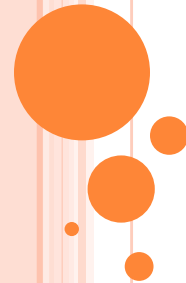


# DECISION MAKING TECHNIQUES IN MANAGEMENT INFORMATION SYSTEMS (MIS)

## LECTURE -6- (Structuring the problem, Cognitive Mapping)



### STRUCTURING THE PROBLEM

- Both **defining** the problem and **identifying** the elements of the model to be used in the analyzing the various alternative courses of action.
- An imaginative creative process of translating an initially ill-defined problem into a set of well-defined elements, relations and operations.

## STRUCTURING METHODS

- **Cognitive Mapping**
- Value Hierarchy (Value Tree)
  - Top down (objectives driven) approach
  - Bottom up (alternatives driven) approach
- Soft Systems Methodology
- Influence Diagrams
- Lateral Thinking

## COGNITIVE MAPPING

- Cognitive mapping is the task of mapping a person's thinking about a problem or issue (Tolman, 1948).
- One of the practical aims of cognitive mapping is to attain an appropriate and powerful **link** between the **qualitative aspects** of a problem definition and the role of **quantitative analysis** (Eden et al., 1986)
- Cognitive mapping is a tool which enables a group of experts and/or specialists to negotiate a definition of the problem that is **visualized** in the form of a model amenable to further elaboration and to the analysis of complexity (Eden, 1988)
- Cognitive maps have been studied in various fields of science, such as
  - psychology, planning, geography and management.

## DEFINITION

- Cognitive maps are ***cause-effect networks***, with nodes representing concepts articulated by individuals, and directional linkages capturing causal dependencies (Srinivas and Shekar, 1997).
- Cognitive maps provide **graphical descriptions** of unique ways in which individuals view a particular domain (Axelrod, 1976; Eden, 1990).
- The networks have **nodes** representing **concepts**, and **arcs** representing **directional relationships** between these nodes.

## REPRESENTATION

- In cognitive mapping concepts (nodes) are connected to the others by **incoming** or **outgoing** arrows.
- When there is a **negative** relationship between concepts a **minus sign** is attached to the arrow.
- For **positive** relationships **plus sign** may or may not be attached.
- This representation is also referred as signed directed graph.

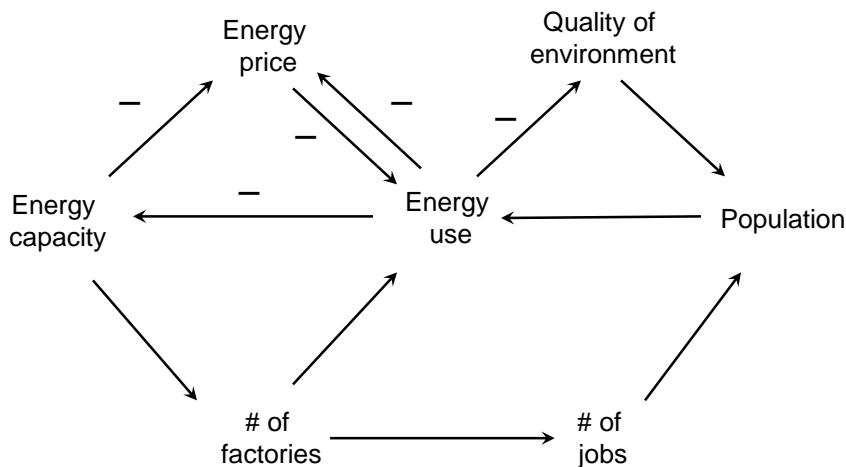
## HEADS AND TAILS

- Typically a node which has no implication (outgoing arrows) is referred to as a “head”, and a node which has no in-arrows is referred to as a “tail”.
- The node which has the highest total of incoming and outgoing arrows is the most central element of the map.

## DIRECTED GRAPH

- The problem is represented by a signed digraph (directed graph) of basic elements where
  - A concept variable is symbolized as a point, and
  - The causal assertion (belief) of how one concept variable affects another (relationship between the variables) is symbolized as an arrow
  - A **plus sign** is attached to the arrows that show positive relationships (changes occur in the same direction)
  - A **minus sign** is attached to the arrows that show negative relationships (changes occur in the opposite direction)

## SIGNED DIGRAPH FOR ENERGY DEMAND



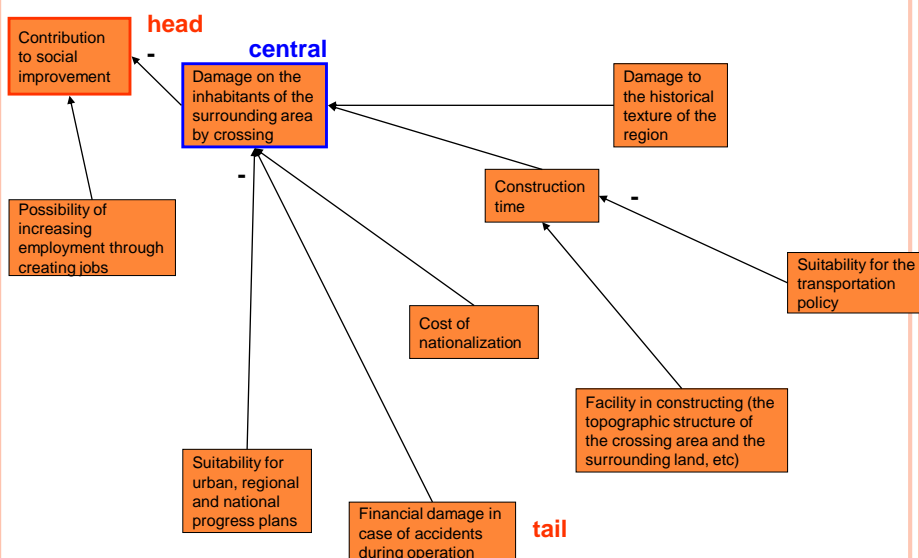
## DERIVING COGNITIVE MAP

- There are three basic ways of deriving a cognitive map of the expert opinion (Hwang & Lin, 1987):
  - questionnaire survey,
  - documentary coding, and
  - interviews.
- A questionnaire survey can be divided into three phases (Roberts, 1976):
  - identifying potentially relevant variables,
  - limiting the number of variables by rating their importance, and
  - the choice of arrows and signs

## ANALYSING COGNITIVE MAP

- Decision Explorer software package (Banxia Software, 1996)
  - Domain analysis (centrality)
  - Head-Tail analysis”
  - Cluster analysis
  - ... ..
- Centrality
  - The total number of concept variables (directly) affected by concept i is “outdegree” of variable i
  - The total number of concept variables (directly) affects concept i is “indegree” of variable i
  - outdegree + indegree = total degree (centrality)

### EXAMPLE (ULENGIN, TOPCU, ONSEL, 2001)

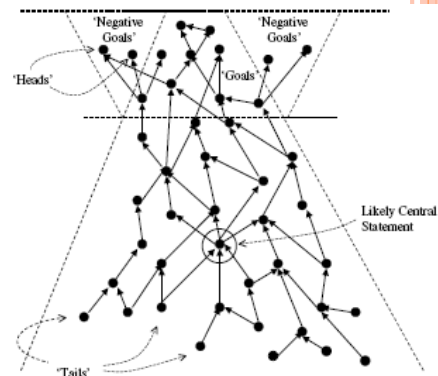


## HEADS AND TAILS

- Heads will usually be “goal” type statements: expressions of desired or not-desired outcomes.
- Tails will be “options”.

## STRUCTURAL PROPERTIES

- When a cognitive map is pictured in graph form it is then relatively easy to see how each of the concepts and causal relationships relate to each other, and to see the overall structure of the whole set of portrayed assertions” (Axelrod, 1976).



## PROBLEM/ISSUE COMPLEXITY

- Both cognitive scientists and organizational scientists have been fond of simple analyses of cognitive maps.
- These analyses are supposed to indicate the central features of a directed graph.
  - The first of these simple analyses explores the total number of nodes and the total number of arrows;
  - The second is concerned with “**cognitive centrality**” of particular nodes.

## THE EXTENT OF THE MAP

- The more nodes (or concepts) are there in a map, the more complex is the map and the issue.
- The map, as model, acts as a device for establishing a mutual understanding of the issue.
- The number of concepts elicited during an interview is dependent upon the length of the interview and the skills of the interviewer.



## THE COMPLEXITY OF THE MAP AS A NETWORK

- An alternative analysis of issue complexity is to determine the ratio of arrows to concepts. A higher ratio indicates a densely connected map and supposedly a higher level of complexity.
- Ratios of 1.15 to 1.20 is fine for maps elicited from interviews.

## REPRESENTATION

- Graph
  - Helps to see the causal relationships between variables better
- Matrix
  - Allows mathematical analysis in an effective way.

## EXAMPLE: HOW CAN WE MOTIVATE EMPLOYEES?

- Variables
  - Motivation
  - Salaries
  - Problems in the work environment
  - Good attitude of the employer
  - Good attitude of the colleagues
  - Career possibilities

## CAUSAL RELATIONSHIPS BETWEEN THE VARIABLES

- positive (+)

salary  $\xrightarrow{\quad}$  motivation

- negative (-)

problems in the work environment  $\xrightarrow{\quad}$  motivation

- no relationship

attitude of colleagues      salary

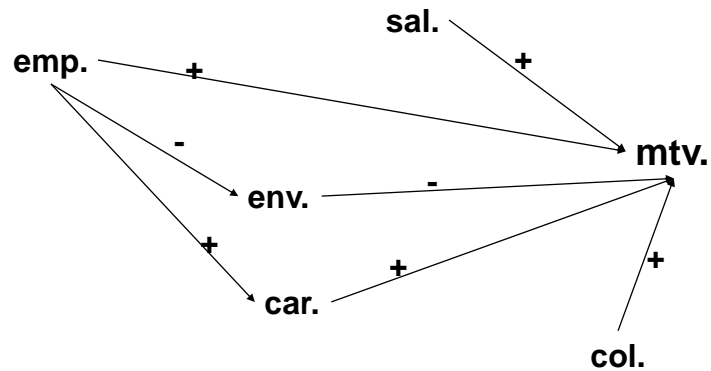
## DETERMINATION OF THE CAUSAL RELATIONSHIPS

- Construction of a square matrix including all concepts
- Determination of the causal relationships by pairwise comparisons

## HOW CAN WE MOTIVATE EMPLOYEES?

|             | <b>mtv.</b> | <b>sal.</b> | <b>env.</b> | <b>emp.</b> | <b>col.</b> | <b>car.</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>mtv.</b> | 0           | 0           | 0           | 0           | 0           | 0           |
| <b>sal.</b> | +           | 0           | 0           | 0           | 0           | 0           |
| <b>env.</b> | -           | 0           | 0           | 0           | 0           | 0           |
| <b>emp.</b> | +           | 0           | -           | 0           | 0           | +           |
| <b>col.</b> | +           | 0           | 0           | 0           | 0           | 0           |
| <b>car.</b> | +           | 0           | 0           | 0           | 0           | 0           |

## HOW CAN WE MOTIVATE EMPLOYEES?

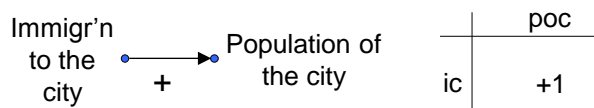


## MATRIX ALGEBRA

- Valency Matrix
- Centrality
- Reachability Matrix

## VALENCY MATRIX

- The adjacency matrix
- $V$  is a square matrix of  $n \times n$ , where  $n$  is the total number of concept variables
- Entry displays the direct effect of the column variable on the row variable



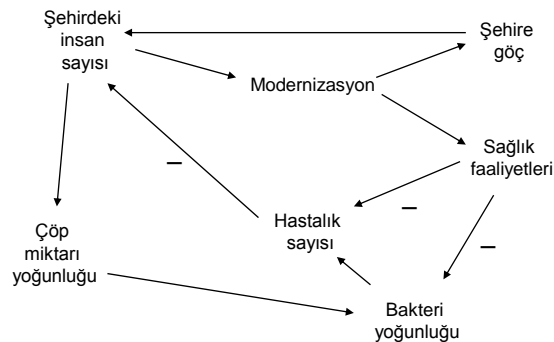
- The valency matrix indicates only direct relations between concept variables, that is, concept linkage paths of length 1

## CENTRALITY

- The row sum of the absolute values of the elements of  $V$  for row  $i$  gives the outdegree (od) of variable  $i$ .
- The column sum of the absolute values of the elements of  $V$  for column  $i$  gives the indegree (id) of variable  $i$ .
- The sum of  $od_i$  and  $id_i$  gives the total degree of  $i$  ( $td_i$ ) which is a useful operational measure of that variable's cognitive centrality in the opinion structure of the experts

## INDIRECT EFFECT

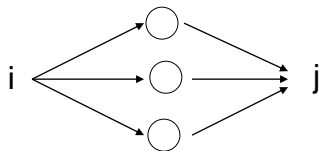
$V_{ij}^n$ : for the path of length  $n$ , indirect effect of variable  $i$  on variable  $j$



$V_{sis,hs}^3=0$  (two alternative paths)

## INDIRECT EFFECT

Reachability of variable  $i$  on variable  $j$



For the path of length 2, the cumulative indirect effects of variable  $i$  on variable  $j$

$V_{i,j}^2 = +3$  (Three paths +)

$V_{i,j}^2 = +1$  (Two paths +, one path -)

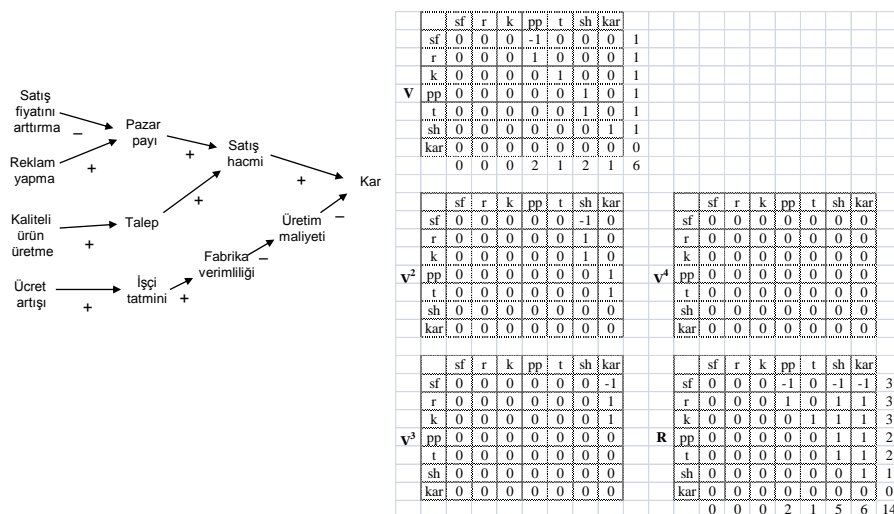
$V_{i,j}^2 = -1$  (Two paths -, one path +)

$V_{i,j}^2 = -3$  (Three paths -)

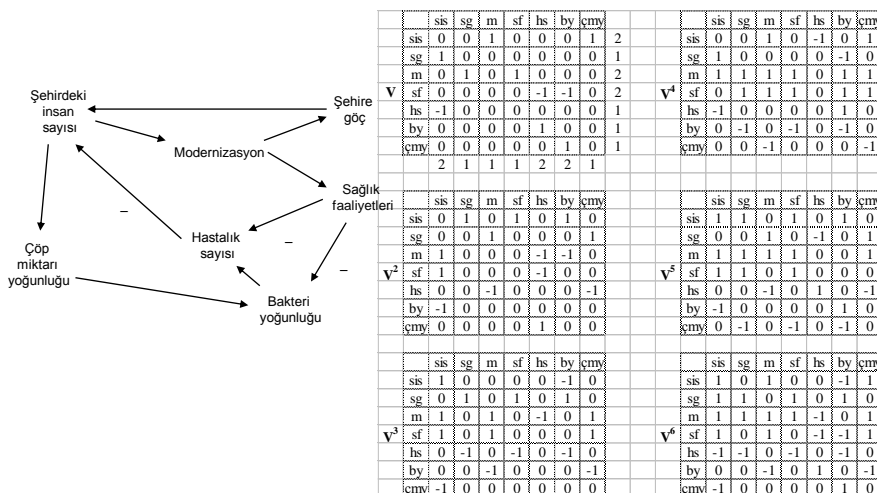
## REACHABILITY MATRIX

- R reflects the existence of indirect relations
- If the adjacency matrix contains no feedback loops, the cumulative indirect effects (R) are calculated as:  $R = V + V^2 \dots + V^{n-1}$
- The sum of the absolute values for row  $i$  of R shows the total number of variables reachable from variable  $i$
- The sum of the absolute values for column  $i$  of R shows the total number of variables reaching variable  $i$

## EXAMPLE



## EXAMPLE



## EXAMPLE-1

Slashes show where the text has been broken into its constituent concepts – a single slash / indicates the start of a phrase; a double slash // indicates the end of a phrase. Possible goals are italicised and marked with a «G».

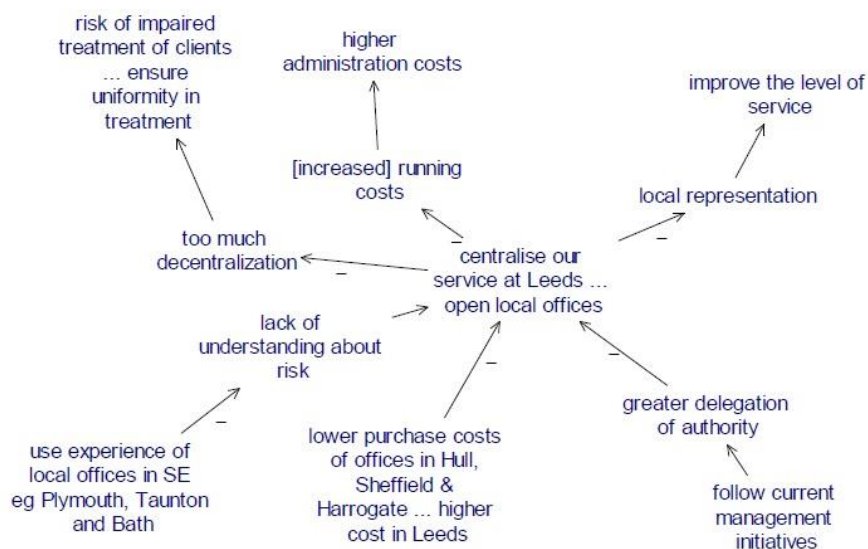
"We need to decide on our accommodation arrangements for the York and Humberside region. We could /centralise our service at Leeds// or /open local offices// in various parts of the region. The /level of service we might be able to provide could well be improved G// by /local representation// but we guess that /administration costs would be higher// and, in this case, it seems likely that /running costs// will be the most important factor in our decision. The office /purchase costs in Hull and Sheffield// might however be lower than in /Leeds//. Additionally we need to /ensure uniformity in the treatment of clients// in the region and this might be /impaired// by /too much decentralization//. However we are not sure how great this /risk// in this case; /experience of local offices in Plymouth, Taunton and Bath in the South East may have something to teach us//. Moreover /current management initiatives// point us in the direction of /greater delegation of authority//."



## CONCEPTS

- centralise our service at Leeds...open local offices
- improve the level of service we provide
- local representation
- higher administration costs
- [increased] running costs
- lower purchase costs of offices in Hull and Sheffield and Harrogate...higher cost in Leeds
- ensure uniformity in the treatment of clients
- [lack of understanding about risk]
- too much decentralization
- use experience of local offices in SE eg Plymouth, Taunton and Bath
- follow current management initiatives
- greater delegation of authority

## MAPPING



## HEADS

### **List of all heads.**

- 2 Risk of impaired treatment of clients ... Ensure uniformity in treatment
- 6 Higher administration costs
- 9 Improve the level of service

## TAILS

### **List of all tails.**

- 5 Use experience of local offices in SE eg Plymouth, Taunton and Bath
- 8 Lower purchase costs of offices in Hull, Sheffield & Harrogate ... higher cost in Leeds
- 12 Follow current management initiatives

## CENTRALITIES

- 1 Centralise our service at Leeds ... Open local offices (8 from 11 concept)
- 11 Greater delegation of authority (5 from 11 concepts.)
- 10 Local representation (5 from 11 concepts.)
- 7 Increased running costs (5 from 11 concepts.)
- 4 Lack of understanding about risk (5 from 11 concepts.)
- 3 Too much decentralization (5 from 11 concepts.)
- 8 Lower purchase costs of offices in Hull, Sheffield & Harrogate ... higher cost in Leeds (4 from 11 concepts.)
- 12 Follow current management initiatives (2 from 7 concepts.)
- 9 Improve the level of service (2 from 7 concepts.)
- 6 Higher administration costs (2 from 7 concepts.)
- 5 Use experience of local offices in SE eg Plymouth, Taunton and Bath (2 from 7 concepts.)
- 2 Risk of impaired treatment of clients ... Ensure uniformity in treatment (2 from 7 concepts.)

## EXAMPLE -2

### «MELEK YATIRIMCILAR NASIL KARAR ALIYOR: TÜRKİYE'DEN BİR BİLİŞSEL HARİTALAMA ÇALIŞMASI»

**Yrd. Doç. Dr. Adem YAVAŞ, Kocaeli Üniversitesi**

«Türkiye bağlamında melek yatırımcıların kendi yatırım kararlarını anlama ve geliştirme, diğer taraftan ise girişimcilerin melek yatırımcılardan yatırım alabilmek için kendilerinden nelerin beklendiğini bilme ihtiyacı vardır. Bilindiği kadarı ile bu çalışma Türkiye’de bilişsel haritalama yöntemi kullanılarak bir melek yatırımcının yatırım kararının incelendiği ilk çalışma olma özelliğine sahiptir.»

## YÖNTEM

«Araştırmada bilişsel içeriğin tespitinde basamaklı mülakat tekniği uygulanmıştır.»

«Araştırmada basamaklı mülakat çerçevesinde "Yatırım kararı alırken sizin için önem arz eden faktörler nelerdir?" sorusu sorulmuş ve "Bu niçin önemli" sorusu ile yatırımcının üst kavramlarına, "Buna nasıl karar veriyorsunuz" sorusu ile de alt ( operasyonel ) kavramlara ulaşılmaya çalışılmıştır.»

«Çalışma 3 farklı günde yürütülmüş ve son gün melek yatırımcının ortaya çıkan haritayı teyidi ile sonlandırılmıştır.»

## ALAN ANALİZİ

**Alan Analizi :** Bilişsel haritalarda merkezîyet, bir kavrama kaç kavramın bağlı olduğunu gösterir. Bir kavram ne kadar merkezi ise, önemi de o kadar büyük olarak kabul edilir.

**Alan Analizi Neyi İfade Eder ? :** Bu analiz sonuç olarak melek yatırımcının haritasında hangi kavramların diğerlerine göre daha önemli olduğunu gösterir.

## ALAN ANALİZİ SONUÇLARI

Alan analizi bilişsel haritalarda hangi kavramların diğerlerine göre önem arz ettiğini bulmak için kullanılır. Bu çalışmada aşağıdaki kavramların diğer kavramlara göre melek yatırımcı için daha önemli olduğu tespit edilmiştir;

- Girişimcinin yatırım yapılabilir kişiliğe sahip olması,
- Girişimcinin şirkete veya projeye olan yüksek hakimiyeti,
- İş modelinin yenilikçi olması,
- Projenin kısa zamanda rekabete açık olmaması,
- İnovatif olmak.

## KÜME ANALİZİ

**Küme Analizi :** Tipik bir harita, tek bir küme halinde değildir, kavram kümelerine ayrılabilir. Kümelerin analiz edilmesindeki amaç, araştırılan konuyu oluşturan problem sistemlerinin tanımlanmasıdır. Böylelikle, her küme anahtar kelime ile özetlendiğinde konunun, konudan göreceli olarak ayrılabilir bölümünü temsil eder.

**Küme Analizi Neyi İfade Eder? :** Bu analiz sonuç olarak melek yatırımcının yatırım kararı verirken hangi problem alanları üzerinde değerlendirme yaptığını gösterir.



## SONUÇLAR

Bu çalışmanın ana sonuçları kısaca başlıklar halinde aşağıdaki gibi özetlenebilir;

- Haritası çıkarılmış melek yatırımcının yabancı melek yatırımcılarla benzer özellikler gösterdiği, yatırım değerlemesi yaparken kullandığı ipuçlarının literatürde yeri olduğu,
- Melek yatırımcının uzun süreli karlılık vaat etme koşulu ile, şirket veya projesine yüksek hakimiyeti olan ve birlikte kararları hızlı ve sağlıklı alabileceğine inandığı girişimciye yatırım yapacağı,
- Yatırım kararı alırken hem fırsat hem de girişimcinin özelliklerini birlikte değerlendirdiği,
- Girişimci riski almak yerine fırsatla ilgili riskleri almayı tercih ettiği,
- Girişimci söz konusu olduğunda iletişim kaynaklı problemlerin hızlı ve sağlıklı kararlar alınmasında engel teşkil edeceği kaygısı yaşadığı,
- İş modeli ve inovasyona atfettiği değer rekabetle ilişkili olduğu, dolayısı ile bu kavramları rekabetin en önemli araçları olarak gördüğü,
- ...

## REFERENCES

- Lecture notes of “Prof. Dr. Y. İlker Topçu”,  
<http://web.itu.edu.tr/topcuil/>
- «Melek yatırımcılar nasıl karar alıyor: Türkiye’den bir bilişsel haritalama çalışması», Yrd. Doç. Dr. Adem YAVAŞ