A GENERAL PRODUCTION AND FINANCIAL PLANNING MODEL FOR INTEGRATED POULTRY ORGANIZATIONS

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

A GENERAL PRODUCTION AND FINANCIAL PLANNING MODEL FOR INTEGRATED POULTRY ORGANIZATIONS

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For the last two decades, demand for poultry meat has been soared, since it is healthier and less costly than its substitutes. In order to meet this increasing demand, integrated poultry organizations have been established all over the world. Usually, an integrated poultry organization has the divisions of breeder coops, incubation house, broiler coops, feed mill, slaughterhouse and marketing. This complex structure makes production planning activities more difficult for integrated poultry organizations. The aim of this study is to propose a production and financial planning model for Önder Integrated Poultry Incorporation using mathematical modelling techniques and statistical methods.

Keywords: Integrated Poultry Organization, Production Planning, Statistics, Mathematical Modelling

ÖZ

ENTEGRE TAVUK ORGANİZASYONLARI İÇİN GENEL ÜRETİM VE FİNANSAL PLANLAMA MODELİ

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Son yirmi sene içerisinde, tavuk etinin daha sağlıklı ve ikâmelerinden daha ucuz olması dolayısı ile talebi artmıştır. Artan talebi karşılamak amacı ile bütün dünya üzerinde entegre tavuk organizasyonları kurulmuştur. Alışılagelmiş bir entegre tavuk organizasyonunda, damızlık kümesleri, kuluçkahâne, piliç üretim kümesleri, yem fabrikası, kesimhâne ve pazarlama bölümleri bulunmaktadır. Bu karmaşık yapı, entegre tavuk organizasyonlarındaki üretim planlama faaliyetlerini zorlaştırmaktadır. Bu çalışmanın amacı, Önder Entegre Tavukçuluk A.Ş. için, matematiksel modelleme teknikleri ve istatistik yöntemleri kullanarak bir üretim ve finansal planlama modelinin önerilmesidir.

Anahtar Kelimeler: Entegre Tavuk Organizasyonu, Üretim Planlama, İstatistik, Matematiksel Modelleme

To My Mother, Father, And Wife

And

In Memory Of Çağri

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CHAPTER 1

INTRODUCTION

Demand of poultry meat, such as chicken meat and turkey meat, has been increased for the last two decades all over the world, since it is healthier and less costly than its substitutes, such as red meat, fish meat, buffalo meat, etc. Harvey and Ritson (1997) gives the relationship between real income and poultry meat consumption as: *"The real income growth during this period (1970-80) encouraged greater meat consumption in the diet ...,much of this growth was in the white meats: poultry, pork and young beef..."* for the situation in European Union. Boyar (1997) analyzes the trend in poultry meat consumption for the period of 1979-1994. In those years, there exist a sharp increase in the percentage of poultry meat in total production. In Table 1.1, FAO statistics of chicken meat production in terms of percentage can be seen to be increasing, both for the world and Turkey for the period 1999-2002. In Table 1.2, FAO statistics of the chicken stocks can be seen to show a positive trend for the same period, as expected from the production figures.

Initially, demand for poultry meat had been supplied by farmers, but with the increasing trend of demand, slaughterhouses had been established. Following this first industrialization step, better feed rations and feed production methods, better races that give more meat in return of consumed feed by chickens, better utilization rates for incubation were sought by the firms for being more compet-

Table 1.1: Poultry Meat and Total Meat Production in World and Turkey

WORLD'S PRODN.	**1999**	**2000**	**2001**	**2002**
Beef and Buffalo Meat	59,320,592	59,874,844	59,277,761	60,977,877
Sheep and Goat Meat	10,937,638	11,339,947	11,458,072	11,548,850
Chicken Meat	55,960,358	58,699,207	60,882,844	63,400,358
Total Meat	229,844,106	233,660,923	237,525,719	245,046,734
% of Chicken on Total	24.35	25.12	25.63	25.87
TURKEY'S PRODN.	**1999**	**2000**	**2001**	**2002**
Beef and Buffalo Meat	354,877	358,683	333,884	352,100
Sheep and Goat Meat	368,000	374,000	351,000	332,500
Chicken Meat	596,854	643,436	614,726	612,000
Total Meat	1,340,941	1,396,726	1,319,140	1,314,084
% of Chicken on Total	44.51	46.07	46.60	46.57

(In Metric Tonnes.)
Reference: FAO (2003)

Table 1.2: Chicken Stocks in World and Turkey

	1999	**2000**	**2001**	**2002**
WORLD'S STOCKS	13,861,801	14,731,162	15,301,674	15,853,857
TURKEY'S STOCKS	236,997	239,748	258,168	217,575

(In thousands.)
Reference: FAO (2003)

itive in this new market. Poultry slaughterhouses became "Integrated Poultry Organizations", by including new divisions to them, such as feed mill, breeder coops, incubation house, broiler coops, and marketing department to achieve the aims of competitiveness mentioned above. All divisions have close relations among them in terms of information, material, and cash flows. This makes the structure of integrated poultry organizations more complex. Boyar (1997) gives minimum number of chickens to be processed in order to be called as integrated poultry organization as 2.5 million chickens per year.

For an integrated poultry organization, forming a general production and financial plan is a very complex structured problem. The term "general production and financial plan" refers to a set of decisions for possible future business activities and cash flows, such as buying breeders, chick entrances to coops, raw material purchases for feed mill, etc. Strategic decisions require very long horizons and they are discarded from the scope of the study. But, in terms of constraints, such decisions (such as building new breeder houses, capacity expansion decision of slaughterhouse, etc.) are analyzed in the sensitivity analysis part of the study.

Breeders are the key elements of production. In general, a breeder starts giving eggs, which become broiler chicks after incubation, at the age of 24 weeks. It continues laying eggs until the age of 70 weeks. So, a new bought breeder chick has a life of 70 weeks which should be considered in the planning activities of the integrated poultry organization. Forecasting demand, capacities of production, and expected market prices become problematic for such a long horizon. With the complex structure of integrated poultry organizations, these factors make general planning activities very hard.

Roughly speaking, Önder Integrated Poultry Incorporation supplies 15,000 tonnes of chicken meat to the market yearly, and a kilogram of chicken meat is about $2. This gives an expected annual revenue of $30 million. Any improvement in terms of efficiency on the production system brings significant benefits. Besides this, the poultry industry is a highly competitive industry and all the organizations in the industry are continuously seeking ways of cost reduction in their processes.[1] The aim of this study is to propose a mathematical model for the purpose of production and financial planning that covers all the divisions of Önder Integrated Poultry Incorporation, which can be generalized and applied for any other integrated poultry organization. Unfortunately, because of competition reasons, the organization permitted the author to use the data for the years 2000 and 2001. The study is expected to be applied in the organization with fresh data. In this study, only the backbone of a general planning model is drawn with this old data. The thesis is organized as follows. After this introductory chapter, the next chapter focuses on the analysis of the problem and give general information about Önder Integrated Poultry Incorporation and its current system. Also, literature review is given in this chapter. Chapter 3 is about the analysis of the organization's demand structure. This analysis is the base of the mathematical model which is explained in Chapter 4. Lastly, conclusions are presented in Chapter 5.

[1] An example of cost reduction using mathematical modelling approach is given in Taube-Netto (1996) for a specific integrated poultry organization.

CHAPTER 2

PROBLEM ANALYSIS

Problem analysis is a very crucial step in a problem solving approach. This chapter will draw the context of the organization's problem and general idea of the methods to be followed in the latter chapters of the study.

2.1 Introduction

Problem analysis of an integrated poultry organization requires careful and detailed work, because of the complex structure of them. The main product of all integrated poultry organizations is the chicken meat. After slaughtering and eviscerating of live birds, the skeleton, meat and skin is called "carcass". Carcass can be either with neck or without neck. Number of products based on this single carcass of an integrated poultry organization varies from hundreds to thousands. But, all these products can be grouped under basic parts, as given in Figure 2.1 below. The idea behind this aggregation can be explained with an example better. Fillet is one of the products of chicken meat. A fillet can be with or without skin; fresh or frozen; in plate, in paper box or in strongbox; whole or divided into 2 parts; natural, covered with flour, or sauced; etc. Only the above factors will result in 72 combinations, which means 72 different products to track for the organization. But all those 72 products can be viewed under "fillet" for production planning purpose. The detailed analysis is given in Section 3.1.

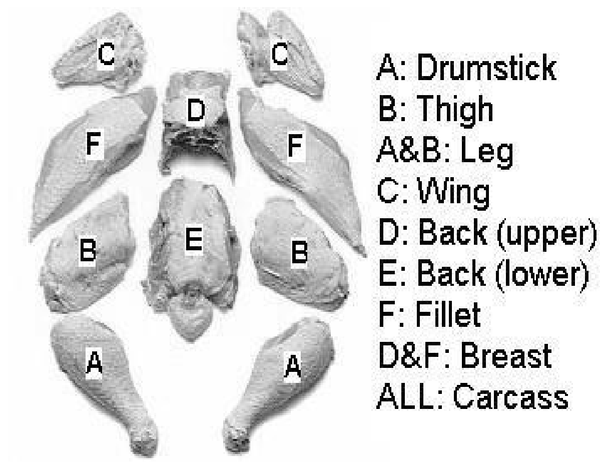

Figure 2.1: Chicken Meat Parts and Their Names

The production system to produce chicken meat is composed of several divisions as mentioned in Chapter 1. In order to propose a solution methodology for the organization's production planning problem, all these units and their structures, and the relationships between those units should be carefully examined.

2.2 General Information About The Organization

Önder Integrated Poultry Incorporation is one of the leading integrated poultry organizations in Turkey, which produces only broiler chicken meat. Slaughterhouse capacity of the organization is about 50,000 chickens per day. Integration has processed 11.3 million chickens in 2000 and 7.3 million chickens in 2001, and the resultant total chicken meat supplied to the market were 15,950 tonnes in 2000 and 12,815 tonnes in 2001. The organization has the divisions of feed mill, breeder houses, and incubation house which are located in Düzce; broiler coops in Istanbul, İzmit, Adapazarı, and Düzce; and slaughterhouse located in Adapazarı. The organization has the head office in İstanbul.

2.3 Characteristics Of The Problem

The general schema for Önder Integrated Poultry Incorporation is given in Figure 2.2. The schema also gives a general idea of all integrated poultry organizations.

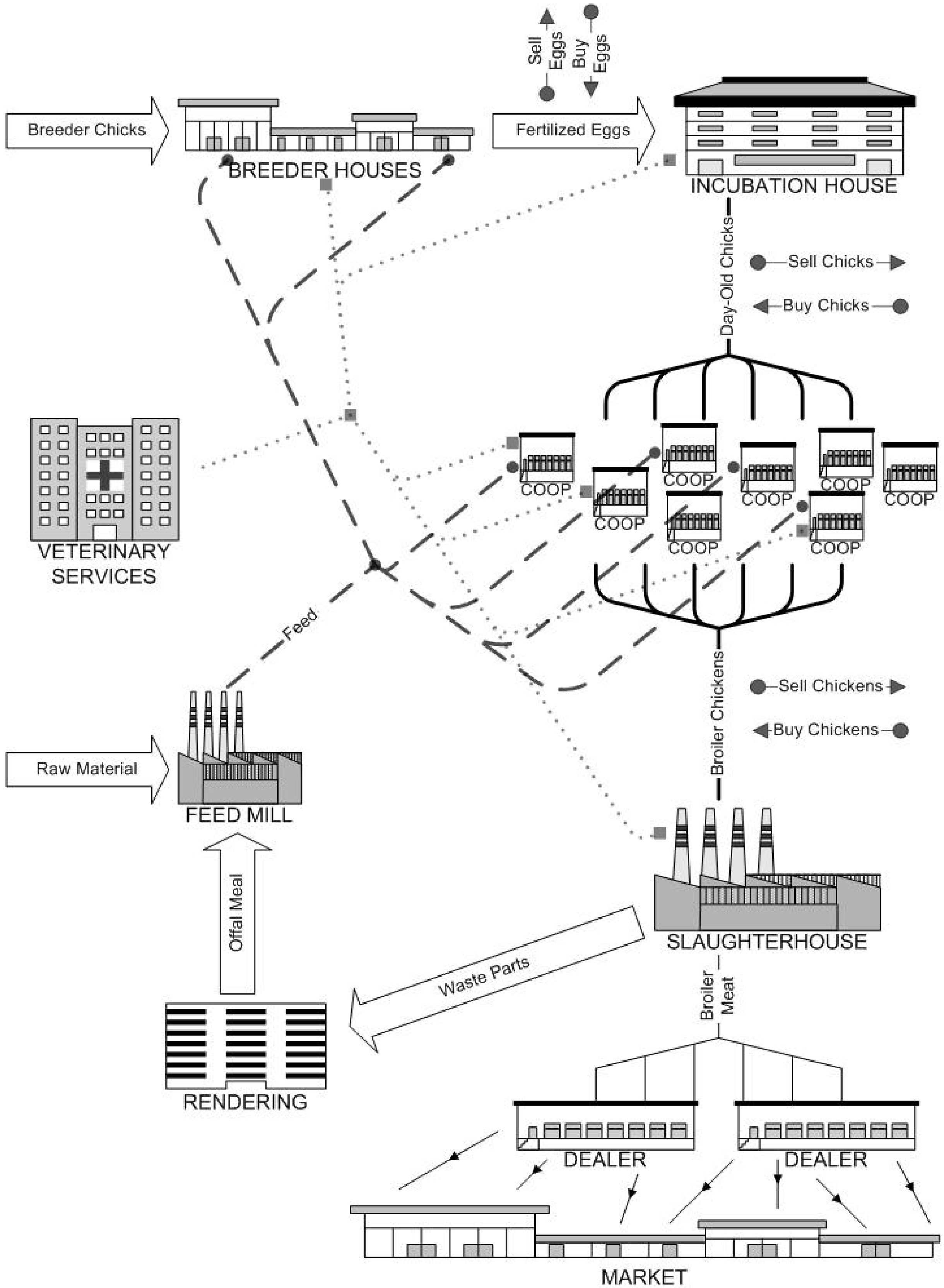

Figure 2.2: General Integration System of Önder Integrated Poultry Incorporation

In the schema, the overall process can be seen as a "chain". Breeder coops are the initial ring of the chain. They are for the sake of producing fertilized eggs, so that broiler chicks can hatch. The inputs of this part are chicks of breeders which are purchased from specialized genetic firms that produce pure breeder races for high performance, feed for breeders and workforce. Breeders' life is about 1.5 years. The output of breeder houses are fertilized eggs, and these are the inputs of incubation house. Incubation house requires electricity for heating eggs and 3 weeks for hatching. The output is day-old-chicks (which will be called as "chicks" for the rest of the study) and they will be the inputs of coops. Coop owners are farmers, and this process is a subcontracting process. The organization supplies chicks, feed and veterinarian service to coops. After 6 weeks, chicks grow up and become broiler chickens (which will be called as "chickens" for the rest of the study). Coop owners ship these chickens to slaughterhouse, and payments according to the performance of coops are done by the organization. There are 3 performance criteria for coops: food conversion ratio (FCR), mean live weight (MLW), and death percentage rate (DPR). FCR is the ratio of total feed consumption to total live weight of chickens. MLW is simply the mathematical average of total live weight of chickens. DPR is the rate of total number of dead chickens in the growing period to the total number of chick entrance. The calculation formula for coops payment is given in Subsection 4.3.6, as $COOPE_t$. The next step in the chain is slaughtering and evisceration of chickens in order to produce carcasses. According to demand, carcasses are partitioned into parts. The waste parts, such as feathers, bones, shanks, toes, combs, etc., are sent to rendering unit to make offal meal. The meat products are sent to markets, and the only cash inflow of the organization is at this step. Indeed, firm can sell eggs, chicks and live chickens, but the revenues of these activities are negligible. All other steps only include cash outflow processes. While all these processes occur, feed mill provides feed for breeders and coops. Feed mill uses maize, barley, chemicals, offal meal, etc., as raw material. Feed produced for breeders are cheaper than those for broiler chickens. Also, veterinarian services are provided to all the units included in the organization, but most of this effort is for coops.

2.4 Literature Review

Studies in this part can be grouped under two main headings according to their relation with the thesis: closely related studies and related studies. There are three studies which are closely related with the subject: Taube-Netto (1996), Kırca and Köksalan (1996), and Boyar (1997). Only Taube-Netto (1996) covers all the aspects of production planning for an integrated poultry organization. Most of the parts and the problem approach structures of the studies of Kırca and Köksalan (1996), and Boyar (1997) are used in the thesis. The rest of the selected studies are used partially. The context of the studies and their usages in the thesis are as follows.

Taube-Netto (1996) discusses the results of operations research and management science applications at Sadia Concórdia S.A., which is one of the biggest integrated poultry organizations in the world with the capacity of 300 million chickens and 11 million turkeys per year. Some of the several benefits of those applications are savings of $ 50 million over 3 years, improved FCR, flexibility to market demand. Sadia includes one more previous step in the production chain, the parents of breeders. Sadia has 7 processing plants, which creates allocation of products to plants problem. The overall outline of the applied model is very similar to the one that is given in Chapter 4. The motivations of the model are described with the questions about parents of breeders purchases' amounts and times, breeders planning, coops selection and entrances, slaughtering plan of coops, and product distribution to plants. The longest horizon for the application is 18 months, which is very close to 80 weeks as used in the model in Chapter 4. The paper does not include details of the techniques of the application, but gives an outline of the approach.[1]

Kırca and Köksalan (1996) proposes an integrated production and financial planning model for a high-voltage transformers manufacturer. The model includes both financial and production systems. Inflation, which is faced with high rates

[1] The company in charge of applications at Sadia Concórdia is UNISOMA. Contacting with UNISOMA in order to get the details is tried, but the the responsible of company, who is the author of the paper Miguel Taube-Netto actually, did not help at this point.

in Turkey in those years, is accounted for. With this modelling approach, a global solution for the manufacturer is achieved. End-of-horizon effect, such as borrowing a great amount of money, is considered and prevented. Similar methodology for general production and financial planning problem is followed in the model in Chapter 4. Both financial side and production side of Önder Integrated Poultry Incorporation is considered.

Boyar (1997) proposes a decision support system for a broiler producer for production planning and production control activities. Production control subsystem is based on relational database, and provides decision support to decision maker. Production planning subsystem does the forecasting of demand and simulation of the system. Forecasting module considers autocorrelations and seasonality effects, which are also considered in the demand analysis in Chapter 3.

After these three studies which are closely related with this thesis study, information about other related studies are given as follows.

Tadei et.al. (1995) introduces a production scheduling problem and its proposed solution methodology, and results for a company which produces alimentary preserves that are perishable. Plant of the company is composed of several production lines, on which a number of different products are processed. Product sets for each production line are distinct. Set-up times are required for shifting from one product to another. Specialized workforce is the main resource constraint, while non-specialized workers are available any time. Seasonality of demand requires varying workforce level for non-specialized workers throughout a year. Sales forecasts are provided by the marketing department and meeting their due dates are important for the company. Goals of the scheduling of production lines are minimizing inventory costs and personnel costs, and stabilizing number of shifts for each production line. Specialized workforce and seasonal products' schedule are taken as parameters for the problem. Two mathematical models are proposed for the problem, annual planning model and short-term (one month) scheduling model. Objective of the annual model is minimization of inventory level. Constraints for personnel, demand and capacities of production are satisfied. Output of the model is the monthly assignment of specialized workers to production lines, which is the input for the short-term planning model. Other two goals defined above are included in the second model by direct summation with weight factors for goals. Annual model is a linear programming model and solved by a package program. Short-term planning model is solved by a heuristic technique based on local search approach, as it belongs to the NP-hard class of problems. Annual model has many similarities with the model in this thesis.

Kuru (1988) discusses a linear programming model used for the long term planning problem of Turkish iron industry. Problem can be shortly defined as minimizing total cost of all the sector as net present value. Costs are investment (building a new integrated steel plant and capacity expansion of old ones), operating, transportation, and import balance costs. Basic constraints are the capacity of the sector, maximum import and export amount of raw material, intermediate products and final products, material balances of production, and technological constraints on production. A team composed of government, private sector and university representatives were involved. The approach was starting with a small linear programming model and then improving it into a final shape as a mixed integer model. Benefits of the approach are ease of debugging and realizing significance of parts of the model. Problem is solved in terms of several scenarios for demand. Demand scenarios approach to the problem is like the approach in this thesis.

Wade and Fadel (1997) develop a mixed integer linear programming model for a facility producing caviar and meat from white sturgeon. Horizon of the model is 51 years, and such a long horizon makes artificial constraints for end-of-horizon effect unnecessary. Model is solved by GAMS[2] Version 2.01 software. Present value of the total profit is tried to be maximized for the horizon. Model has several similarities with the one used in this thesis study, such as workforce consideration, including financial aspect of the problem, live fish requirements, etc. The physiology of the white sturgeon is too slow compared to the chicken physiology. Time is considered as 6-months periods, which makes a total of 102 periods.

[2] GAMS is the abbreviation General Algebraic Modelling Language, and GAMS is the software used in this thesis study.

The number is close to the horizon period used in general planning model. Basic difference is consideration of a capital limit. Other differences come from living environment of white sturgeon, such as oxygen, tanks and pumps requirements. By including additional constraints or modifying existing ones, different production scenarios are tested.

Whitaker and Cammell (1990) proposes a model for balancing demand of lamb and beef carcasses. Cutting Stock (or Trim Loss) Problem Structure is applied to the problem. The difference of a generic problem in meat case is the predetermined patterns of carcass partitioning. They also partition the cutting patterns to carcass sections in order to decrease the size of the problem. For chicken case, such a reduction is unnecessary. They indicate the time required to define the cutting patterns and yields for patterns for the company is very large. Their model is used by the company as a tool for pricing also. The same idea is followed and a mathematical model is formed for chicken case with some differences that come from the nature of chickens. But, that model is beyond the scope of this thesis and is not discussed here.

Soman et al. (forthcoming) present a literature review about combined make-to-stock (MTS) and make-to-order (MTO) production situations. The study is based on food processing companies that are in the process of shifting from MTS to MTO production environment. So, it can be said that such companies are in a combined MTO-MTS environment. Authors propose a hierarchical production planning framework that covers the important production management decisions given in food processing companies. Hierarchical approach to planning problem mainly brings the advantage of partitioning global problem into smaller manageable component sub-problems. Sequentially solving these sub-problems is one alternative. In that case, the solution of a sub- problem poses constraints on the subsequent sub-problem, and each level solves its own problem and performance feedback is given to the upper level. The other alternative is simultaneous solution of sub-problems in a co-ordinated way. Whatever method is used, considering dynamic structure of the manufacturing events and deciding on the number of levels and classifying the decisions for these levels in hierarchical planning are important for the subject. Decision to take at a level is dependent on the time horizon for the decision and level of aggregation. Higher levels are concerned about product groups and larger time horizons, while lower levels deal with individual products and shorter time horizons. If events are assumed to occur in a discrete spectrum, hierarchical structure can be based on the frequency of occurrences of different types of events. The lower level activities occur more frequently and higher level ones occur less frequently. The important events for this thesis study and their occurrence frequencies are as follows: forecast changes-low, production cycle-medium/low, manpower allocation-high/medium/low, production sequencing-high, operation(production)-high. It is suggested to take into account specialities of the industry in the paper, such as high capacity utilization, sequence-dependent set-ups and limited shelf life.

Fourer (1997) elucidates fundamental principles of database construction for the specific case of large-scale mathematical programming and gives an example of a steel mill planning model. For large-scale mathematical models, description, manipulation and display of data has great importance. The mathematical model used in this thesis is a moderate sized model, and such details of database design is not considered. But, partially user-friendliness is considered and the coordination of software package of linear optimization and other applications, like spreadsheets, are built.

Recio et al. (2002) design a decision support system (DSS) for medium-large farms for advising complex farm activities. DSS basically gives advices about the crop selection at the start of each season and be able to plan crops every year. Farm properties, like machinery stock and personnel, irrigation infrastructure, etc., are taken into account. Crop production involves many decision-making processes, so there exist a wide variety of alternatives on which decisions have to be made, such as the choice of crops, field operations to perform, completion time of these operations, selection of machinery, fertilizers and other chemicals, etc. A mathematical model is embedded into DSS and the model is a mixed-integer linear model, which includes about 3500 binary variables that are defined for tasks and resources. A user-friendly interface is built for DSS. Except the user-friendly interface, the result of this thesis can be seen as a DSS, because the outputs of the mathematical model will help managers at their decision making processes.

Reiner and Trcka (forthcoming) introduce a supply chain system which is specific for food industry, namely pasta production. They show that the design of the system depends on the demand situation: smooth or volatile. The main objective is assumed to reduce uncertainties, sources of which are the forecast horizon, input data, administrative and decision processes, inherent uncertainties, etc. They use a simulation model to evaluate the performance of the supply chain design. In this thesis study, evaluation of the proposed model is done by using different demand scenarios.

Minegishi and Thiel (2000) propose a generic model for supply chain of poultry production and discuss the simulation results. They figure out that the system dynamics help them understand the complex logistic behavior of the industry. The application is made on an infection case and some suggestions made to the managers are discussed. They make analysis on different horizons and demand patterns, which are further discussed in Section 3.3.

From literature review, it can be concluded that, this thesis study is based on many different ideas and approaches. The coordination between the units in the production system has great importance and considered all over the study. With combining all these units as a system in a study, the production planning activity for an integrated poultry organization is believed to be done more precisely and effectively.

2.5 Proposed Solution Methodology

In order to form a production planning model that covers all the divisions, the organization's demand is analyzed first. The analysis is handled in Chapter 3. It is the initial step of the general production and financial planning problem, which is analyzed in Chapter 4 in detail, and includes all the divisions of the organization, with simplifying assumptions on the divisions. The result of the problem is a long term plan of breeders and total coop entrances for 80 weeks.

The individual coops' decisions to be given by the organization's decision makers, who are veterinarians, for chick entrances are not handled as a separate problem, because it is better to consider this problem as embedded in general production and financial planning problem. The past performance data of the coops are used, and only 8 weeks is considered for coops planning. This horizon is selected, since availabilities of coops are "guessed" by veterinarians and the guesses of veterinarians become incorrect beyond 8 weeks. The term "guess" is used, because a coop owner may not want to enter chicks at an available week, may change the organization to work with, or may have problems that hinders chick acceptance such as workforce problems, or construction activities of coops. Also, coops entrances are such dynamic and complex activities, which includes chick buying and selling, making contracts with farmers, negotiating with new farmers, and depends on egg purchasing, incubation house production, feed mill production, and financial plans of the organization. All these uncertainties are tried to be overcome by short horizon selection.

CHAPTER 3

DEMAND ANALYSIS

Demand analysis and forecasting the future demand is one of the main tools that is used in production planning activities. In this study, demand analysis will be done and the outputs of this chapter will be the inputs of model in the next chapter.

3.1 Analysis Of Demand Characteristics

First of all, it should be noted that the data are the sales data, not the demand data. The reason is, unfortunately no one keeps the tracks of unmet demands in an organization. So, the unmet demand, which is the difference between real demand and realized sales, is not taken into account. For integrated poultry organizations, the situation is rather serious. Poultry market demand (the direct summation of all different products' demands) is more than twice of the produced meat at peak periods.[1] But, the excess demand cannot be supplied. If it were supplied, some parts of the chicken carcass would have been unsold. This would have resulted in excess frozen meat production and excess frozen meat inventory. The organization has more than 450 different products in its product mix. When the total sales by product types for 2 years, 2000 and 2001, are sorted in a descending order, it is seen that sales of first 90 products constitute more than 99%

[1] This situation is known by the experiences of the author in the industry.

of total sales. The analysis is performed for these 90 products.

Direct summation of all sales would be very harmful for analysis. The idea of analyzing the problem in this thesis study requires thinking in terms of production and production requirements, not the sales. Considering the production requirements of a sales is more important than focusing on the sales solely. Reverse bill-of-materials (BOM) makes such approach harder. Product structure of chicken carcass can be seen in Appendix A. The schema summarizes the experiment done by the author on 150 number-13 carcasses (a number-13 carcass is between 1250 and 1349 grams). It is seen that, carcass is basically partitioned into 3 main groups, breast, leg and wing groups. These groups are analyzed in the following paragraphs.

Breast group follows a production structure beginning with "breast with back". That basic product can be further processed to form "backless breast", "fillet with skin" and "skinless fillet". That production stream of breast group has a property. At any step, only one desired product is produced. By-products, "back", "bone", "crumb" and "skin" are not the aim of production. So, any product that is produced and sold from breast group can be expressed in terms of "breast with back". For example, "Fresh/In Plate/Half Fillet" with code number M41436 is nothing but, divided form of "skinless fillet" into 2 pieces and sold in plate as fresh. So, "Fresh/In Plate/Half Fillet" is another form of "skinless fillet", and such kind of products can be grouped and viewed as "skinless fillet". 1,000 grams production of "Fresh/In Plate/Half Fillet" requires 1,165 grams of "fillet with skin". Any product produced from "skinless fillet" can be expressed in terms of one level upper, "fillet with skin". By this approach, all the products that are produced from breast group can be expressed in terms of "breast with back" using the ratios of Appendix A. As a result, total production requirement for breast group is calculated as:

$$(BreastGroupProductionRequirement) = (BreastWithBackSales) + \\ (BacklessBreastSales) \times 1.23 + (FilletWithSkinSales) \times 1.82 \\ + (SkinlessFilletSales) \times 2.12$$

Leg group has a little bit different structure. 2 main subgroups are formed by partitioning "backless leg", which are "drumstick" and "thigh with skin". Up to those subgroups levels, the idea used in breast group is used. Total requirements for those subgroups are expressed as "backless leg" using the expression:

$$(BacklessLegProductionRequirement) = (BacklessLegSales) \\ + \max[((ThighWithSkinSales) + (SkinlessThighSales) \times 1.35) \times \\ 2.49\ ; (DrumstickSales) \times 3.31].$$

Product directly produced from "leg with back" and "backless leg" are easily grouped under those headings. Resultant calculation for leg group is as:

$$(LegGroupProductionRequirement) = (LegWithBackSales) \\ + (BacklessLegProductionRequirement)$$

Wing group production requirement is calculated by summation of all wing sales. One can think of using a similar approach of leg group because "leaf of wing" and "thigh of wing" are 2 main products formed by partitioning "wing", but production volume of wing group is very low compared to all production. So, direct summation has no significant disadvantage.

All the 3 main groups' production requirements are summed up with "whole carcass" sales and "other products" (such as giblets, liver, etc.) sales. Total carcass requirement for production is calculated by this method. As a result, the below formula is used:

$$(TotalCarcassRequirement) = (BreastGroupProductionRequirement) \\ + (LegGroupProductionRequirement) + (WingGroupProduction \\ Requirement) + (WholeCarcassSales) + (OtherProducts'Sales)$$

Monthly total carcass requirements for production and total sales by direct summation of all sales for years 2000 and 2001 can be seen in Appendix B as a graph. The differences between those two lines are very little, and these difference are due to the by-products, "back", "bone", "crumb" and "skin", which are not the aim of production and have no significant economic value compared to the main products.

In this analysis, frozen and fresh meat sales are combined. The idea behind this aggregation is as follows. The organization produces frozen meat for two purposes: exportation and stock. The common aim is to protect meat from perishing. The difference is exportation is profitable and desired by the organization, but producing frozen meat for stock is only to impede the loss of "excess" products. For example, if the organization produces too much "drumstick", in order not to throw away the "thigh with skin" that is produced as "excess" with "drumstick", "thigh with skin" is frozen. This kind of frozen production is sold in the domestic market. Most of the frozen sales is the exportation sales. The exportation demand is balanced, i.e. the export customers make parts demands as to form a whole carcass. Also, exportation demand is nearly supplied at the desired levels and immediately, as exportation is more profitable for the firm than the internal market sales. There is no need to calculate the required carcass using max operator, as in the leg group production requirement. Besides, total frozen sales is 17.13% of total sales. Because of those reasons, all frozen sales are aggregated with fresh sales by direct summation.

3.2 Forecasting

Forecasting is a very important tool for production requirement series analysis. Nahmias (1997) mentions the characteristics of forecasting. Some of them that are related with this study are as follows:

- Aggregate forecasts are more accurate.
- A single forecast value is not enough for a good forecast.
- Longer horizon forecasts are less accurate.

The aggregation of products as done in the previous section brings the first advantage of the three advantages reminded above.

After the model fitting, the variances of residuals will be checked in order to decide if the variation is tolerable or not. Also, 95 percent confidence intervals will be given for the forecasted values. So, the forecast will not be left as a single number, as mentioned as the second characteristic of forecasts.

Unfortunately, the planning time horizon is too long, 80 weeks. The data of past sales are for 2 years. This obstacle will be dealt with using Box-Jenkins type time series models.

Available data are monthly total sales for 2 years arranged in product codes. The whole list is very long, and is not given in the appendix. Data are supplied as paper prints by the organization. Input and corrections on spreadsheet took much time and effort. Latter paragraphs clarifies the approach to forecasting of production requirements.

The sales has a time-dependent nature. Smoothing and time series models are appropriate for forecasting purpose. Exponential smoothing model is applied on series initially. Smoothing constant α is found to be 0.9 according to mean squared error (MSE) and 0.6 according to mean absolute deviation (MAD). Nahmias (1997) recommends α to be between 0.1 and 0.2 for production applications.[2] This high value of α indicates instability. Because of that reason, exponential smoothing is not selected. Winter's Method is not applied as the plot of production requirements versus time does not show seasonality. Therefore, time series methods are implemented.

Time series methodology used in application to the series is given in Appendix C. All statistical operations are done using software EViews Version 3.1, except the normality tests. Those tests are done using Minitab 13.1. All the screens-shots of the software are shown in Appendix D in order to make the reader familiar with the concept, methodology and software. As explained in Chapter 1, production requirements data of the years 2000 and 2001 will be used in forecasting model.

Forecasting methodology is applied on production requirements as follows: Graph of data, which can be found in Appendix D Figure D.1, indicates no obvious seasonal effect. Bairam of Sacrifice[3] begins on 16 March 2000 and 05 March 2001 and lasts for 4 days, and it seems to have no negative effect on sales. Series' autocorrelation chart shows that there is a pattern of autocorrelation, but this pattern again gives no indication of seasonality and Bairam of Sacrifice effect.

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[2] Nahmias (1997),p.75.

[3] "Kurban Bayramı" in Turkish.

First autocorrelation coefficient is significant. In addition to this, partial correlation chart gives us a clue about the order of the process as 1, because only the first partial correlation coefficient is significant[4], as it is outside of the tolerance limit. These charts can be found in Appendix D Figure D.2. ADF (Augmented Dickey-Fuller) test on the series is done using only the intercept term. The test statistics is -2.35, and greater than -3.7497, MacKinnon Critical Value , so null hypothesis of unit root existence is failed to be rejected. Test results can be found in Appendix D in Figure D.3. The clue that partial autocorrelation coefficient gives as AR(1) (Auto-Regressive of order 1) process cannot be applied to the series for this case, because stability requirement of the series has failed.

The same procedure is followed for first differences for the series. Only second values of autocorrelation and partial correlation charts seem to be significant. The rest of autocorrelation chart seems to follow a pattern, but the pattern is not very clear. The reason may be the insufficiency of data. ADF test statistics is -4.955, and less than -3.7667, MacKinnon Critical Value , so null hypothesis of unit root existence is rejected for the first differences. Related charts and test results can be found in Appendix D in Figures D.4 and D.5.

Estimation is done for AR(0), AR(1), AR(2) and AR(3) processes on the first differences. So, the models tested for the series are ARIMA(0,1,0), ARIMA(1,1,0), ARIMA(2,1,0),and ARIMA(3,1,0) models indeed. Results can be found in Appendix D in Figures D.6, D.7, D.8, and D.9. AIC (Akaike Information Criteria) is at its smallest value for ARIMA(2,1,0) process. $\bar{R}^2$ value also shows that ARIMA(2,1,0) process is preferred as it is at its highest level. SBC (Schwarz Bayesian Criteria) is at its smallest value for ARIMA(0,1,0) process. AIC and $\bar{R}^2$ (Adjusted R-Square) indication is taken into account and ARIMA(2,1,0) process is preferred. The summary of results are given in Table 3.1 below. QQ-Plot of residuals is seen to be normally distributed, as a line fitted to the residuals (by hand or eye) pass close to point (0,0) and line is approximately 45^0. QQ-Plot can be found in Appendix D in Figure D.10. Statistics of residuals can be seen in Appendix D in Figure D.11. P-value for Anderson-Darling Normality Test is 0.337

[4] Detailed information can be found in Makridakis (1983), p.375.

Table 3.1: Summary of Test Results for the Selected ARIMA Models for Production Requirements

MODEL	AIC	SBC	$\bar{R}^2$
ARIMA(0,1,0)	27.87	27.92	0.000
ARIMA(1,1,0)	27.87	27.97	-0.049
ARIMA(2,1,0)	27.84	27.99	0.048
ARIMA(3,1,0)	28.00	28.20	-0.044

and that for Kolmogrov-Smirnov Normality Test is greater than 0.15. Related results of Minitab 13.1 can be seen in Appendix D in Figures D.14 and D.15. So, normality assumption about residuals is corrected. DW (Durbin-Watson) statistics for the ARIMA(2,1,0) model is 1.9648, $dL(23,3)$=1.08 and $dU(23,3)$=1.66. As a conclusion, serial correlation does not exist. The resultant estimated model is ARIMA(2,1,0), and shown as in Equation 3.1 below:

$$\Delta Y_t = 9,593 + 0.0134\Delta Y_{t-1} - 0.3512\Delta Y_{t-2} + e_t \tag{3.1}$$

Actual, fitted and residuals of the model can be found in Appendix D in Figure D.12. Before continuing for forecasting, the model is checked for its assumptions. But after all, when R^2 and $\bar{R}^2$ values of ARIMA(2,1,0) process result are considered, which are found to be 0.143 and 0.048 respectively, it is seen that the model cannot explain much about the requirement series' process. So, using this model for forecasting is not meaningful. Although model is not appropriate, the dynamic forecasts of the series using ARIMA(2,1,0) process is given for 18 months in Appendix D in Figure D.13, with 2σ limits. Forecasts are seen to be stabilizing in 4 months, and after 7 months, forecasts become a single fixed value. The inappropriateness of the model is also seen from this point of view.

As the forecasting procedure does not produce a useful model, several requirement scenarios are considered for the mathematical model in the next chapter. Requirement scenarios and their disaggregation for mathematical model are presented in the next section.

3.3 Demand Scenarios

In this section, scenarios about carcass requirements for production are discussed. The section heading is demand scenarios, because it is the common term for such a purpose, besides there exist a slight difference between demand and requirements as indicated in Section 3.1.

Minegishi and Thiel (2000) discusses three hypothetic sales variations, which are: stepwise, pulse and random patterns. Patterns and important behaviors are summarized at Table 3.2. Stabilizations of all systems at the state of balance are very good, random high amplitudes. Losses due to freezing excess production is a very important concept for an integrated poultry organization, which is discussed with the mathematical model in the next section. All the systems' losses due to freezing are seen to stabilize. Adaptation speeds of all systems change from each other.

Table 3.2: System behavior according to sales patterns

Sales variations hypothesis	Qualitative behavioral analysis
Sales increasing by a step	Slow and progressive adaptation Very good stabilization at balance state Stabilization of the losses due to freezing
Exceptional and repetitive variations (pulse)	Fast adaptation Better adaptation of repetitive sales for drops Very good stabilization at balance state Stabilization of the losses due to freezing
Random variations	Adaptation to all amplitudes of the hazards Stabilization for low amplitudes: ± 10-20% Stabilization of the losses due to freezing for low amplitudes

In this thesis study, five types of hypothetic requirements are considered, which are as follows:

1. Actual Past Requirements Scenario

2. Constant Requirements Scenario
3. Trend Requirements Scenario
4. Seasonal Requirements Scenario
5. Random Requirements Scenario

Before beginning the explanations of scenarios, it should be mentioned that February is shorter than other months. In the scenario generations, each month is assumed to be composed of 9 half-weeks, except February which is assumed to be 8 half-weeks. 18 months of the period between January 2000 and June 2001 contains two February months, and the period is 160 half-weeks in the total, which makes 80 weeks. After the explanations of scenarios, the disaggregation of monthly-generated scenarios to weeks is described.

For actual past requirements scenario, the period between January 2000 and June 2001 is considered.

Overall monthly average of the period between January 2000 and June 2001 is taken as the constant demand value for constant requirements scenario. February demands are taken as 8/9 times of the overall average.

Trend component is found by the difference between averages of first six months (i.e. through January 2000 and June 2000) and the next six months (i.e. through July 2000 and December 2000) of the period for trend requirements scenario. The term is found to be a positive value, 25,129 kilograms monthly. February months are treated with adjustment as above.

For seasonal requirements scenario, year 2000 is divided into 4 parts, which constitute 3-month seasons. Averages of those seasons are compared with the overall average of the year, and the seasonal factors are found to be 0.80, 1.12, 1.06 and 1.01 for winter, spring, summer and autumn respectively. The overall averages of years 2000 and 2001 are multiplied with the seasonal factors, and first 18 months are taken into account, as the horizon of the mathematical model is 80 weeks. For all months of a particular season of the year, the requirements are found to be equal, except February months. The resultant scenario is a stepwise function.

Smoothing of the function is done in the disaggregation procedure discussed below.

Normality of the requirements series for years 2000 and 2001 are checked using Minitab 13.1 and the results can be seen in in Appendix E in Figures E.1 and E.2. P-value for Anderson-Darling Normality Test is 0.925 and that for Kolmogrov-Smirnov Normality Test is greater than 0.15. From the figures, the left-hand side point seems as an outlier, but normality test are successful and the distribution is assumed to be normal. Mean and standard deviations are found to be 1,280,245 and 287,163 respectively, and five series are randomly generated using Minitab 13.1, which will be denoted with R1 to R5 through the study. Those random generations can be found in Appendix E in Table E.1.

3.4 Disaggregation of Scenarios

After five scenarios are formed for 18 months horizon, disaggregation of them to weekly requirements has to be done, as the mathematical model in the next chapter has a weekly structure. Each month is assumed to be composed of 9 half-weeks, except February which is assumed to be 8 half-weeks. The starting month of scenario horizons are assumed to be January, so each scenario contains two February months. 18 months horizon becomes exactly equal to 80 week horizon. Disaggregation is done using a nonlinear program, as follows:

$$MinZ = \sum_{i=1}^{159} (X_{i+1} - X_i)^2 \tag{3.2}$$

$$REQ_t = \sum_{i=9t-8}^{9t} X_i \; ; \; \forall t \; where \; t = 1, 2, ..., 17, 18 \tag{3.3}$$

where X_i is the free-variable that takes requirement values for 160 half-weeks, and REQ_t is the monthly requirements of the related scenario for 18 months. Except February months, the constraint satisfies the summation of the requirements of half-weeks of the month are equal to the requirements of the month. Objective function minimizes the sum of squared differences of consecutive half-weeks.

Models for each scenario are solved by using GAMS Version 2.01. Solutions give half-week requirements. These requirements are summed as consecutive couples in order to find out weekly requirements. Figure F.1 in Appendix F that shows the comparison of actual and weekly disaggregated requirements for actual past requirements scenario is given as an example. Weekly requirements graphs for first four scenarios can be found in Appendix F Figure F.2, and for five randomly generated series under normality assumption can be found in Figure F.3.

After constituting weekly requirements, the mathematical model for general production and financial planning can be solved. The model and its solutions are analyzed in the next chapter.

CHAPTER 4

GENERAL PRODUCTION AND FINANCIAL PLANNING

General production and financial planning is important in the organization's perspective, since decisions about the organization's critical activities are determined. The problem is a structured problem and the decision makers will be better off if they are supported by results of a mathematical model.

4.1 Introduction

This problem is tried to be solved with the help of a mathematical model for the purpose of planning production and financial aspects of Önder Integrated Poultry Incorporation. In the model, all the components of the system -which are actually the divisions of the organization- are thought as simple as possible, but at the same time this simplicity is not formed to affect the model's performance in a negative manner.

The components of the system and their short explanations are given in Figure 2.2 and Section 2.3 respectively. In this section, the main variables of the system, the relations among the components and the constraints of components are focused.

The initial step of the production chain is the breeder coops. The decision of "*how many* and *when* to buy breeder chicks" is the key decision of breeders. Indeed, this is also one of the most important decisions of the whole system. Feed and workforce requirements of the breeder coops are adjusted according to this decision. The basic constraint for this component is the capacity of available breeder coops. The component has relations with feed mill and incubation house, in terms of demand for feed and supply of fertilized eggs.

Incubation house supplies chicks to broiler coops, which are produced from fertilized eggs. Before the egg entrance to incubation house, it is possible to buy and sell eggs at the market. This is true also for chicks. So, the term "available" is used for the numbers that are used by the production system as the total numbers, without considering the source of eggs and chicks. The market sizes for chicks and eggs are highly different. Market for chicks is well-developed and it is possible to sell or buy at high quantities, but the same is not true for eggs market. Currently, the organization buys nearly half of available chicks, but the number of sold eggs to domestic produced eggs is negligible. This is not due to the capacity of the incubation house, but the egg market conditions.

The available chicks are entered to selected coops among suitable ones decided by veterinarians. The most critical decision of the system is weekly decision of total number of chicks to enter. Indeed, the breeder plan should be more critical as the number of domestic produced chicks depend on that plan. But as seen in the results section, breeder coops are fully utilized. Besides, the number of chicks bought is very high for the current situation as indicated in the above paragraph. This makes the chick plan the most important decision for the production chain. Feed requirement is the most important constraint, and this constitutes a relation between coops with feed mill. The relations of coops with the incubation house and with the chick market are in terms of produced chicks and bought-sold chicks respectively.

After the chicks grow at coops, they become chickens. Decision of buying and selling chickens at the market determines available chickens to be slaughtered. Slaughterhouse is considered to produce an aggregated product: the chicken meat. The meat is sent to market via dealers, where meat sales is the main source of cash inflow to the system. Other cash inflows due to selling chicks, eggs and chickens are negligible compared to that of meat sales. There exists a weak relation between the feed mill and the rendering unit. Feed mill supplies waste parts to rendering unit, which are converted into offal meal that becomes a supply to feed mill. Capacity constraint is seen as a limitation to meat production for this component. Although, the most complex structure of the organization is slaughterhouse, many simplifying assumptions make this component tractable easily in the model. For example, defining an aggregate product ignores the demand balance. Bill of material of chicken meat is reverse, as the parts are not combined to obtain a product as usual, but instead, carcasses are partitioned into parts to produce products. This partitioning will result in "unsold" parts. So, partitioning level should be determined for maximum profit from partitioning operation, but this is ignored at building constraints for slaughterhouse. Also, customers are not treated different from each other and a single customer is defined, which is unrealistic in real application as credibilities and importance of each customer is different than the others. Another ignored fact is on the demand allowances. In the poultry meat industry, allowances for customer demands are possible in two folds; upper sending and lower sending allowances. These allowances construct a region around the ordered quantities, which is acceptable for the customer. All those assumptions mentioned above are the most strict ones. Even with the others that are not mentioned here, all assumptions do not constitute a rigid framework for the slaughterhouse for the purpose of general planning.

Feed mill uses raw material, and produces feed for growing breeders and chicks. Production is adjusted according to breeder and chick plans, considering the capacity of feed mill. Safety stock for raw material of feed mill is another constraint for the component.

The model is a linear programming (LP) model, as workforces and binary variables indicating coop entrances are considered as continuous variables in the model. The reason for the first relaxation is to make sensitivity analysis on workforces, and for the second one is just for the sake of linearizing the model. These are not very harmful assumptions, as a fractional worker requirement can be rounded up to the nearest integer, and modifications of coop entrances can be easily made by the veterinarians. The requirement scenarios at Chapter 3 will be used as inputs of the model. In the next section, the LP model built is explained.

4.2 The Model

For all requirement scenarios, identical LP models are used. Time horizon of the LP model is 80 weeks. This horizon is selected, since life of a breeder is nearly 70 weeks. The following subsections explain the sets, parameters, variables, constraints and the objective function of the LP model.

4.2.1 Sets

There are two sets in this model. Coop set is a very long set, and a small part of the set can be tracked from Appendix G Table G.2.

i Coops

t Time (weeks) /1,2,...,79,80/

4.2.2 Decision Variables

Units of decision variables are given in parenthesis next to their explanations. Number of workers and binary variables indicating coop entrances are not considered as integer variables for the purpose of sensitivity analysis.

Z Objective value

POSITIVE	VARIABLES
BB_t	Breeders bought (at time t in terms of # of breeder chicks)
EG_t	Domestic produced eggs at incubation house (#)
EG_t^+	Bought eggs (#)
EG_t^-	Sold eggs (#)
EGG_t	Available eggs (#)
BFC_t	Total breeder feed consumption (tonnes)

CHI_t	Domestic chicks produced (#)
CHI_t^+	Chicks bought (#)
CHI_t^-	Chicks sold (#)
$CHICK_t$	Available chicks (#)
$X_{i,t}$	Chicks placed to coop i (#)
X_t^+	Chickens bought (#)
X_t^-	Chickens sold (#)
$Y_{i,t}$	Relaxation of binary variable indicating entrance to coop i
CFC_t	Total chicken feed consumption (tonnes)
SLG_t	Chickens available for slaughtering (#)
$SLGP_t$	Slaughterhouse meat production sold (kilograms)
REQ_t^+	Over sent demand (kilograms)
REQ_t^-	Under sent demand (kilograms)
FMP_t	Feed mill production (tonnes)
$RMIFM_t$	Feed mill raw material inventory (tonnes)
RMB_t	Raw material bought for feed mill (tonnes)
$RMPURC_t$	Raw material purchase for feed mill (million TL)
$PEFM_t$	Production expense of feed mill (million TL)
$ICCFM_t$	Inventory carrying charge for feed mill (million TL)
SLE_t	Slaughterhouse expense (million TL)
$COOPE_t$	Coop expense (million TL)
$INCE_t$	Incubation house expense (million TL)
BE_t	Breeder expense (million TL)
TE	Total expense (million TL)

$EXSL_t$	Expense of over and under sales (million TL)
REV_t	Revenue generated (million TL)
EXB_t	Expense of bought eggs, chicks, chickens (million TL)
$REVS_t$	Revenue from sold eggs, chicks, chickens (million TL)
TR	Total revenue (million TL)
$REVH$	End-of-horizon revenue (million TL)
$EXPH$	End-of-horizon expense (million TL)
WB_t	Workers at breeder houses
WI_t	Workers at incubation houses
WS_t	Workers at slaughterhouse
WF_t	Workers at feed mill
HWB_t	Hired workers at breeder houses
HWI_t	Hired workers at incubation houses
HWS_t	Hired workers at slaughterhouse
HWF_t	Hired workers at feed mill
FWB_t	Fired workers at breeder houses
FWI_t	Fired workers at incubation houses
FWS_t	Fired workers at slaughterhouse
FWF_t	Fired workers at feed mill

4.2.3 Parameters

Values and units of parameters are given in parenthesis next to their explanations. For long strings of parameters, reader is referred to Appendix G Tables G.1 and G.2, where requirements in the first table are for actual past requirements scenario and the second table only includes a sample of coops related parameters and availability matrix. Cost related parameters are based on USD exchange rates, which are retrieved from Central Bank of Republic of Turkey (2003), because all the important inputs; such as raw material for feed mill, breeder chicks, chick prices,etc., depend on exchange rates. Estimation of parameters which are about the organization are done with the responsible employees.

SCALARS	
BCP	Breeder chick price Mo$ (multiplier of $) (2.5)
FEB	Fixed expense Mo$ of breeder houses (200)
$CAPBR$	Total breeder capacity (60000#)
IP	Incubation performance (0.80,ratio of chicks to eggs)
$FEIE$	Fixed expense Mo$ of incubation (300)
$PCEI$	Per chick expense Mo$ of incubation (0.01)
$CAPINC$	Total incubation house capacity (380000#)
$PAYLIVE$	Payment Mo$ per kg live weight (0.35)
$PAYFEED$	Payment Mo$ for deviation of FCR from 2.00 (0.350)
$PAYDEATH$	Payment Mo$ for deviation of death rate from 6% (0.65)
$FIXCOOP$	PM$ for fixed expense of working with a coop (50)
$CAPCOOP$	Total coop capacity (295000#, maximum of past entrances)
$RMIFM_0$	Initial raw material of feed mill (300 tonnes)
$CFMRM$	Raw material capacity of feed mill (1600 tonnes)
$CFMP$	Production capacity of feed mill (1300 tonnes)
$MPRMB$	Price Mo$ of raw material bought (150 per tonne)
$MCFER$	Chicken feed production expense rate Mo$ (150 per tonne)
$MBFER$	Breeder feed production expense rate Mo$ (80 per tonne)
SC	Slaughterhouse capacity (300000#)
SP	Slaughterhouse performance (0.74, ratio of meat produced to live weight of chicken slaughtered)

FES	Fixed expense Mo$ of slaughterhouse (1700)
$SLMPC$	Production charge Mo$ for slaughterhouse (0.1 per kilogram)
$OSPF$	Over sales penalty Mo$ of demand (0.15 per kilogram)
$USPF$	Under sales penalty Mo$ of demand (0.20 per kilogram)
$MMMP$	Meat market price Mo$ (1.97 per kilogram)
IR	Weekly interest rate (0.005)
$EGPB$	Egg price Mo$ for bought eggs (0.35 per egg)
$EGPS$	Egg price Mo$ for sold eggs (0.28 per egg)
$LCPB$	Live chicken price Mo$ bought (1.2 per kilogram)
$LCPS$	Live chicken price Mo$ sold (0.8 per kilogram)
$MPCB$	Market price Mo$ of chick bought (0.45 per chick)
$MPCS$	Market price Mo$ of chick sold (0.30 per chick)
$REQ^{+}All$	Allowance for REQ^{+} (20%)
$REQ^{-}All$	Allowance for REQ^{-} (40%)
$MaxEG^{+}$	Maximum eggs that can be bought from market (20000#)
$MaxEG^{-}$	Maximum eggs that can be sold to market (5000#)
$MaxCHI^{+}$	Maximum chicks that can be bought from market (170000#)
$MaxCHI^{-}$	Maximum chicks that can be sold to market (50000#)
$MaxX^{+}$	Maximum chickens that can be bought from market (20000#)
$MaxX^{-}$	Maximum chickens that can be sold to market (10000#)
$MWage$	Worker wage Mo$ (55 per worker)
$MHire$	Hiring cost Mo$ (220 per worker)
$MFire$	Firing cost Mo$ (440 per worker)
$WBrd$	Number of breeders that require 1 Worker (10000)
$WInc$	Number of eggs that require 1 Worker (30000)

$WSlg$	Number of processed chickens require 1 Worker (2500)
$WFeed$	Tonnes of feed that require 1 Worker (100)
WB_0	Initial workers at breeder houses (6)
WI_0	Initial workers at incubation houses (4)
WS_0	Initial workers at slaughterhouse (97)
WF_0	Initial workers at feed mill (10)
$MPPC$	Per chicken profit Mo$ for end-of-horizon effect (1.3)

PARAMETERS

BPM_t	Breeder performances (# of eggs given by breeder for a t-week-old breeder)
$PREGG_t$	Projected egg production with current breeders (# of eggs for period t)
$BFCR_t$	Breeder feed consumption parameter (grams by week age)
$PRBFC_t$	Projected breeder feed consumption of current breeders (tonnes)
$PRBB_t$	Projection of current breeders (# for period t)
USD_t	$ exchange rates of Central Bank of Turkey (million TL)
REQ_t	Production requirements for the related scenario (kilograms)
$CFCR_t$	Chicken feed consumption (grams of a t-week-old chicken) /1 150,2 350,3 550,4 700,5 800,6 1000/
$PRCFC_t$	Projected chicken feed consumption (tonnes) /1 820,2 710,3 590,4 450,5 290,6 110/
$PRCHICK_t$	Projected chick production at incubation for the following weeks (#) /1 135000, 2 142000,3 140000/

PRX_t	Projected chickens to be slaughtered (#)
	/1 185000,2 205000,3 197000,4 210000,5 188000,6 190000/
PR_t	Payment rate
	/1 0.4, 2 0.3, 3 0.3/
CR_t	Collection rate
	/1 0.5, 2 0.25, 3 0.25/
$PPFM_t$	Projected payments for feed mill (million TL)
	/1 50000, 2 25000/
$PCFS_t$	Projected collections for sales (million TL)
	/1 150000, 2 75000/
$COOPCAPA_i$	Coop capacity (maximum of past entrances of coop i)
FCR_i	FCR estimate of coop i
LW_i	MLW estimate of coop i
$DEATH_i$	DPR estimate of coop i

DERIVED	PARAMETERS
$PRMB_t$	Price of raw material bought (million TL per tonne)
	$PRMB_t = USD_t * MPRMB$
MMP_t	Meat market price (million TL per kg)
	$MMP_t = USD_t * MMMP$
$CFER_t$	Chicken feed expense of production (million TL per tonne)
	$CFER_t = USD_t * MCFER$
$BFER_t$	Breeder feed expense of production (million TL per tonne)
	$BFER_t = USD_t * MBFER$
$Wage_t$	Worker wage (million TL)
	$Wage_t = USD_t * MWage$

$Hire_t$	Worker hiring cost (million TL)
	$Hire_t = USD_t * MHire$
$Fire_t$	Worker firing cost (million TL)
	$Fire_t = USD_t * MFire$
PPC_t	Per chicken profit for end-of-horizon effect (million TL)
	$PPC_t = USD_t * MPPC$

TABLE	
$AVA_{i,t}$	Availability matrix of coops.

4.3 Mathematical Formulation

4.3.1 Breeders

While formulating breeders, they are thought to be available in the market anytime to buy. Besides, race effect on performance of breeders is ignored. Performance of breeders, which is the number of eggs laid by a female breeder per week, is considered to be an average value for a breeder flock.[1]

$$\sum_{l=1}^{t} BB_l BPM_{(t-l+1)} + PREGG_t = EG_t \quad \forall t \tag{4.1}$$

$$EGG_t = EG_t + EG_t^+ - EG_t^- \quad \forall t \tag{4.2}$$

$$EG_t^+ \leq MaxEG^+ \quad \forall t \tag{4.3}$$

$$EG_t^- \leq MaxEG^- \quad \forall t \tag{4.4}$$

$$\sum_{l=1}^{t} BB_l \times BFCR_{(t-l+1)}/10^6 = BFC_t \quad \forall t \tag{4.5}$$

$$\sum_{l=\max(1,t-70)}^{t} BB_l + PRBB_t \leq CAPBR \quad \forall t \tag{4.6}$$

$$WB_{t-1} + HWB_t - FWB_t = WB_t \quad \forall t \tag{4.7}$$

$$WB_t \geq (\sum_{l=\max(1,t-70)}^{t} BB_l + PRBB_t)/WBrd \quad \forall t \tag{4.8}$$

[1] Generally, the ratio of female breeders to male breeders is 10. The performance is thought as if it includes males. So, the performance is not "per female breeder chicken" but "per breeder chicken"

First equation calculates number of eggs produced with domestic breeders. For time t, a breeder bought at time l is at the age of $t-l+1$, and egg performance of the breeder of that age is multiplied by the total number of breeders. This value is added to egg projections of current breeders, and domestic egg production is found. In the second constraint, bought and sold eggs are considered and available number of eggs available at time t is found. Third and fourth constraints put limits on eggs to buy and sell on the egg market. Fifth equation calculates breeder feed consumption at time t using feed consumption parameter of corresponding age of breeders. Sixth constraint is the capacity constraint of breeder houses, where only live breeders are counted in. Seventh equation is the workforce level equation. Eight constraint assures that required number of workers are employed for breeders care.

4.3.2 Incubation House

Incubation house performance is thought to be constant for the horizon.

$$CHI_t = PRCHICK_t + EGG_{t-3} * IP \quad \forall t \tag{4.9}$$

$$CHICK_t = CHI_t + CHI_t^+ - CHI_t^- \quad \forall t \tag{4.10}$$

$$CHI_t^+ \leq MaxCHI^+ \quad \forall t \tag{4.11}$$

$$CHI_t^- \leq MaxCHI^- \quad \forall t \tag{4.12}$$

$$EGG_t \leq CAPINC \quad \forall t \tag{4.13}$$

$$WI_{t-1} + HWI_t - FWI_t = WI_t \quad \forall t \tag{4.14}$$

$$WI_t \geq EGG_t/WInc \quad \forall t \tag{4.15}$$

First equation calculates number of chicks produced with available eggs at time t using incubation performance, and projections of current incubation situation. Note that, for $t = 1, 2, 3$, EGG_t is set to parameters $PRCHICK_t$. For $t \geq 4$, parameter $PRCHICK_t$ takes on value of zero. Second equation calculates number of chicks available at time t considering a chick market to sell or buy chicks. Third and fourth constraints put limits on chicks to buy and sell on the chick market. Fifth constraint is for the capacity of incubation house. Sixth equation is the workforce level equation. Seventh constraint assures that required number of workers are employed for incubation house.

4.3.3 Coops

The organization owns no coops. All the coop owners have a subcontracting relationship with the organization. There are about 250 coops that the organization is working with, but only 150 coops are put into coops set. The reason is explained in the next paragraph. The organization is working with 149 of the selected coops. 150^{th} coop is the DUMMY coop. Coop planning is considered for the first 8 weeks. This horizon is selected, since the model depends on "availability matrix" of coops, which define the week that the coop is available to enter chicks. Forming this matrix is done by veterinarians and beyond 8 weeks, the "guesses" of veterinarians become uncertain. The term "guess" is used, because a coop owner may not want to enter chicks at an available week, may change the organization to work with, or may have problems that hinders chick acceptance such as workforce problems, or construction activities at the coops. Also, coops entrances are such dynamic and complex activities, which includes chick buying and selling, making contracts with farmers, negotiating with new farmers, and depends on egg purchasing, incubation house production, feed mill production, and financial plans of the organization. All these uncertainties are tried to be overcome by short horizon selection. For the rest of the total horizon, namely 72 weeks, DUMMY coop is used. Availability matrix, $AVA_{i,t}$, is defined as follows: for the first 8 weeks, DUMMY coop is not available, and after then, only DUMMY coop is available. DUMMY coop's performance measures are assumed to be the overall averages of past performances of coops.

Performances of coops are the other important information used in the model. The performances of coops are estimated as follows. All the performance measures (FCR, MLW and DPR) are scrutinized. Because of data input errors and diseases of chickens at coops, some data are found to be extremely different, such as a 70% DPR, or 4.7 FCR. These data are also discarded. Then, coops which have less than 5 entrances in the past are discarded, because less than 5 entrances cannot give proper clues about performances. Resultant data are for 149 coops and 1449 entrances, and analyzed by finding averages and standard deviations of performances of coops' past entrances. The averages are taken as estimates of performance measures.

Coop capacities information is obtained by simply finding the maximum chick entrance of past entrances of coops. Similar to breeders, race effects are ignored.

$$\sum_{set\ i} X_{i,t} = CHICK_t \quad \forall t \tag{4.16}$$

$$PRCFC_t + \sum_{l=t-6}^{t} CFCR_{t-l+1}(\sum_{set\ i} X_{i,l})/10^6 = CFC_t \quad \forall t \tag{4.17}$$

$$X_{i,t} \leq Y_{i,t} \times COOPCAPA_i \quad \forall t \tag{4.18}$$

$$\sum_{t=1}^{8} Y_{i,t} \leq 1 \quad \forall i; \quad i \neq DUMMY \tag{4.19}$$

$$Y_{i,t} \leq \sum_{l=1}^{t} AVA_{i,l} \quad \forall i, t \tag{4.20}$$

The first equation ensures all the chicks are placed in coops. Second equation calculates chicken feed consumption at time t using feed consumption parameter of chickens for corresponding ages. Third constraint ensures total chicken capacity of coops is not exceeded. Fourth constraint ensures that the capacity of the coop (except DUMMY) is not exceeded, because each coop is considered to be entered chicks once in 8 weeks. As growing chickens need 6 weeks and cleaning the coop after the flock needs 1 week, this equation is realistic. Also, for example, while the chickens in a coop is at age 3 weeks, new chicks cannot be entered to the coop besides the elder chickens, although there may exist an unused capacity in the coop. DUMMY defines all the coops after the first 8 weeks, so it must be available for each week after then. As $Y_{i,t}$ is not defined as binary variable, a coop can be entered more than once in the first 8 weeks, without exceeding total capacity. In practice, different ages of chicks cannot be taken care of in the same coop. Although the constraint may allow such a result, manual solution for that spacial case by veterinarians is very easy to do. Fifth constraint ensures the coop entrance occurs at most once (or if fractional entrances occur in the solution, which is discussed above, total of fractions cannot exceed 1). Last constraint is about the availability of coops and ensures the entrance of chicks to coops starts from the first available week. Coops are considered to be available for all the first 8 weeks after the first available week. This may seem to be unrealistic, because if in a few weeks of waiting the coop as empty, coop owner may have contract with another organization. But, this is not a case generally occurring. Also, in 8 weeks horizon, such a situation can be ignored safely.

4.3.4 Slaughterhouse

Slaughterhouse production and market demand are assumed to be in aggregate units, kilograms of chicken meat, as noted in the previous parts.

$$PRX_t + \sum_{seti}((1 - DEATH_i) \times X_{i,t-6}) + X_t^+ - X_t^- = SLG_t \quad \forall t \qquad (4.21)$$

$$SLG_t \leq SC \quad \forall t \qquad (4.22)$$

$$SLG_t \times SP \times LW_{DUMMY} = SLGP_t \quad \forall t \qquad (4.23)$$

$$SLGP_t = REQ_t + REQ_t^+ - REQ_t^- \quad \forall t \qquad (4.24)$$

$$WS_{t-1} + HWS_t - FWS_t = WS_t \quad \forall t \qquad (4.25)$$

$$WS_t \geq SLG_t / WSlg \quad \forall t \qquad (4.26)$$

$$REQ_t^+ \leq REQ_t \times REQ^+All \quad \forall t \qquad (4.27)$$

$$REQ_t^- \leq REQ_t \times REQ^-All \quad \forall t \qquad (4.28)$$

$$X_t^+ \leq MaxX^+ \quad \forall t \qquad (4.29)$$

$$X_t^- \leq MaxX^- \quad \forall t \qquad (4.30)$$

First equation calculates total chickens to slaughter at time t assuming a market of chickens to sell or buy. Note that, similar to incubation house case, $\sum_{seti}(X_{i,t-6})$ is parameter PRX_t for $t = 1, ..., 6$ and parameter PRX_t takes value zero for $t = 7, ..., 80$. Second constraint ensures slaughterhouse capacity is not exceeded. Third constraint calculates total meat production of slaughterhouse considering slaughterhouse performance and live weight of DUMMY coop, which is nothing but the overall average. Fourth constraint constitutes demand-production relation for meat. Fifth equation is the workforce level equation. Sixth constraint assures that required number of workers are employed for slaughterhouse production. The latter two constraints are about demand tolerances. In poultry industry, over sending and under sending at acceptable limits is possible. For example, customer orders 100 kg. meat, but the organization sends 110 kg. or 90 kg. Most of the time, that customer will not reject to buy the amount that the organization has sent. But, there exist bounds for this issue, which are given with the above constraints. Last two constraints put limits on chickens to buy and sell on the chicken market.

4.3.5 Feed Mill

Feed mill production is assumed to happen without a loss in raw material. At least half of next week's production amount has to be kept in inventory for safety of production. Feed mill raw material and production capacities are considered.

$$FMP_t = RMIFM_{t-1} + RMB_t - RMIFM_t \quad \forall t \tag{4.31}$$

$$RMIFM_{t-1} + RMB_t \leq CFMRM \quad \forall t \tag{4.32}$$

$$FMP_t = BFC_t + CFC_t \quad \forall t \tag{4.33}$$

$$FMP_t \leq CFMP \quad \forall t \tag{4.34}$$

$$RMIF_{t-1} \geq FMP_t/2 \quad \forall t \tag{4.35}$$

$$WF_{t-1} + HWF_t - FWF_t = WF_t \quad \forall t \tag{4.36}$$

$$WF_t \geq FMP_t/WFeed \quad \forall t \tag{4.37}$$

First equation constitutes production,inventory, and raw material purchase relation, and implicitly assumes there is no loss of raw material in feed production. Second constraint ensures raw material capacity of feed mill is not exceeded. Third equation balances feed demand and supply of the organization. Fourth constraint ensures capacity of feed mill is not exceeded. Fifth constraint assures a safety stock of half of next week's feed production. Sixth equation is the workforce level equation. Seventh constraint assures that required number of workers are employed in feed mill.

4.3.6 Expenses

All expenses are in terms of million TL.

$$RMPURC_t = PPFM_t + \sum_{k=1}^{3} RMB_{t-k+1} \times PRMB_{t-k+1} \times PR_k \quad \forall t \quad (4.38)$$

$$PEFM_t = BFER_t \times BFC_t + CFER_t \times CFC_t + Wage_t \times WF_t + Hire_t \times HWF_t + Fire_t \times FWF_t \quad \forall t \quad (4.39)$$

$$RMIFM_t \times PRMB_t \times IR = ICCFM_t \quad \forall t \quad (4.40)$$

Raw material purchases are divided into 3 weeks, 40% of the purchase is paid in the current week, 60% is paid equally in the next 2 weeks. Feeds of breeders and chickens include different ingredients. Chicken feed is more energetic, so that in 6 weeks, a chick becomes a 2.5 kilograms chicken. Because of that reason, cost of breeder feed is less than that of for chickens. Inventory carrying charge is based on a fixed weekly interest rate, as it is thought to be an opportunity cost only.

$$SLE_t = FES \times USD_t + SLMPC \times USD_t \times SLGP_t + Wage_t WS_t + Hire_t HWS_t + Fire_t FWS_t \quad \forall t \quad (4.41)$$

Slaughterhouse expense consists of fixed expense, fresh and frozen meat production costs, frozen meat inventory carrying charges and labor expenses.

$$COOPE_t = \sum_{seti} USD_t \times [X_{i,t} \times LW_i \times PAYLIVE + X_{i,t} \times LW_i \times (2 - FCR_i) \times PAYFEED + X_{i,t} \times (0.06 - DEATH_i) \times PAYDEATH] \quad \forall t \quad (4.42)$$

Coop expense is the amount of money that is paid to coop owners. Chicks are assumed to grow up in 6 weeks.

$$INCE_t = [(PRCHICK_t + \sum_{k=t-2}^{t} EGG_k) \times PCEI + FEIE] \times UDS_t + Wage_t \times WI_t + Hire_t \times HWI_t + Fire_t \times FWI_t \quad \forall t \quad (4.43)$$

Incubation house expense is the sum of labor expenses and expenses for current eggs processed.

$$BE_t = (BB_t \times BCP + FEB) \times UDS_t + Wage_t \times WB_t$$
$$+Hire_t \times HWB_t + Fire_t \times FWB_t \quad \forall t \qquad (4.44)$$

Breeder expenses are fixed expense, bought breeder chick expense and labor expenses. Salvage value for breeders is not considered, because after their productive (egg laying) life ends, breeders become useless and they are destroyed.

$$EXSL_t = (REQ_t^+ \times OSP + REQ_t^- \times USP) \times MMP_t \quad \forall t \qquad (4.45)$$

Over/Under sales of fresh and frozen meat are penalized.

$$EXB_t = (EG_t^+ \times EGPB + X_t^+ \times LCPB \times LW_{DUMMY}$$
$$+CHI_t^+ \times MPCB) \times USD_t \quad \forall t \qquad (4.46)$$

Bought eggs, chicks and live chicken constitutes the above expense.

$$EXPH = e = RMB_{80} \times (PR_2 + PR_3) \times PRMB_{80} + RMB_{79}$$
$$\times PR_3 \times PRMB_{80} \qquad (4.47)$$

End-of-horizon expense effect is prevented with the above constraint. This constraint ensures that all the cost incurring from raw material bought for feed mill in the last 2 weeks are totally paid.

$$TE = \sum_{t=1}^{80}(RMPURC_t + PEFM_t + ICCFM_t + SLE_t$$
$$+COOPE_t + INCE_t + BE_t + EXSL_t + EXB_t) + EXPH \qquad (4.48)$$

Total expense is simply the summation of all expenses.

4.3.7 Revenues

All revenues are in terms of million TL.

$$REV_t = \sum_{k=t-2}^{t} [(REQ_k + REQ_k^+ - REQ_k^-) \times MMP_k \times CR_{t-k+1}$$
$$+PCFS_t \quad \forall t \quad (4.49)$$

Sales revenues are collected as the following: half of the value of sales is collected in the current week, the remaining is collected equally in the following 2 weeks, i.e. 50%,25% and 25%.

$$REVS_t = (EG_t^- \times EGPS + X_t^- \times LCPS \times LW_{DUMMY} \\ +CHI_t^- \times MPCS) \times USD_t \quad \forall t \tag{4.50}$$

Revenue from other sales are egg, chick, and chicken sales revenues.

$$REVH = \sum_{t=75}^{80} X_t \times PPC_t + [(D_{79} + D_{79}^+ - D_{79}^-) \times MMP_{80} \times CR_3 \\ +(DF_{79} + DF_{79}^+ - DF_{79}^-) \times FRMMP_{80} \times CR_3] + [(D_{80} + D_{80}^+ - D_{80}^-) \\ \times MMP_{80} \times (CR_2 + CR_3) + (DF_{80} + DF_{80-}^+ DF_{80}^-) \times FRMMP_{80} \\ \times (CR_2 + CR_3)] \tag{4.51}$$

End-of-horizon revenue effect is considered twofold. For the last 6 weeks, coop entrances cannot be slaughtered, so they are assumed to be sold as live. Also, the last 2 weeks sales values cannot be collected totally. The reference prices are taken as the last months prices and last collection of the 79^th week's and the last 2 collection of the 80^th week's sales are considered.

$$TR = \sum_{t=1}^{80} (REVS_t + REV_t) + REVH \tag{4.52}$$

Total revenue is the sum of all revenues,

4.3.8 Objective Function

Objective is maximizing the net profit, the difference between total revenue and total cost. Objective function is given below:

$$Z = TR - TE \tag{4.53}$$

4.4 Results

The mathematical model is coded and run by GAMS Version 2.01, and results are examined in Microsoft Excel, with the help of exporting facility of GAMS to Microsoft Notepad, and importing facility of Microsoft Excel from Microsoft

Notepad.

Model is run several times for each scenario, and estimated parameters are verified to be consistent. For example, $SLMPC$, or $PCEI$ are hard to estimate, and model should not be dependent on those kind of parameters closely. Model run results are compared with past realizations of variables. Parameters are adjusted to their last values after ensuring that the model is not depending on those values sensitively. If small amounts of over or under estimations of parameters had been resulted in very different results, the results would have been unreliable.

Model has two important effects. First is the starting effect, where many projections are used, such as egg production, chick production, feed consumption projections. These projections indicate the future effects of current situation of the organization. The model cannot be effective until the decisions about breeders to buy can have effect on egg production. Second effect is the end-of-horizon effect, and it is tried to be removed by adding end-of-horizon expense and revenue. But the model produces results that tend to reduce costs and increase profits towards last weeks. For the last 10 weeks, the results are less reliable. Model reduces breeders, egg production, chick production and feed production for those weeks.

Model includes 27445 variables and 27833 equations. This number can be misleading, because $X_{i,t}$ and $Y_{i,t}$ are defined for all coops for all the periods. Indeed, variables and constraints for DUMMY coop for the first 8 weeks, and that for other coops after the 8^{th} week should be discarded from consideration as they are designed not to take values different than zero. Also, $CHICK_t$ is exactly equal to $X_{DUMMY,t}$ after the 8^{th} week, so there exist no need to treat them separately. SLG_t and $SLGP_t$ are treated as different, but they are only multiplicative derivations of each other. Net number of variables is 5821 and constraints is 6200 (reductions of constraints are from Equations 4.16, 4.18, 4.19, 4.20 and 4.23 by 72, 21472, 1, 8, and 80 number of constraints respectively).

Objective values, total revenues and expenses of scenarios are shown in Appendix G Table G.3. Objective values change from 7.2 to 8.9 trillion Turkish Liras, and maximum value is for trend scenario, as the requirements are continuously increasing. For the planning horizon, the largest total requirement is for trend scenario and it is about 27 million kilograms. The least total requirement is for fourth generated series for random scenario, which is about 22 million kilograms. Those values are seen to be reasonable from the organization's perspective, as currency of those years is the basis of financial calculations. Also, it can be concluded that, if the company can increase its share in the poultry meat market, under current conditions, it can make more profit. This is a very important result for the organization, which can help for strategic marketing decisions.

Model results only for actual scenario from week 20 to 50 can be tracked through Appendix G Tables G.4-G.12. All the results are not given in appendices, because it would consume too much space. 30 weeks results for a single scenario can give an idea about the outputs of the models. In this section, important values of results other than that 30 weeks will also be discussed for all scenarios.

Appendix G Table G.4 shows that in week 37, 14800 breeders are bought. In week 4, 25800 and in week 18, 12000 breeders are also bought, but these cannot be found in the table as all output is not given in the appendix. When results of all the scenarios are compared, the outcome is very interesting. Except for the seasonal scenario, all the scenarios find breeder buying plan exactly identical. BB_t for weeks 1 to 4 for seasonal scenario are 21, 1106, 0, and 24673, which sum up to 25800. At the beginning of the planning horizon, the organization has 34200 breeders on hand. With the first purchase of 25800 breeder chicks in week 4, total capacity of breeders, which is 60000, is fully utilized. The projected breeder chicks drop by 12000 in week 16, and in week 18, exactly the same amount of breeder chicks are purchased. The same situation occurs for depletion in week 36 and purchase in week 37 with the amount of 14800. The capacity of breeders is fully utilized for all scenarios, except few weeks. This result is another important result for the organization. When shadow price for breeder capacity constraint is analyzed below, the concept is investigated in more detail.

Table G.4 shows an increasing trend in eggs available. Indeed, there is a fall between weeks 8-27, and then increasing trend begins until the second fall which begins in week 64 and continues till the end of horizon. For all other scenarios, the results are nearly identical to the actual scenario. Domestic egg productions follow the same patterns for all scenarios. As expected from breeder buying plan, domestic egg productions are exactly identical, except few weeks for seasonal scenario. Total bought eggs vary between 2-5% of total available eggs, and total sold eggs are nearly zero for the scenarios. We can say that, nearly all the domestic produced chicks are from domestic produced eggs of breeders. For the planning horizon, average available eggs and domestic produced eggs for all scenarios vary around 11 million and 10.7 million very slightly. Table 4.1 gives the summary of results.[2]

Table 4.1: Egg Production Results' Summary

TOTALS OF	**ACTUAL**	**CONST.**	**TREND**	**SEASON.**
EGG	11180544	10880330	11074599	11253928
EG(% of EGG)	95.63	98.27	96.55	95.01
EG+(% of EGG)	4.8	2.05	3.77	5.3
EG-(% of EGG)	0.43	0.32	0.32	0.31
R1	**R2**	**R3**	**R4**	**R5**
11045833	11064043	11096620	10997937	10967409
96.8	96.64	96.35	97.22	97.49
3.52	3.68	3.96	3.1	2.83
0.32	0.32	0.32	0.32	0.32

The data related with cost figures could not be obtained from the organization. Besides this, chick entrance plan is very important and gives the summary of a master production plan. All the other activities, such as feed production, breeder buying plan, egg production, chicks purchase, etc., are adjusted according to chick entrance plan. Domestic chick production can be substituted with chick purchasement from the market[3], breeder plan can be adjusted accordingly, etc. Because of those reasons, results which are related with chicks are analyzed in

[2] Sum of percentages of EG, EG+ and EG- exceed 100%, because of initial egg projections.

[3] A study on analysis of variance (ANOVA) for chicken performances for two effects, which are growing region of chickens and chick type -domestic production or bought from the market- is performed by the author. Result is found to be that chick type has no significant effect on performance, so two types can be substituted safely.

detail in the following paragraphs.

Total chick sales are less than 2% of total chick production for all scenarios. Those sales occur after week 75. Reason may be end-of-horizon effect, although it is tried to be removed. As a result, chick sales are not taken into account in the analysis.

The data of realized chick entrances by the organization are available. Comparisons of chick entrance results of scenarios with realized entrances are given in Appendix G Figures G.1 and G.2. Total of chick entrances for scenarios and realization, and production and purchasement of chicks for scenarios are given in Table 4.2. Constant scenario stabilizes in a few months, but starts destabilizing

Table 4.2: Total Chick Data of Realization and Scenarios

	TOTAL	**DOMESTIC**	%	**BOUGHT**	%
REALIZED	17825557	9259403	52	8566154	48
ACTUAL	17156689	9138235	53	8198597	48
CONST.	18095292	8898064	49	9347228	52
TREND	19523371	9053479	46	10619891	54
SEASON.	18347020	9196943	50	9300078	51
R1	17137839	9030466	53	8257373	48
R2	17532556	9045034	52	8637522	49
R3	18057817	9071096	50	9136721	51
R4	16388425	8992150	55	7546275	46
R5	16824695	8967727	53	8006967	48

after week 55. Until week 75, destabilization is not very significant, but after that week, chick entrances drop under 50,000 per week. Indeed, all the scenarios' results follow exactly the same pattern after week 75. Again, this may be attributed to end-of-horizon effect. Interestingly, total chick entrance for the constant scenario is greater than that for realized chick entrances. This may be due to assumptions of efficiencies (efficiencies of incubation house, slaughterhouse, etc.) of the system. All the efficiencies are assumed to be static, although they may be changing with time or seasons, and technology. Also, the parameters about efficiencies may be different from real values. Actual scenario is the one that chick entrance results track realized entrances most closely. Until week 75, the results seem to be satisfactory. In week 75, the same sharp decrease occurs. Trend scenario follows an increasing trend for entrances, which is not surprising. Seasonal scenario tracks the realizations very closely. Between weeks 12-29, the entrances overlap with those of actual scenario. Random scenario's series follow different patterns, but in the overall, they do not deviate from total of realizations significantly. The importance of the selected scenario is clear from this analysis. Domestic produced chicks constitute from 46% to 55% of total available chicks, and the rest are bought. Company's production process highly depends on bought chicks. This situation may be risky for the organization because of market volatilities. While analyzing the equations, it is seen that capacity expansion of breeders is required, which indicates an increase in domestic egg and chick production is needed. Solutions suggest buying chicks at their upper level, namely 170000 chicks, from 8^{th} to 25^{th} weeks, most of which are around week 20. This indicates that the organization needs more chicks for those periods. Besides, the organization needs more domestic produced chicks as they are less costly and that way of production process is less risky.

Live chickens sold and bought are negligible with respect to total slaughtering, but they occur at their bounds for most of the periods. This is because of the limit on live chickens is very low, due to the nature of the industry. Averages of slaughtered chickens per week varies between 195800 and 237500 for scenarios. Maximum of averages is for trend scenario, as expected from chick entrances. Averages of meat production varies between 336 and 277 tonnes per week. The patterns of slaughtering and meat production follow very close patterns with the chick entrances, with a time lead of 6 weeks, of course.

Between weeks 7-60, over sales do not occur for any scenarios. Both under and over sales constitute negligible quantities and far away from their tolerance limits for all scenarios. Appendix G Table G.6 can be seen for the example.

Variable about feed mill can be seen in Appendix G Table G.6 for the example. Those values are adjusted by the models to meet requirements of breeders and chickens. Appendix G Table G.7 shows that worker levels do not vary from initial values too much.Indeed, this is true for all scenarios through the planning horizon.

For expenses and revenues, results are not surprising. Breeder expenses are very different for the breeder buying periods. Sales expenses occur rarely, in which over and under sales occurred. Revenue from sold eggs, chicks and chickens are different from zero for few weeks, especially for the later weeks, but these values are small. Also as last weeks can include end-of-horizon effect, these values can be ignored.

Appendix G Table G.9 shows that shadow prices of maximum sales equations are zero, which is true for all scenarios for most of the periods. Integration has no tendency of selling any product other than chicken meat. For week 24, for example, equation of maximum eggs to buy has a shadow price of 300000 TL. This value is close to an egg's price. For equation of maximum chicks to buy, shadow price increases to 510000 TL, where for chickens to buy, it is 320000TL. The latter value is small when compared to the price of meat produced from a live chicken on average, as expected.

Capacity equations give important clues. Appendix G Table G.10 shows that only for breeder capacity equation there exist shadow prices, which is true for all scenarios. Shadow prices of other equations are zero for all scenarios, except coop capacity equation for trend, seasonal, and 3 of random scenarios for few weeks at negligible amounts. For week 36, shadow price of breeder capacity exceeds 15 million TL, which indicate a 1 unit increase in the capacity breeders will result in a 15 million TL increase in profit. Capacity expansion of breeders is crucial for the organization. Breeders' capacity expansion strategy will also decrease the risk of relying on external chick supply, which is not included in the model directly. As incubation house is not fully utilized, domestic egg production will result in domestic chick production directly.

For the time period of models, exchange rates of $ is highly volatile. Under the assumption of constant exchange rate of 1 million TL, the model is run for actual requirements scenario. Capacity of breeders is considered to be 100,000 and 150,000 for two other runs of actual requirements scenario in order to observe the capacity expansion effect. Chick entrances for actual scenario and modified versions can be seen in Appendix G Figure G.3. The lines cannot be distinguished from each other until week 26. Bought breeders at the start of the horizon for capacity expansion modifications show their effect from that week on. Changing exchange rate does not have a significant effect. Also, the entrances of capacity expansion modifications are not very considerable, but the composition of chick type change substantially. Starting with week 31, nearly no chick is bought and all the chicks are domestic productions. For capacity of 100,000, all capacity is used, but for 150,000 capacity, 131,330 is used as maximum. Roughly speaking, it is concluded that the target capacity of 130,000 breeders is suitable for the organization. Objective values of the models with current, 100,000 and 150,000 capacity are 7.20, 7.97 (11% more than current capacity) and 8.16 (13% more than current capacity) trillion TL respectively. For constant exchange rate, 54% of the chicks are domestic production, where it is 53% actual scenario. Modifications on the actual scenario do not alter the chick entrance, but the production amounts for capacity expansion cases.

Parametric analysis on Equation 4.6 is as follows. In the GAMS output, right hand side (RHS) of the equation (which is upper level, indeed) is given as the net capacity, which is 60,000 minus the number of projected breeders for the actual scenario. For the first week, it is 25,800. For the 100,000 and 150,000 capacity modifications of breeders, that value is 65,800 and 115,800 as expected. RHS increases by 12,000 at week 16, by 14,800 at week 37 and by 7,400 at week 64 for actual scenario and its modifications. Those numbers of breeders are discarded at the corresponding periods, as their productive lives end. The equation is considered as following and parametric analysis on Δ is done.

$$\sum_{l=\max(1,t-70)}^{t} BB_l + \Delta = CAPBR - PRBB_t \quad \forall t \tag{4.54}$$

$$\tag{4.55}$$

For actual scenario, Δ is 25,800 for the first three weeks. As stated previously, at the fourth week 25,800 breeder chicks are bought. Δ is zero from week 4 until week 16. Although Δ is zero for 12 weeks, there exist a shadow price of 1.4 million

TL only for week 15. The reason may be the degeneracy of the solution, which is expected due to the size of the model. For week 16 and 17, Δ is 12,000, which is equal to the discarded number of breeders. At week 18, Δ becomes zero with the purchase of breeder chicks to utilize the all unused capacity. From then on, Δ is always zero until week 64. For those 47 weeks, only for 4 weeks there exist shadow prices, which are 15.2, 4.9, 0.9 and 3.9 million TL for weeks 36, 39, 40 and 46 respectively. The discarded 7,400 breeders at week 64 cause an unused capacity, but no more breeders chicks are purchased. Δ is 7,400 until week 75, and becomes 33,200 from that week to the last week with the new discarded breeders. The plausible reason is the end-of-horizon effect.

For 100,000 capacity modification on actual scenario, the results are more clear. Δ is zero for weeks 35 to 63, and positive for other weeks. Shadow prices are seen for 6 weeks, namely 0.9, 1.1, 1.2, 5.9, 1.4 and 1.2 million TL for weeks 15, 35, 36, 41, 42 and 43 respectively. For 150,000 capacity modification, Δ is zero for all weeks. Shadow prices of all other capacity constraints have to be considered for modifications in addition to breeder house capacity constraint. Other capacities are for the incubation house, coops, slaughterhouse and feed mill divisions of the organization. For 100,000 capacity modification, no shadow price exist for other capacity constraints. For 150,000 capacity modification, the only shadow price exist for incubation house at week 36, which is 1.2 million TL. That is negligible, because incubation house is utilized with full capacity only for 2 weeks, namely weeks 35 and 36. It is well understood that, if the breeder house capacity of the organization is increased to around 130,000, none of the divisions of the organization becomes bottleneck under actual requirements scenario assumption. Of course, this result may change with another requirements forecasting. This result is very important for capacity planning of the organization, as the actual requirements scenario is the most appropriate and the most realistic one among all generated requirements scenarios.

As a conclusion, the models work reasonably good. Performances of models depend on their demand scenarios. An acceptable forecasting procedure would have increased the quality of the results, but for that to occur, more past sales data and a reliable forecasting model are required. A plausible approach to forecasting problem is discussed in Chapter 5 at the further work suggestions. The model is expected to be run for every week when new demand values are observed, at the implementation phase. By that way, master production plan can be modified according to requirements of the new changes and 80 weeks horizon can be rolled.

CHAPTER 5

CONCLUSIONS

The aim of this study had been explained as proposing a production and financial planning model for Önder Integrated Poultry Incorporation, where the model is required to cover all the divisions of the organization. The resultant model in the study for production planning purpose is believed to achieve those requirements. With little modifications, model can be generalized and applied for similar organizations. This is a very important advantage of the model.

The results are seen to be satisfactory at the end of previous chapter. They are not verified using cost figures -as practically it is not possible-, but the chick plans are seen not to be considerably different from the realized entrances. Especially, actual requirements scenario produced considerably good results compared to actual chick entrances. This can be assumed as a proof of effectiveness of the model, given that good forecasts are used.

When all results of requirements scenarios are considered, breeder plans are seen to be identical.[1] For chick entrances, all results are close to each other. Those indicate strength of the model. Of course, the results change with different requirement scenarios, but there is no serious difference between them. As shown in Chapter 3, a satisfactory forecasting procedure could not be formed. But, the

[1] For seasonal requirements scenario, there exist a tiny change for the first four weeks, but the total number of breeder chicks bought is the same with other scenarios for that piece of time.

above comments show that the model is not very sensitive to forecasting, which is a very important advantage as the time horizon used is very long.

The model is open to modifications. Parameters, assumptions, constraints, and even some of the variables can be altered for any situation. For implementation, that flexibility brings an important advantage.

Sadia Concórdia S.A. uses similar applications, and benefited a lot from them.[2] This is like another proof of the effectiveness of the model. Of course, the system that Sadia uses is much more comlicated and advanced, as its size is incomparable with Önder Integrated Poultry Incorporation. But, a successful similar application encourages the usage of the model.

Most of the problems encountered during the study are data problems. First, the organization did not permit the author to use sales data from 2002 January to current date. With old data, the study could form only a backbone of the model. Second problem is the lack of data. Only 2 years monthly sales data were available, and for time series modelling, that total of 24 data is insufficient. Third problem is the data integrity and accuracy. Sales data and coops data were supplied as paper prints, and inputting these to a spreadsheet took nearly six months. Input data are checked for consistency, and many corrections on the data were done due to input errors. Lack of information systems infrastructure appeared at this step clearly and detrimentally. Besides the data problems, the location of the organization is a great problem. It was not possible to visit the organization often. The organization do not use internet, and all the conversations and data exchange were performed using telephone and mail. These problems constitute the weaknesses of the proposed model.

Although there exist many weaknesses, strengths of the proposed model cannot be overlooked. Proposed model solution is based on the similar applications in the literature. Besides, mathematical modelling techniques and statistical methods are used to construct the planning model.

Forecasting the production requirements based on sales data could not be effectively done. Time series models are applied on the data, because of low per-

[2] For further explanations of benefits, see Taube-Netto (1996)

formance of smoothing techniques. Data are aggregated, and this strengthened the forecasts. Stability of series are taken into consideration. Autocorrelation is considered. Residual analysis is performed on series. Although Boyar (1997) suggests using ARIMA(2,1,1) Model among ARIMA, Decomposition, Winter and Harrison Harmonic Methods, ARIMA(2,1,0) Model performance for the Önder Integrated Poultry Incorporation data was very poor. Several scenarios are generated for requirements series. Difficulties come from the data problems discussed above. Forecasts can be done using subjective methods by an expert including the marketing strategies.

General production and financial planning model is simplified by considering all the coops as a single coop, namely DUMMY coop, after the eighth week. For the first eight weeks, model also formed a coops entrance plan. Average of performances of coops are considered in the model. The models' horizon is selected to be eight weeks, because for a longer horizon, estimates about coop availabilities would have been incorrect. Parameters of the model are estimated with the organization managers, and cost-related parameters are considered to depend on exchange rates. The model included all the divisions of the organization, and developed a master production plan for 80 weeks. 80 weeks horizon is chosen as a breeder has a life of approximately 70 weeks. Length of planning horizon was a problem. Model is affected by projections of current situation to initial weeks and end-of-horizon effect. The latter is tried to be removed by including end-of-horizon expense and revenue to the model.

Implementation of the designed model could not be done. The reason behind this problem is that the organization is placed in Adapazarı,and there exist insufficient communication tools with the organization.

Two further works of the study are suggested, and they are as follows. The first one is the construction of a reliable forecasting model. Without that, mathematical model cannot be implemented to the organization. In this study, forecasting model is assumed like a black box. The requirements scenarios are treated as some of the expected results of that black box, and performance of the mathematical model is tested. For a reliable forecasting model, several regressions of the dependent variable, which is sales data, on combinations of independent variables can be run. Independent variables are the ones that are expected to affect chicken meat sales. Those variables can be the series of red meat demand, fish meat demand, gross national product per capita, red meat prices, fish meat prices, inflation, interest rate, etc. After several runs of different regression models for the combinations of independent variables, the most appropriate model can be decided by considering performance criteria of the regression models. Literature review for that purpose is not performed in this study, but a great amount literature exists for such empirical analysis. Such kind of a regression modelling requires too much time and effort, and forming such a model is treated to be beyond the scope of this study.

The second suggested future work is the implementation of the model to the organization. Indeed, this future work requires the accomplishment of the first future work discussed above. In this paragraph, computer application related issues are discussed. Current situation of the mathematical model in the computer environment, i.e. the GAMS Model, is not suitable for end-users. Modifications on codes of GAMS Model is beyond their capability, but even changing inputs for each run -which is their duty actually- and preparing output reports are too much to expect from them. Applications should be designed for having a user-friendly usage of the model. For this purpose, an interface can be designed. Such an interface design requires too much time and effort, and treated to be beyond of the scope of this study. Mathematical models are solved by using GAMS, and interaction of GAMS with spreadsheets is not well developed. LINDO or LINGO would be better for solving the mathematical models at the implementation stage. Spreadsheet interaction of the model is very important as end-users are generally familiar with spreadsheets. Also, the inputs can be defined with a suitable format in spreadsheets, and results can be summarized in many ways, such as graphs, pivot tables, etc. The presentation of results are more effective in the managers point of view, and presenting the GAMS output as it is given by the program would not be favorable. Ad-hoc reports have to be generated from the results for understandability and effectiveness of the results. This would save managers' time, which is very valuable.[3]

Coordinated structure of the organization's divisions in the model constitute a framework for solving the organization's production and financial planning problem. When the yearly revenue of the organization is considered, which is about \$30 million, the importance of the study can be recognized better. The proposed model can be applied to any other integrated poultry organization, with little modifications. It is believed that, the methodology used in the study can shed light on production planning problem of any meat producing industry.

[3] For further discussion of the subject, see Laudon and Laudon (2002)

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APPENDIX A

Results Of The Experiment Of Part Weights For Chicken Carcass

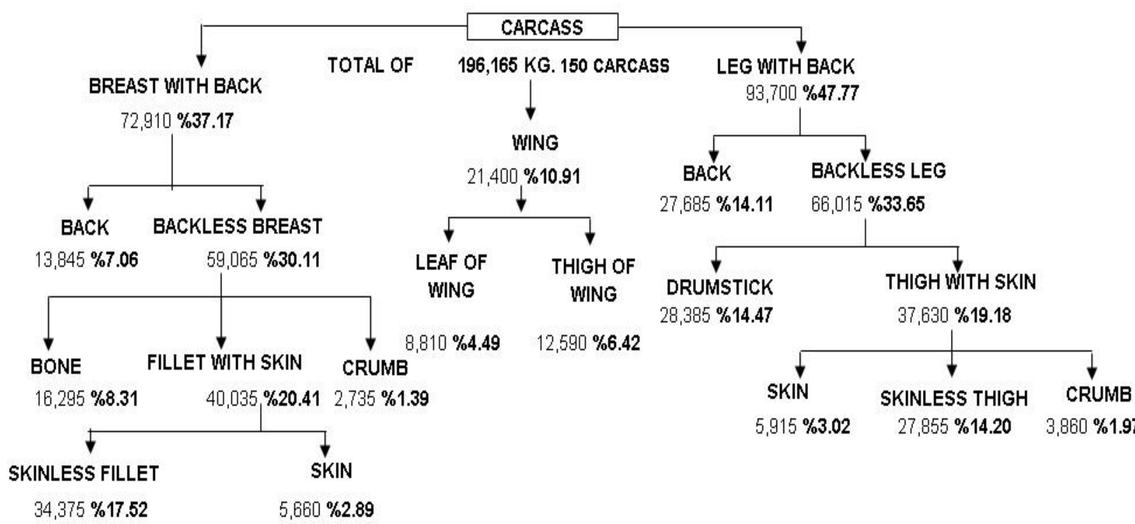


Figure A.1: Part Weights and Percentages of Chicken Carcass

Note: Under each item, there are two numbers. The numbers on the left are the total weights of parts in kilograms, the numbers on the right are the percentage of the parts in a whole chicken. The experiment is done on 150 carcasses of weight 1250-1349 grams(number-13 carcasses).

APPENDIX B

Total Production Requirements and Sales Graph

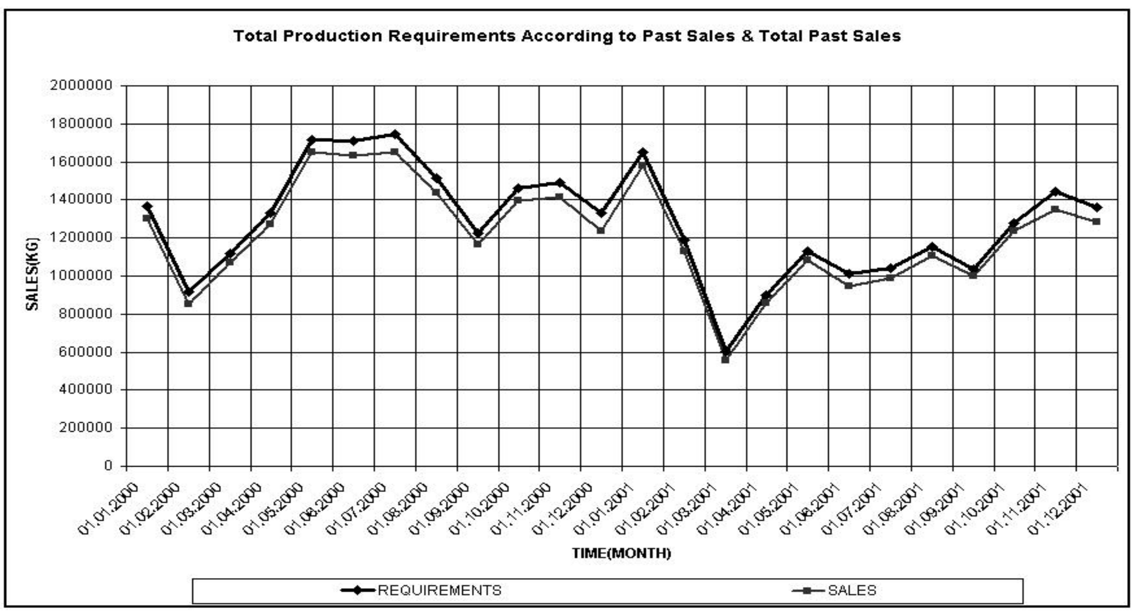


Figure B.1: The Organization's Total Production Requirements According to Past Sales and Total Past Sales

APPENDIX C

Time Series Methodology for Demand Forecasting

Application of time series methodology for demand forecasting has several steps[1], beginning with identification, which requires two basic steps: analysis of the data series and selection of the appropriate model. Analysis of the data series for the groups will involve the following basic steps: plotting of the series vs. time, autocorrelation and partial correlation charts plotting of the series (and series' differences if required), and testing for stability of the series (and series' differences if required). Autocorrelation charts provide information about the process with the partial correlation charts. Several ARIMA models (these models are explained in the next paragraph) and their autocorrelation and partial correlation charts can be found in Enders (1995) and Makridakis (1983). As usual, these charts will be given including 12 lags. Stability is an important concept in time series analysis. If the series is not stable, ARIMA Models cannot be applied to the series. Stability check will be done by Augmented Dickey-Fuller (ADF) Test for unit root. The test has three options: using an intercept, using intercept and trend term, using none. If the series is believed to be a random walk, no term is used. If it is believed to be random walk with drift, only intercept term is used. Intercept and trend are used at the same time if the series is believed to be

[1] Enders (1995),pp.95-100.

random walk with drift including a linear trend. Also, number of lagged variables is selected a priori. In our case, only one lagged variable will be chosen. If ADF statistics is smaller than MacKinnon Critical Value (also 5 percent critical value may be used), so null hypothesis of unit root existence is rejected, and the series is said to be stationary. Indeed, what is tested by ADF is the equality of coefficient of Y_{t-1}, which is ϕ, to zero in the Equation C.1 below. If ϕ is equal to zero, there exist a unit root and the series is not stationary.

$$\Delta Y_t = \mu + \phi Y_{t-1} + \gamma \Delta Y_{t-1} + e_t \; ; \; where \; \Delta Y_t = Y_t - Y_{t-1} \; is \, the \, first \, difference \tag{C.1}$$

After the analysis, an appropriate time series model, or models, will be chosen among Box-Jenkins type models. If more than one model is plausible to fit the data, all alternative models will be analyzed further.

Box-Jenkins models are also called as ARIMA Models. A general ARIMA(p,d,q) Model includes following properties. First two letters of ARIMA is AR, which refers to the "autoregressive" property of the data series. In an AR(p) process, an observation at a point in time depends on the past p observations. Third letter is I and refers to data series to be "integrated". If a series is I(d), the difference of the series at order d is a stationary series, although the series is not. Stationarity is a very important concept, and will be considered in the application. The last letters, MA refers to "moving average", and in an MA(q) process, an observation at a point in time depends on the past (q+1) error terms. A general ARIMA(p,d,q) model is given in Equation C.2 below:

$$Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_p Y_{t-p} + e_t + \theta_1 e_{t-1} + \ldots + \theta_q e_{t-q} \tag{C.2}$$

After model(s) selection, identification will be finished. Then, estimation of the chosen model's parameters will be done. Ordinary Least Squares (OLS) Method will be used for this purpose. If more than one model is plausible to fit the data, all alternative models will be analyzed using Akaike Information Criteria (AIC), Schwarz Bayesian Criteria (SBC) and Adjusted R-Square ($\bar{R}^2$) Statistics. The reason behind using these statistics is that, these criteria are used for comparing different models that include different number of observations, as plausible models will do. First two criteria suggest to select the model with the smallest statistics, while the last suggests the largest.

Diagnostic checking is the next step in the methodology. In this step, normality assumption of residuals of fitted models will be analyzed by using Quantile-Quantile Plot (QQ-Plot) for normal distribution. QQ-Plot analysis is not based on a statistical test, so Anderson-Darling and Kolmogrov-Smirnov Normality Tests are also applied to the series. Also, serial correlation of residuals will be checked using Durbin-Watson (DW) Test. This test is a one-sided test, and the null hypothesis of the test is $H_0 : \exists\ serial\ correlation\ in\ residulas$. DW statistics will be compared with the critical lower and upper values[2], $dL(T, K)$ and $dU(T, K)$, where T is the number of observations, and K is the number of coefficients used in regression. If DW statistics is smaller than $dL(T, K)$, then null hypothesis is rejected and a serial correlation is concluded. If DW statistics is greater than $dU(T, K)$, serial correlation is rejected. If DW statistics is between those values, no conclusion is drawn. If there exist serial correlation, a systematic movement in the series has not been included in ARIMA model. This will indicate an MA(p) process. Indeed, this test is a check on the autocorrelation and partial correlation charts' clue about MA process also.

Lastly, dynamic forecasting will be done, i.e. the forecasted values will be used for forecasting the next periods. With 2 years past sales data, forecasting for 18 months is not so adequate, because as forecasting horizon gets longer, that standard deviation of the forecasted value for the time point increases. But for the long-term planning activities, demand for 18 months should be forecasted. The forecasted values and 95 percent confidence intervals, which is $forecasted\ value \pm 2\sigma$, will be shown to the organization's decision makers, and final values for forecasted demand will be evaluated. After all, forecasted monthly sales will be distributed to weeks, as all planning activities are based on weeks, as a nature of process.

[2] Durbin-Watson $dL(T, K)$ and $dU(T, K)$ critical values can be found at Greene (2003),p.958.

The outline of the approach is as follows:

$$IDENTIFICATION \begin{cases} plotting\ of\ the\ series \\ autocorrelation\ and\ partial\ correlation\ analysis \\ testing\ the\ stability\ of\ the\ series:\ ADF\ Test \\ selection\ of\ ARIMA\ model(s) \end{cases}.$$

$$ESTIMATION \begin{cases} OLS\ estimation\ of\ the\ parameters\ of\ the\ series \\ choosing\ among\ ARIMA\ models\ using\ AIC,\ SBC\ and\ \bar{R}^2 \end{cases}$$

$$DIAGNOSTICS \begin{cases} check\ of\ normality\ of\ residuals:\ QQ-Plots,\ Normality\ Tests \\ serial\ correlation\ of\ residuals\ analysis:\ DW\ Test \end{cases}.$$

$$FORECASTING$$

APPENDIX D

Analysis and Statistics of Production Requirements Series Forecasting

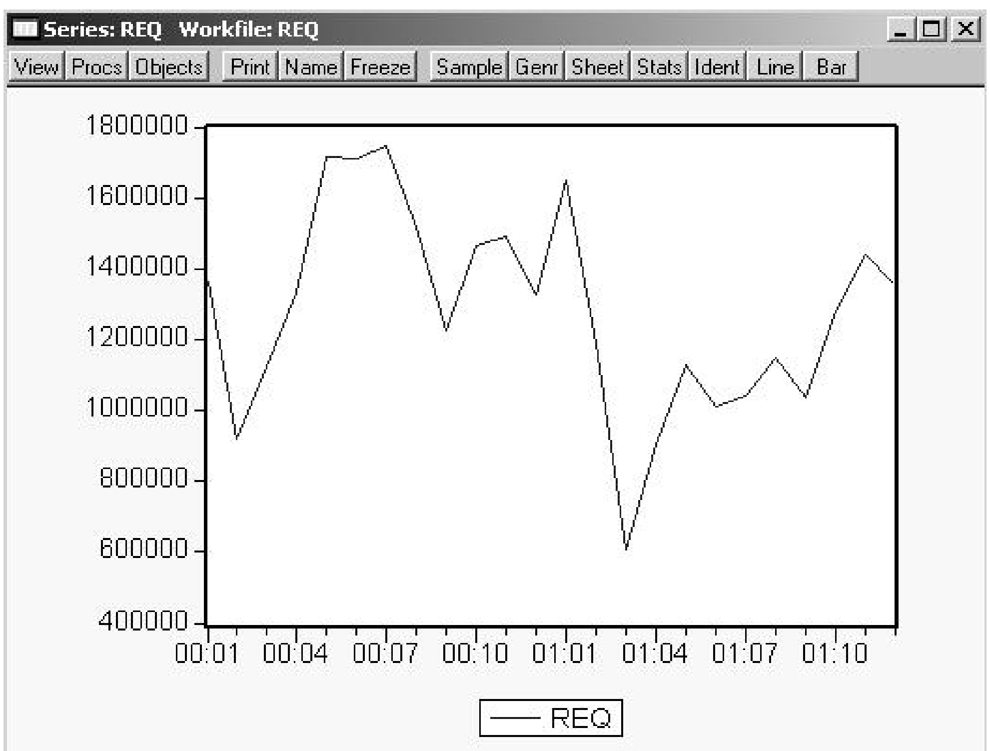
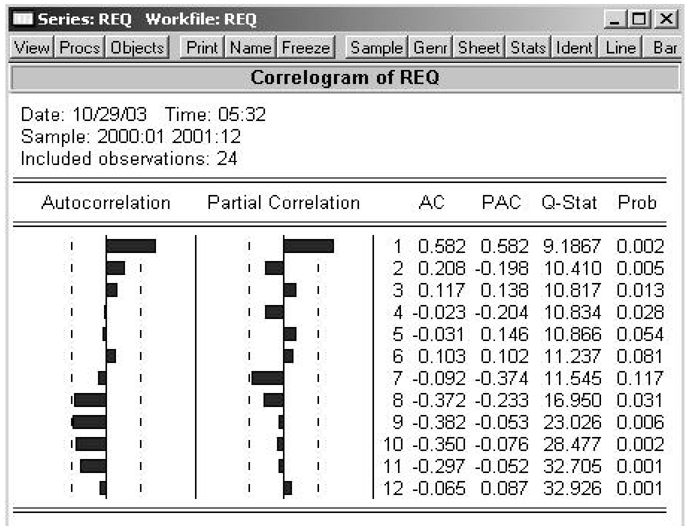


Figure D.1: Production Requirements Series



Series: REQ Workfile: REQ

View | Procs | Objects | Print | Name | Freeze | Sample | Genr | Sheet | Stats | Ident | Line | Bar

Correlogram of REQ

Date: 10/29/03 Time: 05:32
Sample: 2000:01 2001:12
Included observations: 24

	AC	PAC	Q-Stat	Prob
1	0.582	0.582	9.1867	0.002
2	0.208	-0.198	10.410	0.005
3	0.117	0.138	10.817	0.013
4	-0.023	-0.204	10.834	0.028
5	-0.031	0.146	10.866	0.054
6	0.103	0.102	11.237	0.081
7	-0.092	-0.374	11.545	0.117
8	-0.372	-0.233	16.950	0.031
9	-0.382	-0.053	23.026	0.006
10	-0.350	-0.076	28.477	0.002
11	-0.297	-0.052	32.705	0.001
12	-0.065	0.087	32.926	0.001

Figure D.2: Production Requirements Series' Correlation and Partial Correlation Charts

Series: REQ Workfile: REQ

View | Procs | Objects | Print | Name | Freeze | Sample | Genr | Sheet | Stats | Ident | Line

Augmented Dickey-Fuller Unit Root Test on REQ

ADF Test Statistic	-2.350147	1% Critical Value*	-3.7497
		5% Critical Value	-2.9969
		10% Critical Value	-2.6381

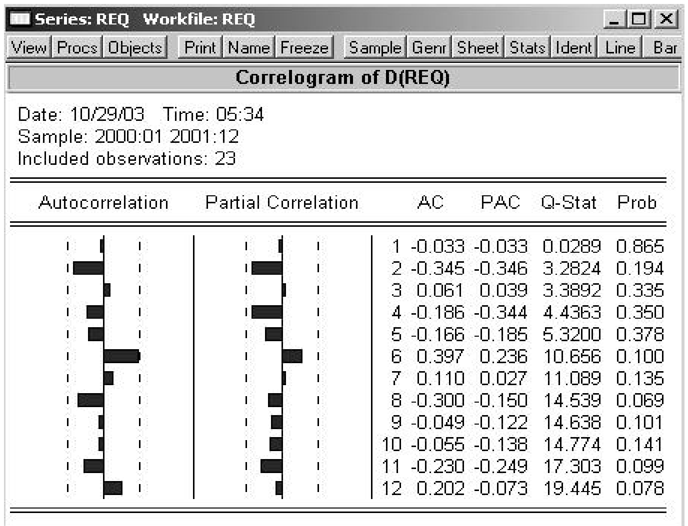
*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(REQ)
Method: Least Squares
Date: 10/29/03 Time: 05:35
Sample(adjusted): 2000:02 2001:12
Included observations: 23 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REQ(-1)	-0.416251	0.177117	-2.350147	0.0286
C	531256.0	231776.3	2.292106	0.0323

R-squared	0.208240	Mean dependent var	-221.3835
Adjusted R-squared	0.170537	S.D. dependent var	267369.0
S.E. of regression	243505.9	Akaike info criterion	27.72661
Sum squared resid	1.25E+12	Schwarz criterion	27.82535
Log likelihood	-316.8560	F-statistic	5.523191
Durbin-Watson stat	1.582167	Prob(F-statistic)	0.028619

Figure D.3: Production Requirements Series' Augmented Dickey-Fuller Test Results


Series: REQ Workfile: REQ

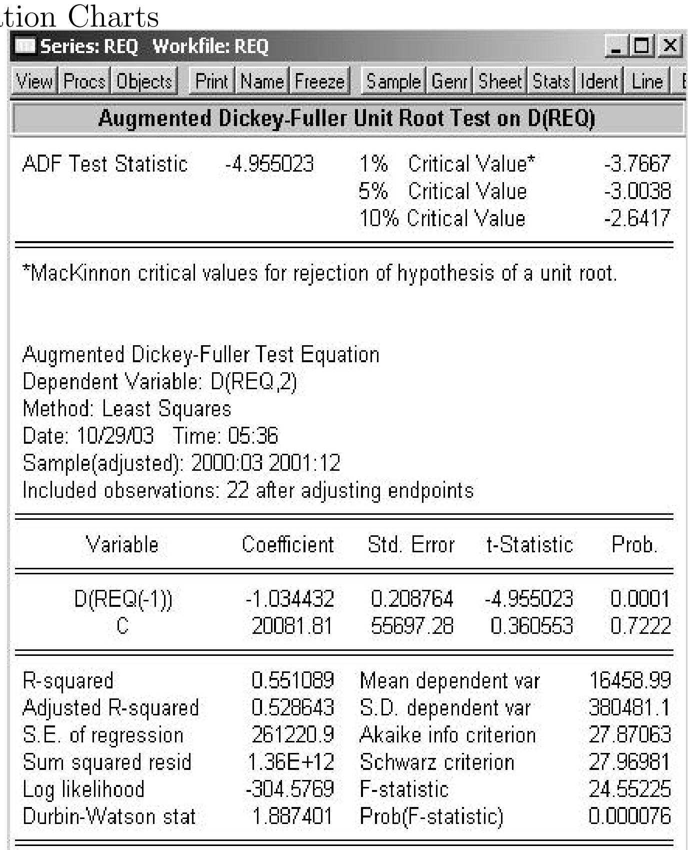
View | Procs | Objects | Print | Name | Freeze | Sample | Genr | Sheet | Stats | Ident | Line | Bar

Correlogram of D(REQ)

Date: 10/29/03 Time: 05:34
Sample: 2000:01 2001:12
Included observations: 23

	AC	PAC	Q-Stat	Prob
1	-0.033	-0.033	0.0289	0.865
2	-0.345	-0.346	3.2824	0.194
3	0.061	0.039	3.3892	0.335
4	-0.186	-0.344	4.4363	0.350
5	-0.166	-0.185	5.3200	0.378
6	0.397	0.236	10.656	0.100
7	0.110	0.027	11.089	0.135
8	-0.300	-0.150	14.539	0.069
9	-0.049	-0.122	14.638	0.101
10	-0.055	-0.138	14.774	0.141
11	-0.230	-0.249	17.303	0.099
12	0.202	-0.073	19.445	0.078

Figure D.4: Production Requirements Series' First Differences' Correlation and Partial Correlation Charts


Series: REQ Workfile: REQ

View | Procs | Objects | Print | Name | Freeze | Sample | Genr | Sheet | Stats | Ident | Line

Augmented Dickey-Fuller Unit Root Test on D(REQ)

ADF Test Statistic	-4.955023	1% Critical Value*	-3.7667
		5% Critical Value	-3.0038
		10% Critical Value	-2.6417

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(REQ,2)
Method: Least Squares
Date: 10/29/03 Time: 05:36
Sample(adjusted): 2000:03 2001:12
Included observations: 22 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(REQ(-1))	-1.034432	0.208764	-4.955023	0.0001
C	20081.81	55697.28	0.360553	0.7222

R-squared	0.551089	Mean dependent var	16458.99
Adjusted R-squared	0.528643	S.D. dependent var	380481.1
S.E. of regression	261220.9	Akaike info criterion	27.87063
Sum squared resid	1.36E+12	Schwarz criterion	27.96981
Log likelihood	-304.5769	F-statistic	24.55225
Durbin-Watson stat	1.887401	Prob(F-statistic)	0.000076

Figure D.5: Production Requirements Series' First Differences' Augmented Dickey-Fuller Test Results

Equation: UNTITLED Workfile: REQ

View | Procs | Objects | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: D(REQ)
Method: Least Squares
Date: 10/29/03 Time: 05:45
Sample(adjusted): 2000:02 2001:12
Included observations: 23 after adjusting endpoints
D(REQ)=C(1)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-221.3835	55750.30	-0.003971	0.9969

R-squared	0.000000	Mean dependent var	-221.3835
Adjusted R-squared	0.000000	S.D. dependent var	267369.0
S.E. of regression	267369.0	Akaike info criterion	27.87315
Sum squared resid	1.57E+12	Schwarz criterion	27.92252
Log likelihood	-319.5412	Durbin-Watson stat	1.936829

Figure D.6: Estimation of Production Requirements Series Using ARIMA(0,1,0) Process

Equation: UNTITLED Workfile: REQ

View | Procs | Objects | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: D(REQ)
Method: Least Squares
Date: 10/29/03 Time: 05:44
Sample(adjusted): 2000:03 2001:12
Included observations: 22 after adjusting endpoints
D(REQ)=C(1)+C(2)*D(REQ(-1))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	20081.81	55697.28	0.360553	0.7222
C(2)	-0.034432	0.208764	-0.164934	0.8707

R-squared	0.001358	Mean dependent var	19961.22
Adjusted R-squared	-0.048574	S.D. dependent var	255098.8
S.E. of regression	261220.9	Akaike info criterion	27.87063
Sum squared resid	1.36E+12	Schwarz criterion	27.96981
Log likelihood	-304.5769	F-statistic	0.027203
Durbin-Watson stat	1.887401	Prob(F-statistic)	0.870652

Figure D.7: Estimation of Production Requirements Series Using ARIMA(1,1,0) Process

Equation: UNTITLED Workfile: REQ

View | Procs | Objects | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: D(REQ)
Method: Least Squares
Date: 10/29/03 Time: 05:43
Sample(adjusted): 2000:04 2001:12
Included observations: 21 after adjusting endpoints
D(REQ)=C(1)+C(2)*D(REQ(-1))+C(3)*D(REQ(-2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	9593.007	55222.52	0.173715	0.8640
C(2)	0.013376	0.216371	0.061818	0.9514
C(3)	-0.351169	0.203024	-1.729696	0.1008

R-squared	0.142985	Mean dependent var	11325.30
Adjusted R-squared	0.047761	S.D. dependent var	258082.2
S.E. of regression	251843.6	Akaike info criterion	27.84257
Sum squared resid	1.14E+12	Schwarz criterion	27.99178
Log likelihood	-289.3470	F-statistic	1.501570
Durbin-Watson stat	1.964758	Prob(F-statistic)	0.249399

Figure D.8: Estimation of Production Requirements Series Using ARIMA(2,1,0) Process

Equation: UNTITLED Workfile: REQ

View | Procs | Objects | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: D(REQ)
Method: Least Squares
Date: 10/29/03 Time: 05:42
Sample(adjusted): 2000:05 2001:12
Included observations: 20 after adjusting endpoints
D(REQ)=C(1)+C(2)*D(REQ(-1))+C(3)*D(REQ(-2))+C(4)*D(REQ(-3))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	7846.726	59844.51	0.131119	0.8973
C(2)	0.030055	0.249268	0.120572	0.9055
C(3)	-0.333743	0.230728	-1.446477	0.1673
C(4)	0.059474	0.236159	0.251840	0.8044

R-squared	0.120424	Mean dependent var	1342.781
Adjusted R-squared	-0.044496	S.D. dependent var	260593.9
S.E. of regression	266328.6	Akaike info criterion	27.99971
Sum squared resid	1.13E+12	Schwarz criterion	28.19885
Log likelihood	-275.9971	F-statistic	0.730196
Durbin-Watson stat	1.802677	Prob(F-statistic)	0.548904

Figure D.9: Estimation of Production Requirements Series Using ARIMA(3,1,0) Process

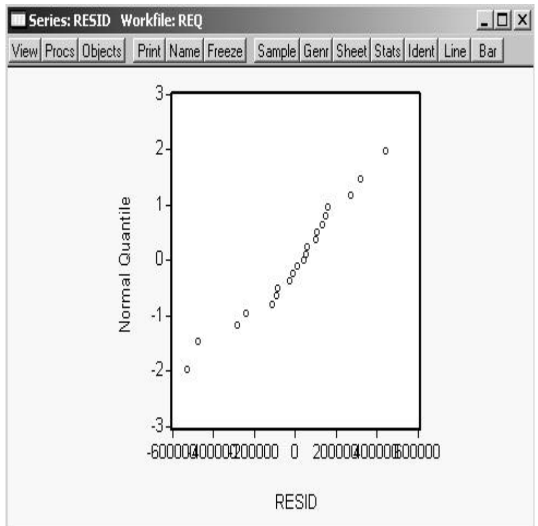


Figure D.10: Production Requirements Series' Residuals' Quantile-Quantile Plot for Normal Distribution

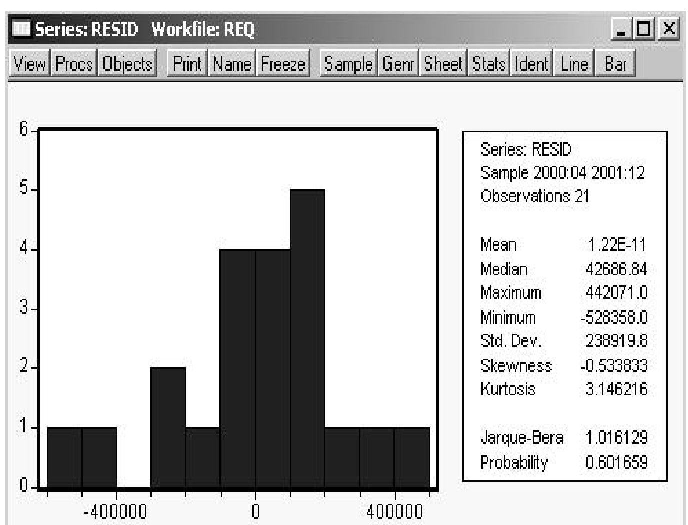


Figure D.11: Production Requirements Series' Residuals' Statistics

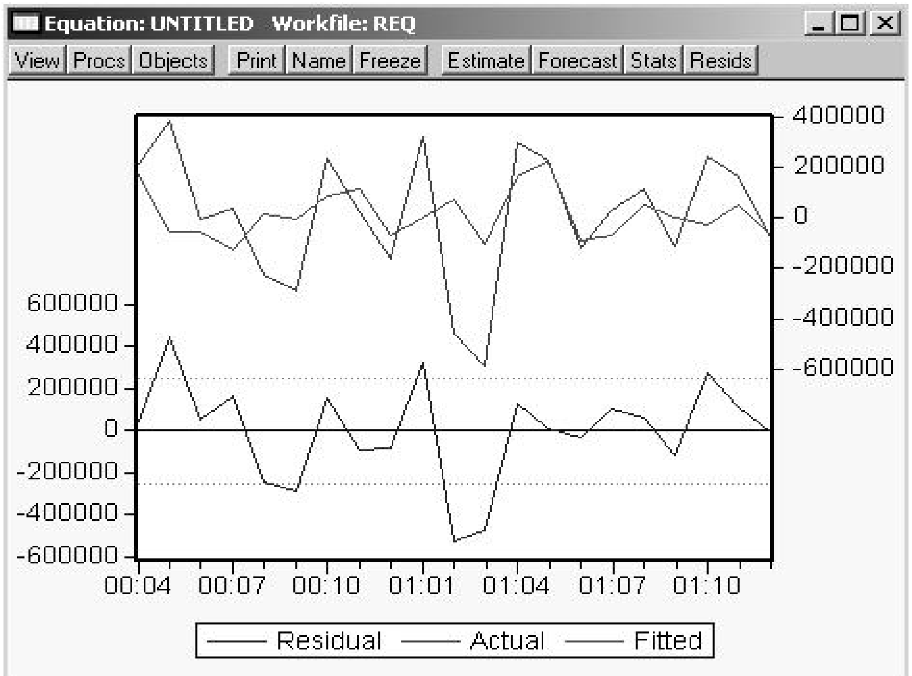


Figure D.12: Actual, Fitted and Residual Values of Production Requirements Series Using ARIMA(2,1,0)

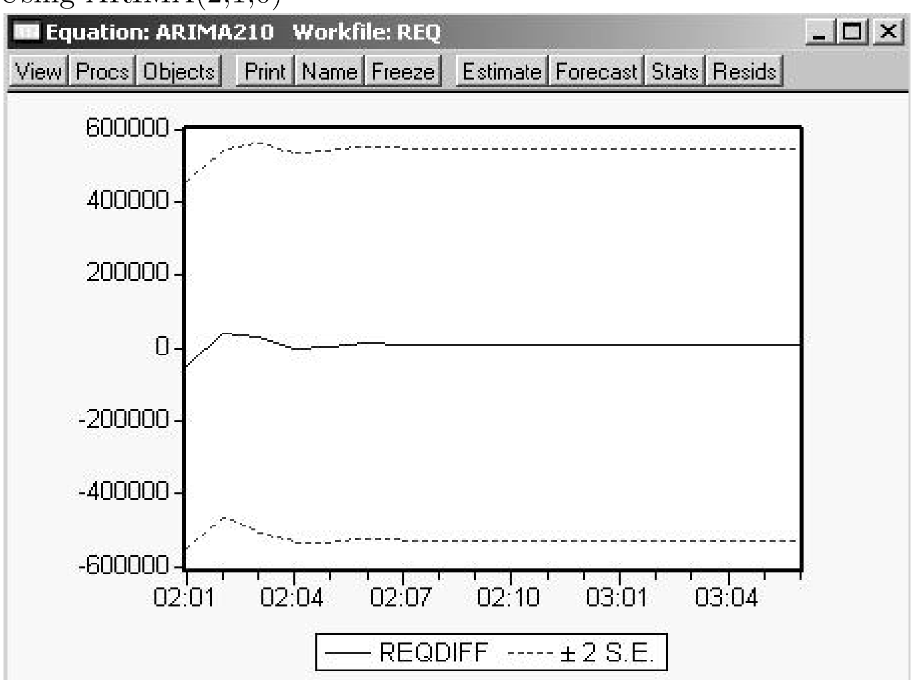


Figure D.13: Forecasted Values and 2σ Limits of Forecasts of Production Requirements Series for 18 Months

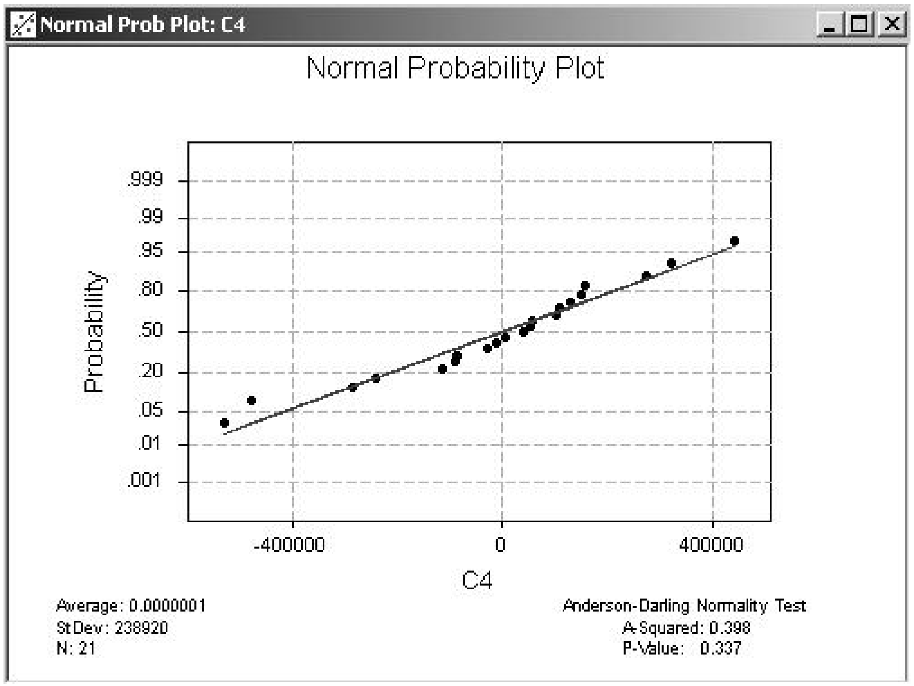


Figure D.14: Anderson-Darling Normality Test Results of Production Requirements Series' Residuals

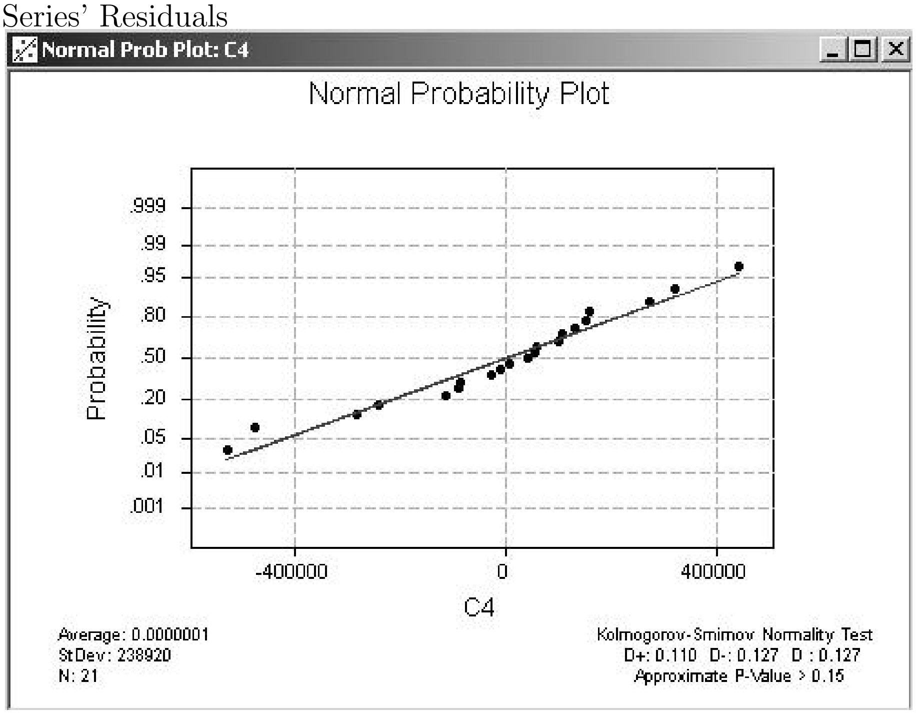


Figure D.15: Kolmogrov-Smirnov Normality Test Results of Production Requirements Series' Residuals

APPENDIX E

Normality Tests and Generated Series for Random Requirements Scenario

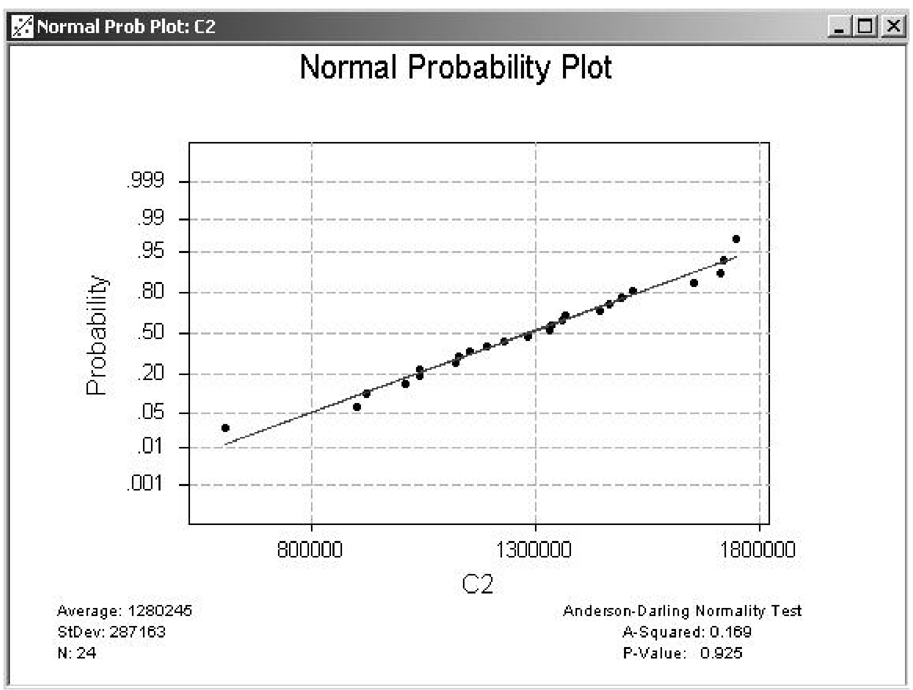


Figure E.1: Anderson-Darling Normality Test Results of Production Requirements Series for the Years 2000-2001

Table E.1: Randomly Generated Series for 18 Months Horizon Under Normality Assumption

MONTH	RNDM1	RNDM2	RNDM3	RNDM4	RNDM5
1	1343079	1222490	1381049	1342056	1091295
2	1399277	1341756	1670012	1215722	1108105
3	1015480	938647	1598275	1292345	1487992
4	845909	902543	1536205	1134282	889565
5	1003332	1563250	1393672	851423	1304949
6	1536205	1780161	1687919	1495139	1594929
7	1358626	1436413	1334027	1631521	1215348
8	1439611	1325771	1470149	963163	1095013
9	1487992	1306292	1146803	864599	1165067
10	1246806	1363958	1206861	1114223	1091647
11	1274760	1138270	972037	1470569	1129581
12	1307762	1799033	1208546	1226354	1527599
13	1520105	1790422	1557771	1547105	1417565
14	1375644	1136176	1610709	1018873	1203269
15	1186856	857369	1193117	1309361	1258325
16	938036	1038799	972387	1310630	1189364
17	1131102	1461849	1673449	1095940	1239706
18	1218494	1290223	1348283	853224	895078

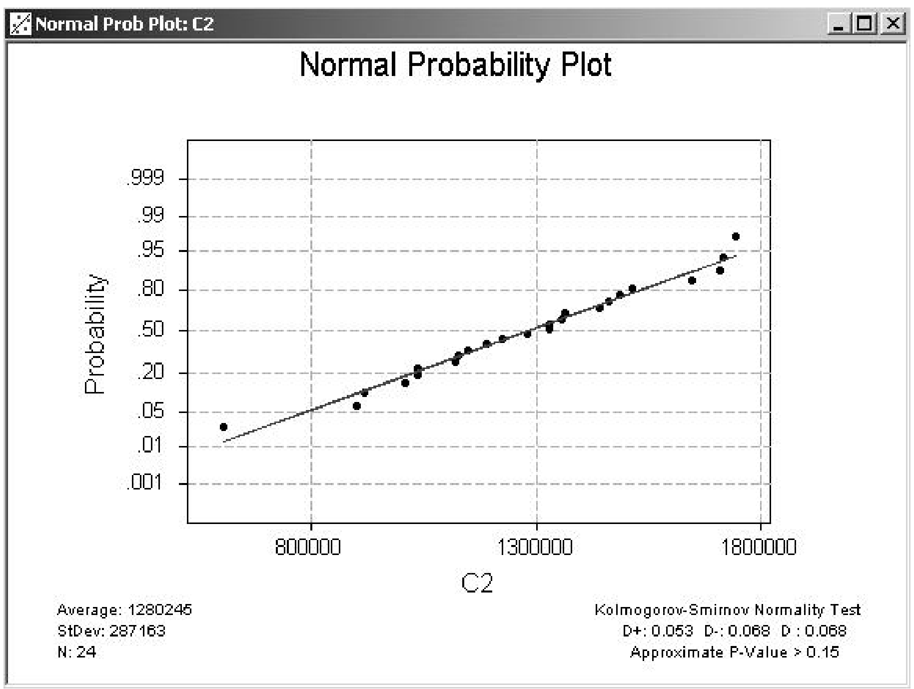


Figure E.2: Kolmogrov-Smirnov Normality Test Results of Production Requirements Series for the Years 2000-2001

APPENDIX F

Graphs of Scenarios

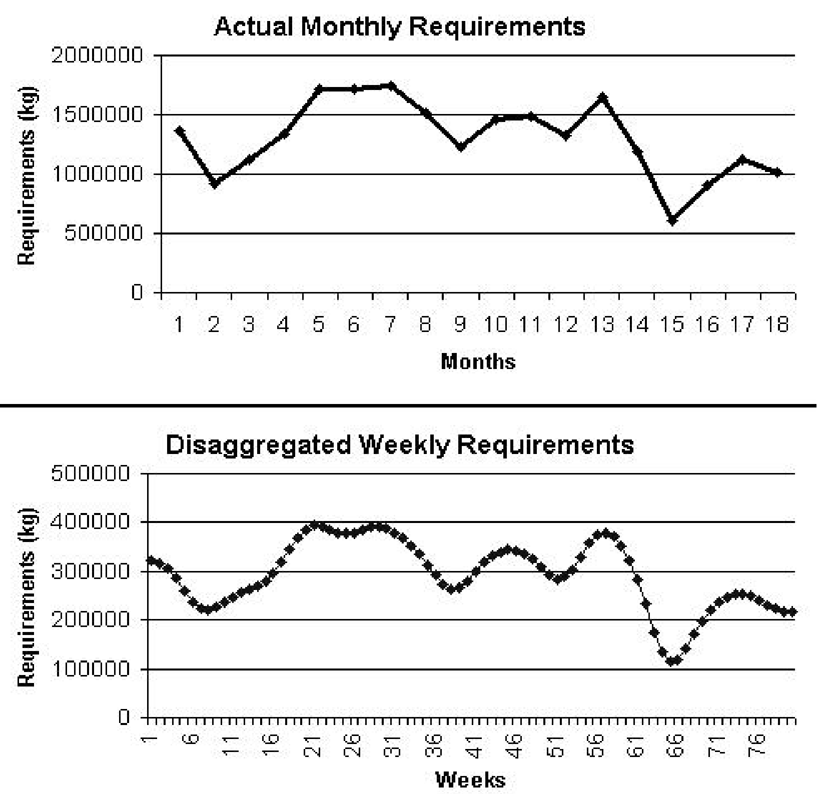


Figure F.1: Monthly Actual Requirements versus Weekly Disaggregated Requirements for Actual Requirements Scenario

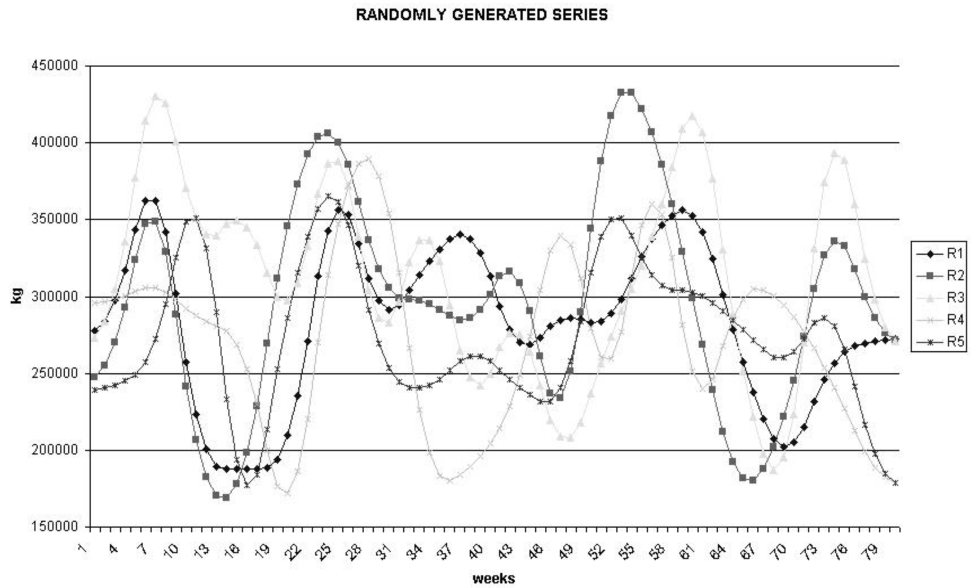


Figure F.2: Weekly Requirements of Randomly Generated Series Graph Under Normality Assumption for Random Requirements Scenario

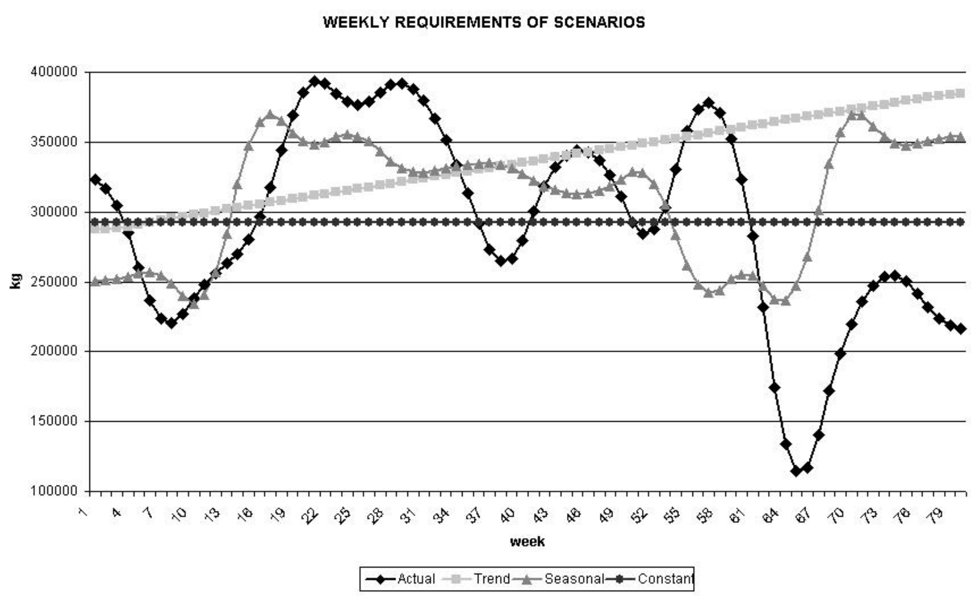


Figure F.3: Weekly Requirements of Actual Past, Constant, Trend, and Seasonal Requirements Scenarios

APPENDIX G

Appendices of General Production and Financial Planning Problem

Table G.1: Parameter Values of General Production and Financial Planning Problem

Time	BFCR	BPM	REQ	PRBB	PRBFC	PREGG	USD
1	80		323372	34200	30.4	110000	0.535
2	90		317068	34200	30.6	110000	0.54
3	105		304457	34200	30.9	110000	0.545
4	120		285542	34200	30.9	110000	0.55
5	135		260330	34200	31.1	110000	0.56
6	155		236988	34200	31.3	110000	0.56
7	175		223696	34200	31.4	110000	0.563
8	200		220454	34200	31.8	98000	0.562
9	225		227263	34200	32.1	98000	0.572
10	255		238386	34200	32.5	98000	0.578
11	290		248093	34200	32.9	98000	0.577
12	330		256383	34200	33.3	98000	0.58
13	380		263252	34200	33.5	86000	0.584

Time	BFCR	BPM	REQ	PRBB	PRBFC	PREGG	USD
14	440		269541	34200	33.7	71200	0.588
15	510		280277	34200	33.7	71200	0.59
16	580		296307	22200	33.4	59200	0.595
17	650		317620	22200	22.9	59200	0.603
18	710		344226	22200	23.1	59200	0.612
19	770		369177	22200	23.3	66600	0.614
20	820		385515	22200	23.5	74000	0.616
21	865		393227	22200	23.5	74000	0.617
22	905		392303	22200	23.7	66600	0.614
23	940		384326	22200	23.7	66600	0.61
24	970	1	378678	22200	23.8	74000	0.611
25	995	2	376942	22200	23.7	74000	0.615
26	1015	2	379117	22200	23.8	74000	0.621
27	1035	3	385184	22200	23.8	74000	0.621
28	1050	3	390857	22200	23.7	81400	0.621
29	1065	4	391840	22200	23.7	66600	0.628
30	1075	4	388154	22200	23.7	66600	0.629
31	1085	4	379793	22200	23.5	66600	0.635
32	1095	4	367051	22200	23.4	66600	0.643
33	1100	5	351655	22200	23.2	66600	0.643
34	1105	5	333888	22200	23	51800	0.649
35	1110	5	313759	22200	22.7	51800	0.65
36	1110	5	291275	22200	22.3	51800	0.655
37	1110	5	272788	7400	21.5	37000	0.665
38	1110	5	264654	7400	8.2	37000	0.67
39	1105	5	266890	7400	8.2	37000	0.665
40	1105	5	279504	7400	8.2	37000	0.667
41	1105	5	300587	7400	8.2	29600	0.67
42	1100	5	318717	7400	8.2	29600	0.677
43	1100	5	331997	7400	8.1	29600	0.683
44	1100	5	340422	7400	8.1	29600	0.682
45	1095	5	343971	7400	8.1	29600	0.68
46	1095	4	342732	7400	8.1	29600	0.682
47	1095	4	336776	7400	8.1	29600	0.687
48	1090	4	326109	7400	8	29600	0.685
49	1090	4	310736	7400	8	22200	0.679
50	1090	4	292720	7400	8	22200	0.681

Time	BFCR	BPM	REQ	PRBB	PRBFC	PREGG	USD
51	1085	4	284446	7400	8	22200	0.679
52	1085	4	287964	7400	7.9	22200	0.671
53	1080	4	303277	7400	7.9	22200	0.666
54	1080	3	330399	7400	7.9	22200	0.668
55	1075	3	357692	7400	7.8	22200	0.669
56	1075	3	373544	7400	7.8	14800	0.671
57	1060	3	377948	7400	7.7	14800	0.679
58	1060	3	370895	7400	7.7	14800	0.676
59	1055	3	352464	7400	7.6	14800	0.679
60	1050	3	323148	7400	7.5	14800	0.688
61	1045	2	283029	7400	7.4	7400	0.92
62	1040	2	232116	7400	7.3	7400	0.903
63	1030	2	174429	7400	7.1	7400	0.94
64	1020	2	134017		6.7		0.971
65	1010	2	114893				0.981
66	1000	1	117065				1.232
67	975	1	140517				1.278
68	950	1	172058				1.215
69	900		198505				1.213
70			219863				1.137
71			236131				1.14
72			247318				1.139
73			253465				1.104
74			254568				1.121
75			250633				1.165
76			241661				1.119
77			231450				1.236
78			223799				1.265
79			218696				1.269
80			216141				1.302

Table G.2: Capacities, Performance Measures and Availability Matrix of a Sample from Coops

					AVA (by weeks)							
COOP	CAPA.	FCR	LW	DEATH	1	2	3	4	5	6	7	8
ABDULLAHG	6900	1.883	2.046	0.051	0	0	0	0	1	0	0	0
ABDULTUR	11500	1.971	1.994	0.066	0	0	1	0	0	0	0	0
ADEMCEKEN	6500	2.146	1.888	0.124	0	1	0	0	0	0	0	0
AHMETAKAN	9250	1.936	1.949	0.071	0	0	0	0	0	1	0	0
AHMETKOC	17000	1.940	2.116	0.069	1	0	0	0	0	0	0	0
AHMETSARI	8700	1.863	1.920	0.057	0	0	0	0	0	1	0	0
ALIAKGUN	11650	1.987	1.847	0.082	0	0	0	1	0	0	0	0
ALIDEMIRLI	21000	1.947	1.719	0.051	0	1	0	0	0	0	0	0
AYHANTER	35000	1.910	1.881	0.062	0	0	0	0	0	0	0	1
BAYRAMGUL	13125	1.954	1.882	0.074	0	0	0	0	0	0	1	0
BEKIRKELES	12100	2.032	1.870	0.084	0	0	0	0	1	0	0	0
BEKIRSEZGIN	14000	2.074	1.889	0.168	0	0	0	1	0	0	0	0
BURHANCEYL	11850	1.826	1.921	0.060	0	0	1	0	0	0	0	0
CALISKANTAV	31500	1.825	1.950	0.042	1	0	0	0	0	0	0	0
CELALETTIN	5400	1.979	1.886	0.090	0	0	0	1	0	0	0	0
CEMALETTIN	14820	1.995	1.878	0.096	0	0	0	0	1	0	0	0
CEMALGULER	14400	2.289	1.859	0.151	0	0	0	0	0	0	0	1
CEMILYILMAZ	3800	2.057	1.947	0.109	1	0	0	0	0	0	0	0
DURSUNBAY	15000	2.120	1.814	0.114	0	0	0	0	0	0	1	0
DURSUNUYG	11300	1.996	1.873	0.064	0	1	0	0	0	0	0	0
EMINKILIC	9540	1.862	2.015	0.147	0	0	1	0	0	0	0	0
ERCANBULUT	67900	2.601	1.971	0.233	0	0	0	0	1	0	0	0
ERDINCBASN	8500	2.237	1.688	0.126	0	0	1	0	0	0	0	0
ERTANISPIR	15500	1.901	1.826	0.085	0	1	0	0	0	0	0	0
ERTUGRULYS	4000	1.887	1.985	0.053	0	0	0	0	0	1	0	0
FARUKTUFE	12500	1.942	1.965	0.082	1	0	0	0	0	0	0	0
DUMMY	295000	2.014	1.912	0.085	0	0	0	0	0	0	0	0

Table G.3: Model Statistics of General Production and Financial Planning Problem According to Requirement Scenarios

	ACTUAL	CONST.	TREND	SEASON.	
Objective	7196737	8130886	8891244	8283929	
Total revenue	35341596	38184868	42444316	40005842	
Total expenses	28144860	30053982	33553073	31721914	
	R1	R2	R3	R4	R5
Objective	7712943	7477382	7707314	7558984	7618121
Total revenue	35994469	36991888	38536649	34701187	35368725
Total expenses	28281527	29514506	30829335	27142203	27750604

Table G.4: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 1

t	BB	EGG	EG	EG+	EG-	CHICK	CHI
20	0	94000	74000	20000	0	233360	63360
21	0	94000	74000	20000	0	233360	63360
22	0	86600	66600	20000	0	239280	69280
23	0	86600	66600	20000	0	245200	75200
24	0	94000	74000	20000	0	245200	75200
25	0	94000	74000	20000	0	239280	69280
26	0	90446.2	74000	16446.2	0	239280	69280
27	0	99800	99800	0	0	245200	75200
28	0	133000	133000	0	0	245200	75200
29	0	118200	118200	0	0	242356.96	72356.96
30	0	144000	144000	0	0	224989.63	79840
31	0	144000	144000	0	0	210709.72	106400
32	0	169800	169800	0	0	204426.77	94560
33	0	169800	169800	0	0	206153.92	115200
34	0	155000	155000	0	0	215897.36	115200
35	0	155000	155000	0	0	232182.5	135840
36	0	180800	180800	0	0	246186.67	135840
37	14800	166000	166000	0	0	256444.54	124000
38	0	166000	166000	0	0	262952.27	124000
39	0	166000	166000	0	0	265693.62	144640
40	0	166000	166000	0	0	264736.58	132800
41	0	170600	170600	0	0	260135.98	132800
42	0	182600	182600	0	0	251896.47	132800
43	0	182600	182600	0	0	240021.9	132800
44	0	194600	194600	0	0	226105.8	136480
45	0	194600	194600	0	0	219714.71	146080
46	0	206600	206600	0	0	222432.12	146080
47	0	206600	206600	0	0	234260.34	155680
48	0	206600	206600	0	0	255210.2	155680
49	0	173400	173400	0	0	276292.14	165280
50	0	185400	185400	0	0	288536.7	165280

Table G.5: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 2

t	CHI+	CHI-	X+	X-	SLG	SLGP
20	170000	0	20000	0	261926	370593.86
21	170000	0	20000	0	261926	370593.86
22	170000	0	20000	0	253142	358165.55
23	170000	0	20000	0	242308.4	342837.31
24	170000	0	20000	0	242308.4	342837.31
25	170000	0	20000	0	233524.4	330409
26	170000	0	20000	0	233524.4	330409
27	170000	0	20000	0	233524.4	330409
28	170000	0	20000	0	238941.2	338073.13
29	170000	0	20000	0	244358	345737.25
30	145149.63	0	20000	0	244358	345737.25
31	104309.72	0	20000	0	238941.2	338073.13
32	109866.77	0	20000	0	238941.2	338073.13
33	90953.92	0	20000	0	244358	345737.25
34	100697.36	0	11625.26	0	235983.26	333888
35	96342.5	0	0	0	221756.62	313759
36	110346.67	0	0	0	205865.52	291275
37	132444.54	0	0	0	192799.39	272788
38	138952.27	0	0	0	187050.49	264654
39	121053.62	0	0	0	188630.84	266890
40	131936.58	0	0	0	197546.08	279504
41	127335.98	0	0	0	212446.99	300587
42	119096.47	0	0	0	225260.8	318717
43	107221.9	0	0	0	234646.75	331997
44	89625.8	0	0	0	240601.32	340422
45	73634.71	0	0	0	243109.66	343971
46	76352.12	0	0	0	242233.97	342732
47	78580.34	0	0	0	238024.43	336776
48	99530.2	0	0	0	230485.27	326109
49	111012.14	0	0	0	219620.04	310736
50	123256.7	0	0	0	206886.8	292720

Table G.6: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 3

t	REQ+	REQ-	BFC	CFC	FMP	RMIFM	RMB
20	0	14921.14	41.53	888.62	930.15	453.76	918.84
21	0	22633.14	43.26	864.27	907.53	445.89	899.65
22	0	34137.45	45.19	846.6	891.78	444.3	890.19
23	0	41488.69	46.72	841.88	888.59	442.91	887.21
24	0	35840.69	48.22	837.6	885.82	714.18	1157.09
25	0	46533	49.45	844.12	893.57	706.44	885.82
26	0	48708	50.75	850.92	901.68	455.55	650.79
27	0	54775	51.89	859.21	911.1	457.96	913.5
28	0	52783.87	52.85	863.06	915.91	684.09	1142.04
29	0	46102.75	53.85	861.15	915	455.37	686.28
30	0	42416.75	54.96	855.78	910.74	689.26	1144.63
31	0	41719.87	55.87	850.73	906.6	693.4	910.74
32	0	28977.87	57	839.17	896.16	436.42	639.18
33	0	5917.75	57.9	814.94	872.84	727.16	1163.58
34	0	0	58.79	786.82	845.61	409.95	528.4
35	0	0	59.47	760.43	819.9	780.1	1190.05
36	0	0	59.92	755.49	815.41	784.59	819.9
37	0	0	61.03	772.81	833.84	766.16	815.41
38	0	0	48.55	806	854.55	448.08	536.47
39	0	0	49.25	846.91	896.16	467.93	916.01
40	0	0	49.89	885.97	935.86	481.85	949.78
41	0	0	50.48	913.22	963.69	636.31	1118.15
42	0	0	50.94	927.23	978.17	621.83	963.69
43	0	0	51.38	928.06	979.44	484.02	841.63
44	0	0	51.99	916.04	968.03	472.84	956.86
45	0	0	52.41	893.28	945.69	458.66	931.51
46	0	0	53.03	864.29	917.33	682.67	1141.34
47	0	0	53.67	836.02	889.69	435.74	642.76
48	0	0	54.16	817.32	871.47	436.1	871.84
49	0	0	55.02	817.19	872.21	448.98	885.08
50	0	0	55.96	841.99	897.95	471.08	920.06

Table G.7: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 4

t	WB	WI	WS	WF	RMPURC	PEFM	ICCFM
20	6	3.13	104.77	9.3	81923.05	84516.68	209.64
21	6	3.13	104.77	9.16	84712.24	82472.69	206.34
22	6	3.13	101.26	9.16	83243.57	80500.33	204.6
23	6	3.13	97.74	9.16	82046.52	79618.68	202.63
24	6	3.13	97.74	9.16	91368.59	79431.05	327.27
25	6	3.13	97.74	9.16	88854.79	80612.4	325.84
26	6	3.13	97.74	9.16	80577.71	82097.76	212.17
27	6	3.33	97.74	9.16	76738.6	82926.12	213.29
28	6	4.43	97.74	9.16	86266.79	83332.51	318.61
29	6	4.43	97.74	9.16	83301.41	84142.29	214.48
30	6	4.8	97.74	9.16	94507.08	83825.19	325.16
31	6	4.8	97.74	9.16	86492.28	84190.03	330.23
32	6	5.66	97.74	9.16	83082.75	84193.45	210.46
33	6	5.66	97.74	9.16	89410.09	81903.1	350.67
34	6	5.66	97.24	9.16	72738.81	79976.26	199.54
35	6	5.66	97.24	9.16	95512.03	77562.07	380.3
36	6	6.03	97.24	9.16	82463.02	77697.08	385.43
37	6	6.03	97.24	9.16	91510.59	80669.79	382.12
38	6	6.03	97.24	9.16	70134.14	83942.86	225.16
39	6	6.03	97.24	9.16	77124.77	87434.06	233.38
40	6	6.03	97.24	9.36	81596.46	91676.24	241.04
41	6	6.03	97.24	9.64	100868.99	94880.12	319.74
42	6	6.09	97.24	9.78	101365.2	97304.97	315.73
43	6	6.09	97.24	9.79	97561.36	98257.41	247.94
44	6	6.49	97.24	9.79	94381.3	96915.28	241.86
45	6	6.49	97.24	9.79	93239.15	94331.89	233.92
46	6	6.89	97.24	9.79	104573.72	91677.96	349.19
47	6	6.89	97.24	9.79	90026.13	89471.9	224.51
48	6	6.89	97.24	9.79	90730.99	87316.04	224.05
49	6	6.48	97.24	9.79	82803.36	86585.05	228.64
50	6	6.48	97.24	9.79	91511.51	89425.1	240.6

Table G.8: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 5

t	SLE	COOPE	INCE	BE	EXSL	EXB
20	27479.69	92514.64	1891.33	326.48	3621.42	84414.18
21	27469.92	92664.83	1985.71	327.01	5502.07	84551.21
22	27403.84	94553.61	1976.06	325.42	8258.39	84140.1
23	26172.41	96261.73	1918.04	323.3	9971.39	83591.96
24	25270.72	96419.53	1921.19	323.83	8628.07	83729
25	24671.82	94707.61	1979.28	325.95	11275.41	84277.14
26	24912.52	95631.58	2022.47	329.13	11917.58	84326.94
27	24912.52	97997.59	2091.5	329.13	13402.02	80752.36
28	25388.46	97997.59	2496.27	329.13	12914.84	80752.36
29	26155.95	97953.17	2545.81	332.84	11407.3	81662.61
30	26197.6	91078.63	2891.3	333.37	10511.97	74758.75
31	25960.82	86111.6	2937.51	336.55	10437.9	63801.86
32	26287.89	84596.44	3458.38	340.79	7341.31	66213.6
33	26780.69	85311.17	3502.61	340.79	1499.22	60741.17
34	26386.34	90176.91	3606.69	343.97	0	49604.57
35	24975.8	97128.39	3516.05	344.5	0	28180.18
36	23695.22	103778.93	3681.19	347.15	0	32524.68
37	22827.6	109753.52	3756.9	24957.45	0	39634.03
38	22454.25	113384.86	3858.84	355.1	0	41894.11
39	22435.38	113711.95	3731.63	352.45	0	36225.3
40	23344.21	113643.12	3742.85	353.51	0	39600.76
41	24861.77	112170.48	3790.5	355.1	0	38391.8
42	26348.92	109752.42	3953.66	358.81	0	36282.74
43	27489.46	105505.46	4093.06	361.99	0	32954.65
44	28023.8	99242.89	4325.77	361.46	0	27506.16
45	28182.95	96154.89	4334.84	360.4	0	22532.22
46	28181.34	97630.43	4586.29	361.46	0	23432.46
47	27978.77	103575.93	4641.9	364.11	0	24293.11
48	27166.63	112510.21	4710.59	363.05	0	30680.18
49	25884.85	120737.35	4550.21	359.87	0	33919.76
50	24734.2	126459.52	4297.38	360.93	0	37772.02

Table G.9: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 6

t	REV	REVS	M.E-B	M.E-S	M.C-B	M.C-S	M.L-B	M.L-S
20	440251.97	0	0.39	0	0.49	0	0.15	0
21	449294.61	0	0.39	0	0.49	0	0.31	0
22	441658.99	0	0.4	0	0.49	0	0.31	0
23	426914.55	0	0.42	0	0.51	0	0.32	0
24	417635.86	0	0.3	0	0.51	0	0.32	0
25	406316.16	0	0.17	0	0.52	0	0.32	0
26	405348.73	0	0	0	0.53	0	0.33	0
27	403236.1	0	0	0	0.38	0	0.33	0
28	408900.49	0	0	0	0.23	0	0.33	0
29	418316.39	0	0	0	0.01	0	0.33	0
30	424536.9	0	0	0	0	0	0.33	0
31	425492.71	0	0	0	0	0	0.33	0
32	426951.8	0	0	0	0	0	0.34	0
33	431762.71	0	0	0	0	0	0.18	0
34	429990.27	0	0	0	0	0	0	0
35	417092.86	0	0	0	0	0	0	0
36	395086.9	0	0	0	0	0	0	0
37	373086.73	0	0	0	0	0	0	0
38	357961.56	0	0	0	0	0	0	0
39	351490.31	0	0	0	0	0	0	0
40	358371.75	0	0	0	0	0	0	0
41	377598.57	0	0	0	0	0	0	0
42	403537.4	0	0	0	0	0	0	0
43	428806.26	0	0	0	0	0	0	0
44	446629.03	0	0	0	0	0	0	0
45	456410.74	0	0	0	0	0	0	0
46	459775.61	0	0	0	0	0	0	0
47	458209.06	0	0	0	0	0	0	0
48	449099.75	0	0	0	0	0	0	0
49	431789.16	0	0	0	0	0	0	0
50	410281.58	0	0	0	0	0	0	0

Table G.10: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 7

t	Brd	Inc	Cps	Slgh	Fdml	WBrd	WInc	WSlgh	WFdml
20	0	0	0	0	0	0	0	-440.88	-34.32
21	0	0	0	0	0	-406.89	0	-32.61	0
22	0	0	0	0	0	0	0	-32.01	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	-39.49	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	-34.16	0	0
28	0	0	0	0	0	0	-66.94	0	-245.19
29	0	0	0	0	0	-171.43	0	0	0
30	0	0	0	0	0	0	-66.44	0	0
31	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	-35.37	0	0
33	0	0	0	0	0	0	-104.17	-395.4	0
34	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0
36	15.21	0	0	0	0	0	-214.72	0	0
37	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	-476.85	0	0	0
39	4.88	0	0	0	0	0	0	0	0
40	0.91	0	0	0	0	0	0	0	-36.03
41	0	0	0	0	0	0	0	0	-35.31
42	0	0	0	0	0	0	-35.91	0	-35.91
43	0	0	0	0	0	0	-37.78	0	-340.23
44	0	0	0	0	0	0	-37.95	0	0
45	0	0	0	0	0	-267.3	-36.96	-343.37	0
46	3.91	0	0	0	0	0	-489.83	0	0
47	0	0	0	0	0	0	-36.91	0	0
48	0	0	0	0	0	0	-35.04	0	0
49	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0

Table G.11: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 8

Coop	Enter	Coop	Enter	Coop	Enter
ABDULLA	0	HALILAR	0	IRFANCA	0
ABDULTU	0	HALILOZ	0	IRFANKE	0
ADEMCEK	0	HALILTA	0	ISMAILD	0
AHMETAK	0	HALILYI	0	ISMAILH	0
AHMETKO	0	HALITAR	0	ISMAILK	0
AHMETSA	0	HASANAR	0	ISMAILS	0
ALIAKGU	11650	HASANCE	0	ISMAILY	0
ALIDEMI	0	HASANCO	0	KAYHANK	0
AYHANTE	0	HASANUZ	0	KAZIMBI	0
BAYRAMG	0	HAYDARA	0	KEMALBA	0
BEKIRKE	12100	HIDAYET	0	KEMALCA	0
BEKIRSE	0	HIDAYET	7220.16	KEMALGE	0
BURHANC	0	HIKMETO	0	KEMALPE	0
CALISKA	0	HILMICE	0	LEVENTE	27500
CELALET	0	HIZIRBU	0	MAHMUTY	0
CEMALET	14820	HUSAMBA	0	MEHALKA	0
CEMALGU	0	HUSALIO	0	MEHAYHA	0
CEMILYI	0	HUSON	0	MEHBILI	0
DURSUNB	0	HUSSEVE	0	MEHCAN	0
DURSUNU	0	HUSTOPK	0	MEHHOS	0
EMINKIL	0	IBRALHA	0	MEHKOKS	0
ERCANBU	0	IBRARSL	0	MEHSAR	0
ERDINCB	0	IBRGOCE	8100	MEHYUKS	0
ERTANIS	0	IBRSARI	0	MELAHAT	0
ERTUGRU	0	IBRUYGU	5500	MUAMMER	3700
FARUKTU	0	IDRISAK	0	MUHARRE	0
FERITYI	0	IHSANDE	0	MUHITTI	0
FIKRETH	0	ILHANER	0	MURATCE	0
FIKRIKE	0	ILHANUZ	0	MUSARSL	0
GURCANS	0	ILYASAL	0	MUSAZIZ	0

Table G.12: Model Results of General Production and Financial Planning Problem for Actual Requirements Scenario- Part 9

Coop	Enter	Coop	Enter
MUSCIRA	0	SALIHYI	3838.24
MUSDOGA	0	SAVASDU	0
MUSEROG	0	SERVERY	0
MUSGULE	0	SERVETK	0
MUSKAVA	3500	SEZGINE	0
MUSKELE	0	SINANBE	0
MUSKESI	0	SITKIER	7600
MUSKONA	0	SONERBA	0
MUSOZCE	0	SUKRUTE	0
MUSPEKB	0	SULEYMA	0
MUSSITA	0	SUREYYA	0
NAZIMCE	0	TAHIRAL	0
NECATIH	0	TAHSINE	0
NEVZATS	0	TALIPAL	0
NURETTI	0	TALIPKA	0
NURIDDI	11500	UFUKKUL	0
OMERBAL	8000	VELIKOS	0
ONURIKE	0	YASARBI	0
ORHANAT	0	YASARKO	0
OSMANDE	0	YASARYE	0
OSMANGO	0	YUSUFHA	0
OZCANHI	0	YUSUFLE	0
PIRIBEY	0	YUSUFOZ	0
RASIMKO	0	YUSUFSE	0
RECEPAY	0	YUSUFYI	0
RECEPGU	20600	ZAHIRKO	0
RECEPTU	0	ZEKIYIL	0
RUHIYES	18100	ZEYNEPY	13000
SALIHOG	0	ZIYAATT	0
SALIHSU	13300	DUMMY	0

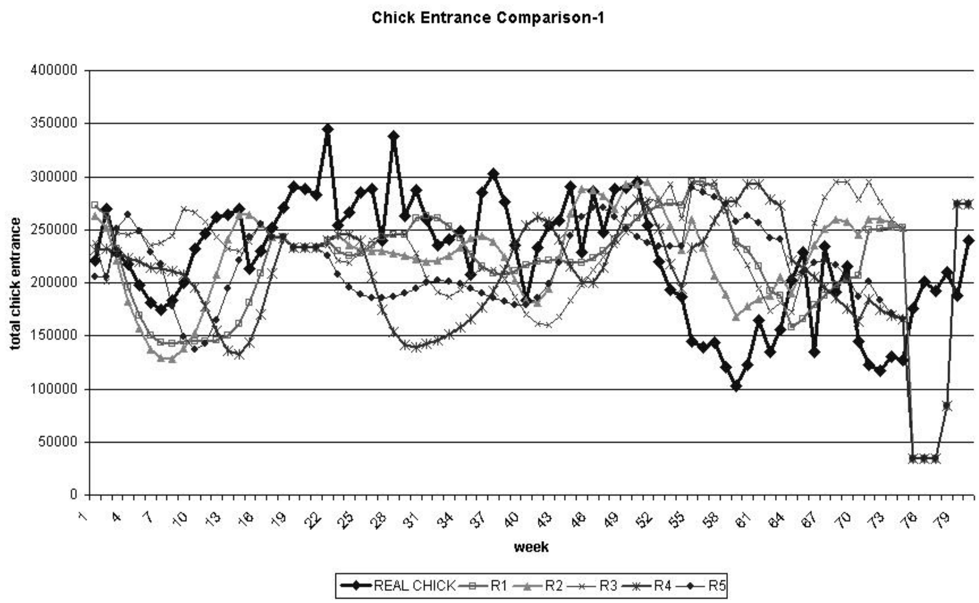


Figure G.1: Chick Entrance Comparison of Random Scenarios' Results with Realized Entrances

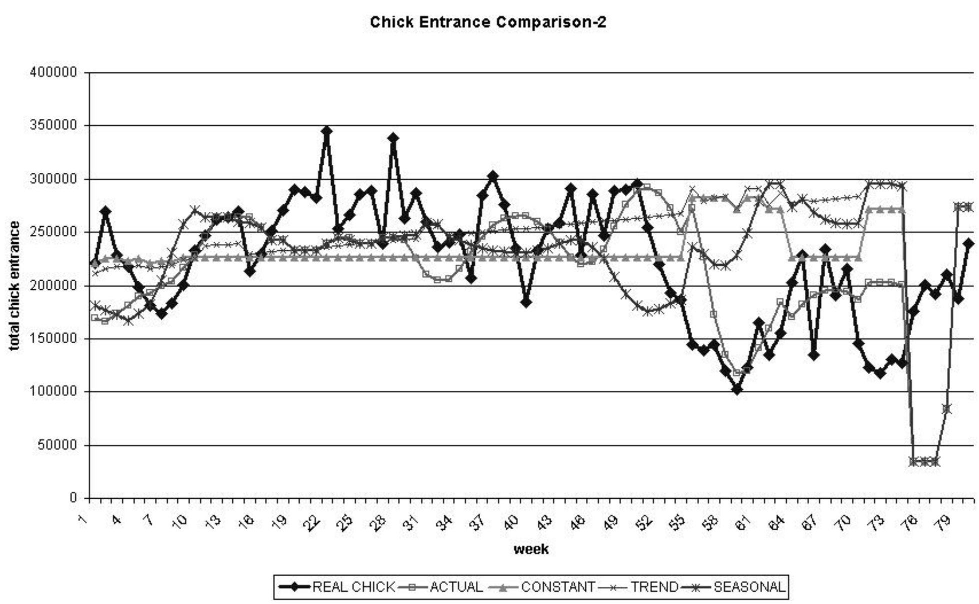


Figure G.2: Chick Entrance Comparison of Actual, Constant, Trend, and Seasonal Scenarios' Results with Realized Entrances

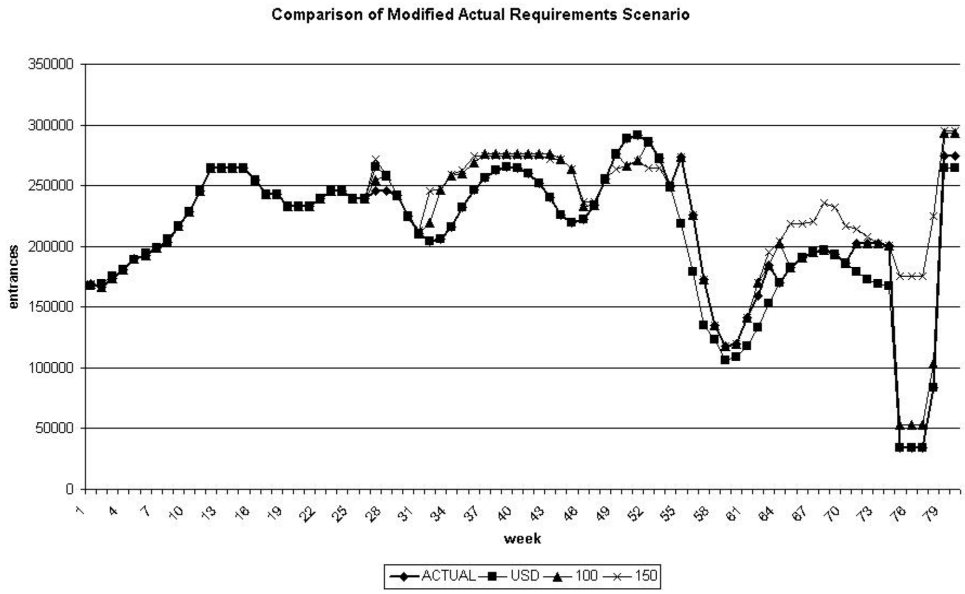


Figure G.3: Comparison of Actual Requirement Scenario's Chick Entrances with Modified Versions