DIGITALISATION AND CIRCULAR ECONOMY:
forestry and forestry based industry implications

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VALUE-BASED MANAGEMENT OF A FURNITURE FACTORY

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AGENDA

1. INTRODUCTION
2. THEORETICAL PREMISES
3. METHODOLOGY
4. RESULTS AND DISCUSION
5. CONCLUSION

INTRODUCTION

- ✓ **Digitalization** – pervasive in all social and economic sectors
- ✓ Management of material and financial resources – a **crucial task**
- ✓ **Enterprise Resource Planning** – ICT-based information system
  - supports management, control and analysis of all processes in an enterprise for the achievement of coordination and efficiency
- ✓ **Alternative for small and medium enterprises (SMEs)** → a **value-focused approach** to decision-making in resource allocation:
  - quantitatively represents the control and production processes by mathematical relations and models
  - system approach that helps managers – decision-makers (DM)
    - to formulate their views and preferences and thus to make decisions regarding business policies
    - to understand better what techniques and methods can be implemented to achieve goals of SME in certain situations
  - helps intensification of business networks

INTRODUCTION

Rational approaches to decision-making are classified as follows:

- **Descriptive methods** – analyse how real people make decisions influenced by their biases regarding perceiving of the situation and the choices of alternatives considering possible outcomes;
- **Normative methods** – strict mathematical theories based on the axiomatic approach and demand the assumption that DM is rational and abstract from cognitive bias;
- **Prescriptive methods** – related to normative methods, determine optimal choices in theory constrained by limitations of real possibilities, generate understanding the alternatives through the inclusion of the empiric subjective knowledge

THEORETICAL PREMISES

- ✓ **Decision-making** – an intentional, consequential action based on knowledge of alternatives and their consequences evaluated in terms of a consistent preference ordering
- ✓ **Human activity in decision-making** – researched from:
  - cognitive perspective – decision-making as interactions with the environment
  - psychological viewpoint – decision-making as a framework of ***rational*** (thinking and feeling) and ***irrational*** (intuition and perception) human consciousness
- ✓ **Rational decision** – analytical approach to decision-making; measurement & utility theory– theoretical basis of decision theory

THEORETICAL PREMISES

- ✓ **Essential aspect** – construction of decision models representing mathematically the decision environment
- ✓ **Value/ Utility function** – an analytic representation of empiric knowledge – a mathematical model that assist in solving complex decision problems –

  value-focused thinking and modelling
- ✓ Decision making theory **includes** system analyses and theories of measurement (scaling), utility, probability, statistics
- ✓ "**Utility**" reveals two main aspects:
  - assessing the utility of an object is in consequence of appreciation
  - a property of an object – quantitatively measured by evaluation of human's preferences in the appropriate scale

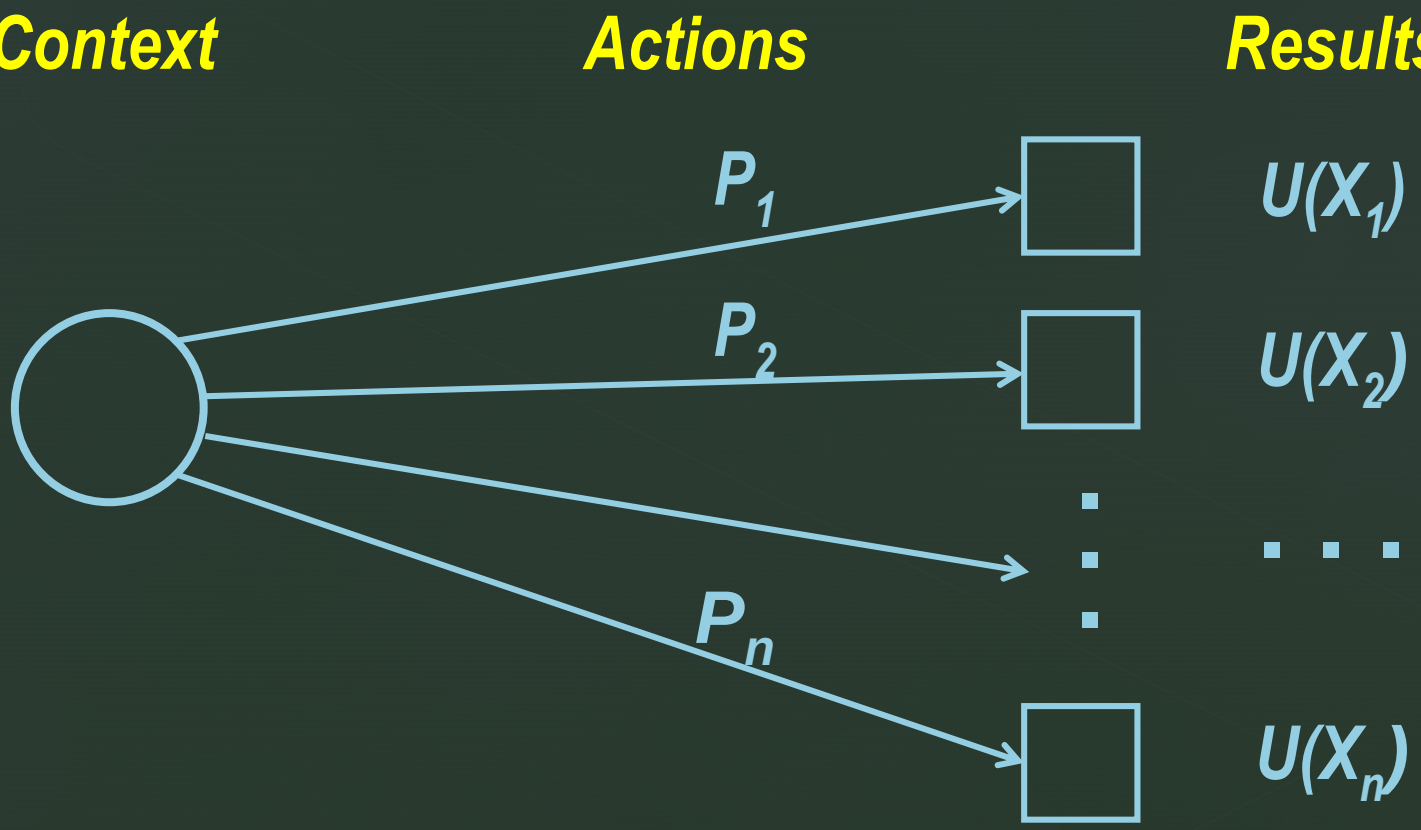
THEORETICAL PREMISES

- ✓ **Utility theory** – the normative (axiomatic) approach in decision-making theory:
  - preferences analytically represented in the interval scale (modelling of human preferences)
  - functional descriptions of complex processes with definitive human opinion
- ✓ **Utility** evaluation process based on DM's preferences and stochastic approximation **as a machine-learning procedure**
- ✓ **Scientists:** R. Keeney, H. Raiffa, M. Aizerman, P. Fishburn, …

THEORETICAL PREMISES

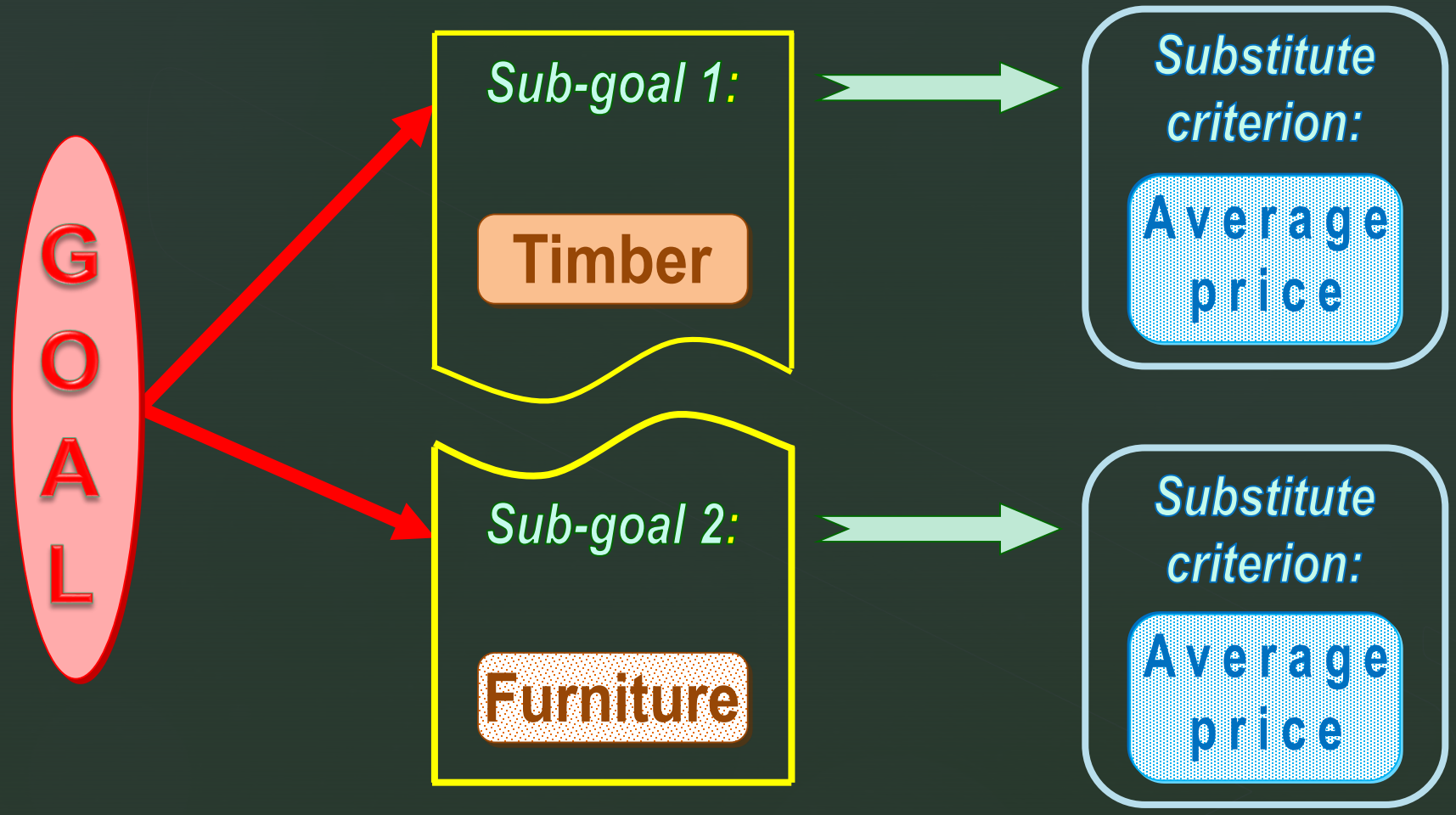
Utility function – measurement of uncertainty, probability distribution and utility of DM's preferences

utility u(.) assesses each of the final results (x_i, $i = 1 \div n$)



METHODOLOGY

Goals and sub-goals in furniture factory



METHODOLOGY

Prototype of information system for evaluation of an individual's utility functions

- Construction of overlapped sets of DM's preferences
- Stochastic pattern recognition of expert's preference sets
- Analytical pattern recognition of these sets by a polynomial function
- Evaluation process of DM's utility by stochastic machine-learning (probabilistic pattern recognition)
- Utility evaluation → stochastic approximation with noise (expert's uncertainty) elimination

Utility evaluation procedure

1. Analytical processing of qualitative, subjective information to set the main goal and corresponding sub-goals – determined on the basis of empirical knowledge and manager's level of experience
2. Choice and design of specific methodology and algorithms for its implementation according to the chosen criteria (sub-goals)
3. Determination of the structure of the multi-attribute utility function and its decomposition to one-dimensional utility functions based on the utility dependence in regards to the production characteristics (sub-goals)
4. Preferences evaluation (by lottery approach) of the one-dimensional utility functions and the determination of appropriate coefficients of the multi-attribute utility function

Utility evaluation procedure

- "Lottery" – every discrete probability distribution over X
- Lottery approach determines the evaluation in the interval scale (with accuracy to a linear transformation)
- The expert compares the **"lottery" <x, y, α>** with **z**

  (the **"learning point" (x, y, z, α)**) and

  ✓with the **probability $D_1(x,y,z,\alpha)$** relates it to the set

  $$A_u = \{(x, y, z, \alpha)/ (\alpha u(x)+(1-\alpha)u(y))>u(z)\}$$

  ✓or with the **probability $D_2(x, y, z, \alpha)$** – to the set

  $$B_u = \{(x, y, z, \alpha)/ (\alpha u(x)+(1-\alpha)u(y))<u(z)\}$$

- At each "learning point" (x, y, z, α) a juxtaposition is made by the expert:
  - f(x, y, z, α) = 1 for ($\succ$ – "better"),
  - f(x, y, z, α) = -1 for ($\prec$ – "worst"),
  - f(x, y, z, α) = 0 for ($\sim$ – "can't answer or equivalent")

  subjective characteristic of the expert which contains the uncertainty of expressing his/her preferences

RESULTS AND DISCUSION

- ✓ Enterprise as an economic system
- ✓ Primary goal → to achieve profit from production activity
- ✓ Sub-objectives underlying the primary goal cover two aspects:
  1) accounting the cost of raw materials used in the production
  2) the assortment of products manufactured from the considered materials
- ✓ Measurement / evaluation of the manager's preferences regarding the sub-goals (factors)
  1) value / cost of the materials and
  2) value / cost of manufactured products

RESULTS AND DISCUSION

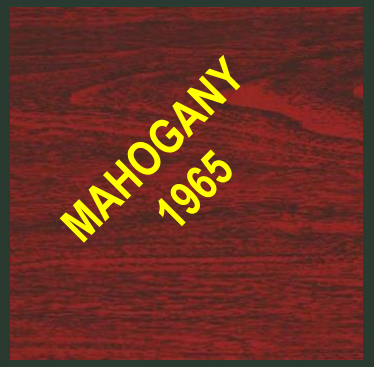
- ✓ Analysis of (in)dependency between the two sub-objectives in terms of the utility
- ✓ The independence concerns the achievement of the primary goal
- ✓ The sub-goal 1 (timber or material) is not utility dependent on the sub-goal 2 (type of product)
- ✓ Determination of independence in terms of utility between sub-goals →

  allows decomposing the multi-factor utility function of the primary purpose to simple (single-attribute) utility functions

$$F(y, z) = f_2(y, z_0)\,[1 - f_1(y_0, z)] + f_3(y, z_1)\,f_1(y_0, z)$$

RESULTS AND DISCUSION

Average price for timber / row material [€ / m³]



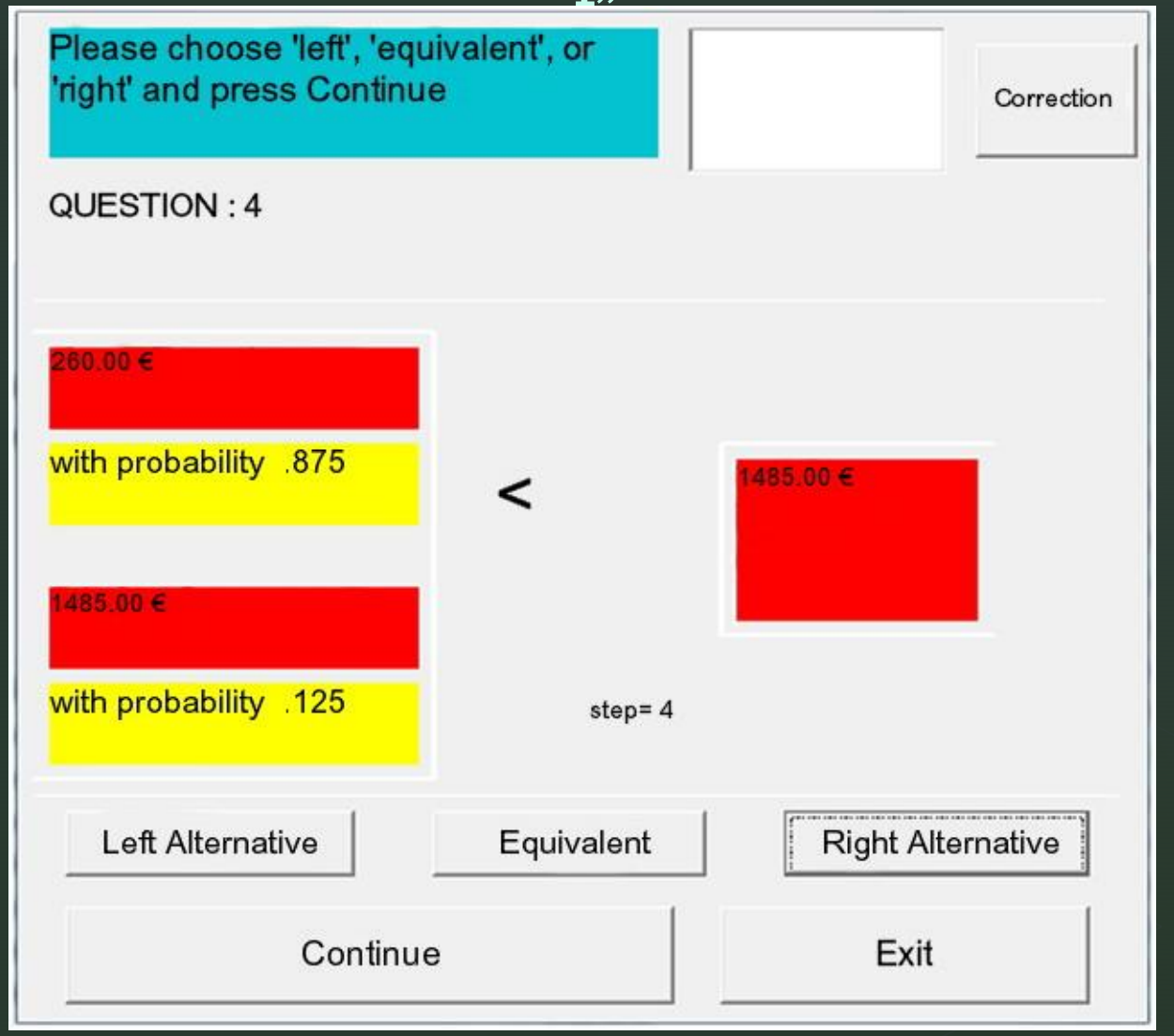
RESULTS AND DISCUSION

Product range – office furniture

№	Product	Average price [€]	
		Min (Chipboard)	Max (Walnut)
1	Shelf 	20	170
2	 Filing cabinet	25	190
3	Bookcase 	30	230
4	Meeting/ conference table 	36	350
5	Cupboard 	40	390
6	 Office Desk	50	430
7	Executive desk 	80	770

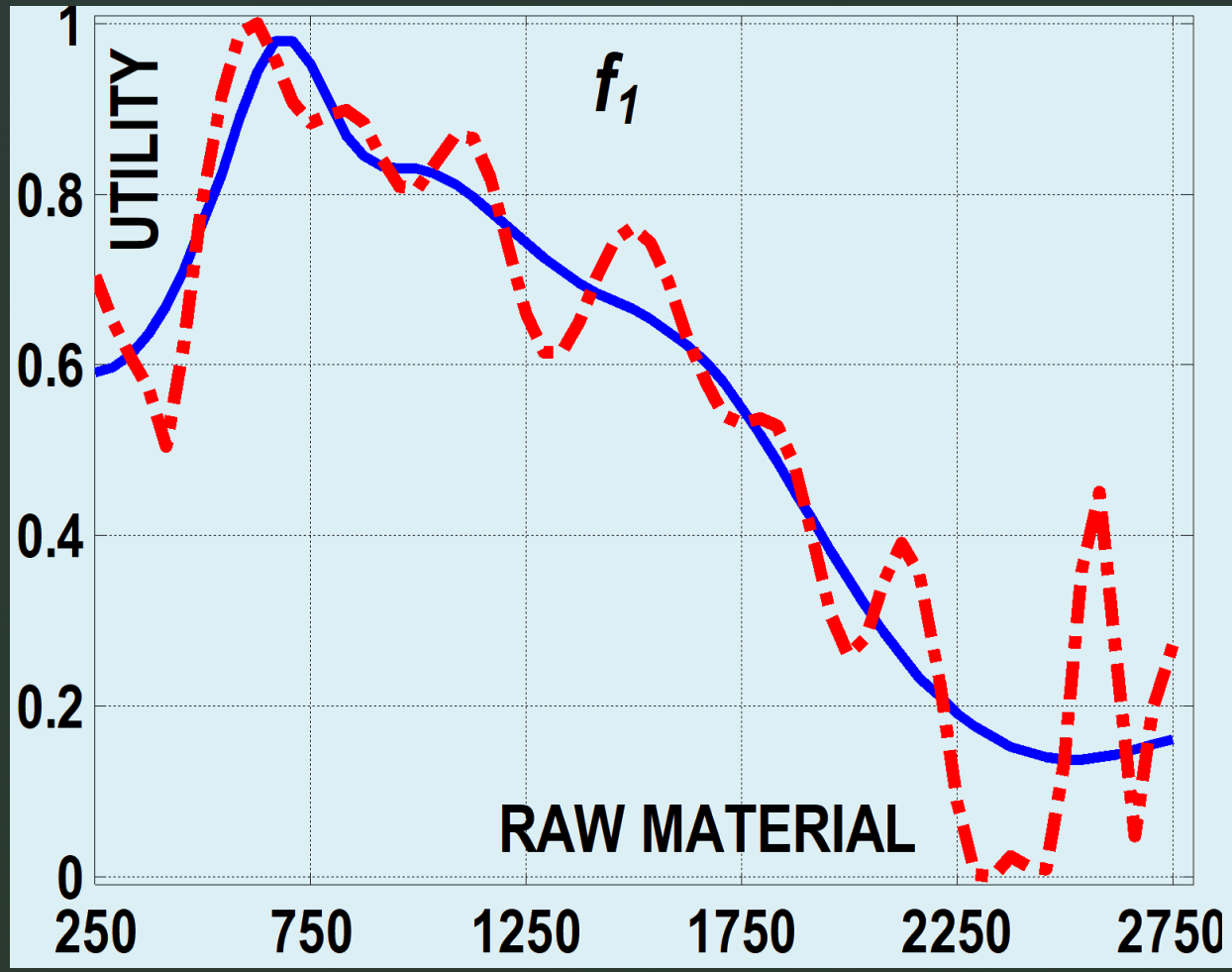
RESULTS AND DISCUSION

“Lottery” approach



RESULTS AND DISCUSION

Single one-dimensional utility function f_1
– the choice of DM in terms of material used for a furniture "shelf"

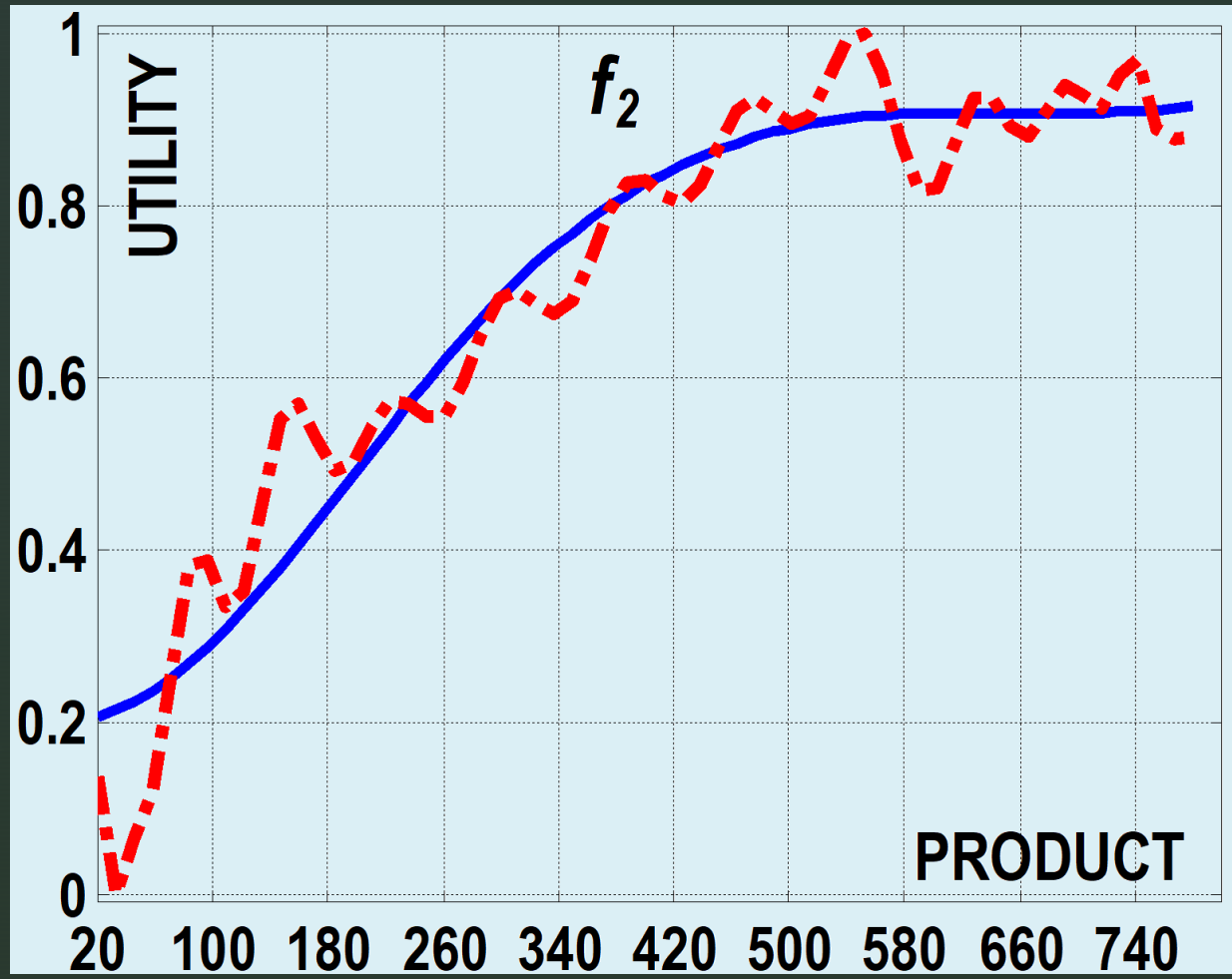


pattern recognition of DM's preferences

polynomial approximations of utility

RESULTS AND DISCUSION

Single one-dimensional utility function f_2
– manager's thinking regarding the range of products for a chosen material

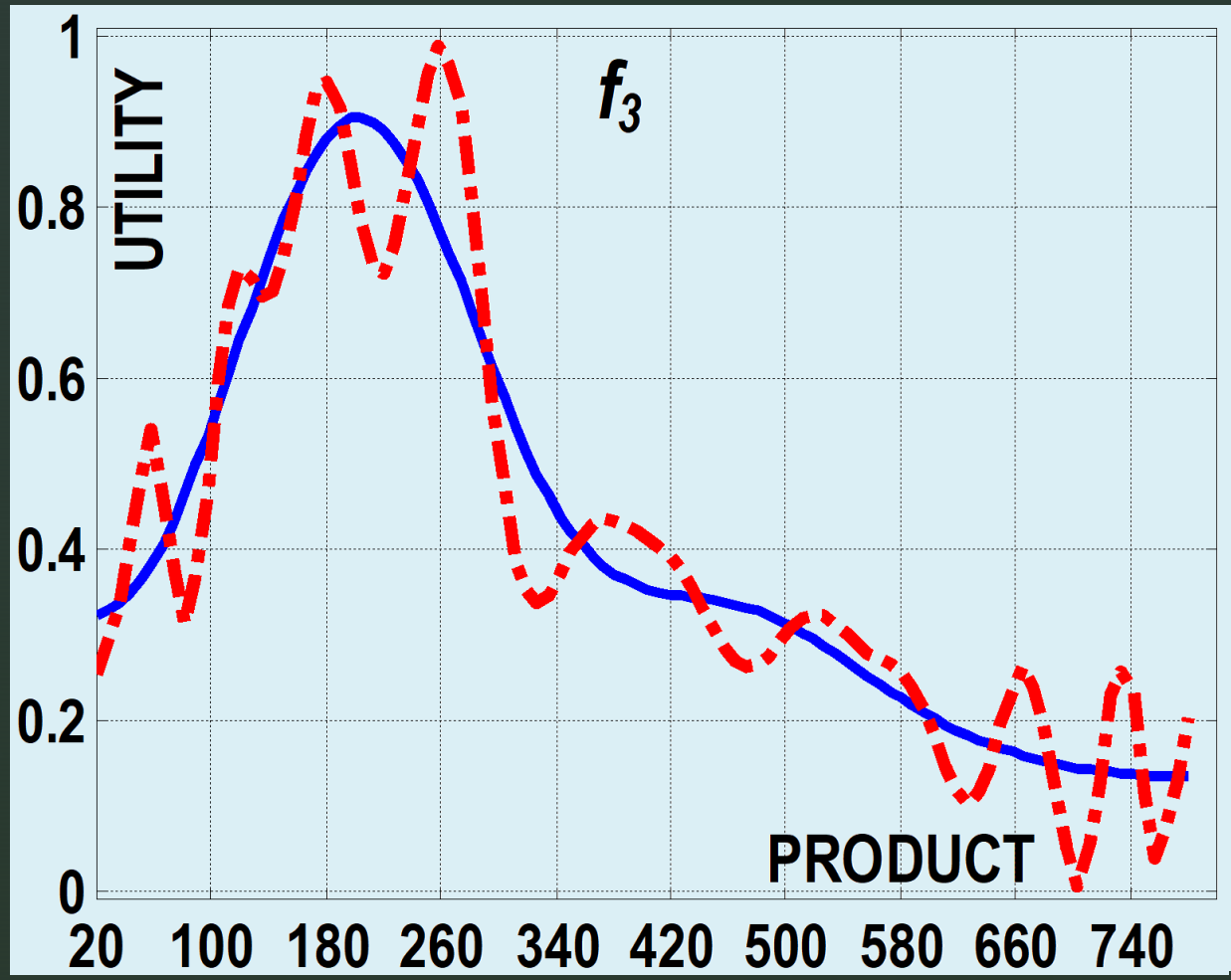


pattern recognition of DM's preferences

polynomial approximations of utility

RESULTS AND DISCUSION

Single one-dimensional utility function f_3
– manager's preference regarding a piece of furniture made by a more expensive raw material (at about 700 €/m^3

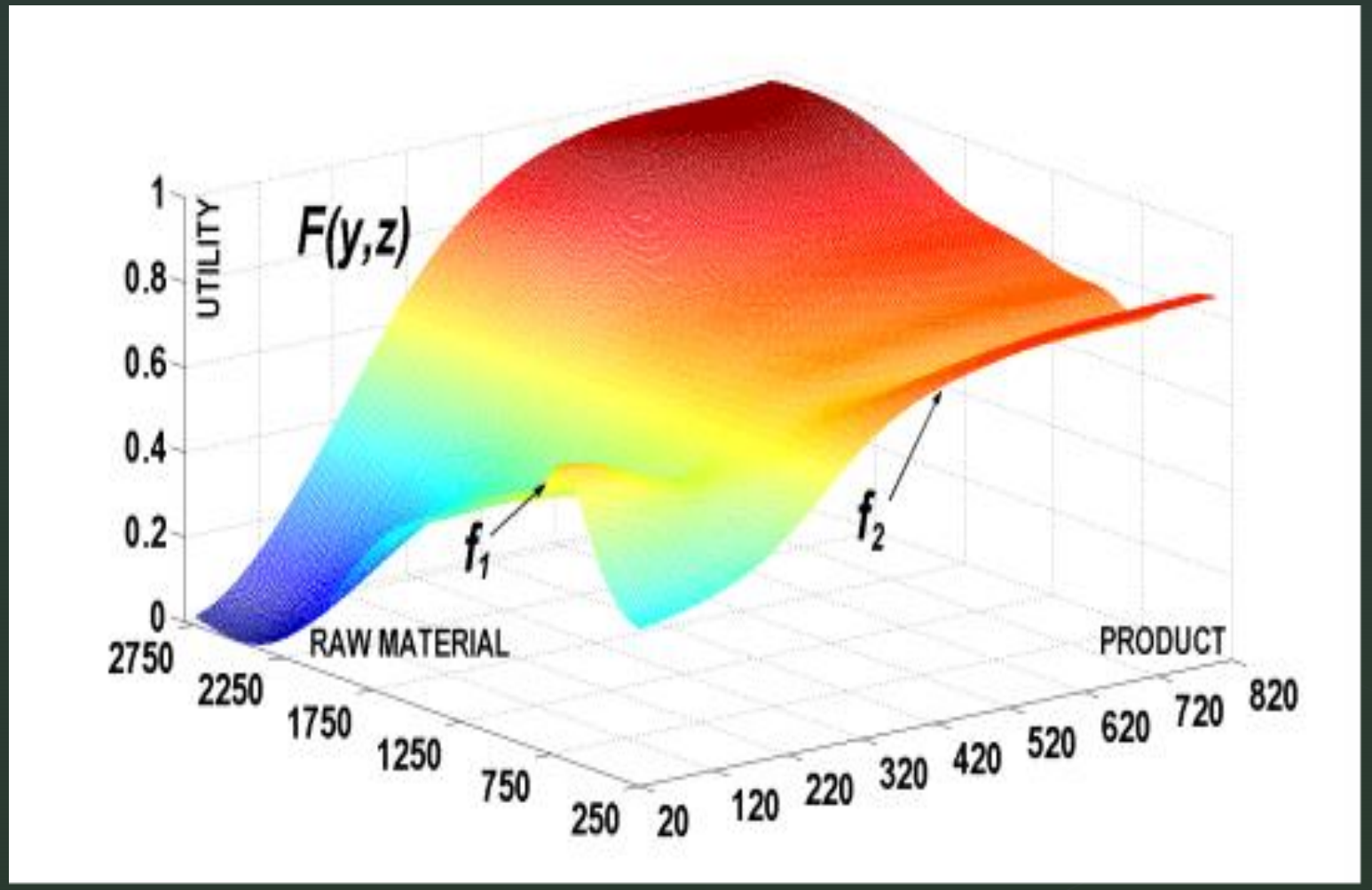


pattern recognition of DM's preferences

polynomial approximations of utility

RESULTS AND DISCUSION

Multi-attribute utility function *F(y,z)* quantitatively represents the DM's main goal



RESULTS AND DISCUSION

- ✓ The profit of SME depends on both raw materials and products; more important is not the material used, but the kind of furniture which customers need
- ✓ The value-based modeling shows that working when the utility function is over 0.7 is efficient
- ✓ The most profitable work area – the plateau of aggregated utility function ***F***
- ✓ Office furniture made of cheaper materials is not very profitable
- ✓ It is preferable to use more high-quality raw materials for more functional and long-lasting furniture

"EXPENSIVE, BUT OF HIGH QUALITY!"

CONCLUSION

- ✓ The approach for utility assessment of DM's preferences → an application of control theory in the management of complex systems (SMEs in the forestry sector) – a step ahead to their digitalization
- ✓ Logically sound formal decision to complex tasks with many factors – complexity of the problem, objectives, empirical and professional knowledge of DMs
- ✓ The DM's subjective preferences (acquired by experience) are of practical benefit – for a particular task they can be evaluated by a utility function

CONCLUSION

- ✓ A value-based mathematical approach to decision-making based on the utility theory applied in the scope of economics
- ✓ Solution to problems about the product range and resource allocation
- ✓ Conventional methods do not provide a logically sound formal decision to complex tasks with many factors (complexity of the problem, objectives, empirical and professional knowledge of DMs)
- ✓ The scientific approach: the decision-making theory and its mathematical kernel – the utility theory

→ value-based modeling and decision-making

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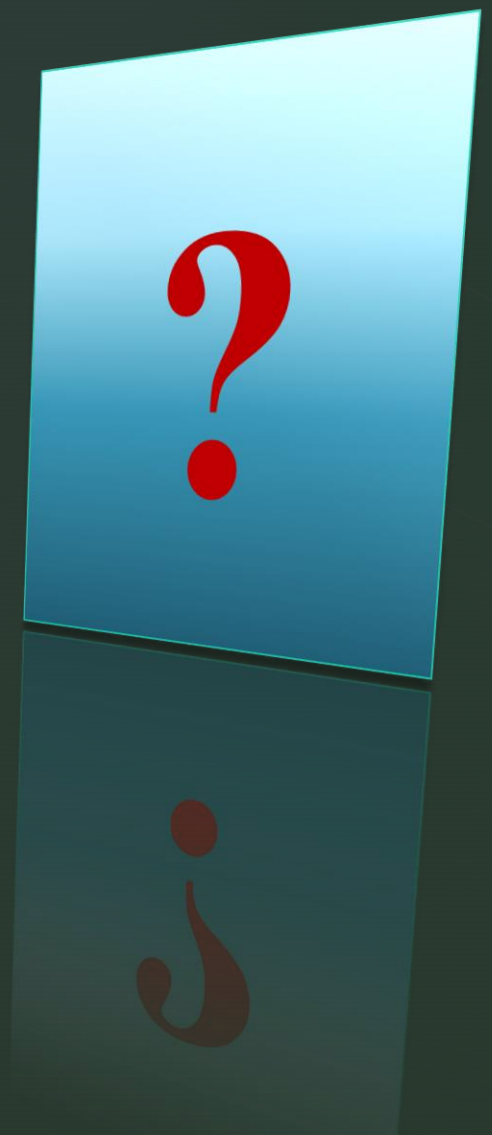
QUESTIONS ?



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