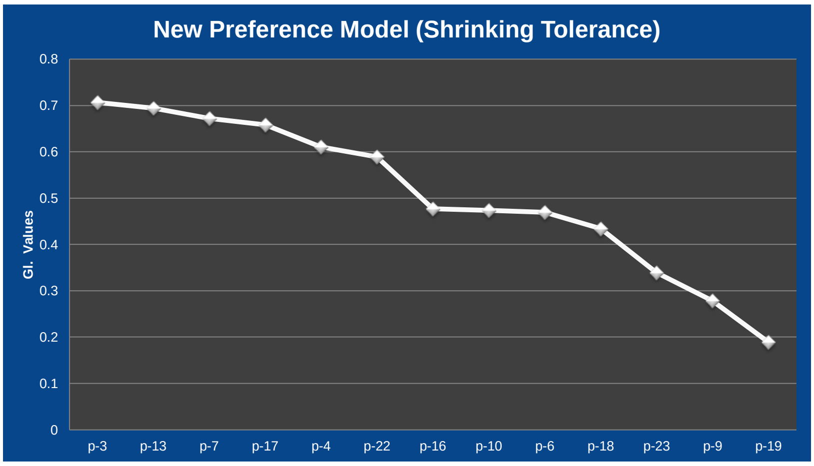
Global Values of the Alternative Actions



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Shrinking Weights Tolerance - Utilisation

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- Robustness Analysis can support the dialogues with the DMs in order to acquire more information concerning his/her preferences.
- Extreme situations (e.x. Zero or very high or very low criteria weights) can be the starting point for dialogues to extract additional preference information by the DM
- Increasing Robustness of the Preference Models can lead to:
  - A better apprehension of the Problem Statement and Preference Structures
  - The realization of their preference attitudes (by the DMs)
- Remaining Low Robustness can lead to:
  - Identification of the reasons why
  - New feedbacks concerning the Problem Formulation, Alternative Actions evaluation on criteria, pre-ranking etc.
- All the Above for the Objective: Support the Decision Making.

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Criteria Prioritization

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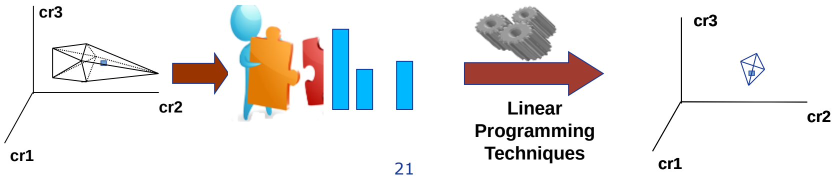
- Establish focused dialogues with the DM in order to extract information about the priorities of the criteria triggered by the analysis of the assessed preference model and the Robustness Analysis.
- (For example: a) Utilize 3 or more alternatives (real or virtual) in order to identify more detailed information for his/her preferences into selected criteria
- b) Insertion of one or more alternatives in the reference set which are representative of a specified subspace of the decision space

- Construction of a new linear program embedding the above information and estimation of a more robust preference model through Post Optimal Analysis or Manas Nedoma Algorithm.



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Criteria Prioritisation – Dialogue Example

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By using virtual or real alternative actions we can acquire additional preferences' data from DM.

For 3 criteria with 3 alternative actions.

	Criteria		
Alternative Actions	Cr1	Cr2	Cr3
alt1	3	3	4
alt2	2	4	4
alt3	4	3	3

Examine Cr1 with Cr2 and Cr3

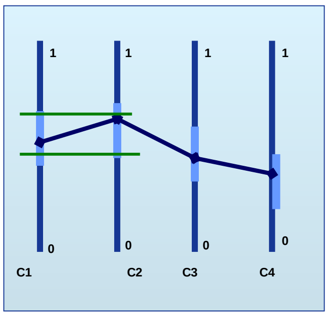
Alt1 P Alt2

Alt3 P Alt1

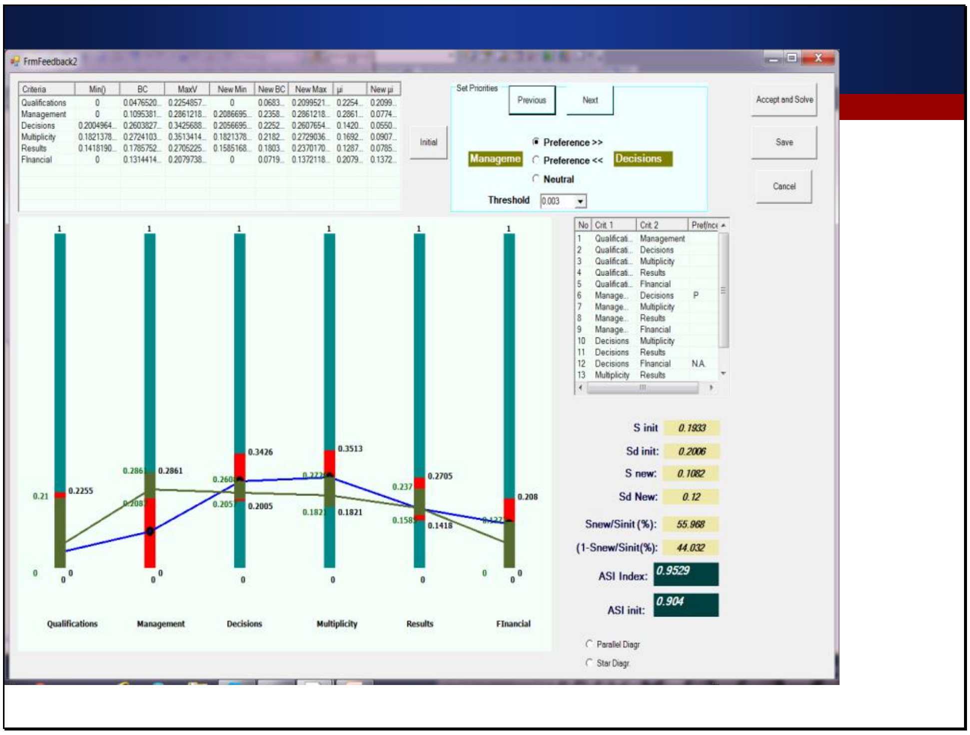
Enriches the Linear Program and can lead to more robust solution

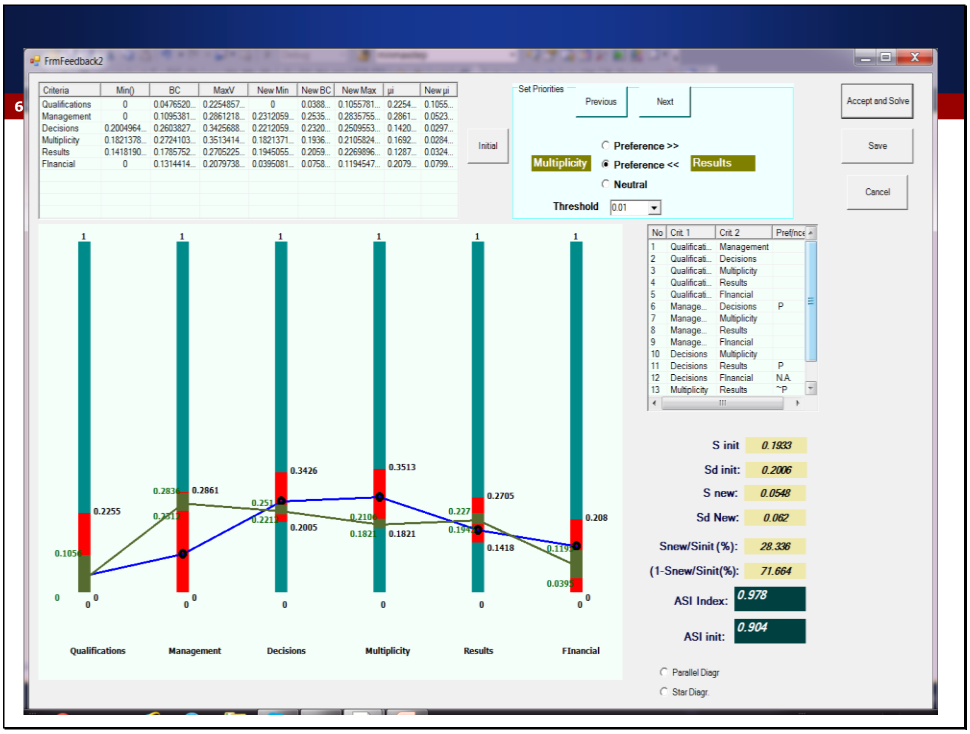
Condition:

The intersection of [MinCr1, MaxCr1] and [MinCr2, MaxCr2] is not null



22


FrmFeedback2
Set Priorities
Previous
Next
Initial
Preference >>
Manageme
Preference <<
Decisions
Neutral
Threshold
0.003
Accept and Solve
Save
Cancel
S init
0.1933
Sd init:
0.2006
S new:
0.1082
Sd New:
0.12
Snew/Sinit (%):
55.968
(1-Snew/Sinit(%):
44.032
ASI Index:
0.9529
ASI init:
0.904
Parallel Diagr
Star Diagr
Qualifications
Management
Decisions
Multiplicity
Results
Financial


FrmFeedback2
Set Priorities
Previous
Next
Initial
Preference >>
Multiplicity
Preference <<
Results
Neutral
Threshold
0.01
Accept and Solve
Save
Cancel
S init
0.1933
Sd init:
0.2006
S new:
0.0548
Sd New:
0.062
Snew/Sinit (%):
28.336
(1-Snew/Sinit(%):
71.664
ASI Index:
0.978
ASI init:
0.904
Parallel Diagr
Star Diagr
Qualifications
Management
Decisions
Multiplicity
Results
Financial

Shrinking Weights Tolerance- Example

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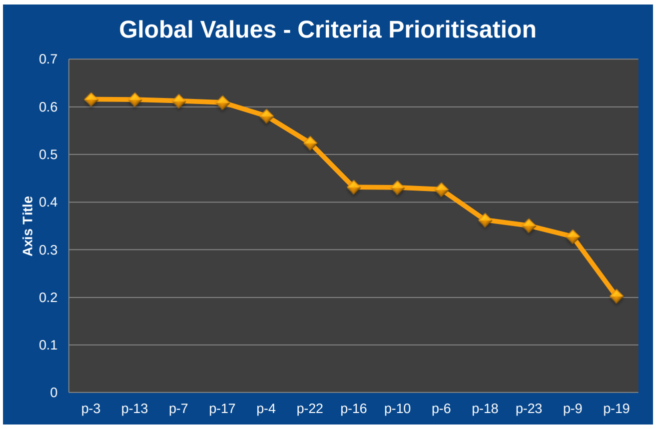
Ranking and Global Values of the alternatives with the new more Robust preference model

Global Values of the Alternative Actions



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Criteria prioritisation - Utilisation

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- Prioritisation of the criteria can be identified in many cases and lead to a more robust preference model
- Can resolve cases which presents straddling in criteria weights prioritization
- Increasing Robustness of the Preference Models can lead to :
  - Clarification of the DMs preference as far as the criteria Importance is concerned
  - The realization of their preference attitudes (by the DMs)
- Remaining Low Robustness can lead to:
  - Identification of the reasons why (in cases where is presented into particular criteria)
  - New feedbacks concerning the Problem Formulation, Alternative Actions evaluation on criteria, pre-ranking etc.

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Comparison of initial and revised global values

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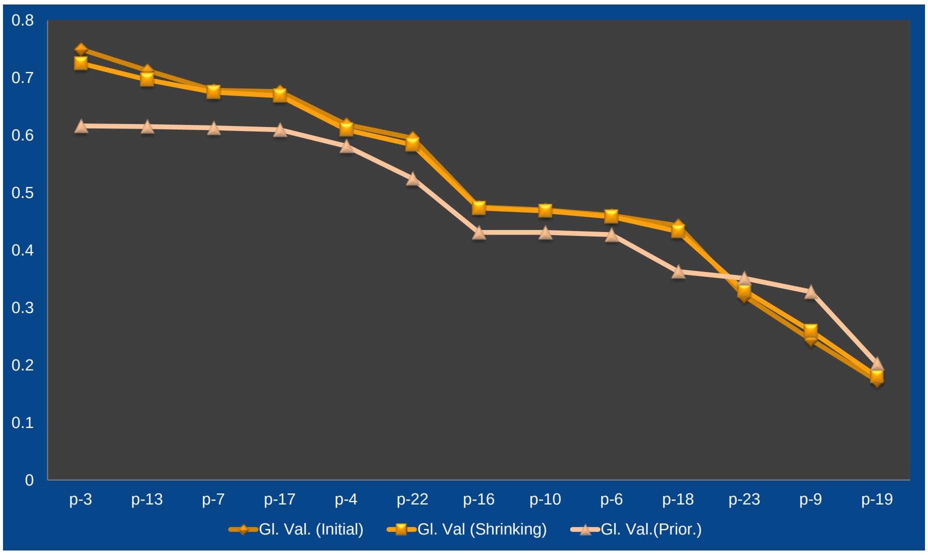

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2nd Case Study
Robustness Analysis and Feedbacks

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The Case Study: Fire Detection

…. Alternatives Evaluated in 6 Criteria. …. Alternatives selected in the Reference Set.

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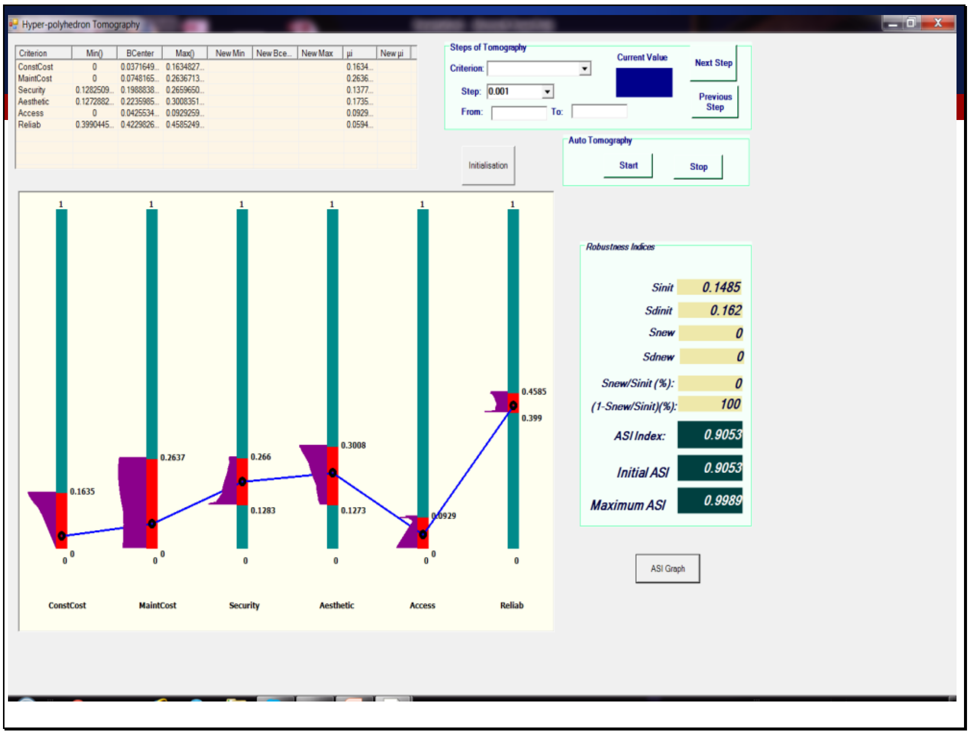
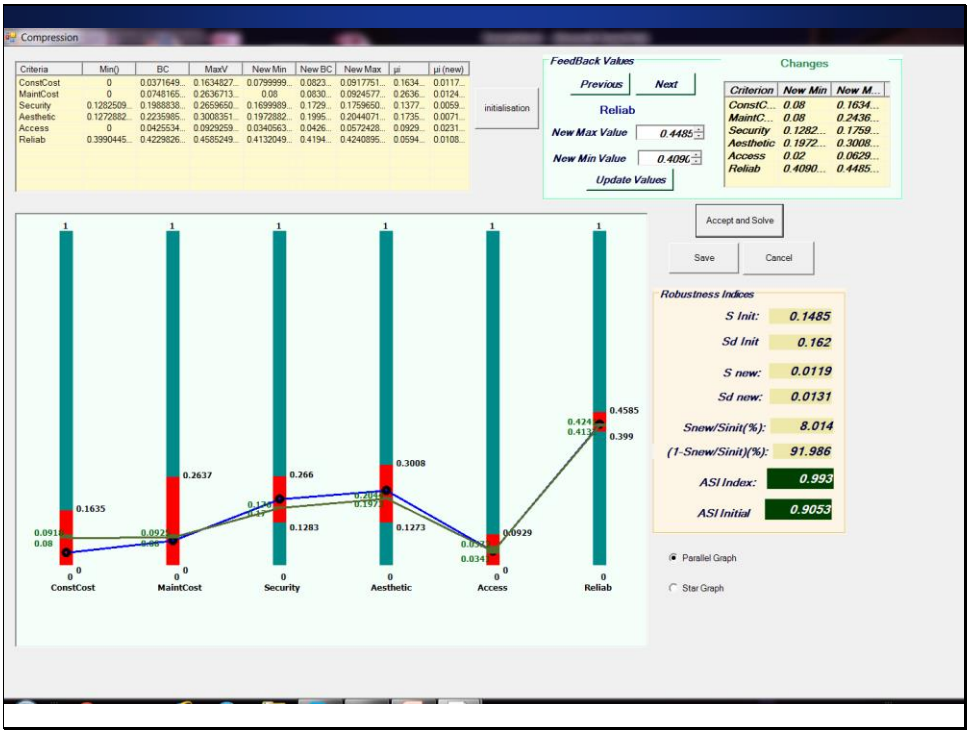
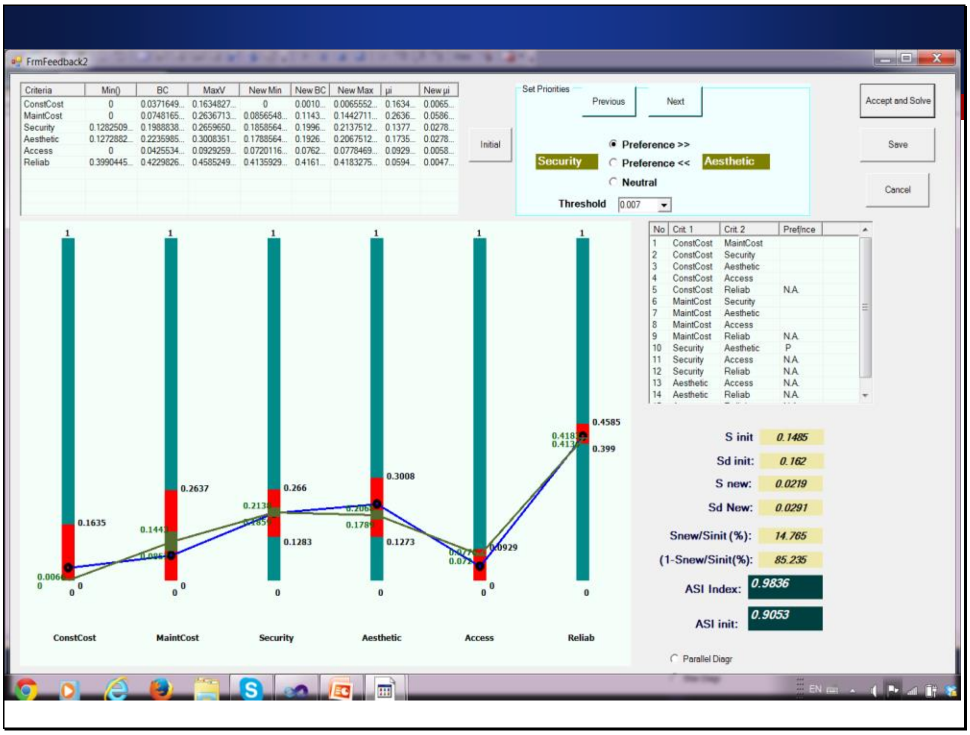
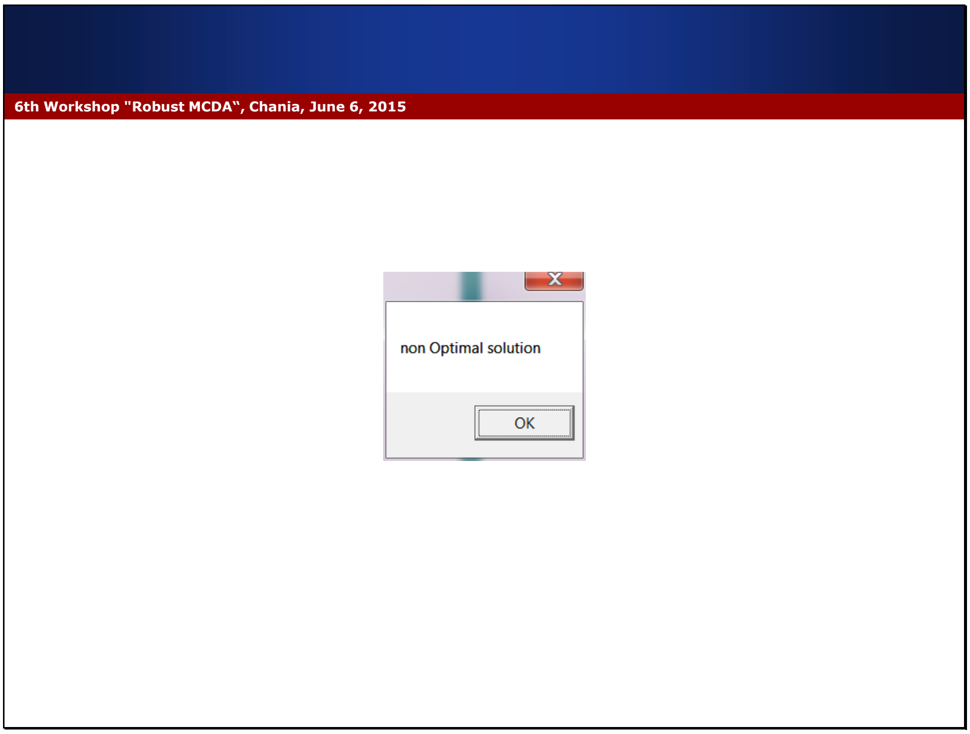

Hyper-polyhedron Tomography
Steps of Tomography
Criterion:
Step: 0.001
From: To:
Current Value
Next Step
Previous Step
Initialisation
Auto Tomography
Start
Stop
Robustness Indices
Sinit 0.1485
Sdinit 0.162
Snew 0
Sdnew 0
Snew/Sinit (%): 0
(1-Snew/Sinit)(%): 100
ASI Index: 0.9053
Initial ASI 0.9053
Maximum ASI 0.9989
ASI Graph
ConstCost
MaintCost
Security
Aesthetic
Access
Reliab


Compression
FeedBack Values
Previous
Next
Reliab
New Max Value
New Min Value
Update Values
Changes
initialisation
Accept and Solve
Save
Cancel
Robustness Indices
S Init: 0.1485
Sd Init 0.162
S new: 0.0119
Sd new: 0.0131
Snew/Sinit(%): 8.014
(1-Snew/Sinit)(%): 91.986
ASI Index: 0.993
ASI Initial 0.9053
Parallel Graph
Star Graph
ConstCost
MaintCost
Security
Aesthetic
Access
Reliab


FrmFeedback2
Set Priorities
Previous
Next
Initial
Security
Preference >>
Preference <<
Aesthetic
Neutral
Threshold
0.007
Accept and Solve
Save
Cancel
S init
0.1485
Sd init:
0.162
S new:
0.0219
Sd New:
0.0291
Snew/Sinit (%):
14.765
(1-Snew/Sinit(%):
85.235
ASI Index:
0.9836
ASI init:
0.9053
ConstCost
MaintCost
Security
Aesthetic
Access
Reliab


6th Workshop "Robust MCDA", Chania, June 6, 2015
non Optimal solution
OK

Conclusions - Perspectives

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- Preference Models with low robustness include useful information about the structure of preferences.
- There is a need to identify why it is caused and how to exploit it.
- Visualisation and measurement of Robustness provides a better knowledge of the preference models and can support the exploration of the DM' preference structures.
- The new proposed Interactive feedbacks enrich the existing tools of D-A approach for detecting representative preference model with a better robustness.

The research is going on:

- Focused on the standardisation of post dialogues for extracting preference information by the DMs indirectly.
- Test the proposed approach in many real world cases and in Group Decision Making.

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Robust MCDA

6th Workshop

Chania

June 6, 2015

Questions

Regularized Estimation for Preference Disaggregation in Multiple Criteria Decision Making

Michael Doumpos, Constantin Zopounidis

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Dept. of Production Engineering & Management
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Preference Disaggregation Analysis

- Objective
  - To construct a model $f(\alpha)$, defined by some parameters α, which is as consistent as possible with the decision making policy of the decision maker (DM)
- Reference set
  - Examples of past decisions
  - Representative alternatives that can be easily evaluated by the DM
  - A subset of the alternatives under consideration
- Given the reference set, a optimization process is used to find the optimal set of parameters α
- Existing formulations are based on the minimization of the fitting error for the reference data, but this is not enough
  - The generalizing ability of the model to new alternatives is crucial

Statistical Learning Theory

- **Problem statement**: Given a set of training examples $\{\mathbf{x}_i, y_i\}_{i=1}^{M}$, construct a model f, such that $f(\mathbf{x}_i) \approx y_i$, for all observations i
- The generalizing performance of the model is:
  - An increasing function of the model's fit to the training data
  - A decreasing function of the model's complexity
- **Regularization**: Construct the model considering its fit to the training data and its stability/complexity
- A stable model is one for which

$$E(\|f - \overline{f}\|_p) \approx 0$$

- For a linear model $f(\mathbf{x}) = \mathbf{x}\mathbf{d} + \gamma$ stability and fit are taking into consideration in a problem of the form:

$$\min_{\mathbf{d}, \gamma \in \mathbb{R}} \|\mathbf{d}\|_p + \lambda \mathcal{H}(f(\mathbf{x}_i), y_i)$$

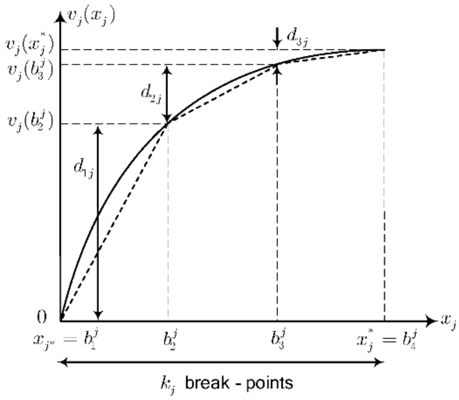
- Ridge regression, weight decay in neural networks, support vector machines, pruning in rule-based methods, ...

UTA methods

- Development of additive value function

$$V(\mathbf{x}) = \sum_{j=1}^{K} v_j(x_j)$$

- Piecewise linear additive value functions



$$v_j(x_{ij}) = \sum_{t=1}^{\ell} w_{ij}^t d_{tj}$$

for all $x_{ij} \in [b_\ell^j, b_{\ell+1}^j]$ for some $1 \leq \ell \leq k_j - 1$

where

$$w_{ij}^t = 1, \quad t = 1, \ldots, \ell - 1$$

$$w_{ij}^\ell = \frac{x_{ij} - b_\ell^j}{b_{\ell+1}^j - b_\ell^j}$$

$$d_{tj} = v_j(b_t^j) - v_j(b_{t-1}^j) \geq 0$$

Thus: $V(\mathbf{x}_i) = \mathbf{w}_i \mathbf{d}$

Ordinal Regression

- Data
  - A reference set of M alternatives $\mathbf{x}_1 \succsim \mathbf{x}_2 \succsim \cdots \succsim \mathbf{x}_M$ ordered in N indifference classes $I_1 \succ I_2 \succ \cdots \succ I_N$, each consisting of $m_1, m_2, \ldots, m_N$ alternatives
- Objective: Construct an additive value model such that

$$V(\mathbf{x}_i) > V(\mathbf{x}_j) \Leftrightarrow \mathbf{x}_i \succ \mathbf{x}_j \quad (1)$$
$$V(\mathbf{x}_i) = V(\mathbf{x}_j) \Leftrightarrow \mathbf{x}_i \sim \mathbf{x}_j \quad (2)$$

- Problem formulation (UTA method)

$$\begin{array}{ll} \min & \mathbf{e}_1^\top \mathbf{y} \\ \text{st:} & (\mathbf{w}_i - \mathbf{w}_{i+1})\mathbf{d} + y_i - y_{i+1} \geq \delta \quad \forall \mathbf{x}_i \succ \mathbf{x}_{i+1} \\ & (\mathbf{w}_i - \mathbf{w}_{i+1})\mathbf{d} + y_i - y_{i+1} = 0 \quad \forall \mathbf{x}_i \sim \mathbf{x}_{i+1} \\ & \mathbf{e}^\top \mathbf{d} = 1 \\ & \mathbf{d}, \mathbf{y} \geq \mathbf{0} \end{array}$$

Ordinal Regression - Alternative Formulation

$$\begin{array}{ll} \min & \mathbf{e}^\top \mathbf{d} + \lambda \mathbf{e}_1^\top \mathbf{y} \\ \text{st:} & (\mathbf{w}_i - \mathbf{w}_{i+1})\mathbf{d} + y_i - y_{i+1} \geq \delta \quad \forall \mathbf{x}_i \succ \mathbf{x}_{i+1} \\ & (\mathbf{w}_i - \mathbf{w}_{i+1})\mathbf{d} + y_i - y_{i+1} = 0 \quad \forall \mathbf{x}_i \sim \mathbf{x}_{i+1} \\ & \mathbf{d}, \mathbf{y} \geq \mathbf{0} \end{array}$$

- With the removal of the normalization constraint $\mathbf{e}^\top \mathbf{d} = 1$, the parameter δ does not affect the optimal solution; it only defines the "scale" of the model
- The solution $(\mathbf{d}^*, \mathbf{y}^*)$ normalizes the model in $[0, \mathbf{e}^\top \mathbf{d}^*]$
- The trivial solution $\mathbf{d} = \mathbf{0}$ is possible

Ordinal Regression - Alternative Formulation

Theorem

Assume that there are no indifferent alternatives and let $\mathbf{P}$ *be the matrix with the differences* $\mathbf{w}_i - \mathbf{w}_{i+1}$ *for pairs of alternatives* $\mathbf{x}_i \succ \mathbf{x}_{i+1}$ *and* $\mathbf{m} = (m_1, m_1 + m_2, \ldots, m_1 + \ldots + m_{N-1})^\top$. *Then, the trivial solution with* $\mathbf{d} = \mathbf{0}$ *is optimal if and only if* $\lambda \mathbf{P}^\top \mathbf{m} \leq \mathbf{e}$

- The maximum value λ^* for the weighting constant that leads to the trivial solution can be identified with the solution of an LP problem (if $m_N > 1$) or from a set of linear inequalities (if $m_N = 1$)
- A model that perfectly fits the ranking of the reference alternatives has $\mathbf{e}^\top \mathbf{d} \geq \theta_r^*$, where θ_r^* is the objective function value that corresponds to λ^*

Classification

- Data
  - A reference set of M alternatives $\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_M$ classified in N ordered classes $C_1 \succ C_2 \succ \cdots \succ C_N$, consisting of $m_1, m_2, \ldots, m_N$ reference alternatives
- Objective: Construct an additive value model such that

$$h_n < V(\mathbf{x}_i) < h_{n-1} \Leftrightarrow \mathbf{x}_i \in C_n$$

- Problem formulation (UTADIS method)

$$\begin{array}{lll}
\min & \mathbf{e}_1^\top(\mathbf{y}^+ + \mathbf{y}^-) & \\
\text{st:} & \mathbf{w}_i\mathbf{d} - h_n + y_i^+ \geq \delta & \forall \mathbf{x}_i \in C_n,\ n = 1, \ldots, N-1 \\
& \mathbf{w}_i\mathbf{d} - h_{n-1} - y_i^- \leq -\delta & \forall \mathbf{x}_i \in C_n,\ n = 2, \ldots, N \\
& h_{n-1} - h_n \geq s & \forall n = 2, \ldots, N-1 \\
& \mathbf{e}^\top \mathbf{d} = 1 & \\
& \mathbf{d}, \mathbf{h}, \mathbf{y}^+, \mathbf{y}^- \geq \mathbf{0} &
\end{array}$$

Classification - Alternative Formulation

$\mathbf{W}_n$ = the matrix that consists of all $\mathbf{w}_i$, $\forall \mathbf{x}_i \in C_n$, $n = 1, \ldots, N$:

$$\begin{array}{lll} \min & \mathbf{e}^\top \mathbf{d} + \sum_{n=1}^{N-1} \lambda_n \mathbf{e}_n^\top \mathbf{y}_n^+ + \sum_{n=2}^{N} \lambda_n \mathbf{e}_n^\top \mathbf{y}_n^- & \\ \text{s.t.} & \mathbf{W}_n \mathbf{d} - \mathbf{e}_n h_n + \mathbf{y}_n^+ \geq \mathbf{e}_n \delta, & \forall n = 1, \ldots, N-1 \\ & \mathbf{W}_n \mathbf{d} - \mathbf{e}_n h_{n-1} - \mathbf{y}_n^- \leq -\mathbf{e}_n \delta, & \forall n = 2, \ldots, N \\ & h_n - h_{n+1} \geq s, & \forall n = 1, \ldots, N-2 \\ & \mathbf{d}, \mathbf{h}, \mathbf{y}^+, \mathbf{y}^- \geq \mathbf{0} & \end{array}$$

Theorem

Let $\sum_{n=1}^{N-1} \lambda_n m_n > \lambda_N m_N$. Then, the trivial solution $\mathbf{d} = \mathbf{0}$ is optimal if and only if:

$$\sum_{n=1}^{N-1} \lambda_n \mathbf{W}_n^\top \mathbf{e}_n - \lambda_N \mathbf{W}_N^\top \mathbf{e}_N \leq \mathbf{e}$$

Classification - Alternative Formulation

Definition

A model defined for some $\mathbf{\Lambda} = (\lambda_1, \ldots, \lambda_N) \geq \mathbf{0}$, with optimal objective function value F^*, is called trivially equivalent if there exists $\mathbf{\Lambda}' \neq \mathbf{\Lambda}$ that leads to the trivial model with $\mathbf{d} = \mathbf{0}$ and objective function value $F_{triv} = F^*$

- If there exists a class C_n with a class average vector $\overline{\mathbf{W}}_n$ such that $\overline{\mathbf{W}}_n \leq \overline{\mathbf{W}}_N$, then irrespective of the selected weighting vector $\mathbf{\Lambda}$, the resulting model will always be trivially equivalent
- A model that perfectly fits the classification of the reference alternatives has $\mathbf{e}^\top \mathbf{d} \geq \theta_c^*$, where θ_c^* is the maximum objective function value that can be achieved for a trivial model

Experimental Evaluation - Data

- Data type
  - Numerical data uniformly distributed in [0, 1]
  - Qualitative data (5-point scale, discrete uniform distribution)
- Number of criteria: 5, 10, 15
- Number of alternatives: 1,500 both in the reference and the validation samples
- Evaluation of the alternatives with an additive value function

$$V(\mathbf{x}) = \sum_{j=1}^{K} p_j v_j(x_j), \text{ with } p_j \sim U(0,1)$$

$$v_j(x_j) = \frac{1-\exp(x_j\gamma_j)}{1-\exp(\gamma_j)}, \text{ with } \gamma_j \sim U(-8,8)$$

- Inconsistencies:
  - Ranking: $V'(\mathbf{x}) = V(\mathbf{x}) + \varepsilon$, with $\varepsilon \sim N(0,\sigma/6), N(0,\sigma/2), N(0,\sigma/2)$
  - Classification: Perturbation of the class assignment for 5%, 15%, 25% of the alternatives

Experimental Evaluation - Factors

- Design factors
  - Number of criteria
  - Type of data
  - Inconsistency level
  - Number of classes (classification case: 2, 3)
- 100 replications for each combination of the design factors
- Factors related to the parameters of the methods
  - Number of subintervals: 2, 4, 8
  - Definition of the subintervals:
    - Subinterval of equal length/size
    - Equal number of alternatives in each subinterval (equal volume)

Ranking Results - Kendall's τ

Factors	Levels	UTA-R	UTA	p-values
Criteria	5	0.7657	0.7391	<0.01
	10	0.7652	0.7511	<0.01
	15	0.7606	0.7531	<0.01
Data type	Continuous	0.7618	0.7410	<0.01
	Discrete	0.7701	0.7681	0.527
Inconsistencies	Low	0.8725	0.8737	<0.01
	Medium	0.7602	0.7445	<0.01
	High	0.6588	0.6252	<0.01
Subintervals method	Equal size	0.7617	0.7405	<0.01
	Equal volume	0.7618	0.7415	<0.01
Number of subintervals	2	0.7551	0.7509	0.155
	4	0.7650	0.7429	<0.01
	8	0.7652	0.7291	<0.01

Ranking Results - MAE

Factors	Levels	UTA-R	UTA	p-values
Criteria	5	2.1629	4.5707	<0.01
	10	1.2456	1.5987	<0.01
	15	0.8818	1.0260	<0.01
Data type	Continuous	1.5225	2.6519	<0.01
	Discrete	1.1528	1.6383	<0.01
Inconsistencies	Low	0.8183	0.8763	<0.01
	Medium	1.4431	2.4613	<0.01
	High	2.0288	3.8579	<0.01
Subintervals method	Equal size	1.5202	2.7629	<0.01
	Equal volume	1.5249	2.5410	<0.01
Number of subintervals	2	1.7524	1.8609	<0.01
	4	1.4178	2.2968	<0.01
	8	1.3974	3.7980	<0.01

Ranking Results - Qualitative Data

	Factors	Levels	UTA-R	UTA	p-values
Kendall's τ	Criteria	5	0.7711	0.7655	0.287
		10	0.7711	0.7710	0.971
		15	0.7679	0.7679	1.000
	Inconsistencies	Low	0.8801	0.8831	<0.01
		Medium	0.7658	0.7664	0.410
		High	0.6643	0.6549	<0.01
MAE	Criteria	5	1.7216	2.9965	<0.01
		10	0.9981	1.1230	<0.01
		15	0.7387	0.7954	0.016
	Inconsistencies	Low	0.5434	0.6225	0.119
		Medium	1.1761	1.5122	<0.01
		High	1.7389	2.7803	<0.01

Classification Results - Accuracy & Gini Index

		Accuracy			Gini index		
Factors	Levels	UTADIS-R	UTADIS	p-values	UTADIS-R	UTADIS	p-values
Criteria	5	0.8038	0.7876	<0.01	0.7124	0.7004	<0.01
	10	0.8021	0.7805	<0.01	0.7161	0.6982	<0.01
	15	0.7941	0.7770	<0.01	0.7112	0.6959	<0.01
Data type	Contin.	0.7999	0.7792	<0.01	0.7145	0.6964	<0.01
	Discr.	0.8006	0.7962	0.165	0.7053	0.7087	0.527
Classes	2	0.8062	0.7898	<0.01	0.6791	0.6580	<0.01
	3	0.7938	0.7735	<0.01	0.7473	0.7383	<0.01
Incons.	Low	0.9064	0.9048	<0.01	0.8997	0.8987	<0.01
	Medium	0.7966	0.7762	<0.01	0.7112	0.6962	<0.01
	High	0.6970	0.6640	<0.01	0.5287	0.4996	<0.01
Subintervals method	Equal size	0.7999	0.7792	<0.01	0.7145	0.6963	<0.01
	Equal vol.	0.7999	0.7793	<0.01	0.7146	0.6945	<0.01
Number of subintervals	2	0.8001	0.7849	<0.01	0.7154	0.7046	<0.01
	4	0.8027	0.7812	<0.01	0.7159	0.6977	<0.01
	8	0.7970	0.7717	<0.01	0.7124	0.6868	<0.01

Classification Results - MAE

Factors	Levels	UTADIS-R	UTADIS	p-values
Criteria	5	2.9940	4.2312	<0.01
	10	1.2149	1.7526	<0.01
	15	0.8824	1.1900	<0.01
Data type	Continuous	1.6903	2.4738	<0.01
	Discrete	1.7384	1.8959	0.028
Classes	2	2.1448	2.9945	<0.01
	3	1.2494	1.7880	<0.01
Inconsistencies	Low	1.1890	1.6163	<0.01
	Medium	1.6783	2.4553	<0.01
	High	2.2241	3.1022	<0.01
Subintervals method	Equal size	1.6891	2.4898	<0.01
	Equal volume	1.6914	2.4578	<0.01
Number of subintervals	2	1.6595	2.1891	<0.01
	4	1.5808	2.1261	<0.01
	8	1.8304	3.1063	<0.01

Classification Results - Qualitative Data

	Factors	Levels	UTADIS-R	UTADIS	p-values
Accuracy	Criteria	5	0.7922	0.8022	0.068
		10	0.8077	0.7951	0.020
		15	0.8018	0.7913	0.050
	Classes	2	0.8054	0.8003	0.236
		3	0.7957	0.7921	0.430
	Inconsistencies	Low	0.9104	0.9181	<0.01
		Medium	0.7944	0.7910	<0.01
		High	0.6968	0.6795	<0.01
Gini index	Criteria	5	0.6848	0.7114	<0.01
		10	0.7158	0.7083	0.424
		15	0.7152	0.7065	0.351
	Classes	2	0.6676	0.6715	0.646
		3	0.7429	0.7459	0.640
	Inconsistencies	Low	0.8972	0.9034	<0.01
		Medium	0.6982	0.7072	<0.01
		High	0.5203	0.5156	0.244
MAE	Criteria	5	3.6119	3.2058	0.016
		10	0.9620	1.5083	<0.01
		15	0.6413	0.9737	<0.01
	Classes	2	2.3425	2.3523	0.935
		3	1.1343	1.4395	<0.01
	Inconsistencies	Low	1.0023	0.9416	0.434
		Medium	1.8395	1.9173	0.506
		High	2.3734	2.8289	<0.01

Conclusions

- A decision model that fits well on the reference alternatives is not necessarily a good model
- Development of new formulations using concepts from the field of statistical learning theory
  - The new formulations enable the connection of the problem data to the quality of the models
  - Improved results in many cases (mostly for numerical data)
- Further validation on real world data
- Extension to other modeling forms such as outranking models

Robust MCDA

OPERATIONAL PROGRAMME EDUCATION AND LIFELONG LEARNING investing in knowledge society
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Co-financed by Greece and the European Union
European Union European Social Fund
NSRF 2007-2013

Robust portfolio optimization: A categorized bibliographic review

Xidonas | Doukas | Mavrotas | Psarras | Matsatsinis

Introduction | Research aims

✓ The study's purpose is

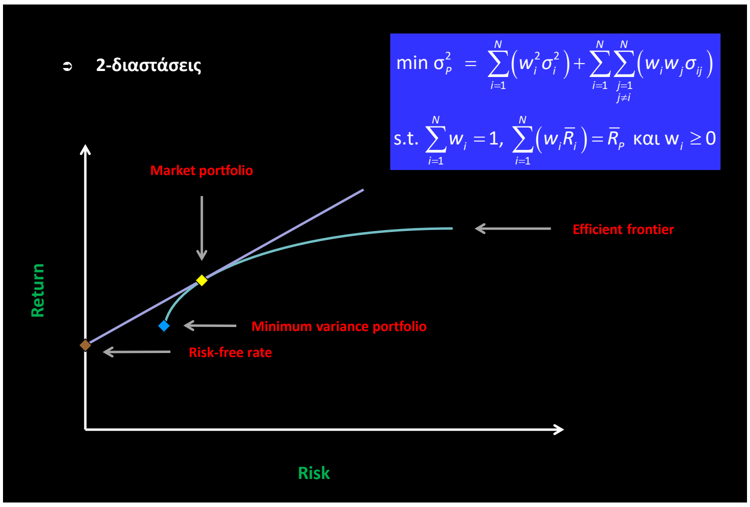
- To provide an elaborate bibliographic **taxonomy of the core contributions** appear in the literature, with regard to the application of robustness optimization techniques in MPT.
- To identify all seminal studies, **both from the operational research and the finance field**, have been compiled and carefully classified, according to the various methodological approaches that are used.

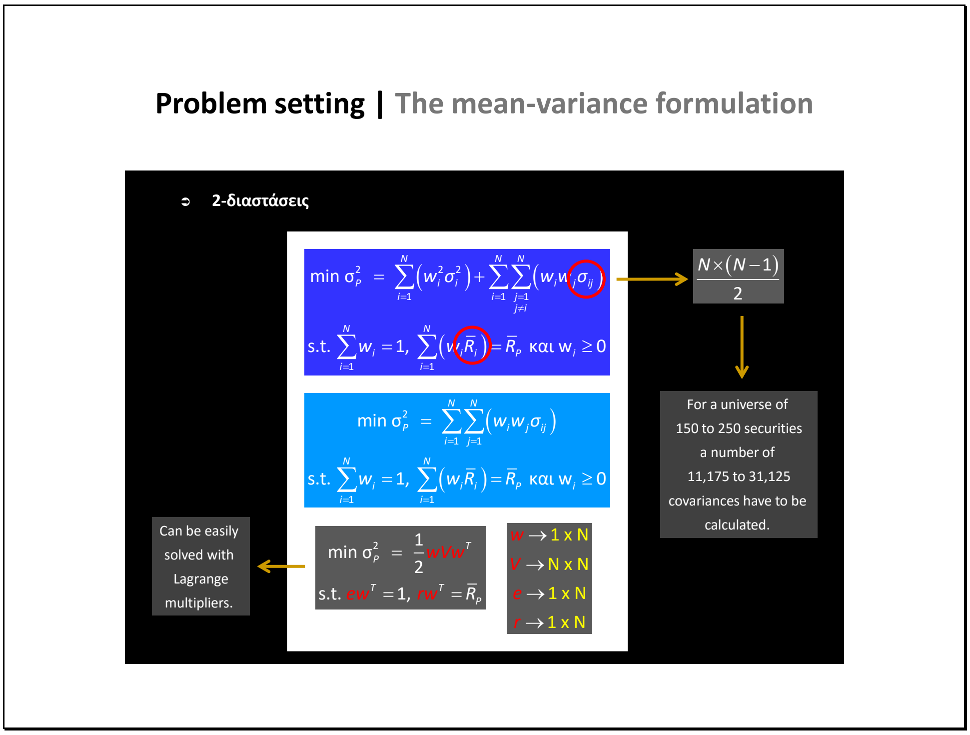
Problem setting | Conventional portfolio selection

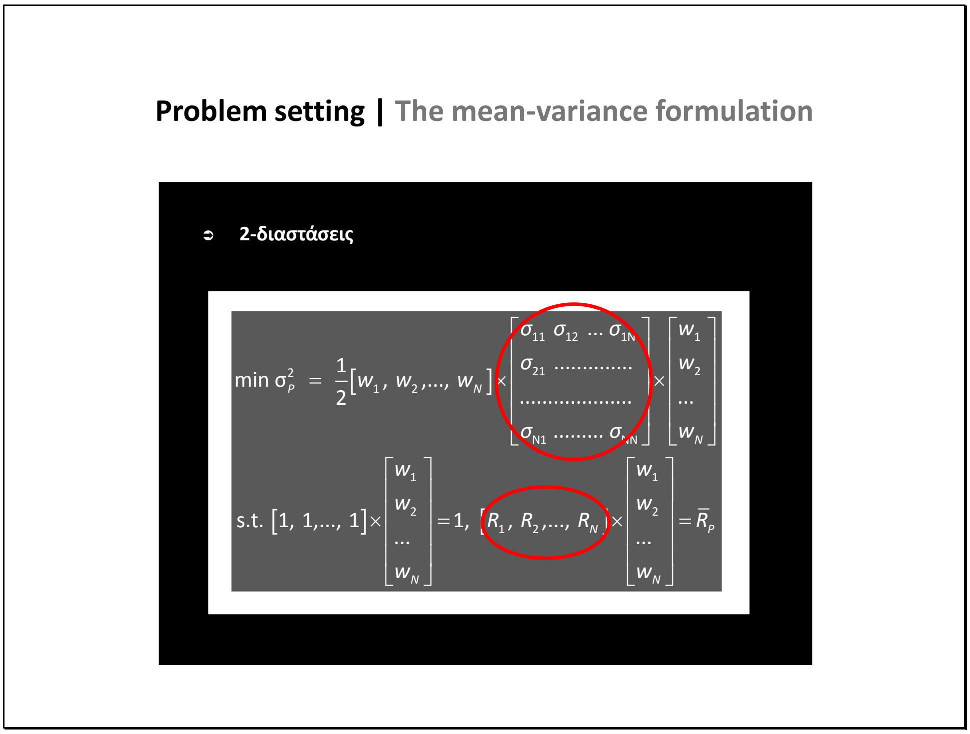
✓ Fundamental remarks

- An efficient frontier in the typical portfolio selection problem consists an illustrative way to express the **tradeoffs between return and risk**.
- Usually security returns distributions are, either **extracted from past data** or being **hypothetically estimated** exploiting analysts' views or even **assumed as of a certain type**, i.e. Gaussian etc.
- But historical time-series incorporate huge **noise bulk**, i.e. skewness or fat tails (kurtosis) and **industry forecasts are subjective**.

Problem setting | The mean-variance formulation

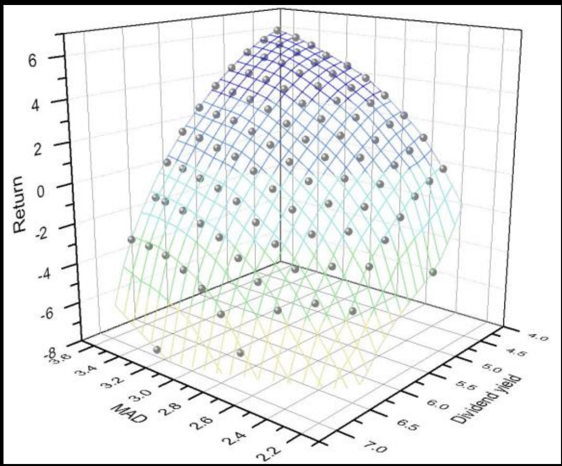



Problem setting | The mean-variance formulation
2-διαστάσεις
$\min \sigma_P^2 = \sum_{i=1}^{N}(w_i^2\sigma_i^2) + \sum_{i=1}^{N}\sum_{j=1, j\neq i}^{N}(w_i w_j \sigma_{ij})$
s.t. $\sum_{i=1}^{N} w_i = 1$, $\sum_{i=1}^{N}(w_i \bar{R}_i) = \bar{R}_P$ και $w_i \geq 0$
$\frac{N \times (N-1)}{2}$
For a universe of 150 to 250 securities a number of 11,175 to 31,125 covariances have to be calculated.
$\min \sigma_P^2 = \sum_{i=1}^{N}\sum_{j=1}^{N}(w_i w_j \sigma_{ij})$
s.t. $\sum_{i=1}^{N} w_i = 1$, $\sum_{i=1}^{N}(w_i \bar{R}_i) = \bar{R}_P$ και $w_i \geq 0$
$\min \sigma_P^2 = \frac{1}{2} wVw^T$
s.t. $ew^T = 1$, $rw^T = \bar{R}_P$
Can be easily solved with Lagrange multipliers.
$w \rightarrow$ 1 x N
$V \rightarrow$ N x N
$e \rightarrow$ 1 x N
$r \rightarrow$ 1 x N


Problem setting | The mean-variance formulation
2-διαστάσεις
$\min \sigma_P^2 = \frac{1}{2}[w_1, w_2, \ldots, w_N] \times \begin{bmatrix} \sigma_{11} & \sigma_{12} & \ldots & \sigma_{1N} \\ \sigma_{21} & \ldots & & \\ \ldots & & & \\ \sigma_{N1} & \ldots & & \sigma_{NN} \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ \ldots \\ w_N \end{bmatrix}$
s.t. $[1, 1, \ldots, 1] \times \begin{bmatrix} w_1 \\ w_2 \\ \ldots \\ w_N \end{bmatrix} = 1$, $[R_1, R_2, \ldots, R_N] \times \begin{bmatrix} w_1 \\ w_2 \\ \ldots \\ w_N \end{bmatrix} = R_P$

Problem setting | Discrete efficient surfaces

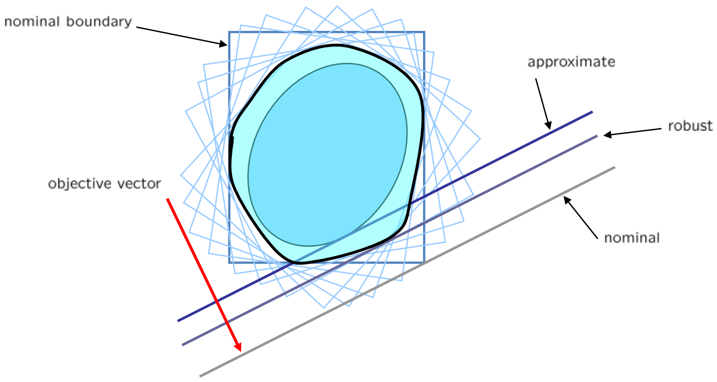
- 3-διαστάσεις



Problem setting | The gap

- ✓ Wrap-up
  - In practice **exact values** of input data **are seldom known**.
  - Moreover, **optimal solutions** may be **implemented with deviations**.
  - **Small deviations** in data values can make **optimal solutions infeasible**.

Problem setting | Robust optimization



Review | Some figures

- ✓ Google scholar
  - When searching for **modern portfolio theory**, we obtained:

    404,000 results
  - When searching for **portfolio optimization**, we obtained:

    241,000 results
  - When searching for **robust portfolio optimization**, we obtained:

    48,700 results

Review | Mass hits

✓ The top-3 popular papers in terms of citations

- Mulvey, J., Vanderbei, R., Zenios, S., 1995. *Robust optimization of large systems.* **Operations Research** (Informs), 43, 264-281.
- Tutuncu, R., Koenig, M., 2004. *Robust asset allocation.* **Annals of Operations Research** (Springer), 132, 157-187.
- Fabozzi, F., Huang, D., Guofu, Z., 2010. *Robust portfolios: Contributions from operations research and finance.* **Annals of Operations Research** (Springer), 176, 191-220.

Review | Research map

✓ Taxonomy results I

No	Authors	Date
14	Maillet, Tokpavi & Vaucher	2015
3	Dupacova & Kopa	2014
6	Fliege & Werner	2014
11	Kim, Kim, Kim & Fabozzi	2014
12	Kim, Kim & Fabozzi	2014
13	Kolm, Tutuncu & Fabozzi	2014
15	Mansini, Ogryczak & Speranza	2014
2	Deng, Dulaney, McCann & Wang	2013
9	Kim, Kim & Fabozzi	2013
10	Kim, Kim, Ahn & Fabozzi	2013
18	Scutella & Recchia	2013
8	Huo, Kim & Kim	2012
7	Gregory, Darby-Dowman & Gautam Mitra	2011
5	Fabozzi, Huang & Zhou	2010
1	Bertsimas & Pachamanova	2008
4	Fabozzi, Kolm, Pachamanova & Focardi	2007
17	Pinar & Tutuncu	2005
19	Tutuncu & Koenig	2004
20	Vassiadou-Zeniou & Zenios	1996
16	Mulvey, Vanderbei & Zenios	1995

Review | Research map

✓ Taxonomy results II

Title	Focus
Global mV portfolio optimization under some model risk: A robust regression-based approach	Risk
Robustness of optimal portfolios under risk and stochastic dominance constraints	Risk
Robust multiobjective optimization and applications in portfolio optimization	Framework
Robust portfolios that do not tilt factor exposure	Framework
Recent developments in robust portfolios with a worst-case approach	Review
60 Years of portfolio optimization: Practical challenges and current trends	Review
Twenty years of linear programming based portfolio optimization	Review
Robust portfolio optimization with VaR-adjusted Sharpe ratios	Risk
Composition of robust equity portfolios	Instruments
What do robust equity portfolio models really do?	Instruments
Robust portfolio asset allocation and risk measures	Asset allocation
Robust estimation of covariance and its application to portfolio optimization	Trading
Robust optimization and portfolio selection: The cost of robustness	Framework
Robust portfolios: Contributions from operations research and finance	Risk
Robust multiperiod portfolio management in the presence of transaction costs	Trading
Robust portfolio optimization	Framework
Robust profit opportunities in risky financial portfolios	Risk
Robust asset allocation	Asset allocation
Robust optimization models for managing callable bond portfolios	Instruments
Robust optimization of large systems	Framework

Review | Research map

✓ Taxonomy results III

Journal	Journal scope	ABS ranking	Publisher
European Journal of Operational Research	Operations Research	4	Elsevier
European Journal of Operational Research	Operations Research	4	Elsevier
European Journal of Operational Research	Operations Research	4	Elsevier
European Journal of Operational Research	Operations Research	4	Elsevier
Journal of Optimization Theory & Applications	Operations Research	3	Springer
European Journal of Operational Research	Operations Research	4	Elsevier
European Journal of Operational Research	Operations Research	4	Elsevier
Journal of Asset Management	Finance	2	Palgrave
Finance Research Letters	Finance	2	Elsevier
Annals of Operations Research	Operations Research	3	Elsevier
Annals of Operations Research	Operations Research	3	Springer
Finance Research Letters	Finance	2	Elsevier
European Journal of Operational Research	Operations Research	4	Elsevier
Annals of Operations Research	Operations Research	3	Springer
Computers & Operations Research	Operations Research	3	Elsevier
Journal of Portfolio Management	Finance	2	IEE
Operations Research Letters	Operations Research	2	Elsevier
Annals of Operations Research	Operations Research	3	Springer
European Journal of Operational Research	Operations Research	4	Elsevier
Operations Research	Operations Research	4	INFORMS

Clues | Basic findings

- ✓ Block I
  - Top-class well-known researchers are heavily involved, such as **Reha Tutuncu**, **Frank Fabozzi**, **Dimitri Bertsimas**, **Petter Kolm** etc.
  - Research pieces in the combined field of robust optimization and portfolio selection, appear for over a **20-yrs time period**.
  - **Stavros Zenios** made the first contribution in 1995, at the *Operations Research* of Informs.

Clues | Basic findings

- ✓ Block II
  - The focus categorization of the papers consists of 6 areas: a) ***methodological framework***, b) ***reviews***, c) ***risk management*** *(emphasis on VaR and CVaR)*, d) ***asset allocation***, e) ***financial instruments*** *(emphasis on equities and bonds),* and f) ***trading procedures*** *(emphasis on transaction costs).*
  - The main bulk of contributions (around 40%) appears in the areas of ***methodological framework*** and ***risk management***.

Clues | Basic findings

- ✓ Block III
  - **European Journal of Operational Research (EJOR)** and **Annals of Operations Research (AOR)** accommodate the biggest number of robust portfolio optimization papers.
  - **Very low number** of contributions appear in **finance journals**.
  - The **journals that publish papers in the combined field** of robust optimization and portfolio selection are all of **excellent quality** according to the **ABS rankings** (mainly 3 and 4 stars).

Epilogue | Last words

- ✓ Strong advocate for
  - The unarguable **necessity of integrating** all contemporary portfolio optimization empirical applications with proper robustness analysis.
  - A constantly growing **underlying research momentum**.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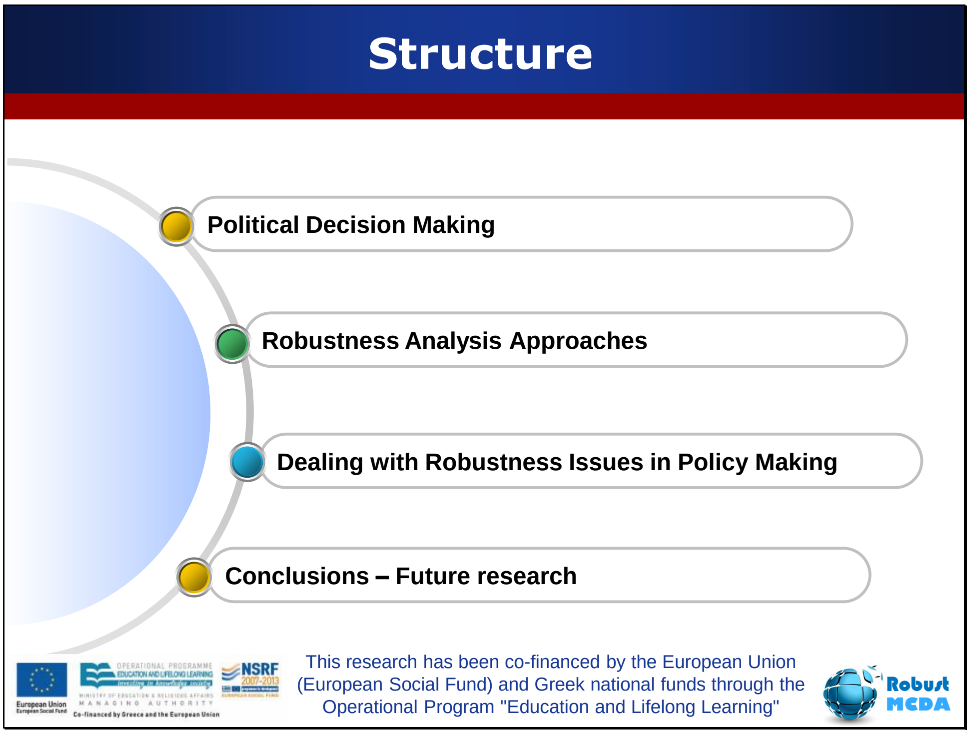
Co-financed by Greece and the European Union
NSRF 2007-2013
Robustness analysis approaches in political decision making
Yannis Siskos, Nikos Tsotsolas, Spyros Alexopoulos


Structure
Political Decision Making
Robustness Analysis Approaches
Dealing with Robustness Issues in Policy Making
Conclusions – Future research
This research has been co-financed by the European Union (European Social Fund) and Greek national funds through the Operational Program "Education and Lifelong Learning"
Robust MCDA

Political Decision Making

Political decisions and formulation of policy: Why in need of decision aid

- Characteristics:
  - Complex
  - Multifaceted
  - Involve many different stakeholders with different priorities/objectives
- Because of the aforementioned reasons:
  - policy-makers often experience difficulty making informed, thoughtful choices in a decision-making environment involving complexity, risks, value trade-offs and uncertainty

Political Decision Making is Complex

Government policy makers seldom seek to maximize just a single welfare objective. Typically they are concerned about a bundle of policy objectives, expressed by contributing variables or indicators, conditional on and constrained by political reality, public opinion, but also by others interests (not so transparent) as well.

The complexity of political decision making is even bigger if we take into consideration that the government's current payoffs are equal to the "net present value" of its anticipated future actions (and resulting victories/losses), not just its present and past policy. So the strategic planning of the government incorporates as an objective the expectations regarding the elections.

Policy Makers

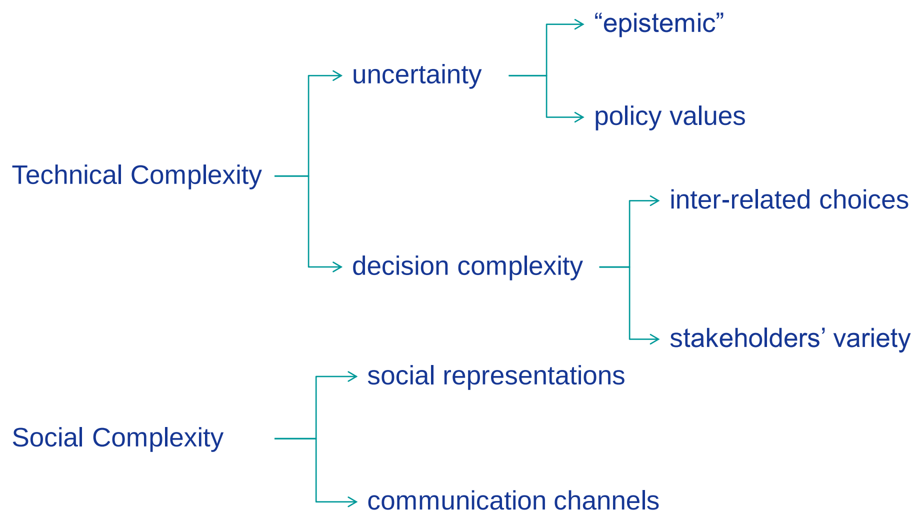
In this context actions of government policy makers can be interpreted as efforts to:

- design “efficient” policies (e.g. those for which every objective is reached with the minimum loss for the other relevant objectives) to improve government performance, as measured by aforementioned indicators, while at the same time
- maintain a political behaviour true to their “political identity” (ideology, values, interests, influences).

Is MCDA Appropriate?

- Modelling and analysis play a key role in the interventions between the discipline of Operational Research (OR) and strategic decision-making.
- The popular view of strategic decisions is that they typically involve a high degree of uncertainty, high stakes, major resource implications, and long-term consequences.
- The Principles of sociotechnical design: Organizational objectives are best met [...] by the **joint optimization** of the technical and the social aspects
- Political decisions (e.g. in economic, fiscal, development fields) are often complex and multifaceted and involve many different stakeholders with different priorities or objectives
- Complex decision problems need a multicriteria decision analysis (MCDA) approach to be adopted, in order to take into account all the criteria/options involved in the analytical process of defining the scope of the decision, to construct a preference model, and to support the decision

Political Decisions and MCDA



The need for robustness analysis

- The stability of a model or/and of a solution should be assessed and evaluated each time
- The analyst shall be able to have a clear picture regarding the reliability and robustness of the produced results
- Stability and reliability shall be expressed using measures which are understandable by the analyst and the decision maker
- Based on these measures the decision maker may accept or reject or adopt the proposed decision model

The need for robustness analysis

We know, perfectly well, that uncertainty is present and has an influence on every decision-making context. But it appears in different ways.

In any way:

- We can not omit nor relegate it;

- We need to focus on its importance;

- We must consider it in an appropriate manner.

As Robustness allows us to experiment with uncertainty, it is necessary to define its concept, its significance and to emphasize its importance in the Multiple Criteria Decision Aid field.

The concepts of robustness in OR and MCDA

Robustness analysis has achieved a remarkable importance in recent years. However, there is some confusion about the different meanings that the term robustness has received.

For that reason it is necessary to discuss the different approaches behind the word “*robustness*”.

- Robust conclusion – valid in all or most pairs (version, procedure) – dealing with system values and gap from reality
- Robust solution – good in all or most cases– dealing with uncertainty of external environment and external factors
- Robust decision in dynamic context – keep open as many good plans as possible for the future – dealing with the unknown future

Robust conclusion

- Under a general discussion, Roy (2008 & 2010) assigns to robustness the role of a tool that supports the analysts against phenomena of “*approaches*” and “*zones of ignorance*”
- It’s necessary for the analysts to take into consideration that the decisions they try to reach will be:
  - applied into the real world which will be probably not 100% compatible with the developed model
  - actually evaluated according to a value system which might not also be in total compliance with the corresponding value system which was used for the development and application of the model

model **vs** reality

- Robust means ‘*good in all or most versions - procedures*’, while a version being a plausible set of values for the parameters of the model (procedure, version)

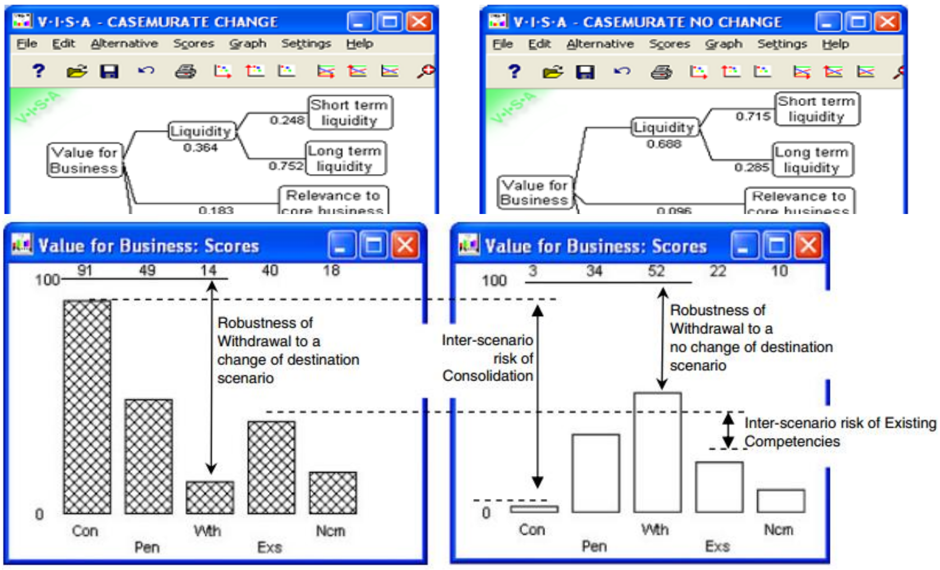
Robust solution

In the 1990s, Kouvelis and Yu represented the uncertainty by scenarios, where a scenario is a specification of all data. Robust solutions are those that perform relatively well across the scenarios.

In MCDA with multiple scenarios, two aspects should be of concern:

- The first one is the robustness of performances of a strategy across scenarios (*inter-scenario robustness*). Thus a strategy that performs relatively well on all scenarios exhibits higher (inter-scenario) robustness than one that performs poorly on a given scenario.
- The second aspect is the spread of performances across scenarios (*inter-scenario risk*). For example, a strategy with very good performance in one scenario and very poor performance in one scenario is considered of high risk.

Robust solution



Robust decision in dynamic context

From late 60s by Gupta and Rosenhead suggested that in sequential planning problems, decisions need to be made through time given different uncertainties. All decisions affect future plans.

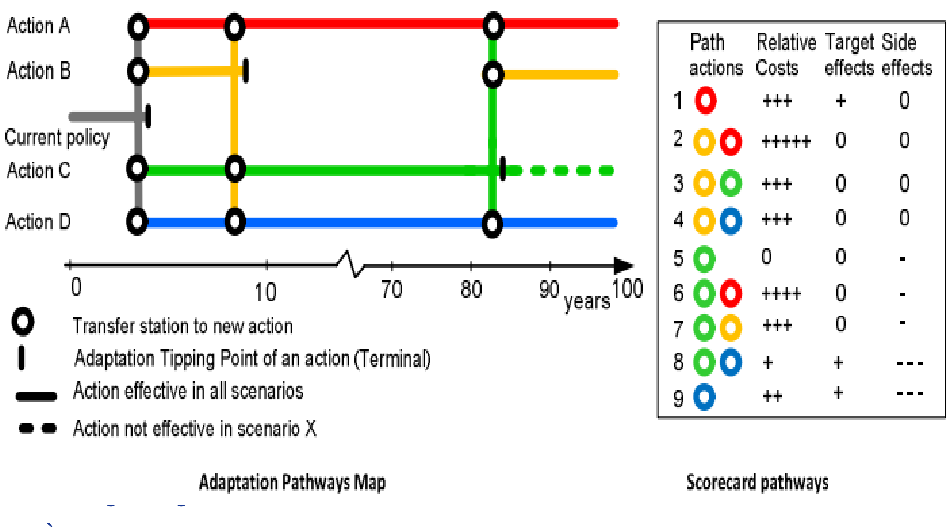
Robustness analysis in this context is applicable when:

- uncertainty is a factor that obstructs confident decision - which has been discussed above, and
- decisions must be or can be staged. - that is, the commitments made at the first stage of a decision do not necessarily define completely the future state of the system. There will be one or more future opportunities to modify or further define it.

The elements to be considered are:

- a set of alternative initial commitments to be considered
- a set of relevant possible configurations of the system which the decisions will modify
- a set of 'futures' representative of possible environments of the system

Robust decision in dynamic context



A Holistic Approach for Robustness Analysis

We propose an extension of the scope of scenarios in relation to the ones proposed in Goodwin and Wright (2001) by including the notion of pair (procedure, version) used by Roy (2010) combined with the effect of subsequent actions on future states of the problem.

Our approach is consisted of the following steps:

- Define a set of *k* alternative actions, $A= \{a_1, a_2, \ldots, a_i, \ldots a_k\}$
- Set future states *fs* where *fs*=0, 1, 2, …, *q*, while *fs*=0 is referring to the present time
- Define a set of plausible variable settings s=(procedure, version), using Roy's approach as an extension to the notion of scenario, in a future state *fs*, $S^{fs}=\{s^{fs}_1, s^{fs}_2, \ldots, s^{fs}_j, \ldots, s^{fs}_{m(fs)}\}$. The cardinality of S^{fs} is probably different for each future *fs*, and equal to *m(fs)*. It is very likely that for the distant futures the information about plausible variable settings maybe poor, so the cardinality of the S^{fs} will be decreased.

A Holistic Approach for Robustness Analysis

The set A of the alternative actions may evolve during the policy circle and new, combined and updated actions might enter in A, so its cardinality $|A|=k$ will be increased.

Each variable setting is also affected by the choice of an initial action a_{ic} at present time ($fs=0$), so the set of plausible variable settings could be represented as:

$S^{fs}(a_{ic})=\{s^{fs}_{1}(a_{ic}), s^{fs}_{2}(a_{ic}), \ldots, s^{fs}_{j}(a_{ic}), \ldots, s^{fs}_{m(fs)}(a_{ic})\}$ for $fs=1, 2, \ldots, q$ given that the selection of choice a_{ic} could affect each s in the future.

For the special case of $fs=0$, present time, the set of plausible variable settings is not affected by the action i: $S^{0}=\{s^{0}_{1}, s^{0}_{2}, \ldots, s^{0}_{j}, \ldots, s^{0}_{m(0)}\}$.

A generic example

alternative actions: $A=\{a_1, a_2, a_3, a_4\}$

a_{ic}: initial choice at $fs=0$

i: criteria→5

fs: future states→ 3 (fixed time, e.g.: yearly)

Total no of lines: **216**

s_j: scenarios→ 24, including:

- 4 versions of the problem
- 3 procedures (e.g. different post optimality algorithms in a UTA method, max-min, Manas-Nedoma, max δ)
- 2 set of parameters of the UTA method

fs	s_j	a_{ic}	cr_1	cr_2	cr_3	cr_4	cr_5	proc	δ	ε
0	1	-	$cr_1(0,1)$	$cr_2(0,1)$	$cr_3(0,1)$	$cr_4(0,1)$	$cr_5(0,1)$	m-m	0.1	0.1
…	…	-	…	…	…	…	…	…	…	…
0	24	-	$cr_1(0,4)$	$cr_2(0,4)$	$cr_3(0,4)$	$cr_4(0,4)$	$cr_5(0,4)$	maxδ	-	0.2
1	1	a_1	$cr_1(1,1)$	$cr_2(1,1)$	$cr_3(1,1)$	$cr_4(1,1)$	$cr_5(1,1)$	m-m	0.1	0.1
…	…	…	…	…	…	…	…	…	…	…
1	19	a_1	$cr_1(1,3)$	$cr_2(1,3)$	$cr_3(1,3)$	$cr_4(1,3)$	$cr_5(1,3)$	m-m	0.2	0.2
…	…	…	…	…	…	…	…	…	…	…
1	24	a_3	$cr_1(1,4)$	$cr_2(1,4)$	$cr_3(1,4)$	$cr_4(1,4)$	$cr_5(1,4)$	maxδ	-	0.2
…	…	…	…	…	…	…	…	…	…	…
2	24	a_4	$cr_1(2,4)$	$cr_2(2,4)$	$cr_3(2,4)$	$cr_4(2,4)$	$cr_5(2,4)$	maxδ	-	0.2

A Holistic Approach for Robustness Analysis

For each alternative a_i an overall evaluation of its **performance** under each plausible variable setting $s^{fs}_j(a_{ic})$, denoted as $\boldsymbol{V(s^{fs}_j(a_{ic}), a_i)}$, shall be calculated.

Robustness of all alternative actions across the plausible variable settings shall be evaluated using three types of measures:

- $\boldsymbol{R_{st}(s^{fs}_j(a_{ic}), a_i)}$: The *Standard Type*, highlights solutions that are good enough in most scenarios and not very bad at any scenario.
- $\boldsymbol{R_{cr}(s^{fs}_j(a_{ic}), a_i)}$: The *Credibility Type*, evaluates the robustness of a solution during post-optimality analysis by calculating stability and credibility measures.
- $\boldsymbol{R_{cr}(s^{fs}_j(a_{ic}), a_i)}$: The *Flexibility Type*, where an action a_i is considered to be robust, or equally flexible, if a significant number of 'good' or at least 'acceptable' plans are kept open in future states *fs*.

Conclusions

- MCDA could be extensively used for supporting extremely complex decisions in both public and private organisations
- The proposed approach will deal with epistemic uncertainty, multiple objectives, complex policies and long-term consequences
- We believe that the key aspect in efficiently tackling political circles is to develop robust strategies against multiple scenarios
- More studies on robustness of strategic options under multiple scenarios is required; for example, about suitable operators and graphical displays for interacting with policy makers.
- Long term consequences is an open area for research by MCDA, and developments in other areas (e.g., cost benefit analysis) could be analysed and adapted to the context discussed here.
- Structuring policies composed by options that are interconnected is an area almost unexplored, from a decision analysis perspective, and ideas from the field of problem structuring methods may be relevant for this intent.

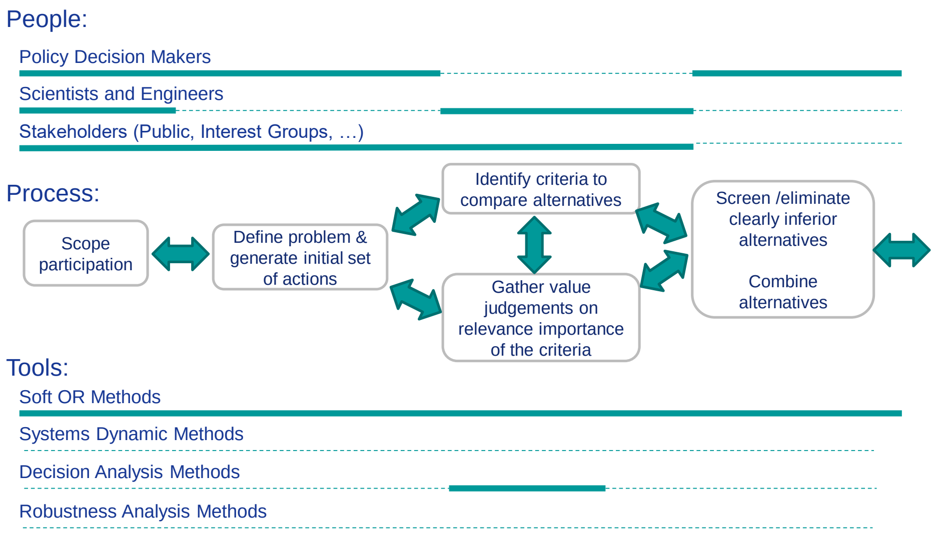
Future Research

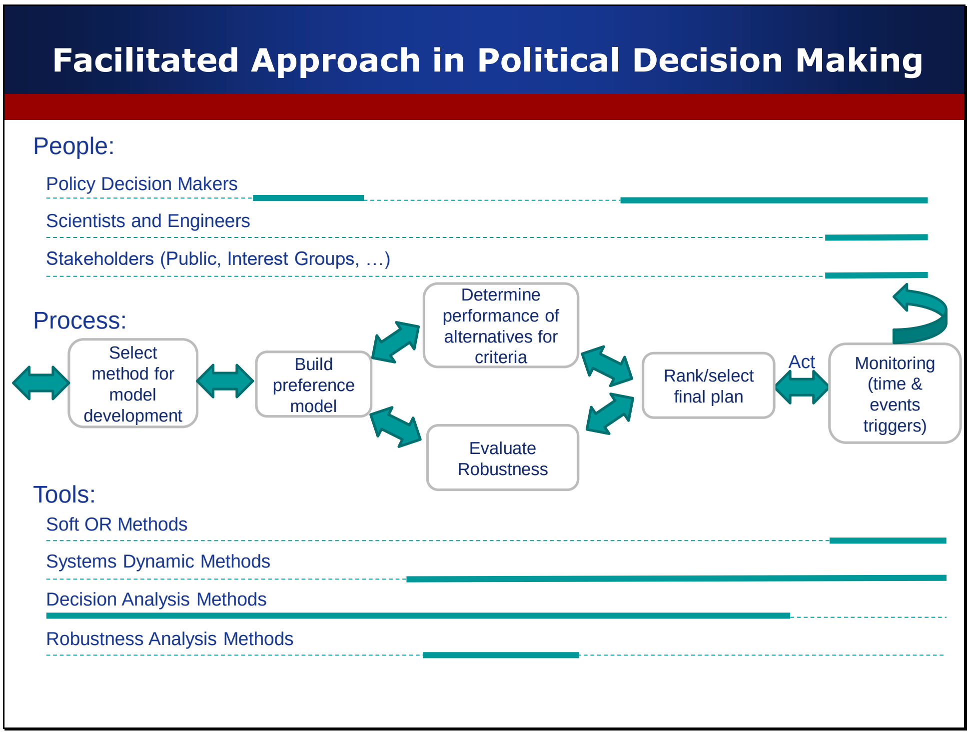
The proposed methodology meant to be an integrated part of an iterative, continuous process with feedback and forward loops supporting prospective and retrospective analyses based on multiple views and multiple states of the future, along with its focus on the aforementioned robustness concerns.

Such a framework shall be consisted of several discrete stages:

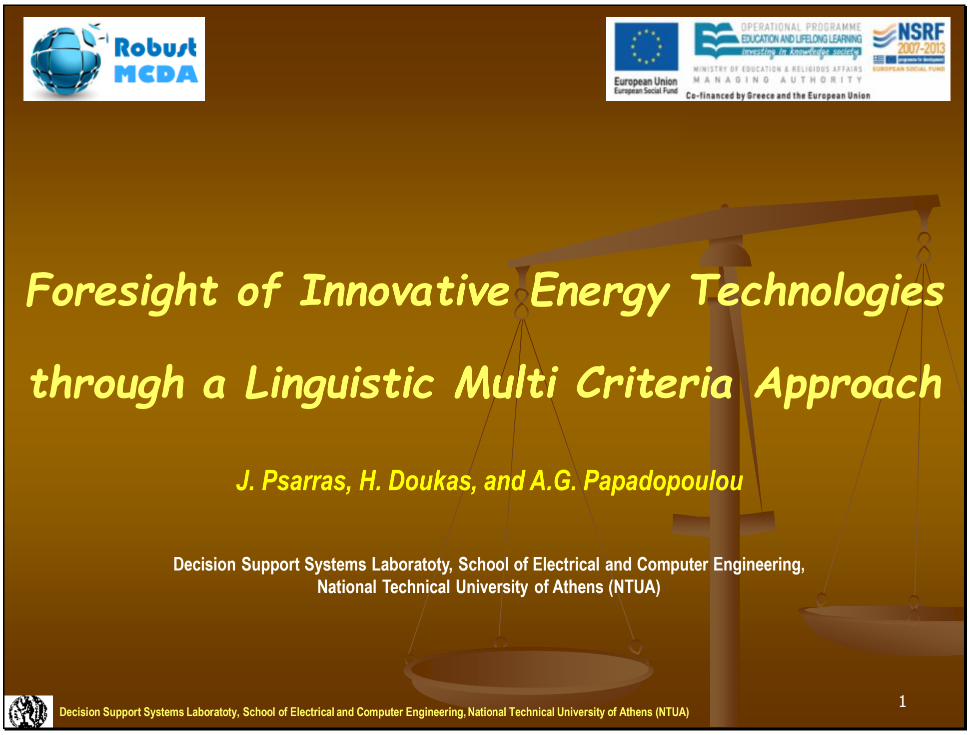
- defining the problem
- scoping participation
- tackling uncertainty with future scenarios
- considering multiple objectives
- designing and appraising complex strategic options, and
- considering long term consequences

Facilitated Approach in Political Decision Making




Facilitated Approach in Political Decision Making
People:
Policy Decision Makers
Scientists and Engineers
Stakeholders (Public, Interest Groups, …)
Process:
Select method for model development
Build preference model
Determine performance of alternatives for criteria
Evaluate Robustness
Rank/select final plan
Act
Monitoring (time & events triggers)
Tools:
Soft OR Methods
Systems Dynamic Methods
Decision Analysis Methods
Robustness Analysis Methods


Thank you for your attention.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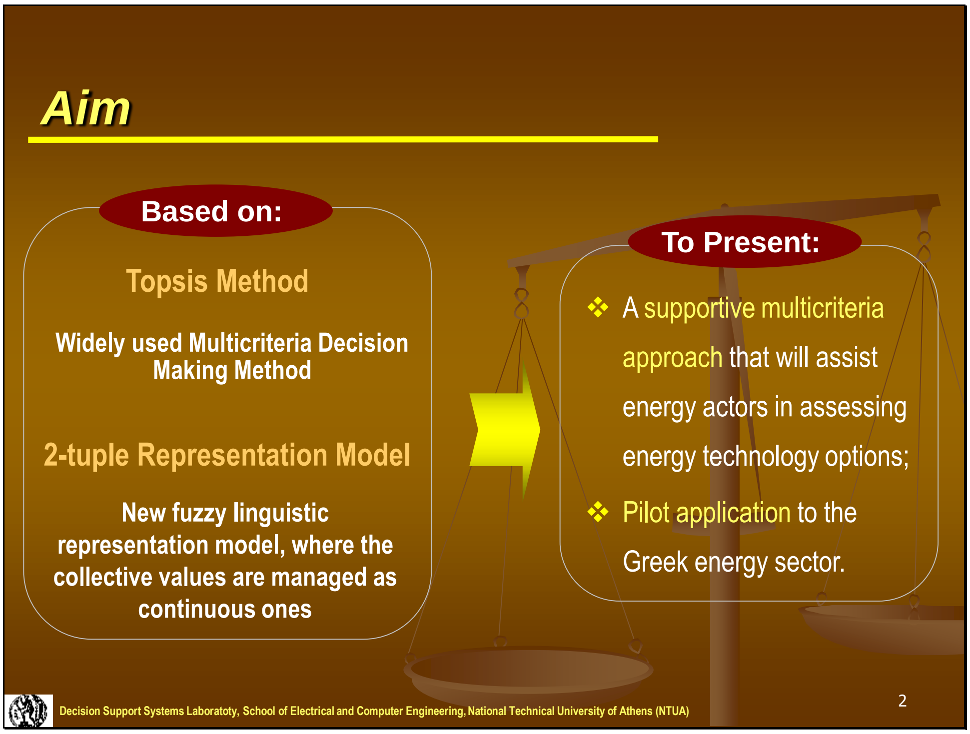
Foresight of Innovative Energy Technologies
through a Linguistic Multi Criteria Approach
J. Psarras, H. Doukas, and A.G. Papadopoulou
Decision Support Systems Laboratoty, School of Electrical and Computer Engineering,
National Technical University of Athens (NTUA)
Decision Support Systems Laboratoty, School of Electrical and Computer Engineering, National Technical University of Athens (NTUA)
1


Aim
Based on:
Topsis Method
Widely used Multicriteria Decision Making Method
2-tuple Representation Model
New fuzzy linguistic representation model, where the collective values are managed as continuous ones
To Present:
A supportive multicriteria approach that will assist energy actors in assessing energy technology options;
Pilot application to the Greek energy sector.
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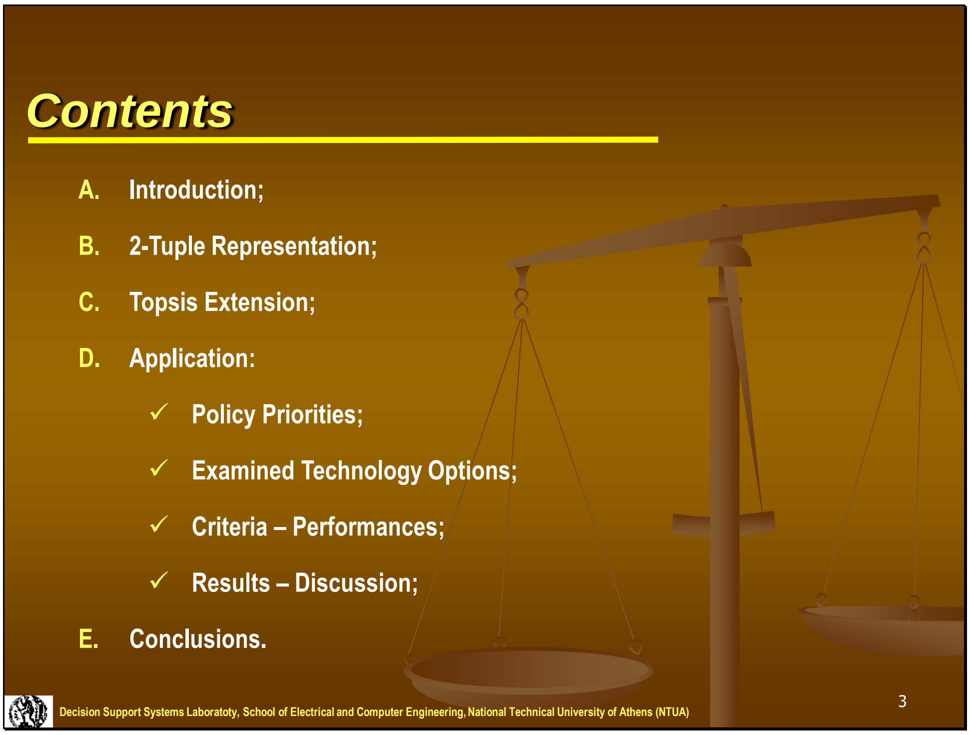
2


Contents
A. Introduction;
B. 2-Tuple Representation;
C. Topsis Extension;
D. Application:
✓ Policy Priorities;
✓ Examined Technology Options;
✓ Criteria – Performances;
✓ Results – Discussion;
E. Conclusions.
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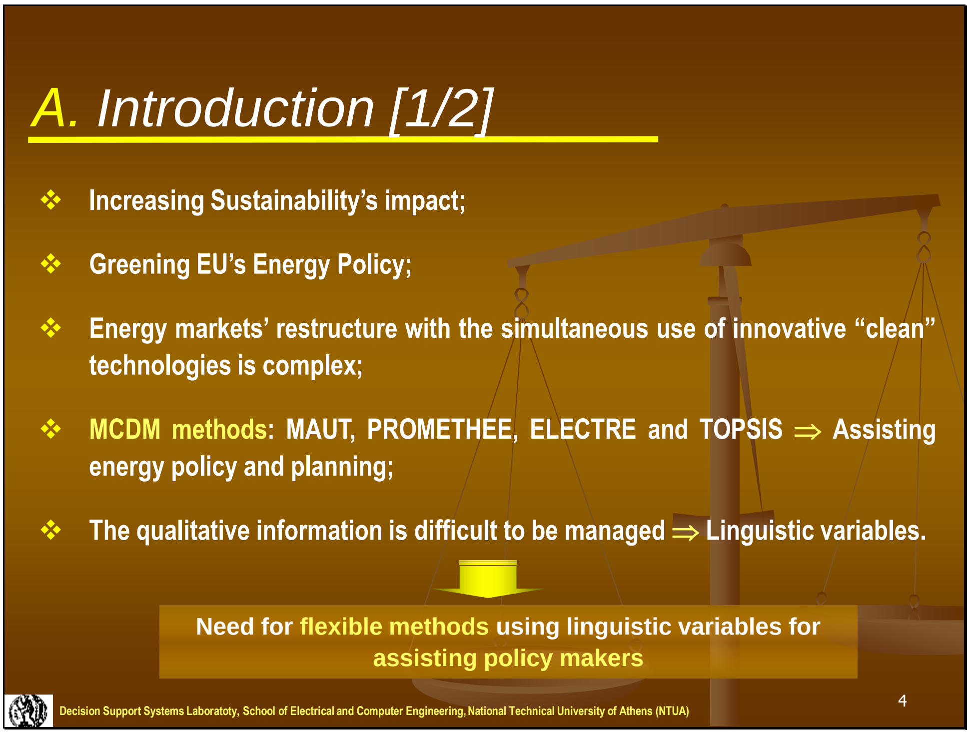
A. Introduction [1/2]
Increasing Sustainability's impact;
Greening EU's Energy Policy;
Energy markets' restructure with the simultaneous use of innovative "clean" technologies is complex;
MCDM methods: MAUT, PROMETHEE, ELECTRE and TOPSIS ⇒ Assisting energy policy and planning;
The qualitative information is difficult to be managed ⇒ Linguistic variables.
Need for flexible methods using linguistic variables for assisting policy makers
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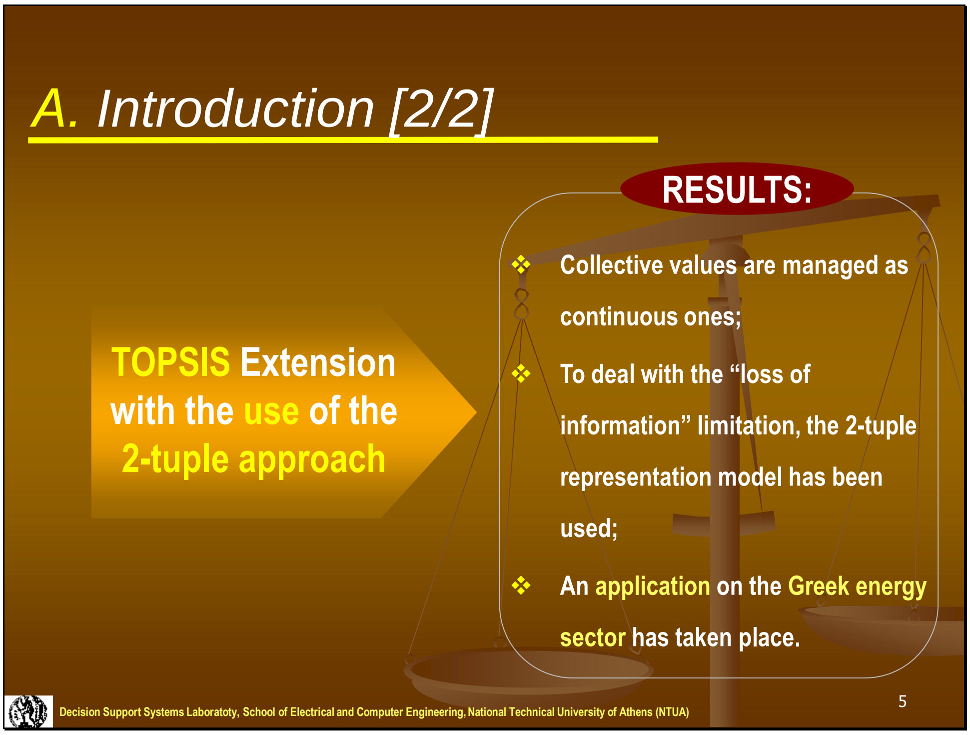
4


A. Introduction [2/2]
TOPSIS Extension with the use of the 2-tuple approach
RESULTS:
Collective values are managed as continuous ones;
To deal with the "loss of information" limitation, the 2-tuple representation model has been used;
An application on the Greek energy sector has taken place.
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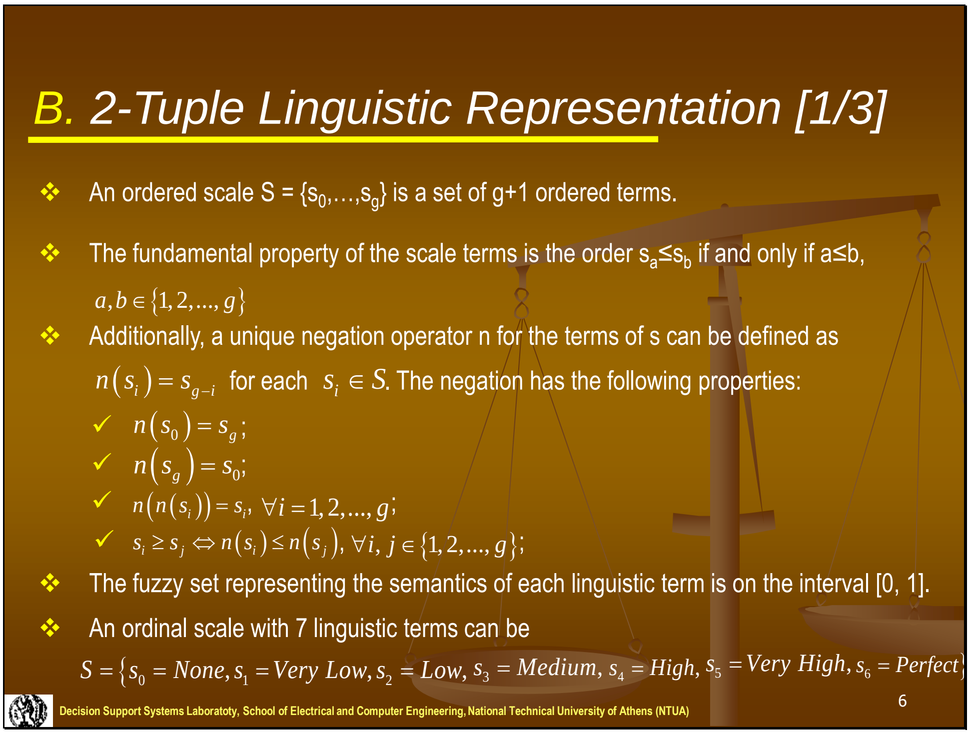
5


B. 2-Tuple Linguistic Representation [1/3]
An ordered scale S = {s_0,…,s_g} is a set of g+1 ordered terms.
The fundamental property of the scale terms is the order $s_a \leq s_b$ if and only if a≤b, $a,b \in \{1,2,...,g\}$
Additionally, a unique negation operator n for the terms of s can be defined as $n(s_i) = s_{g-i}$ for each $s_i \in S$. The negation has the following properties:
$n(s_0) = s_g$;
$n(s_g) = s_0$;
$n(n(s_i)) = s_i, \ \forall i = 1,2,...,g$;
$s_i \geq s_j \Leftrightarrow n(s_i) \leq n(s_j), \ \forall i,j \in \{1,2,...,g\}$;
The fuzzy set representing the semantics of each linguistic term is on the interval [0, 1].
An ordinal scale with 7 linguistic terms can be
$S = \{s_0 = None, s_1 = Very\ Low, s_2 = Low, s_3 = Medium, s_4 = High, s_5 = Very\ High, s_6 = Perfect\}$
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B. 2-Tuple Linguistic Representation [2/3]

- Let S = $\{s_0,\ldots,s_g\}$ be a linguistic term set.
- Assume that a symbolic method aggregating linguistic information obtains a value $\beta \in [0, g]$ and $\beta \notin \{0,1,\ldots,g\}$
- Let $\beta \in [0, g]$ be the result of an aggregation of the indexes of a set of labels assessed in a linguistic term set S.
- Let i=round(β) and α=β–i be two values such that $i \in \{0,1,\ldots,g\}$ and $a \in [-0.5, 0.5)$
- The meaning of symbolic translation α lies in the "difference of information" between $\beta \in [0, g]$ and $i \in \{0,1,\ldots,g\}$ that indicates the index of the closest linguistic term $s_i \in S(i = round(\beta))$
- Based on the above a linguistic representation model was developed, representing the linguistic information by means of 2-tuples (s_i, α_i), $s_i \in S$ and $a \in [-0.5, 0.5)$, where:
  - ✓ $s_i \in S$ represents the linguistic label center of the information;
  - ✓ α_i is the symbolic translation.

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B. 2-Tuple Linguistic Representation [3/3]

- Let S = $\{s_0,\ldots,s_g\}$ be a linguistic term set and $\beta \in [0, g]$ a value representing the result of a symbolic aggregation operation, then the 2-tuple expressing the equivalent information to β is obtained with the following function:

$$\Delta : [0, g] \to S \times [-0.5, 0.5)$$

$$\Delta(\beta) = (s_i, a) \quad \text{with} \quad \begin{cases} s_i \in S \text{ and } i = round(\beta) \\ a = \beta - i, a \in [-0.5, 0.5) \end{cases}$$

- The definition of function Δ implies that there is always a function $\Delta^{-1} : S \times [-0.5, 0.5) \to [0, g]$ such that from a 2-tuple it returns its equivalent numerical value $\beta \in [0, g]$. Then the following function is considered: $\Delta^{-1}(s_i, a) = i + a = \beta$
- A 2-tuple's negation can be defined as: $Neg(s_i, a) = \Delta\left[g - \Delta^{-1}(s_i, a)\right]$
- Let (s_k, α_1) and (s_l, α_2) be two 2-tuples. Their comparison can be achieved as follows:
  - ✓ If k<1 then (s_k, α_1) < (s_l, α_2)
  - ✓ If k=1 three cases exist:
    - If α_1=α_2 then (s_k, α_1) = (s_l, α_2)
    - If α_1 <α_2 then (s_k, α_1) < (s_l, α_2)
    - If α_1 > α_2 then (s_k, α_1) > (s_l, α_2)

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C. Topsis Extension [1/3]

Representation:

- Alternative's "i" performance in every criterion "j" represented as $z_{ij} = s_{\beta_{ij}} \in S$, $\beta_{ij} \in \{0,1,\dots,g\}$
- Therefore $\Delta^{-1}(s_{\beta_{ij}}, 0) = \beta_{ij} \in \{0,1,\dots,g\} \subset [0,g]$ expresses the equivalent numerical information;
- Each criterion "j" weight can be represented as $w_j = s_{\lambda_j} \in S$, $\lambda_j \in \{0,1,\dots,g\}$
- Therefore $\Delta^{-1}(s_{\lambda_j}, 0) = \lambda_j \in \{0,1,\dots,g\} \subset [0,g]$ expresses the equivalent numerical information;

The incorporation of weights in the Topsis method can be developed as:

$$\mathbf{X} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1k} \\ x_{21} & x_{22} & \cdots & x_{2k} \\ \vdots & \vdots & \cdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nk} \end{bmatrix} \quad \text{where} \quad x_{ij} = \frac{\lambda_j \cdot \beta_{ij}}{\sum_{j=1}^{k} \lambda_j} \in [0, g] \, \forall i, \forall j \quad \text{so as} \quad \sum_{j=1}^{k} \frac{\lambda_j}{\sum_{j=1}^{k} \lambda_j} = 1$$

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C. Topsis Extension [2/3]

- The ideal alternative α^+ can be identified as follows:

$$\alpha^+ = (\max_i x_{i1}, \ \max_i x_{i2}, \ \dots \max_i x_{ij}, \ \dots \max_i x_{ik}) = (x_1^+, x_2^+, \dots x_j^+, \dots x_k^+)$$

- The negative ideal alternative α^- can be defined as:

$$\alpha^- = (\min_i x_{i1}, \ \min_i x_{i2}, \ \dots \min_i x_{ij}, \ \dots \min_i x_{ik}) = (x_1^-, x_2^-, \dots x_j^-, \dots x_k^-)$$

where $\alpha_j^+, \alpha_j^- \in [0, g]$

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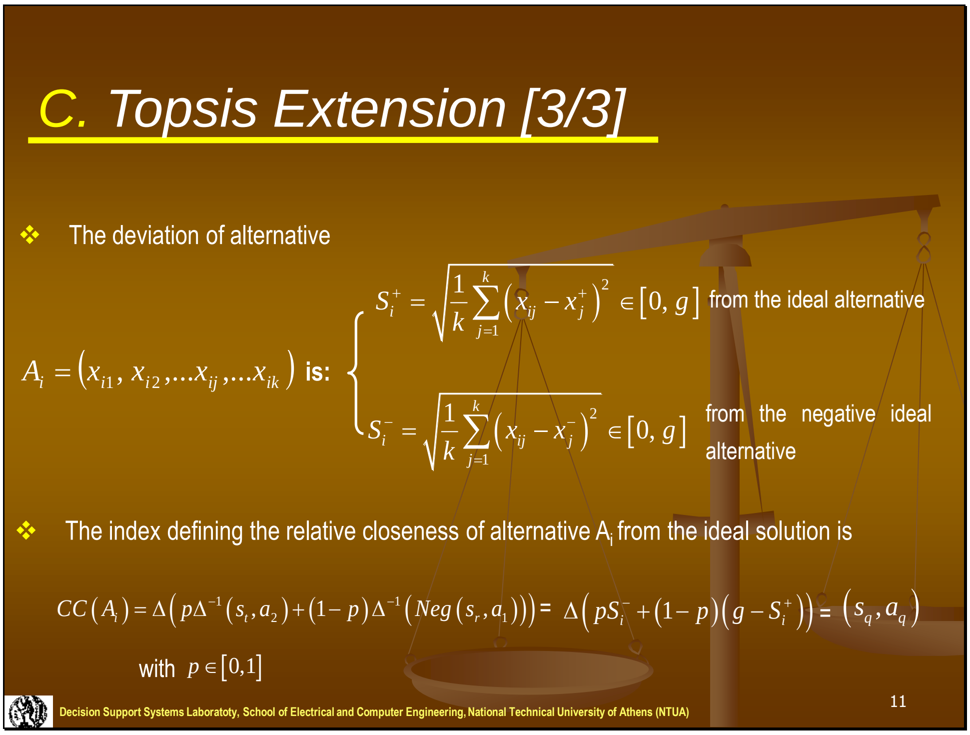
10


C. Topsis Extension [3/3]
The deviation of alternative
$A_i = (x_{i1}, x_{i2}, \ldots x_{ij}, \ldots x_{ik})$ is:
$S_i^+ = \sqrt{\frac{1}{k}\sum_{j=1}^{k}(x_{ij} - x_j^+)^2} \in [0, g]$ from the ideal alternative
$S_i^- = \sqrt{\frac{1}{k}\sum_{j=1}^{k}(x_{ij} - x_j^-)^2} \in [0, g]$ from the negative ideal alternative
The index defining the relative closeness of alternative A_i from the ideal solution is
$CC(A_i) = \Delta(p\Delta^{-1}(s_t, a_2) + (1-p)\Delta^{-1}(Neg(s_r, a_1))) = \Delta(pS_i^- + (1-p)(g - S_i^+)) = (s_q, a_q)$
with $p \in [0,1]$
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D. Application [1/6]
Policy Priorities
Domestic energy resources' exploitation;
Creation of domestic infrastructure;
Construction of electrical interconnections with neighboring countries;
Meeting the Kyoto Protocol Target;
Diversification of supply.
Decarbonisation of the Greek energy system by introducing low carbon (natural gas) or non-carbon (renewable) energy sources
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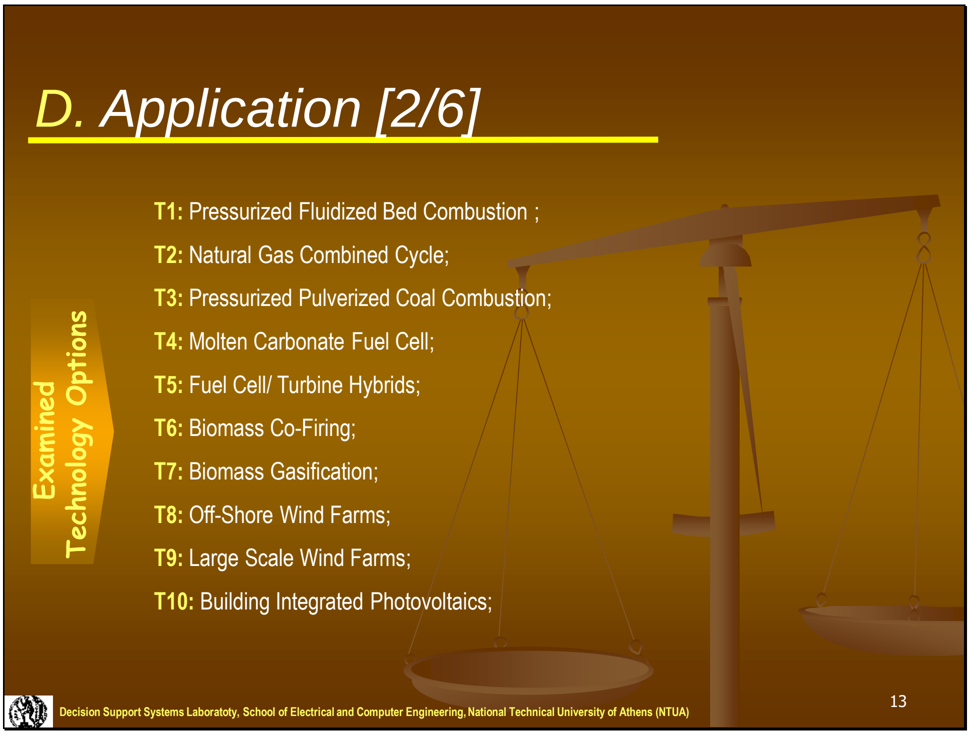
D. Application [2/6]
Examined Technology Options
T1: Pressurized Fluidized Bed Combustion ;
T2: Natural Gas Combined Cycle;
T3: Pressurized Pulverized Coal Combustion;
T4: Molten Carbonate Fuel Cell;
T5: Fuel Cell/ Turbine Hybrids;
T6: Biomass Co-Firing;
T7: Biomass Gasification;
T8: Off-Shore Wind Farms;
T9: Large Scale Wind Farms;
T10: Building Integrated Photovoltaics;
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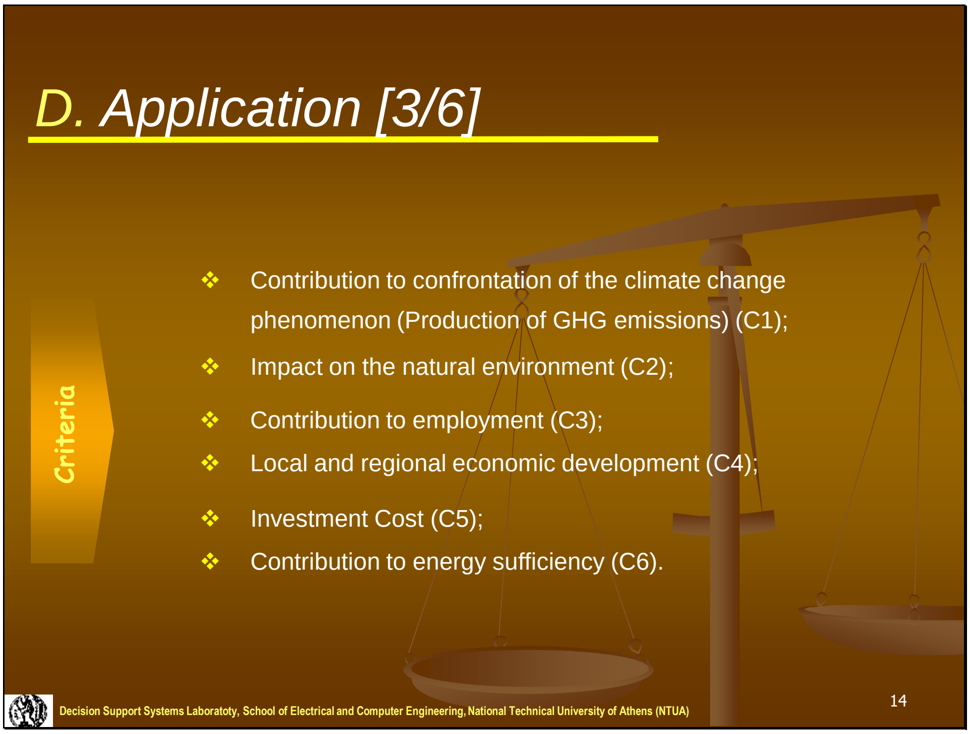
D. Application [3/6]
Criteria
Contribution to confrontation of the climate change phenomenon (Production of GHG emissions) (C1);
Impact on the natural environment (C2);
Contribution to employment (C3);
Local and regional economic development (C4);
Investment Cost (C5);
Contribution to energy sufficiency (C6).
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D. Application [4/6]

- Weights, Performances ⇒ None (N), Very Low (VL), Low (L), Medium (M), High (H), Very High (VH), Perfect (P).

Performances

Criteria	Weights	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
		Technology Options									
C1	P	M	M	N	M	H	N	P	P	P	VH
C2	M	L	VH	N	M	P	L	VH	M	L	P
C3	VH	VH	H	VH	VH	M	VH	P	VH	VH	M
C4	M	M	H	H	M	M	H	VH	VH	P	L
C5	L	H	VH	H	N	VL	P	M	H	VH	VL
C6	H	P	VL	P	VH	VH	P	P	P	P	P

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D. Application [5/6]

Results

Ranking	Technology Options	Results s_q	Results a_q
1	**T7:** Biomass Gasification	3	0,36
2	**T9:** Large Scale Wind Farms	3	0,30
3	**T10**: Building Integrated Photovoltaics	3	0,29
4	**T5:** Fuel Cell/ Turbine Hybrids	3	0,16
5	**T8:** Off-Shore Wind Farms	3	0,09
6	**T1:** Pressurized Fluidized Bed Combustion	3	0,06
7	**T4:** Molten Carbonate Fuel Cell	3	0,02
8	**T2:** Natural Gas Combined Cycle	3	-0,03
9	**T6:** Biomass Co-Firing	3	-0,11
10	**T3:** Pressurized Pulverized Coal Combustion	3	-0,15

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D. Application [6/6]
Discussion
Outputs:
Biomass Gasification + Large Scale Wind Parks ⇒ Able to be realized in large scale.
Building Integrated Photovoltaics + Fuel Cell/ Turbine hybrids ⇒ Promising options;
Evaluation:
RES options are standing out, comprising the first five;
Conventional fuel based technologies boxed in the lower places of the evaluation ⇒ Continually increased environmental awareness and energy dependence on countries with unstable geopolitical characteristics.
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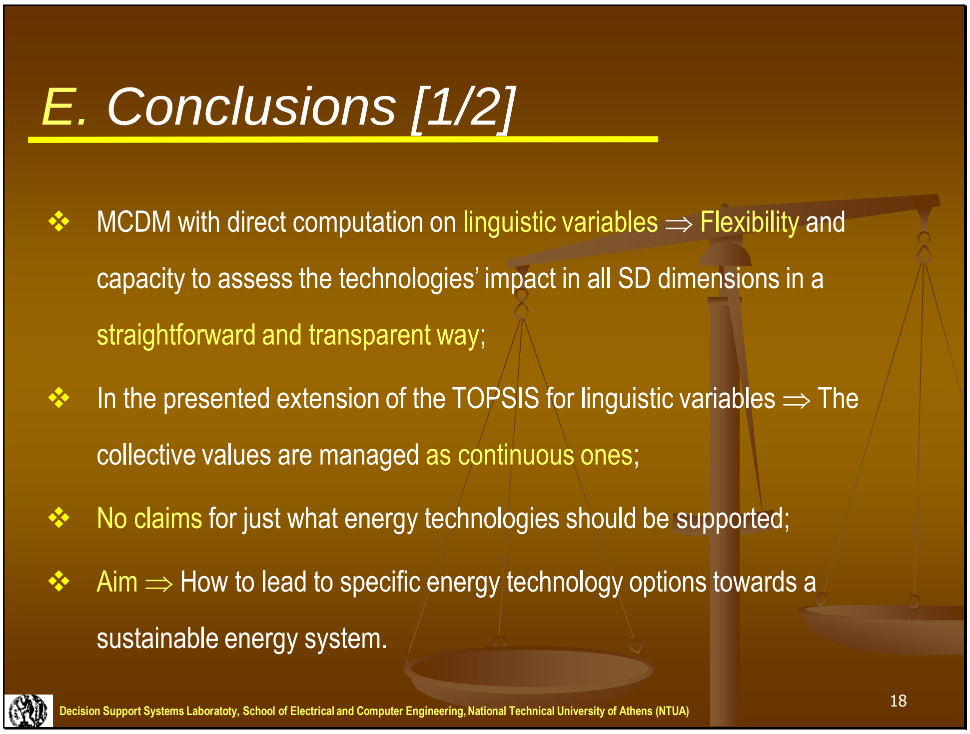
E. Conclusions [1/2]
MCDM with direct computation on linguistic variables ⇒ Flexibility and capacity to assess the technologies' impact in all SD dimensions in a straightforward and transparent way;
In the presented extension of the TOPSIS for linguistic variables ⇒ The collective values are managed as continuous ones;
No claims for just what energy technologies should be supported;
Aim ⇒ How to lead to specific energy technology options towards a sustainable energy system.
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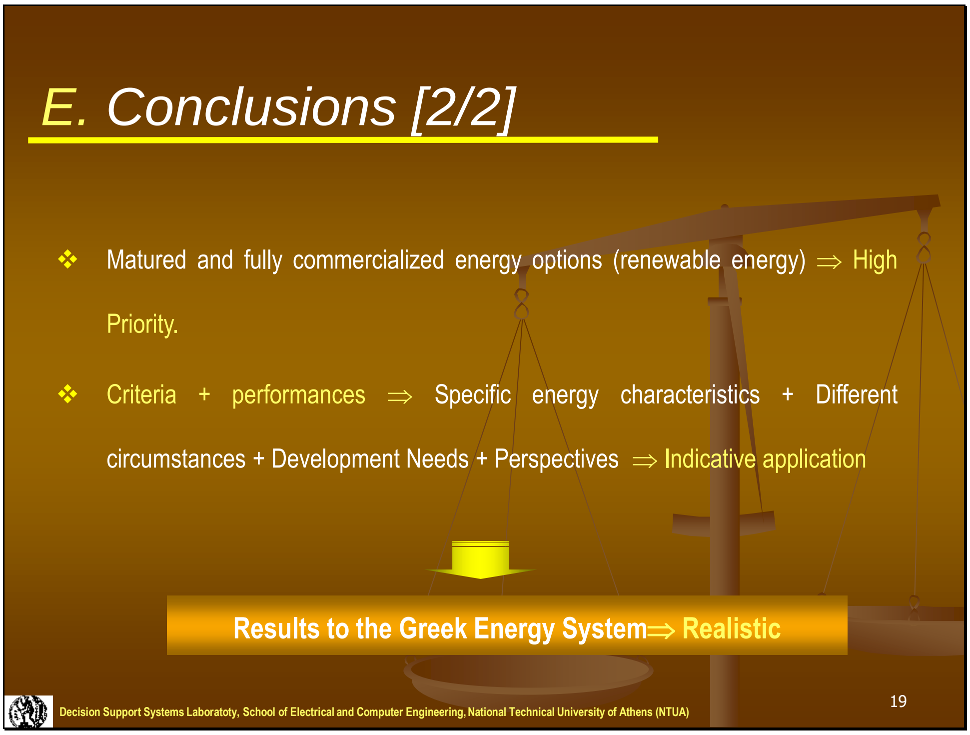
E. Conclusions [2/2]
Matured and fully commercialized energy options (renewable energy) ⇒ High Priority.
Criteria + performances ⇒ Specific energy characteristics + Different circumstances + Development Needs + Perspectives ⇒ Indicative application
Results to the Greek Energy System⇒ Realistic
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Thank you very much
for your attention!
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