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Logistics Processes Prioritization in the Agrifood Sector

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ABSTRACT

As logistics become a substantial part of a firm's operations, the corresponding processes increases in importance. Identifying key logistics processes using a structured approach will align their outcomes to deliver the business goals, design appropriate measures and allocate sufficient resources for their improvement. This paper proposes a methodological framework for the identification, categorization and prioritization of logistics processes in the agrifood sector. Finally, a proposed mathematical model for the prioritization of logistics processes is presented. The proposed model is based on the fundamental idea of Data Envelopment Analysis (DEA) method, measuring the efficiency of the logistics processes by taking into account the multiple inputs utilised and outputs produced by them.

KEYWORDS: logistics processes; agrifood supply chain; business process management; methodological framework; linear programming model

1. Introduction

Processes lie at the heart of everything that organisations do to maintain their existence and grow (Dalmaris *et al.* 2007). According to Rensburg (1998) business processes are simply defined as a series of interrelated activities linked together to produce customer value. Davenport and Short (1990) define business process as a set of logically related tasks performed to achieve a defined business outcome. Porter (1985) and Davenport (1993) argue that business processes can be subdivided into primary and supporting. Primary Business Processes are those involved in the creation of the product, its marketing and delivery to the buyer (Porter, 1985). Supporting Business Processes facilitate the development, deployment and maintenance of resources required from primary processes. Supply Chain Management focuses on primary processes from the point of origin to the point of consumption (Lambert and Cooper, 2000). The success of the supply chain networks highly depends on the effectiveness and efficiency of logistics processes (Bask and Juga, 2001). Companies must identify, model and optimize their logistics processes so as to remain competitive; and not only their inner processes but the common processes that share with the other members of a supply chain (Christopher and Jüttner, 2000).

In most business environments, a maximum 12 to 15 functions are considered as key business processes. Some of them may span horizontally and internally across most of the departments of a company, or even externally and across the entire supply chain, while companies may implement different practices for monitoring and assessing them (Quesada and Gazo, 2007).

Companies may also have distinct key processes when compared to its competitors, which may be related to the company's own approach and strategies for pursuing new opportunities and meet challenges according to its own unique geographic location, market positioning, future aspiration, technology portfolio or regulatory frameworks. Intuitively, a company's stakeholders are aware of the activities or processes that are important for their organization, for example for a manufacturing company, the importance of production and sales processes are well appreciated by all (Curran and Ladd, 1999; Radjou, 2003). On the other hand, there are processes which have an equal or bigger impact on the organization although they never receive the appropriate attention such as the logistics processes.

The identification and prioritization of the business processes has been the main objective of many research initiatives (Kanji, 2002; Kaplan and Norton, 1992, 1993, 1996, 2000). Doyle *et al.* (2009) proposed a user interface to establish dynamic prioritization of business process instances. Moreover, Quesada and Gazo (2007) developed a methodology to help manufacturers determine and rank key internal business processes based on critical success factors.

As logistics become a substantial part of a firm's operations, the corresponding processes increase in importance (Sweeney and Park, 2010). Identifying key logistics processes using a structured approach, aligning their outcomes to deliver the business goals, designing appropriate measures and allocating sufficient resources for their improvement is the key to success.

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This paper proposes a systematic approach, by the use of a mathematical model, for the identification and prioritization of logistics processes is proposed. The proposed methodology is demonstrated in a case study dealing with enterprises of the Agrifood sector. The research is focused on the enterprises of the Agrifood sector because of its high significance for the Greek and the EU economy.

The logistics processes in the Agrifood sector include a number of processes such as the collection, aggregation, storage and transport of agricultural produce from the farm to the consumer. Why do we concentrate in this sector?

- First, the great majority of the agrifood companies do not have the required know-how, the high-skilled workers and the advanced information technology infrastructure in order to design, execute, control and monitor the above business processes (Manikas and Terry, 2009; Manikas *et al.* 2010).
- Second, a significant proportion of them does not maintain and use any enterprise information system (ERP, CRM, SCM, etc.) at all, and even if they do, it does not support a holistic approach of the monitoring and management of business processes (Argyropoulou *et al.* 2007).
- Third, a lot of companies maintain a quality standard (such as ISO, HACCP); however they are not able to use it as a tool/mechanism for the effective re-design of logistics processes and the improvement of their competiveness.

Another critical point is the opportunity that is given to these companies. Companies can focus on the key logistics processes in order to optimize their critical aspects such as time and cost issues, resources planning and scheduling, as well as, queues and delays (Christopher, 2005; La Londe and Masters, 1994; Johnson *et al.* 1999).

The following sections of the paper are organized as follows; Section 2 presents and analyses the proposed methodological framework for the identification and the prioritization of the logistics processes. The next section (Section 3) presents the mathematical model for the prioritization of the logistics processes, while Section 4 presents a case study of the application of the proposed methodology to the agrifood supply chain. The findings reveal the priorities that the managers of the examined companies consider about logistics processes. Finally, at the Conclusions part, the findings of the survey are discussed and the scope of further research is provided.

2. Materials and Methods

In this paper, a methodology is proposed for the identification and prioritization of logistics processes including four main steps (Figure 1):

Step 1: Assessment of business structure and functions.

Step 2: Classification of the generic areas of business processes.

Step 3: Identification of logistics processes based on the generic framework.

Step 4: Weighting, prioritization and selection of logistics processes.

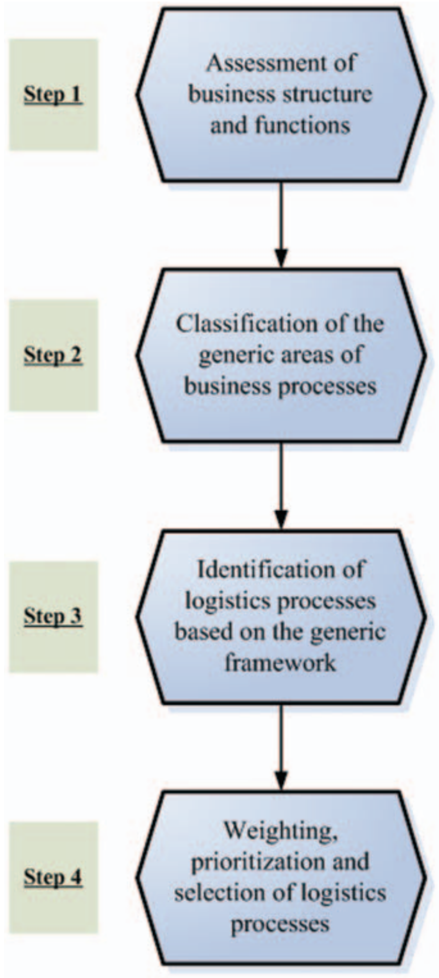

Figure 1: Methodological framework for identification and prioritization of logistics processes

Prior to the beginning of any taxonomy of logistics processes, it is important to carry out an assessment of the business structure and functions. In other words a detailed cartography of internal and external business environment needs to be conducted.

The next step deals with classification of the generic areas of business processes. Generally speaking, a business process consists of logically related activities performed together to produce a defined set of results according to a company's strategy. Since every company has different strategic objectives goals and mission, internal business processes may differ from one organization to another. Thus, it is necessary to identify the internal business processes and classified them under a generic framework. Camp (1995) proposed a list of the most important internal business processes that should be considered when evaluating firm's performance against other competitors. He proposed 11 areas of business processes: 1) Market Management, 2) Product design and engineering, 3) Product operations, 4) Supplier management, 5) Customer engagement, 6) Logistics and inventory management, 7) Product maintenance, 8) Business management, 9) Information and technology management, 10) Financial management, and 11) Human resource management. The first six are considered as 'operational' business processes and the rest as 'support' business processes.

APQC International Benchmarking Clearinghouse in partnership with Arthur Andersen & Co (1996) proposed a Process Classification Framework of 13 areas: 1) Understand markets and customers, 2) Develop vision and strategy, 3) Design products and services, 4) Market and sell, 5) Produce for manufacturing and deliver for service organization, 6) Produce and deliver for manufacturing organization, 7) Invoice and service customers, 8) Develop and manage human resources, 9) Manage information, 10) Manage financial and physical resources, 11) Execute environmental management program, 12) Manage external relationships, and 13) Manage improvement and change. Correspondingly with Camp's framework the first seven processes are 'operating' processes and the rest 'management and support' processes.

Diaz *et al.* (2004) identified 9 generic intra-organizational business processes: 1) Product development, 2) Procurement, 3) Order fulfilment, 4) Transformation, 5) CRM, 6) Asset management, 7) After-sales services, 8) Human resources management, and 9) Business process management. These processes are grouped in three types: 'core' (the first six processes) and 'support' business processes (the rest). In the literature many research initiatives regarding the classification of business processes can be found (Curran and Ladd, 1999; Radjou, 2003; Malone *et al.* 1999; Lambert *et al.* 1998). There are also a number of business processes models such as the Value Chain Model (Porter, 1985) the QFD model, etc. All of them proposed the logistics processes as key and critical business processes.

In Step 3 the identification of logistics processes based on the generic framework is carried out. In this step, a careful recognition of logistics processes in each generic business area need to be done in order to match supply chain capabilities to demand requirements from the point of origin to the point of consumption (Lambert *et al.* 1998; Day, 1994).

The last step deals with the selection of the key logistics processes. Particularly, in this step, the logistics processes that came out from the previous step should be prioritized and classified based on specific criteria. The criteria should be selected according to the business strategy and needs. For example, criteria can be pertained to operational efficiency, generation of profit, generation of competitive advantage, etc.

3. Results and Discussion

Problem Definition

As mentioned above, the selection of the key logistics processes in the agrifood business sector is an important issue. Based on our extensive work in the agrifood supply chain management as well as on the related bibliography (see Section 2), we have identified eight (8) generic business areas and their logistics processes (Table 1).

In order to identify the key logistics processes in this particular business sector, we have selected the criteria and categorized in two main groups: inputs and outputs. In Table 2, the selected inputs and outputs of the key logistics processes are provided. The above selection is based on the works of Davenport (1993), Dervitsiotis (2006), Madison (2005), Ioannou (2005), and Laguna and Marklund (2004).

Model Formulation

In the relevant literature, there are many techniques – methodologies employed for the measurement of the level of processes' efficiency and productivity. In this subsection, we present the proposed model aiming at the prioritization of logistics processes. The proposed model is a binary linear programming model and is based on the basic idea of Data Envelopment Analysis (DEA) method, measuring the efficiency of the logistics processes by taking into account the multiple inputs utilised and outputs produced by them.

Nowadays, DEA has been recognised as an important tool for the analysis and evaluation of the performance of manufacturing and service operations (Cooper *et al.*, 2011; Talluria *et al.*, 2006).

Below, we provide the related nomenclature:

$i = 1,\ldots,I$: group of logistics processes.

$j = 1,\ldots,J$: logistics processes.

$k = 1,\ldots,K$: output produced.

$p = 1,\ldots,P$: input utilized.

Next, in Table 3 we provide the nomenclature for the decision variables and the parameters of the model.

Consequently, the following binary linear programming model is formulated:

Maximize:

$$\sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{i=1}^{I}\sum_{j=1}^{J}\left[\left(\left(c_k\frac{\left(out_{kij}-out_{ki}^{\min}\right)\left(S_{\max}-S\min\right)}{out_{ki}^{\max}-out_{ki}^{\min}}\right)+1\right)-\left(\left(c_p\frac{\left(in_{pij}-in_{pi}^{\min}\right)\left(S_{\max}-S\min\right)}{in_{pi}^{\max}-in_{pi}^{\min}}\right)+1\right)\right]\cdot y_{ij}$$

Subject to:

$$\sum_{j=1}^{J} y_{ij} \le N_i,\ \forall i \tag{1}$$

$$y_{ij} \in \langle 0,1 \rangle \tag{2}$$

The objective function aims at maximising of the performance of the logistics processes taking into account the results – outputs produced minus the necessary inputs utilized. As it can be easily seen, the quantified values of all inputs and outputs are scaled in a range of 1–10, in order to facilitate monitoring and direct comparison between them. Equation (1) provides the maximum number of logistics processes that can be selected in each group. Finally, equation (2) represents binary constraints.

4. Case Study

A brief and illustrative case study is presented herein for demonstrating the applicability of the proposed model while further obtaining managerial insights on the properties of the optimal solution. Our goal was to identify the three (3) key logistics processes of each business area in the agrifood sector. In order to succeed that, a survey conducted from July 2010 to February 2011, to the managers (CEO's, Operations and Logistics Managers) of the 80 largest agrifood companies in Greece. Of the questionnaires distributed, 57 completed questionnaires were returned by those surveyed. The effective response rate was very good (71%). A

Table 1: Main business areas and the related logistics processes in the agrifood sector

Group	Logistics processes
Production support	Planning of primary production [PR1] Procurement for production [PR2] Harvesting [PR3] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5] Production planning [PR6] Selection of production machines and lines [PR7] Layout planning [PR8]
Transportation and Distribution	Planning of distribution tasks [DIST1] Planning of distribution network [DIST2] Planning of transportation management [DIST3] Control and monitoring of transportation management [DIST4] Selection of transportation means [DIST5] Selection of transportation materials [DIST6] Monitoring and tracing of product [DIST7] Routing and scheduling of transportation means [DIST8] Planning of distribution tasks [DIST9]
Warehousing and Inventory Management	Location of warehouse or distribution center [WARE1] Layout of warehouse or distribution center [WARE2] Selection of warehousing facilities [WARE3] Selection of warehousing materials [WARE4] Coding of products and storage positions [WARE5] Materials management [WARE6] Inventory management [WARE7] Inventory control (monitoring) [WARE8] Demand forecasting [WARE9] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Management of infrastructure for order handling [ORDE2] Planning of picking [ORDE3] Execution of picking [ORDE4] Orders packing [ORDE5] Planning of shipment facilities [ORDE6] Shipments management [ORDE7] Execution of shipments [ORDE8] Returns management [ORDE9]
Procurement	Planning of procurement [PROC1] Execution of procurement [PROC2] Monitoring of execution of procurement [PROC3] Proposals management [PROC4] Selection of suppliers and assignments [PROC5] Evaluation of suppliers[PROC6]
Materials handling	Planning of inbound materials handling [MATE1] Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3] Traceability and monitoring of production and material handling [QUAL4]
Environment	Unused final and semi-final products handling [ENV1] Byproducts handling [ENV2] Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4] Byproducts transportation management [ENV5] Energy consumption management [ENV6]

corresponding number of interviews were arranged with the above managers. The main objective of the survey was the assessment of the logistics processes of the examined companies (sample) according to the inputs and outputs of the proposed methodology. Managers were asked to rank the logistics processes that were presented in Table 1. Managers could choose from 7: Very high significance to 1: Very low significance, in order to evaluate the logistics processes that were categorized to 8 groups according to Table 1.

The resulting optimization model consists of 56 binary variables, and 64 non-negativity constraints. It was solved on a Pentium 4 computer with 3.6 GHz CPU, and 1 GB RAM, via the CPLEX® v.9.1 solver and through the mathematical programming language AMPL®. The computational time is a few seconds for all the generated problem instances and thus the solution performance of the proposed model is quite satisfactory.

An interesting 'what-if' analysis involves the exploration of different scenarios for the selected inputs and

Table 2: Selected inputs utilised and outputs produced by key logistics processes

Inputs	Outputs
Data Resources Capital Resources Labour Resources Technological Resources	Value added to end products and services Free of defects, errors and delays Operational efficiency

outputs. Sensitivity analysis paradigm can be used to cover the above requirements because it gives the ability to apply what-if analysis in order to explore the impact of varying input assumptions and scenarios (Triantaphyllou and Sanchez, 1997). For the scope of this work, we have applied a simple sensitivity analysis in inputs (adopting the common 3:1:1 ratio), by using eight (9) different scenarios (Table 4).

The key logistics processes of each business area for all different scenarios are shown in Appendix tables 1 to 9.

5. Conclusions

This paper focused on the logistics processes of a specific sector, the Agrifood Supply Chain. These processes can be described to be of high task complexity and high knowledge intensity. For these processes a methodological framework (based on the DEA paradigm) for the identification, categorization and prioritization of logistics processes in the agrifood sector was proposed and applied using a number of 'what-if' analyses and a corresponding number of scenarios. The following resources were applied as inputs to the above analysis: Data, Capital, Labour and Technological resources.

According to the findings of the above scenarios for each category we have the following:

- Production support: for all scenarios we have the same result: first, the Planning of primary production, second Production scheduling and materials planning, and third the Production of finished and semi-final products regardless the significance of the resources. This result was expected due to the nature of the industry and the specific needs of the products. Agrifood companies have invested a lot in the planning of production process. Therefore, it is critical for the agribusiness companies to develop a number of performance measurement indexes and metrics for this process.
- Transportation and Distribution: the Planning of distribution tasks appears to almost all the scenarios. The Monitoring and tracing of product, and Routing and scheduling of transportation means appears in most scenarios. Once again the planning is considered as the most critical process. Moreover, it refers to the planning of the tasks. So mangers must standardize this process and apply continuous improvement approaches.
- Warehousing and Inventory Management: in this category the following scenarios appear in most cases and equivalently for the first key processes: Inventory management, Inventory control (monitoring), and the Layout of warehouse or distribution center. The Physical inventory appears in the third place in most cases.
- Order processing: In most cases the Order handling is the most significant logistics process. Picking and Packing follows. This is expected because mainly to the nature of the (perishable) products.
- Procurement: the Planning of procurement is the most significant logistics process.The Execution and the Monitoring of the Procurement procedure appear in most scenarios after the Planning.
- Materials handling: Forecasting of inbound materials handling, Execution of inbound materials handling, and Monitoring of inbound materials handling are the most significant processes according to the respodents.
- Quality management (including traceability): Quality control, Total Quality Management, and Quality of services appear in most scenarios. Most managers consider them as the processes that support their companies' competiveness.
- Environment: in this category the Packaging materials handling it considered as the most critical logistics process. This evident need further proofing since many companies address sustainability as a driving

Table 3: Decision variables and parameters of the proposed model

Variables	y_{ij}	Binary decision variable that determines the selection or not of logistic process j in the i group. For $y_{ij}=0$ the specific logistic process is not promoted, whereas for $y_{ij}=1$ the logistic process is proposed
Parameters	out_{kij} $out_{ki}^{\max}$ $out_{ki}^{\min j}$ in_{pij} $in_{pi}^{\max}$ $in_{pi}^{\min}$ c_k c_p $S_{\max}$ $S_{\min}$ N_i	Amount of output *k* produced by logistics process *j* in the *i* group Maximum amount of output *k* produced in the *i* group Minimum amount of output *k* produced in the *i* group Amount of input *p* utilised by logistics process *j* in the *i* group Maximum amount of input *p* utilised in the *i* group Minimum amount of input *p* utilised in the *i* group Weight percentage deviation for output *k* Weight percentage deviation for input *p* Maximum value of selected scale Minimum value of selected scale Maximum number of selected processes in group *i*

Table 4: Sensitivity analysis scenarios

Input Scenario	Data Resources	Capital Resources	Labour Resources	Technological Resources
1	100%	0%	0%	**0%**
2	0%	100%	0%	**0%**
3	0%	0%	100%	**0%**
4	0%	0%	0%	**100%**
5	25%	25%	25%	**25%**
6	50%	16.67%	16.67%	**16.67%**
7	16.67%	50%	16.67%	**16.67%**
8	16.67%	16.67%	50%	**16.67%**
9	**16.67%**	**16.67%**	**16.67%**	50%

force that increases competitiveness as well as value to a company processes. Energy consumption management follows.

A number of limitations/restrictions of the above research can be stated; first, the subjectivity of the answers, due to the fact that the respondents came from the production and quality functional areas of the companies. Furthermore, the answers could also have differed in cases of companies that came from different sectors. A bigger sample might have provided with more reliable results. However, the size of the companies and their positions in the Greek market strengthened the quality of the sample and the credibility of the research outcomes. Finally, the difficulty of the accurate definitions of logistics processes can lead to incorrect results. Usually, in most companies there is a strong relationship between the processes and especially between logistics processes. For most processes across the value chain the output of one process is the input for another process.

Future studies of this subject should consider expanding the proposed methodology into specific sectors and/or products. Having a bigger sample will help identify both the key logistics processes and the appropriate key process indicators. Moreover, the usage of more criteria can be suggested in order to estimate the significance of the logistics processes, except for the criticality for the customer, their cost, their contribution to the added value of services and products, and the reasons that generate problems, errors and delays.

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Appendix

Appendix Table 1: Results of Scenario 1

Scenario 1	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Control and monitoring of transportation management [DIST4] Monitoring and tracing of product [DIST7] Routing and scheduling of transportation means [DIST8]
Warehousing and Inventory Management	Layout of warehouse or distribution center [WARE2] Inventory control (monitoring) [WARE8] Demand forecasting [WARE9]
Order processing	Order handling [ORDE1] Order's packing [ORDE5] Execution of shipments [ORDE8]
Procurement	Planning of procurement [PROC1] Execution of procurement [PROC2] Evaluation of suppliers[PROC6]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Total Quality Management [QUAL2] Quality of services [QUAL3] Traceability and monitoring of production and material handling [QUAL4]
Environment	Unused final and semi-final products handling [ENV1] Gas emission/pollutants production [ENV4] Byproducts transportation management [ENV5]

Appendix Table 2: Results of Scenario 2

Scenario 2	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production planning [PR6]
Transportation and Distribution	Planning of distribution tasks [DIST1] Monitoring and tracing of product [DIST7] Routing and scheduling of transportation means [DIST8]
Warehousing and Inventory Management	Materials management [WARE6] Inventory management [WARE7] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Planning of picking [ORDE3] Order's packing [ORDE5]
Procurement	Planning of procurement [PROC1] Execution of procurement [PROC2] Proposals management [PROC4]
Materials handling	Planning of inbound materials handling [MATE1] Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3]
Quality management (including traceability)	Quality control [QUAL1] Quality of services [QUAL3] Traceability and monitoring of production and material handling [QUAL4]
Environment	Byproducts handling [ENV2] Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4]

Appendix Table 3: Results of Scenario 3

Scenario 3	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Planning of distribution tasks [DIST1] Monitoring and tracing of product [DIST7] Planning of distribution tasks [DIST9]
Warehousing and Inventory Management	Inventory control (monitoring) [WARE8] Demand forecasting [WARE9] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Management of infrastructure for order handling [ORDE2] Order's packing [ORDE5]
Procurement	Planning of procurement [PROC1] Proposals management [PROC4] Evaluation of suppliers[PROC6]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3]
Environment	Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4] Energy consumption management [ENV6]

Appendix Table 4: Results of Scenario 4

Scenario 4	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Planning of distribution tasks [DIST1] Control and monitoring of transportation management [DIST4] Monitoring and tracing of product [DIST7]
Warehousing and Inventory Management	Layout of warehouse or distribution center [WARE2] Inventory management [WARE7] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Management of infrastructure for order handling [ORDE2] Shipments management [ORDE7]
Procurement	Planning of procurement [PROC1] Monitoring of execution of procurement [PROC3] Proposals management [PROC4]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3]
Environment	Byproducts handling [ENV2] Packaging materials handling [ENV3] Energy consumption management [ENV6]

Appendix Table 5: Results of Scenario 5

Scenario 5	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Planning of distribution tasks [DIST1] Monitoring and tracing of product [DIST7] Routing and scheduling of transportation means [DIST8]
Warehousing and Inventory Management	Inventory management [WARE7] Inventory control (monitoring) [WARE8] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Planning of picking [ORDE3] Order's packing [ORDE5]
Procurement	Planning of procurement [PROC1] Execution of procurement [PROC2] Proposals management [PROC4]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3]
Environment	Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4] Energy consumption management [ENV6]

Appendix Table 6: Results of Scenario 6

Scenario 6	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Planning of distribution tasks [DIST1] Monitoring and tracing of product [DIST7] Routing and scheduling of transportation means [DIST8]
Warehousing and Inventory Management	Inventory control (monitoring) [WARE8] Demand forecasting [WARE9] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Planning of picking [ORDE3] Order's packing [ORDE5]
Procurement	Planning of procurement [PROC1] Execution of procurement [PROC2] Evaluation of suppliers[PROC6]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3]
Environment	Unused final and semi-final products handling [ENV1] Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4]

Appendix Table 7: Results of Scenario 7

Scenario 7	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Planning of distribution tasks [DIST1] Monitoring and tracing of product [DIST7] Routing and scheduling of transportation means [DIST8]
Warehousing and Inventory Management	Inventory management [WARE7] Inventory control (monitoring) [WARE8] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Planning of picking [ORDE3] Order's packing [ORDE5]
Procurement	Planning of procurement [PROC1] Execution of procurement [PROC2] Proposals management [PROC4]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3]
Environment	Byproducts handling [ENV2] Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4]

Appendix Table 8: Results of Scenario 8

Scenario 8	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Planning of distribution tasks [DIST1] Monitoring and tracing of product [DIST7] Planning of distribution tasks [DIST9]
Warehousing and Inventory Management	Inventory control (monitoring) [WARE8] Demand forecasting [WARE9] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Planning of picking [ORDE3] Order's packing [ORDE5]
Procurement	Planning of procurement [PROC1] Proposals management [PROC4] Evaluation of suppliers[PROC6]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3]
Environment	Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4] Energy consumption management [ENV6]

Appendix Table 9: Results of Scenario 9

Scenario 9	
Production support	Planning of primary production [PR1] Production scheduling and materials planning [PR4] Production of finished and semi-final products [PR5]
Transportation and Distribution	Planning of distribution tasks [DIST1] Monitoring and tracing of product [DIST7] Routing and scheduling of transportation means [DIST8]
Warehousing and Inventory Management	Layout of warehouse or distribution center [WARE2] Inventory management [WARE7] Physical inventory [WARE10]
Order processing	Order handling [ORDE1] Planning of picking [ORDE3] Order's packing [ORDE5]
Procurement	Planning of procurement [PROC1] Execution of procurement [PROC2] Monitoring of execution of procurement [PROC3]
Materials handling	Forecasting of inbound materials handling [MATE2] Execution of inbound materials handling [MATE3] Monitoring of inbound materials handling [MATE4]
Quality management (including traceability)	Quality control [QUAL1] Total Quality Management [QUAL2] Quality of services [QUAL3]
Environment	Packaging materials handling [ENV3] Gas emission/pollutants production [ENV4] Energy consumption management [ENV6]