DYNAMIC IMPACTS OF PERFORMANCE BASED PAYMENT SYSTEM ON PUBLIC HOSPITALS IN TURKEY

by

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ABSTRACT

DYNAMICIMPACTSOFPERFORMANCE BASEDPAYMENTSYSTEMONPUBLIC HOSPITALSIN TURKEY

The goal of pay for performance (P4P) system in healthcare is to increase the efficiency of healthcare resources by paying physicians and hospitals for performance. Ministry of Health in Turkey has implemented P4P since 2004. The purpose of this study is to investigate the dynamic impacts of P4P on performance of hospitals and behaviors of physicians. The model includes physicians' interactions with patients, revenue pressures on physicians, and the resulting impacts on health outputs and quality. In order to increase productivity, physicians are induced to perform more medical activities. Physician, who experiences revenue pressure, may try to increase his/her revenue by performing more medical activities and give less importance to quality. Resulting inadequate treatments and wrong diagnosed patients would have negative effects on health quality. On the other hand, physicians who do not have any revenue concerns may give the quality of healthcare absolute priority, meanwhile undermining the productivity. This tendency may result in hospital crowding and high crowding pressures on physicians. Such conflicting pressures are included in model to investigate the impacts of P4P on health outputs in public hospitals. Results obtained concur with our dynamic hypotheses summarized above and agree with some of the general behaviors recently observed in Turkish healthcare.

ÖZET

PERFORMANSA DAYALIÖDEMESİSTEMİNİNTÜRKİYE’DEKİDEVLETHASTANELERİÜZERİNDEDİNAMİKETKİLERİ

Sağlıkta performansa göre ödeme (PGÖ) sisteminin amacı hekimlere ve hastanelere performansa göre ödeme yaparak sağlık hizmet kaynaklarının verimliliğini arttırmaktır. Sağlık Bakanlığı Türkiye’de 2004 yılından itibaren PGÖ sistemini uygulamaktadır. Bu çalışmanın amacı PGÖ’nin hastaneler ve hekimler üzerindeki dinamik etkilerini araştırmaktır. Model doktorların hastalar ile etkileşimlerini, gelir baskısının hekimler üzerindeki etkisini ve sağlık göstergeleri ve kalitesi üzerine etkileri içermektedir.Verimliliği arttırmak için, hekimler daha fazla medikal aktivite gerçekleştirmeye teşvik edilmektedir. Gelir baskısını üzerinde hisseden hekim, gelirini daha fazla muayene, teşhis ve ameliyat gerçekleştirerek arttırken kaliteye daha az önem verebilir. Bunun sonucu olarak yetersiz tedavi edilen ve yanlış teşhis konulan hastalar sağlıkta kaliteyi olumsuz olarak etkiler. Buna karşın, gelir endişesi olmayan doktorlar, sağlıkta hizmet kalitesine birincil öncelik vererek verimliliği düşürebilirler. Bu yaklaşım hastanedeki yoğunluğa ve hekimler üzerindeki yoğunluk baskısına neden olur. Birbirine ile çelişen etkiler sağlıktaki göstergelere PGÖ’nin etkilerini araştırmak amacıyla modele dahil edilmiştir. Elde edilen sonuçlar, dinamik hipotez ve Türk sağlık sisteminde görülen genel sistem davranışları ile örtüşmektedir.

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LIST OF ACCRONYMS/ABBREVIATIONS

PBPS	Performance Based Payment System
P4P	Pay for Performance
MOH	Ministry of Health
OECD	Organization for Economic Co-operation and Development
TSPE	Time Spent per Examination
TSPT	Time Spent per Tests
TSPS	Time Spent per Surgery
WHO	World Health Organization

1. INTRODUCTION AND PROBLEM IDENTIFICATION

The main goals of health system are to protect people's health, to treat them if they need any medical support and to provide better life quality. Modern treatment techniques try to provide permanent treatment of diseases and illnesses. Since industrial revolution, there have been major improvements in healthcare, medicine technology and treatment techniques. Developments in technology, economy and society have increased the average life expectancy. Life expectancy in the US was 49.2 years in 1900 and went up to 77.5 years in 2003 (CRS Congress Report, 2006). Acute death cases have decreased over years due to improvements in health technology and chronic illness became more important problem for countries. Developments in health technology have changed disease type from acute diseases to chronic diseases. In the U.S., the Centers for Disease Control and Prevention (CDC) estimates that chronic illnesses are responsible for 70% of all deaths and 75% of all health care costs (CMS, 2007). The aging of the U.S. population and increases in risk factors such as obesity and diabetes indicate that chronic diseases will be a greater problem in the future (Homer, 2007).

According to the OECD health statistics, average annual growth rate in total health expenditure per capita was 4.8 % in US between 2003 and 2009. Moreover, average growth rate in total health expenditure was 4 % in US between 2003 and 2009 (OECD,2012). Despite the amount of money spent on healthcare, the performance of healthcare is lower than expected. Developed and developing countries still have to confront chronic and unsolvable problems in healthcare. Rising share of health expenditure in GDP; unsolvable problems such as long waiting times for examination, inaccessibility and disparities in healthcare and deaths due to incorrect diagnoses and medical operations draw attention to the inefficiency and the ineffectiveness in healthcare. Developed and developing countries investigate new solutions for decreasing the costs of health meanwhile improving the healthcare quality. Consequently, they try to implement new policies and programs for solving healthcare problems.

One of the most recently applied methods in healthcare is pay for performance (P4P) or performance based payment system (PBPS). P4P is a common method of medical payment system, incorporating additional payments with output and/or quality improvement. P4P system's goal is to increase the efficiency of healthcare resources by paying bonus for increased performance. Healthcare providers usually achieve incentives for improvements in process measures or in outcome measurers. Outcome measure is the result of patient care whereas process measure is the care that is provided (Pomp, 2010).

Selecting process measures or outcome measures is a controversial issue. There are advantages and disadvantages for each of these options. Process measures are easy to control and accessible to obtain adequate information. Conversely, outcomes depend not only on physician effort, but also on other factors beyond the control of medical professional such as socio-economic background and environmental factors. Process measures can be defined as time spent per examination, number of medical operations performed, number of drugs used by patient. Outcomes can be defined as the percentage of permanent recovery, complications due to wrong medical operations, the number of inadequate treatments etc. In order to gain success in outcome measures, structural improvements and process improvements are needed. In general, process measures and outcome measures are combined to get better results from monitoring the health system, providing better health care quality, and efficient utilization of health resources (Pomp, 2010).

The problems in developing countries are structural in nature as opposed to process problems. Structural problems are organizational problems, lack of adequate supply and high demand in healthcare, laws and policies bringing about disparities and chronic problems in healthcare. For instance, before 2003, Turkish Health System can be defined as the presence of several different public institutionsfinancingand providing healthcare, some vertically integrated and others relying on contractual relationships (Mollahalioğlu, 2009).These agencies served different parts of population in different hospitals and different health centers. Therefore, accessibility and disparity problems in healthcare might partially have resulted from the structure of health organization itself in Turkey.

According to OECD report “Turkish Health Performance Determinants” in 2006, physician per 1000 capita is 1.6 in Turkey whereas the OECD average for physician per 1000 capita is 3.6. Taking developing and developed country examples, it can be easily seen that insufficiency in the number of physicians is a serious problem for Turkish Health system. The average number of graduated physician rate for 1000 capita in Turkey is 4% per year in 2006, whereas the OECD average is 3% per year. However; increase in birth rate and aging population make physician graduation rate inadequate to meet the health demand. Unfortunately, unlike developed countries, physicians may examine approximately 100 patients a day in Turkey and spend approximately four to nine minutes per examination to meet the health demand. This tendency may result in inadequate treatments, possible readmissions to hospitals and increase in hospital visits per year. As a result, government decided to meet the health demand by increasing the productivity of health resources. Long waiting lines, waiting times, inaccessibility to consultation, disparities in healthcare motivated the ministry of health to implement new health program: Health Transition Program (HTP). Thus, government has initiated HTP in 2003. Government’s aim was to make the health system more effective and efficient by improving user and provider satisfaction and long term financial sustainability (OECD Health Report, 2006).

First, government consolidated public agencies and transformed health system into single payer provider. Then various reforms and programs have been implemented in healthcare since 2003. Due to reforms and policies, there have been improvements in health statistics. Share of health expenditure in GPD increased from 4.5% to 5.6% between 2003 and 2006 (OECD Health Report, 2006). Consultations per physician increased from 2000 patients per year to 3700 patients per year between 2002 and 2006. Hospital admissions increased by 32% in 2004, increased by 81% in 2005 and became stable in 2006 (MOH Health Report, 2007). Hospital bed capacity and clinical rooms for examination have increased and health costs have risen since 2003. Additional payments to physicians per year increased from 400 million TL to 2.923 billion TL. Together with high increases in health demand, drug expenditures increased 16% between 2003 and 2006 despite drug discounts. Hospital visits per capita increased from 1.88 per year to 4.11 per year between 2002 and 2010 (MOH Health Report, 2010).

One of the reforms which government implemented as a part of HTP is Performance Based Payment System (PBPS). Basically, the system awards physicians who perform more medical operations compared to the average physician performance. The aim of this program is to increase the productivity of health resources for meeting the growing health demand.

PBPS was first implemented in pilot centers in 2003. Then, the program was extended to cover first step public hospitals throughout the country. There were two phases of this program. One-year implementation of PBPS in 2004 provided the participation of health employees and health centers. Moreover, the implementation provided required infrastructure for enabling the performance measurement of health centers and employees. Some quality measures were tested and implemented throughout the country in 2005. Corporate performance measurement was included in this program by the ministry of health in 2007 (Gazi, 2006).

PBPS has been in practice since 2004. This system has been applied in *first, second and third step* public health centers, except university hospitals. This classification was made by the ministry of health in 2003 (MOH Health Classification Report, 2003) First step public health centers are small health centers such as infant health centers, village clinics and family planning centers. Second step public health centers have more capability for providing more complex and complete health service. Second step public health centers are public hospitals, social insurance institution hospitals and other state hospitals. Third step public health centers are education and research hospitals and university hospitals. Since February 2011, PBPS has been implemented in university hospitals. In the meantime, full-day employee has been implemented in public hospitals and university hospitals. According to this law, dual employment is not allowed in public health centers, with very few exceptions. For instance, professors in university or education and research hospitals who work in private hospitals can work as instructor, cannot examine patients, not perform medical operations and not take additional payments from revolving budget. The main goal is to increase health resources' productivity as much as possible for meeting the growing health demand.

PBPS is used for determining how much additional payments physicians take due to their performance. The additional payments of physicians are highly dependent on the number of examinations and the medical operations they perform. Depending on hospital's financial performance, hospital's management can allocate more money to their employees. Therefore; if a hospital earns more money by performing value added medical operations, hospital's management can pay employees more reimbursements from revolving budget. As a result, hospitals may induce physicians for more examination and medical operations in order to increase their revenue.

1.1. Problem Identification

PBPS has been implemented in second and third step public health centers, except university hospitals since 2004. When resource utilization increased in first and in second step public health centers, government decided to implement PBPS in university hospitals in 2011.

The purpose of this study is to investigate the dynamic effects of PBPS on the performance of *second step public hospitals*. These effects can be separated into three parts: the effects on treatment quality, the effects on health costs and the effects on health productivity.

In order to understand the effect of PBPS on treatment quality, it is necessary to characterize and define the health quality. While defining the health quality, it is important to take health system as a whole and to have a whole-system perspective (WHO, 2006).

According to the IOM, health quality consists of the "degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge".

According to the WHO Health Report 2006, health quality has 6 dimensions. These dimensions are important to understand the scope of the health definition (WHO, 2006).Health quality dimensions are effectiveness, efficiency, accessibility, acceptability/ patient-centered, equity and safety.

Health policy makers should keep in mind to construct measurable quality variables to fulfill basic health dimensions above. These variables can be time spent per examinations, the correct treatment percentage, unit cost of medical activities and health expenditure due to the health quality outcomes. Moreover, the effect of physician's revenue, health system construction, health crowding and interactions within these variables should be taken into account for achieving desired health quality.

With respect to the health quality definitions, dimensions and variables, PBPS should be analyzed in order to investigate the effect of the system on these variables and interaction within health sub-systems in Turkey.

PBPS implementation in Turkey considers public health centers as revenue generating places. The aim of health ministry is to increase the productivity, quality and efficiency in healthcare. However these goals may contradict with each other in some ways.

With the high importance of revenue concerns of hospitals and health employees, healthcare quality may decline to second priority. Unnecessary medical operations and examinations may be induced in order to increase hospital's revenue. Examination crowding in hospitals may increase to a point where health resources cannot meet. And the gap between capacity and health demand, which is also the main problem and the main motivation of Turkish Health System, may widen. Another result may be increases in health expenditures which would affect the continuity of PBPS implementations. While hospital resources have been used more efficiently since PBPS, health care expenditures have also increased due to rising prescriptions, surgery, medical operations and examinations (OECD Health Report, 2006).

Treatment, rather than examination or surgery is an important factor for health service quality. One way to measure treatment in healthcare is the percentage of permanent treatment of patients. PBPS may induce physicians to perform more examinations and surgeries rather than treat patients permanently. The other way of measuring the treatment quality is time spent per examination. With the effect of revenue concerns of hospitals and physicians; physicians may spend less time on examination, give less attention to patients' complaints, diagnose quickly and prescribe unnecessary medicines. Time spent per examination in Turkey, which is very important for the correct diagnosis and permanent treatment of patients, changes between four minutes to nine minutes. This is far lower than the OECD average. In order to increase health service quality, time spent per examination should increase. However; with the implementation of PBPS, time spent per examination may decrease. Reduction of time spent per examination may cause incorrect or incomplete diagnosis, unnecessary tests / analysis and inadequate treatments.

In order to test the dynamic hypothesis above, system dynamics method is selected for understanding the dynamics of public hospitals under PBPS. The base model will represent the dynamic impacts of PBPS on second step public hospitals.

2.LITERATURE REVIEW

2.1.System Dynamics and Public Health Modeling

System dynamics is one of the most common methodologies for examining the dynamics of complex and feedback nature systems. Health sector and public health modeling provides opportunities for simulation modeling and SD models. In this section, the studies about public health modeling will be briefly explained.

First, it is important to point out that, simulation modeling is generally used in modeling healthcare problems.The reason is the difficulty to model dynamic and continuous problems with static programming or modeling approach. In addition to this, interrelations within the system and the relations with other systems make static modeling insufficient. Owing to the benefits of dynamic modeling, there are numerous studies over health modeling for healthcare problems.

Fone *et al*.(2003) study computer simulation modeling literature in healthcare. They methodologically review the literature. The review is carried out articles and conference papers from 1980 to 1999. The criteria are designed to evaluate the articles. 182 articles are met these criteria. The main topics of the studies in literature are as follows: hospital scheduling and organization, communicable disease, screening, cost of illness and economic evaluation.

Hospital scheduling and patient-flow management is one of the key topics in health modeling.El Darzi *et al*. (1999) use discrete-event simulation modeling for understanding the flow of patients in geriatric department. The flow modeling approach and the discrete event simulation modeling is used to analyze the effectiveness of queue constraints.

Discrete-event simulation modeling is not able to deal with dynamic-feedback nature. On the other hand, system dynamics methodology provides flexibility, captures long term behavior and tests policies with respect to healthcare management problems.

Wolstenholme (1999) analyzes patient flows' dynamics in U.K Healthcare via SD approach. National–level system dynamics model is developed for policy analysis. The intervention policies are defined as post-hospital, hospital and post-hospital interventions. Then alternative policies are tested. The bigger impact on the hospital crowding stems from intermediate care and length of stay reductions, rather than changes in hospital bed capacities.

Garcia *et al*. (1999) construct a SD model for analyzing waiting list problems in Spanish public hospitals. High waiting listsare chronic problem for Spanish health system. The SD model is developed in order to test the current policies of government. These policies are subcontracting, special programs and waiting list updating. The model is validated bycomparing with historical data. From the simulation results, it can be seen that the policies in practice have no significant impact on reducing waiting lists.

Ackerea and Smith (1999) also study patients' flow and waiting list problems via system dynamics approach. They try to find policies and solutions for growing waiting list problem. The macro model of National Health Service is developed. Themodel considers the problem with two sides, demand and supply sides.

Bronkhorst *et al*. (1990) investigate the dynamics of dental care system. Supply and demand parts of dental care system are modeled with SD approach. The model is extended from 20 state variable-systems to 440 state variable systems in order to match the expectations of current policy managers. The demand model mainly consists of the activities which are visiting, caring, periodontal diseases and treatment. In the supply model, dentists and dental hygienists and the processes that required for treatment of patients are included.

Royston *et al*. (1999) use system dynamics approach for developing and implementing health policies in England. This study explains the motivation of this article and problems in UK Healthcare, and gives an overview about important studies of system dynamics in health care industry. The model contains subsystem and sectors which represents all the aspect of health care system. The elective care and hospital discharge are included into the model in order to explore these factors' impacts on healthcare.

Brailsford *et al*. (2004) study emergency and on-demand health care structure. SD model represents whole system review of demand health care in Nottingham to understand the increasing demand and to find what could be done to reduce this pressure. Model is calibrated using the historical data. Various scenarios are tested to improve health system. Long waiting time is found as not necessarily a bad thing which might discourage inappropriate demand. The system is operating close to its capacity and from the scenarios, if the growth in emergency admissions continues; hospitals may see a considerable decrease in elective admissions.

Hwang (2005) constructs a system dynamics model to evaluate policies for the financial imbalance of National Health Insurance in Taiwan.The objective of this study is to understand the dynamics of NHS in Taiwan and understand the effect of national program launched in 1995. The main problem of NHS in Taiwan is deficit in financial status of health care service. The reason for this deficit is the fluctuations in benefit payments. Moreover the reason behind these fluctuations is the new system (Fee-per Service) that had been implemented since 1995. System dynamic model is developed and three policies aretested according to three scenarios. Beneficiary payment is found out to have a significant effect on the dynamics of the model.

McDonnell*et al*. (2004) use SD approach for analyzing Health System Performance within WHO Framework. The aim of this study is to analyze healthcare system performance within WHO framework. System dynamics model is built in order to use this framework for evaluating the healthcare system. The model includes aging chain, using physician as resources, financing sector, and distribution sector and feedback structures. The model is a macro model of health system based on WHO framework.

Hirsch and Homer (2004) aim to construct a system dynamics model for understanding the complexity of chronic illness management (CIM) which consists of long delays and feedbacks. The authors present some propositions about the dynamic interplay with issues of service capacity, demand and provision. Firstly, these propositions are used to build a model about diabetes management which aims to manage the nursing resource. Three scenarios based on available number of nurses, were tested considering fraction of diabetics, backlog of patients and death due to disease. Secondly, the model is developed in order to evaluate health plan investments in clinical efficiency and CIM.

Hirsh*et al*.(2005) examine health care reform issue in US. In order to achieve desired health care reforms, dynamics of healthcare are analyzed via system dynamics. First, a disease process for population (macro level) is built andthe growth of high tech medicine process, the development in technology and the living conditions and citizen involvementare added into model.

McDonnell and Dwedney (2006) analyze political and economic dynamics of health policy. Their focus is US health system. This study extends the research of system approach to US health system to international sphere. Health care system is studied as an industry with consumer, with professional and society right with citizen. Three control mechanisms are hierarchical, market, and network. Causal loop diagram of the overall influences of the three control mechanisms on key indicators of healthcare performance and some intermediary effects is constructed. The disease progress chain is used in modeling phase. Regulation variable is implemented into the model for constructing the effect of government on health care system.

McDonnell*et al*. (2006) develop a model for understanding the dynamics of China's health system (before changing in socialist economy to state capitalist economy).Socialist and capitalist versions of healthcare are compared via SD modeling.Market based policy is found as unsuccessful policy for China which results in high demand and supply shortage for service and inequity between rural and city health centers.

Hirsh (2006) examines health coverage issue with SD perspective. A model is built to examine health coverage and access for the uninsured patients. The reinforcing loops are built in order to represent government interventions, reduce risk and preventive options of government. Moreover, resistances to current policies are added into the model. Policy choices are also represented in causal loop diagram which represents access and potential effects on success.

Rwashana and Willams (2007) use system dynamics approach for the immunization coverage problem in Uganda. The paper demonstrates main health problems in Uganda. The information system which has been used in Uganda since 1990's, has abilities to meet the requirements of developed countries not developing countries like Uganda. The information management of health care system is central based system, but health care system is separated into health care districts and sub-districts which had autonomy to manage own policies. This provides easiness for scheduling and planning but it needs a lot of information feedback which is not feasible considering the low internet connection and inadequate IT infrastructure. The authors use the qualitative part of SD, causal loop diagrams for understanding the immunization system in Uganda and perhaps improve it. The causal loop diagram which represents the factors associated with demand for immunization as well as shows the key factors for designing adequate and effective information system.

Cooke *et al*.(2007) investigate the main reasons for overcrowding in hospital emergency centers. Discrete-event simulation model of one department is constructed in order to understand the system and use this model as a development point for system dynamic model which enables users to test alternative policies and decisions. The discrete-event simulation model is calibrated with data between 1997 and 2003 which showing the admissions to emergency departments.

Cody*et al*. (2007) usesociological terms and approach for building system dynamics model. The aim is to use SD model for representing the dynamics of social capital. The model is macro model, details about model or health dynamics are not presented.

Thomson points out the important aspects of US Health Care with SD approach (2006). National-level health system dynamics model is developed in order to stimulate how consumptions' attitude change due to various forces in health care market and to study the behavior of consumer, provider and other actors.

Homer (2007) presents a system dynamics model for investigating the dynamics of chronic illness management model. The model's level is national. Main causal loop diagram consists three parts: population stocks, feedback structure that explains historically growth in spending and additional components for improving the health. The model is calibrated using US NHES data (50 year time horizon). The policies are tested by using this model. These policies are no price up, no coverage down, no reimburse down and base policies.

2.2. Performance Based Payment System

Performance based payment system (PBPS) or pay for performance (P4P) system is one of the common methodologies and tools to improve health service quality in health systems. In this section, recent studies are presented with its results and main characteristics.

Fairbrother *et al*. (1999) investigate the effects of P4P system on immunization activity of physicians. For measuring health service quality, quality-indicator based payment system is constructed. Physicians are awarded for improvement in these indicators. Bonus payments are strictly related with improvements over baseline, and physicians whom reach %100 improvement from baseline can earn 7500$ per year. According to the results, percentage of immunizations increases significantly after implementation of P4P.

Eichler *et al*. (2001) study the impacts of PBPS on health services in Haiti. In order to establish acceptable P4P system, payers must have the capability and capacity to establish performance indicators, measure performance, and implement new contracting processes. Case study is the implementation of P4P in Haiti. Seven performance indicators are determined: five indicators related to improving health impact, one to increasing consumer satisfaction by reducing waiting time, and one to improving coordination with the Ministry of Health.

Beaulieu *et al*. (2005) examine the effects of performance based payment system on patients with diabetes. With combined quality indicators, health quality is measured. First, the weaknesses of incentive programs-P4P are demonstrated. Then, the importance of infrastructure investment is pointed out. Physician training programs for achieving success in the implementation of P4P is also found essential. According to results, five of ten quality measures increased significantly before P4P.

Cutler (2006) analyzes the economics of payments in healthcare. The contradiction between cost control and accessibility to sufficient healthcare is argued. The study suggests that if the value of medical care is high than accessibility should be preferred. The failures in chronic disease management are studied. Providing high quality in chronic disease care has important impact on cost effectiveness. Quality and cost relations are examined to diagnose P4P system's effect on quality.

Rosenthal *et al*. (2007) doa research about the experiences and the problems which are faced by early adopters of P4P system. The experiences of twenty-seven early adopters are examined. For making P4P efficiently worked, three major challenges are presented: overcoming physician resistance, determining the necessary size of incentive pools, finding the resource necessary to carry on the programs.

Millett *et al*. (2007) examine the impact of P4P system incentive on support for smoking cessation and smoking prevalence among people within diabetes in a multiethnic population. Data is collected before (June-October 2003) and after (November 2005-January 2006). In order to distinguish the differences in the frequency distribution of indicators between 2003 and 2005, the McNeymar test and conditional logistic regression method are used. For results part, smoking within diabetes patients decrease within 15 months andP4P incentives seem to be effective in increasing the delivery of cessation advice and in reducing the prevalence of smoking among patients with diabetes.

Mullen *et al*. (2007) evaluate the effectiveness of P4P system. In this paper, before and after the implementation of pay-for-performance in 2002, health quality is compared with a control group of providers who are not affected. The importance of finding the right measures for the right outcomes in P4P is argued. Several dimensions inn quality is formulated and mathematical model for analyzing the effect of interventions on quality is constructed.The size of award mechanism is found as essential for success of P4P implementation.

Pearson *et al*. (2007) investigate the implementation and impacts of P4P on health care quality in Massachusetts. The effectiveness of P4P on health care quality in Massachusettsis evaluated. The size of incentives is found as no effect on quality improvement. The results show that P4P system improved performance measures in all groups. Among thirty contract-measure pairs, twenty two (73%) show an improvement trend.

Rosenthal and Dudley (2007) examine the current P4P systems and evaluate the strategies in order to make P4P system work efficiently and effectively. Maintopics are presented in order to improve P4P system. For effective P4P system, a mixed approach is preferable for payment system construction. Another topic is paying the right amount: multiple thresholds are suggested: reward significant improvement and reward for each patient that receives recommended care. The last design topic is prioritizing quality improvements for underserved population. Reducing disparities and increasing accessibility in healthcare is both national and international goal.

Scott (2007) studies the effects and strategic issues of P4P system in Australia. First, an overview about P4P system is given, and then the weak and strong parts of system are demonstrated. Also, author gives suggestion about implementation of P4P considering previous studies and implementations. In order to get better improvements, bonus payment to small individuals or small groups is selected as best strategy. Moreover, study shows that non-financial strategies for improving care quality (such as clinical guidelines, audits, feedback) yield improvements too. In order to gain improvements in healthcare, bonus payments should be 15% -25% of physician’s income or 4% of hospital income. In addition to this, the quality measures should be ideally clinically relevant, reasonably stable over 2-3 years, accurate and actionable with high impact. One other point that should be considered is unethical use of P4P by physicians such as non-treatment of very sick patient. Finally the study presents guidelines for implementation of P4P in Australia.

Casalino and Elster (2007) focus on the adverse effects of P4P system and quality reporting on healthcare. An unintended effect of P4P and reporting system on healthcare is argued: disparities. While governments try to improve quality with implementing new policies; unintended effects may occur. Possible reasons and outcomes of disparities inhealth care are investigated. The physicians, who work in poor communities, may not treat potentially low insured people which are disadvantage for their revenue. Also, P4P and reporting policies cause physicians tendency to focus on measurable treatment not the main illness. Moreover, P4P and public reporting might induce individual physicians and medical groups to avoid patients whom they perceive as being likely to lower their quality scores. Six suggestions are made in order to prevent disparities in health care: absolute quality scores and improvement over time; using risk adjustment; rewarding both overall quality and reduction in disparities and using these policies when there is available data for measuring and improving the system.

Lisk,Gimm and Peterson (2007) seek the right health policy for improving the well-baby care. Five Medicaid Health Plans are analyzed and compared. Implementation includes sixty thousand babies with 2400 physicians whom were eligible to get incentives. According to the results, all plans improve the quality of well-baby care with respect to quality indicators. However, the improvements in quality slow in second year.

Russell *et al*.(2008) study the effects of P4P system. According to this study, P4P systems generally produce weak performance due to the financial concerns. Costs of P4P systems may be higher than the benefits of P4P on health quality. The quality part of health service can be underestimated for financial expectations. Although, P4P may help improving health service delivery, there is a considerable riskwhichimplementation will cost much and return little.

Eldrige *et al*.(2009) present systematic review of studies which focus on performance based payment system. In majority of papers, P4P system is used as a tool for improving the service delivery, health quality and accountability. In order to achieve an acceptable success from the implementation of P4P, the followings must be provided: strong political and management support, the room for change and innovation and the strong health information infrastructure.

Mcdonald and Ronald (2009) compare the implementation and unintended consequences of P4P in England and California. The authors interview with primary care physicians in California (20) and England (24). P4P system has unintended effects on care and on physician motivation. These effects include encouraging physicians to avoid sicker patients, increasing disparities and giving less priority on types of care for which quality is not measured and awarded. In this study, the differences between US and UK implementation are also examined. Both programs involve paying physicians based on performance via targets, but the number of targets is higher in English initiative. Patient visit is highly affected in UK due to reduction eye-to eye contact and revenue concerns of physicians. In California, patient visit is not affected same as UK due to less participation of physicians and low incentivized medical activities. Despite more targets in UK, physicians are more supportive than California. The unintended consequences of P4P programs may differ owing to the design and implementation of the performance program.

Lindenauer *et al*.(2009)perform a study about the relationship between public reporting and P4P system and theirs effects on health service quality. Health Quality Evaluating System is constructed with quality measures. There are 10 individual and 4 composite measures. Over 2 year periods, 613 hospitals are measured with these quality measures. The quality measures are health failure, acute myocardinal infarction and pneumonia and a composite of 10 measures. For the analysis part the multi-variate regression method is used to understand whether there is significant effect of P4P on quality measures. From the results, it can be interpreted that, with P4P the greater improvements in healthcare measures can be achieved rather than public reporting. In addition to this, public reporting is important tool for close persistent gaps in the quality and safety of health care. But little is known about public reporting's effectiveness on quality. The authors also argue for the effectiveness of P4P and how to make it work efficiently.

Campbell *et al*.(2009) examine the effects of P4P on Quality of Primary Care in England. Study is based on government application of P4P into primary healthcare. This implementation includes family practice physicians. The payment system enables physicians to earn %25 maximum bonus payment per year. For measuring quality, 136 performance indicators are selected. These indicators cover the management of chronic diseases, practice organizations and patients' experience with respect to healthcare. Two data(before-after) are compared with time series analysis method. According to the results, two of three chronic conditions for health quality increase in short term. Afterthe targets are reached, the improvements in quality of health care slow.

Mandel (2009) studies P4P effectiveness on quality and tries to determine whether setting design characteristics of a pay for performance system for asthma patients-care quality improvement. Participants of the implementation are forty-four pediatric physicians with 13.380 children with asthma. Payment methodology is constructed in three levels. Each level, physicians can earn 7% increase of their revenue by performance payments due to the quality improvements. Data collection is held between October 1, 2003 and December 31, 2004. From the results, it can be interpreted that, P4P system has positive impact on quality. Between October 1, 2003 and November 30, 2006 the percentage of asthma population receiving perfect care increases from 4% to 88. On the other hand, it is pointed out that such increase might stem from the lack of enrollment system.

Chen *et al*.(2010) examine the impacts of P4P program on low performing physicians in Hawaii. P4P program impacts in Hawaii are compared with South Hawaii where P4P program is not implemented. Quality indicators are such as Hba1c testing, mammography, cervical cancer screening and varicella vaccine administration. Physicians within P4P program could earn 1.5%-7.5% additional payment due to their medical performance.According to the results, physicians within P4P program increase their quality scores more than non-P4P comparison group. Moreover, performance scores of the low performance physicians yield high increases from 1st to 2nd year of evaluation.

Ireland *et al*. (2011) perform a research about P4P system and its effects on healthcare. According to this study P4P can be used as a strategic tool for gaining structural improvements in developing countries. P4P implementation in Rwanda and its positive effects are illustrated in this study. Since promising improvements have been achieved due to the implementation of P4P system, the contributions to the health quality in developed countries are arguable according to this study.

Sulku (2011) investigates the impacts of healthcare reforms on the efficiency of the Turkish public hospitals. Data envelopment approach and Malqumist index are used to examine before and after the implementation of P4P. For defining productivity, two productivity types are defined as follows technical productivity and scale productivity. According to this study, one of the weaknesses of the P4P system is that the bonus payments are done mainly depending on the output but not the outcome. Between the years of 2001 and 2006, the mean outpatient visits, inpatient cases, and total number of surgeries rose 78%, 30% and 122%, respectively. Thus, these increases raise the question of whether the unnecessary demand has been induced.

Mollahalioglu *et al*. (2009) publish a report about the health resource and quality policy in Turkey.The impacts and outcomes of Healthcare reform in Turkey are presented. First, background on the Turkish Health Reform is explained, in order to give the motivation of government's intervention. Then, interpretation and opinions about statistical data of Turkish Health care reform outcomes are given. From the results, after the program had been introduced and implemented, there have been several improvements in healthcare system. Hospital admission rate, consultations per physicians and patient satisfaction level show that the reform has been had a positive effect on health care system. Moreover, full-day employee law's effectson healthcare are analyzed. There has been significant decrease in dual employment since the health care program was implemented.

3. METHODOLOGY AND DATA ANALYSIS

3.1. Methodology

The purpose of this study is to construct a model for examining the dynamic impacts of P4P system on public hospitals in Turkey. In order to build a simulation model, it is important to define the system and its boundaries. The system dynamics model includes revenue concern of physicians and hospitals, hospital crowding, quality indicators and treatment structures. The interactions within these variables have a non-linear feedback nature. Thus, it is difficult to analyze possible managerial actions with analytical methods. With the capability of handling complex feedback structures, system dynamics is a convenient method for the analysis, considering the aim of this study.

System Dynamics methodology is selected and used in modeling the dynamic impacts of P4P system on Turkish public hospitals. Barlas (2002) explains the system dynamics disciplineas follows:

> "System dynamics discipline deals with dynamic policy problems of systematic, feedback nature. Such problems arise from interaction between system variables and from the interactions between system variables and from the feedbacks between the managerial actions and the system reactions. The purpose of a system dynamics study is to understand the causes of a dynamic problem, and then search policies that alleviate/eliminate them."

Considering health system and interactions within sub-systems or other systems, the problem needs to be examined in a methodological and systematic way. Moreover, P4P system's effects on healthcare, managerial actions/policy decisions and the system responses are the result of feedback nature. Thus, system dynamics methodology is appropriate for modeling the problem, understanding the main relations within the system and system behavior and proposing alternative policies which help system to improve.

The following methodology has been used through the study:

- Problem Identification
- Formulation of Dynamic Hypothesis
- Formulation of System Dynamics Model
- Validity and Sensitivity Tests
- Scenario and Policy Analysis

3.2. Data Analysis

Performance based payment system has been in practice in second step public hospitals since 2004. There have been changes in health service, physician-patient relations and hospital health provider relations.

According to WHO, health services include all services dealing with the diagnosis and treatment of disease, or the promotion, maintenance and restoration of health.

After the implementation of P4P system, health service providers' primary motivation becomes high profit with high productivity. The reason behind this motivation is a payment system which is constructed to award increases in productivity and decreases in health costs.

Unmet health demand is a chronic problem for health policy makers in Turkey. Although MOH has continued to increase university hospitals and health employee resources to meet abundant health demand, yet health demand is much higher than health resources' capacity. With short-term solution perceptive, P4P provides increase in productivity in theory. When changes after P4P system implementation are examined, it can be interpreted that there have been positive and negative impacts onhealth statistics. These impacts can be classified as follows:

- Physician Revenue
- Number of Examinations
- Number of Surgeries
- Number of Tests- Analysis Activities

- Health Expenditures

3.2.1. Physicians' Revenue

Physicians' revenue is an important indicator for physicians' job satisfaction and health service quality. With P4P system, physicians have ability to increase their revenue by increasing their medical activity performance. Considering the lowest income in OECD countries, physicians increased their medical productivity and thus their revenue. The changes in physician revenue between 2004 and 2012 in 2005 reel values are shown in Figure 3.1 (Health Statistical Yearbook,2011). Physicians' revenue increased in 2005 but decreased again and remained stable during five years. As a result, physicians increased their medical activity performance, yet they couldn't increase their revenue in real values via fluctuations in inflation rates.

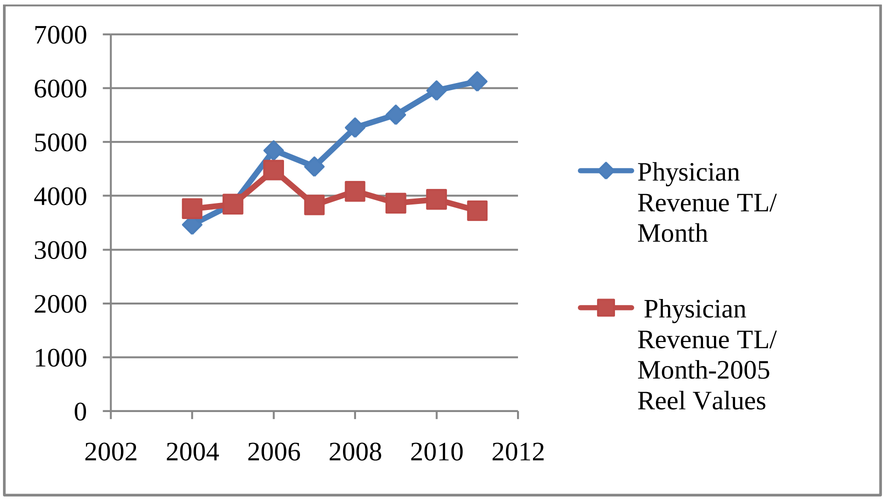

Figure 3.1.Physicians' Revenue per month with real values.

3.2.2.Number of Examinations-Applications

Numbers of applications and examinations in health centers have increased since P4P system implementation. Physicians increased their medical performance for revenue and crowding concerns. As a consequence, they decreased time spent per medical activity for increasing productivity. Thus, underestimating the health quality resulted as increase in inadequate treatments, wrong diagnoses and wrong surgeries. The changes in number of applications to MOH hospitals can be seen from Figure 3.2 and Figure 3.3(Health Statistical Yearbook,2011).

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Patients have started to visit hospital more frequently since 2002. Changes in hospital applications may be resulted from inadequate treatments, wrong diagnoses as well as change in hospital visit habits.

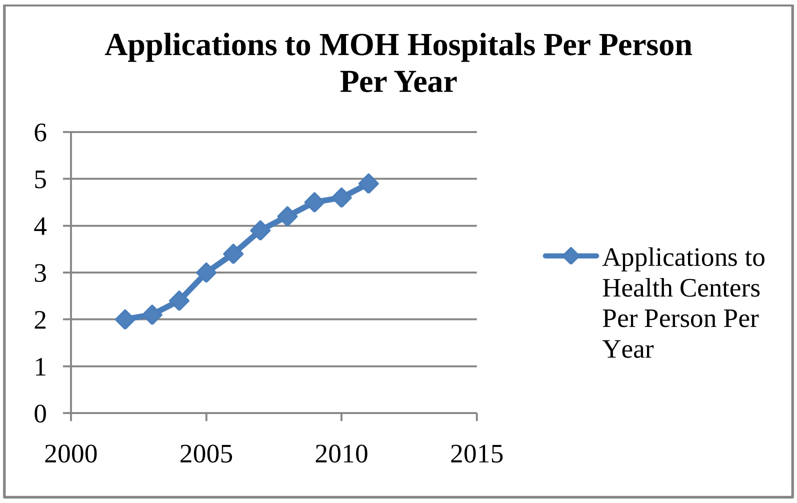

Figure 3.2. Number of Applications to MOH Hospitals per person per year.

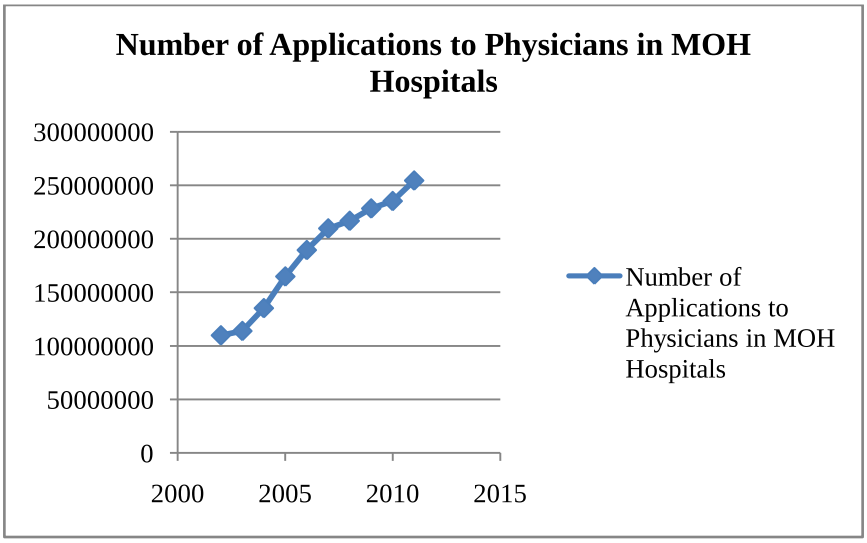

Figure 3.3.Number of Applications to Physicians in MOH Hospitals.

3.2.3. Number of Surgeries

Same as other medical activities, number of surgeries performed over the years increased since P4P system. Surgeons started to refer more patients to surgery in order to increase their revenue. More unnecessary surgeries might havebeen performed for revenue concerns. The change in number of surgeries performed per year ispresented in *Figure 3.4* (Health Statistical Yearbook,2011). According to TTB's survey in 2009, 70% of physicians believed that unnecessary medical operations increased since P4P. The graph below shows the change in number of surgeries in MOH Hospitals over the years.

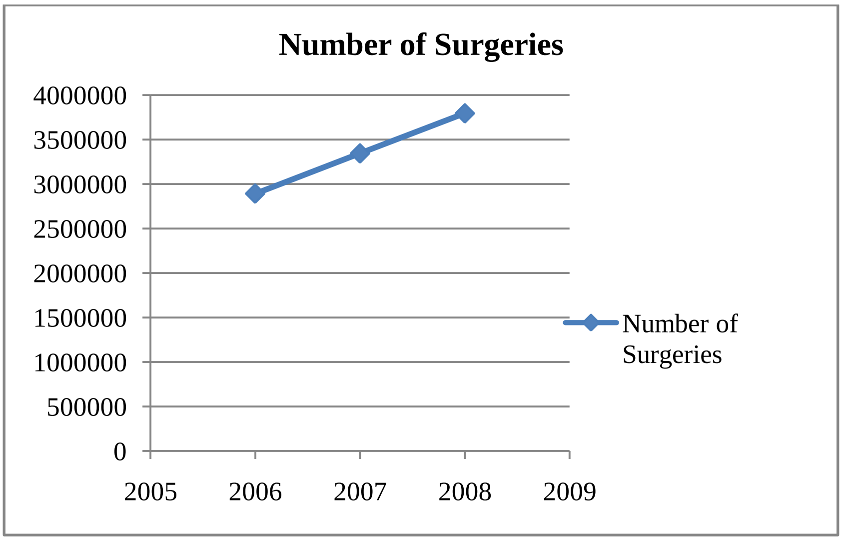

Figure 3.4. Number of Surgeries performed per year.

3.2.4. Number of Tests-Analysis Activities

Tests and analysis activities are one of the primary revenue resources for hospitals and physicians. Hospitals can increase their revenue by providing more tests and analysis to patients. In addition to this, diagnostic physicians can increase their performance by performing more tests and analysis. As a result, number of tests and analysis activities are expected to increase since 2004. The following graph shows the changes in test activities in second step public hospital in İstanbul. As can be seen from below, number of tests performed per year has increased since P4P system. Between 2004 and 2009, there has been significant increase in tests activity performance. After 2009, the changes have some oscillations.

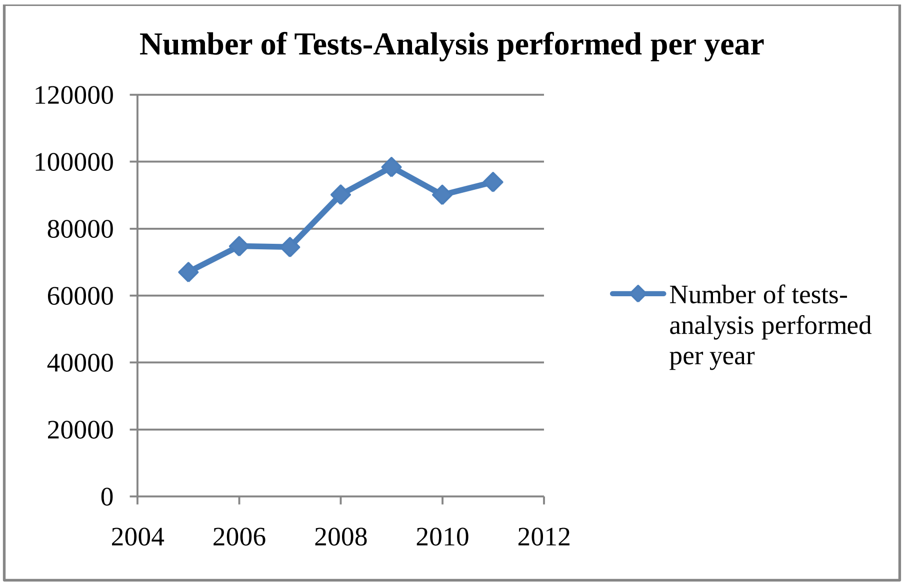

Figure 3.5. Number of Tests / Analysis Performed per year.

3.2.5. Health Expenditures

Health expenditures have increased since 2004. Increase in health productivity, improved medical activity over the years, consequently health expenditures. Moreover, number of medicine prescribed per year increased over the years. With performance based payment system's adverse impacts, physicians start to spend less time per examination and complete eye-examination by prescribing unnecessary medicine. Also, they can perform more examinations, surgeries and tests-analysis to increase their performance revenue. As a result; while physicians improved their revenue by performing more medical activities, health expenditures increased.The following graph shows the changes of health expenditures of Turkey between 2002 and 2010.

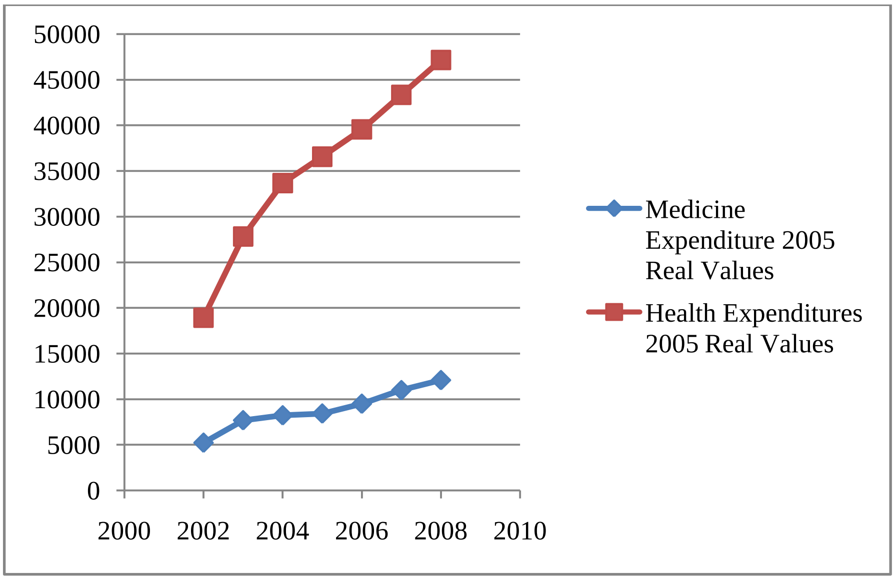

Figure 3.6. Health Expenditures between 2002 and 2010.

4. OVERVIEW OF THE MODEL

Dynamic simulation model includes patients, physicians, physician’s medical activities and performance calculation related variables. System dynamics methodology is used in constructing the model. The motivation of this modeling study is to examine dynamic impacts of PBPS on health outputs and quality in second step public hospitals.

The initial conditions, the number of physicians and physician reference revenue values are the average of second step public hospitals in Istanbul.

In general, the main variables are patient-flow related variables in hospital, salary related variables for physicians, and revenue related variables for hospitals. Revenue related variables are representation of the simplified version of the complex PBPS.

For investigating patient-flows in hospitals: correct diagnose rate, wrong diagnose rate, correct treatment rate, wrong treatment rate, inadequately treated patients, surgical correction rate and patients applying for treatment to another hospital are taken into account for building a base stock-flow diagram that represents second step public hospital reactions to PBPS.

There are four main stocks in model: treatable patients with diagnostic, treatable patients, inadequate treatments, chronic patients and inadequate surgeries. Treatable patients with diagnostic represents patients who apply for medical treatment to hospital and wait for diagnose of their health problems. Treatable patients are patients who pass diagnose process and wait for treatment. What is meant by treatment is the treatment of special patients such as diabetes, asthma and cancer patients. Treatment of these chronic patients is to resolve the patient complaints and provide acceptable live standards and the continuity of healthcare.

Other important stock variables are inadequate treatments and inadequate surgeries. These variables are the result of wrong diagnoses and treatments flows and affected in various waysby time spent per examination and tests by directly or indirectly.

The main variables which affect the stocks and dynamics of the model are time spent per examinations, number of physicians (health employee resources), hospital bed capacity, unit performance points.

Number of patients inadequately treated is a result of inadequate treatments and affected by time spent per examination, number of patients examined per month. Treatable patients with diagnostic represents patients whose diagnoses are not complete and need medical examinations and tests more than regular patients, visit hospital and apply for treatment more than the average per month.

Time horizon of the model should extend far enough back in history to show how the problem emerged and describe its symptoms. It should extend also far enough into to the future to capture delayed and indirect effect of potential changes (Barlas, 1996).

The problem/purpose of this study is the potential adverse effects of PBPS on second step public hospitals. Time horizon for base model should be long enough to understand the effects of PBPS. As a part of HTP, PBPS has been active since 2004.

Since, PBPS is generally based on the calculation of medical activities per month and a long term perspective is adopted, time unit of the problem was selected as month. In order to capture the real system behavior and problem dynamics, time horizon was selected as 48 months.

Interactions between revenue variables and quality variables are included in model. Physicians' revenue concern affects TSPE. With spending less time on examinations, physicians can increase their productivity and as a result their performance revenue. Simplified stock–flow model is presented in Figure 4.1.

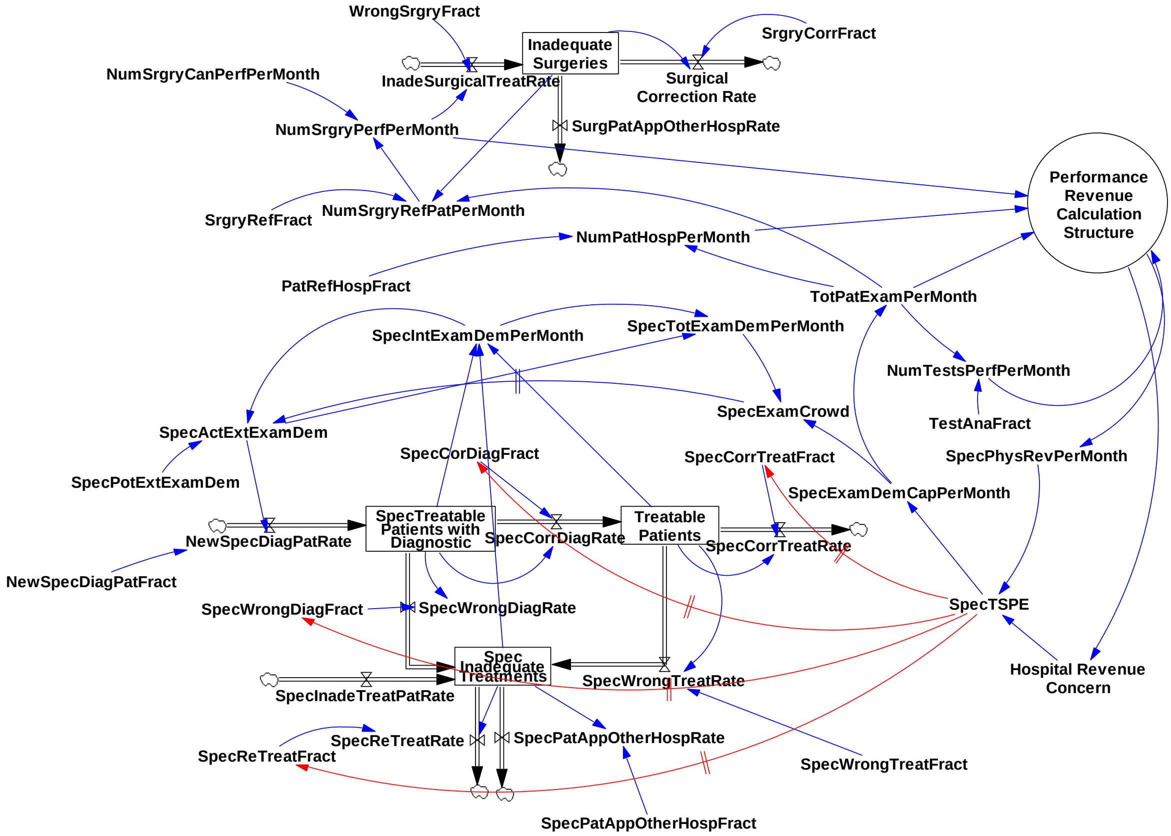

Figure 4.1. Simplified Version of the Stock-Flow Diagram.

4.1. Treatment Structure

One of the main structures in the model is specialist treatment structure. This structure represents diagnose and treatment process (Figure 4.2, below). External demand is the input of this structure.

After correct diagnoses, patients become eligible for treatment activity. Treatment and diagnose activities are both affected by health quality indicators. Main indicators are time spent per examination and time spent per tests. If a physician spend more time per patient, it is likely to see increase in correct diagnose and treatment rates. However, when physicians spend less time per examinations and other medical activities, wrong diagnose and treatment rates increase.

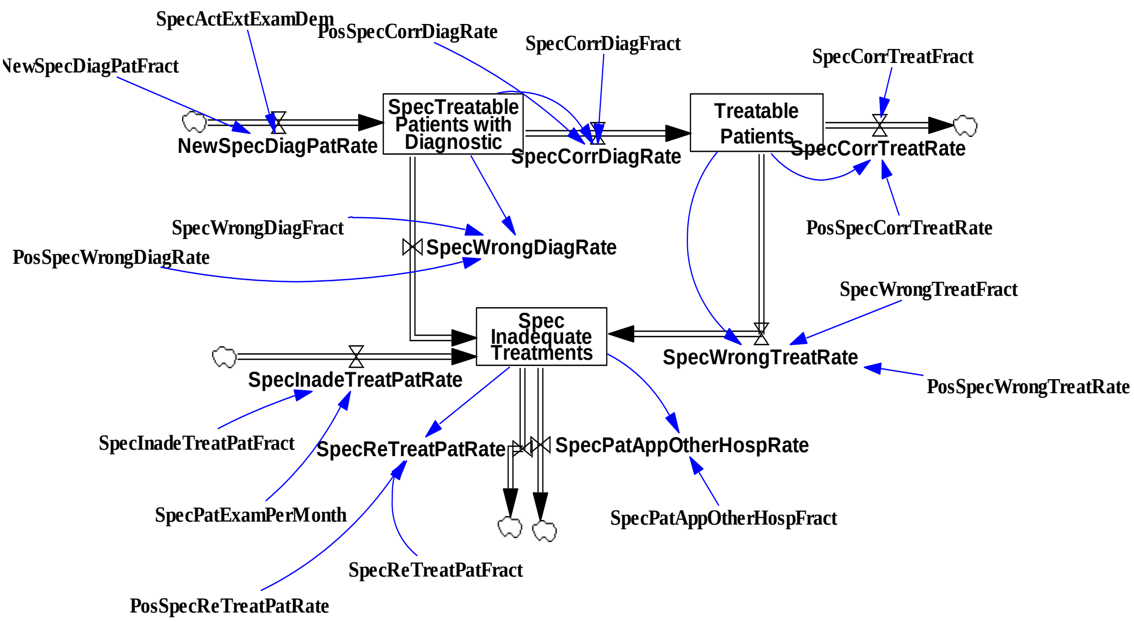

Figure 4.2. SpecialistTreatment Structure.

4.2. Demand Structure

Two different demand sources are included in model. One is external demand and the other one is internal demand. The internal demand is generated by visits of patients who are still in treatment structure. Internal demand structure is affected by external demand. If internal demand increases due to decreases in health quality or health employee resources, crowding increases as a result. Since hospital has limited capacity for medical activities, external demand can decrease owing to increases in internal demand.

The Demand Formulation Structure is expressed in Figure 4.3:

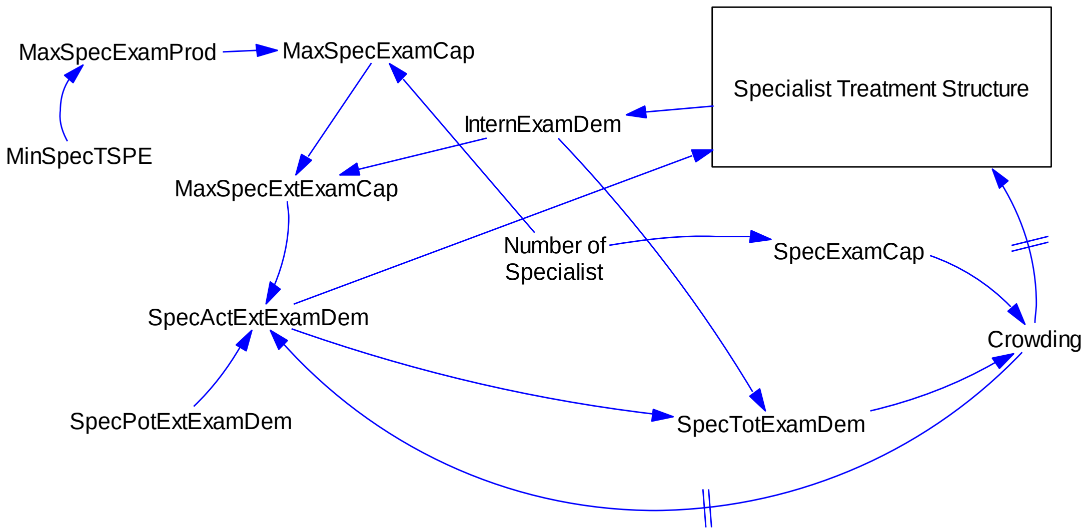

Figure4.3. Internal-External Demand Structure.

Internal examination demand is generated by specialist treatment structure and affects external demand by effect of crowding in time. On the other hand, internal demand is affected by external demand. For instance, 15% of the external demand is in-flow for internal demand each month.

4.3. Performance Revenue Calculation Structure

PBPS has complex revenue formulations. Physicians perform medical activities and in return, they obtain performance points. Each medical activity has unique performance points. Physicians may prefer high incentivized points in order to increase their individual performance. Current performance point formulation is composed of individual and group based performance point calculation.

Considering the types of medical operations performed, number of doctors in hospital is divided into three parts in SD model: surgeon physicians, specialist physicians and diagnostic physicians. Apart from specialist physicians, surgeon physicians also perform surgery and can get additional payments due to the number of surgeries performed per month. Diagnostic physicians are responsible for performing tests and aiding physicians to diagnose correctly with supplying test results.

Salary calculations for specialist physicians and surgeon physicians are pretty much same except surgery payments to surgeons. For each month, physicians and surgeons examine patients, perform medical operations, make hospital visits and get additional payments due to their medical activities. If a physician performs more medical operations, then PBPS awards him/her with more additional payments. Diagnostic physicians obtain performance point respect to the number of tests that they perform. Salary calculations are based on performance point calculation for month and simplified version of current PBPS.

In order to gain model simplicity and not to lose important effects and interactions following formulation in Figure 4.4is used.

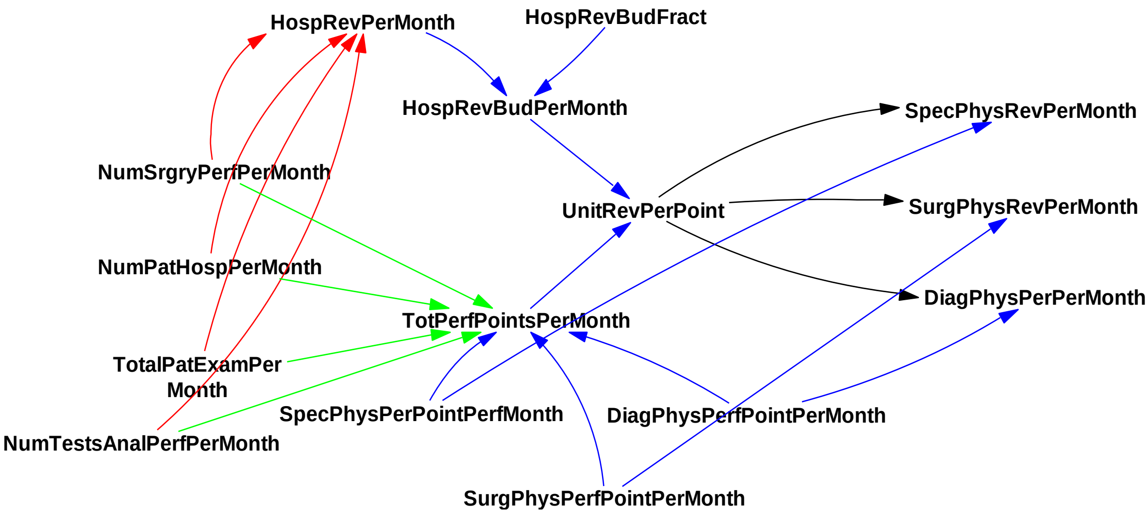

Figure 4.4. Performance Revenue Calculation Structure.

4.4. Hospital Revenue Calculation Structure

Another important variable for PBPS is the revenue of hospital. Additional payments from revolving budget are strictly related to the hospital's revenue. As a result, hospitals may induce physicians and surgeons to perform more examination and medical operations for increasing hospitals' income. Moreover, physicians may tend to refer more patients to hospital care and to increase patients' length of stay in hospital to increase the revenue of hospital. Furthermore, surgeons may refer patients to surgery care for revenue purposes, even if patients' condition is not severe enough for surgery care. In addition to medical operations; tests and analysis, which are performed in hospitals, increase hospital revenue.

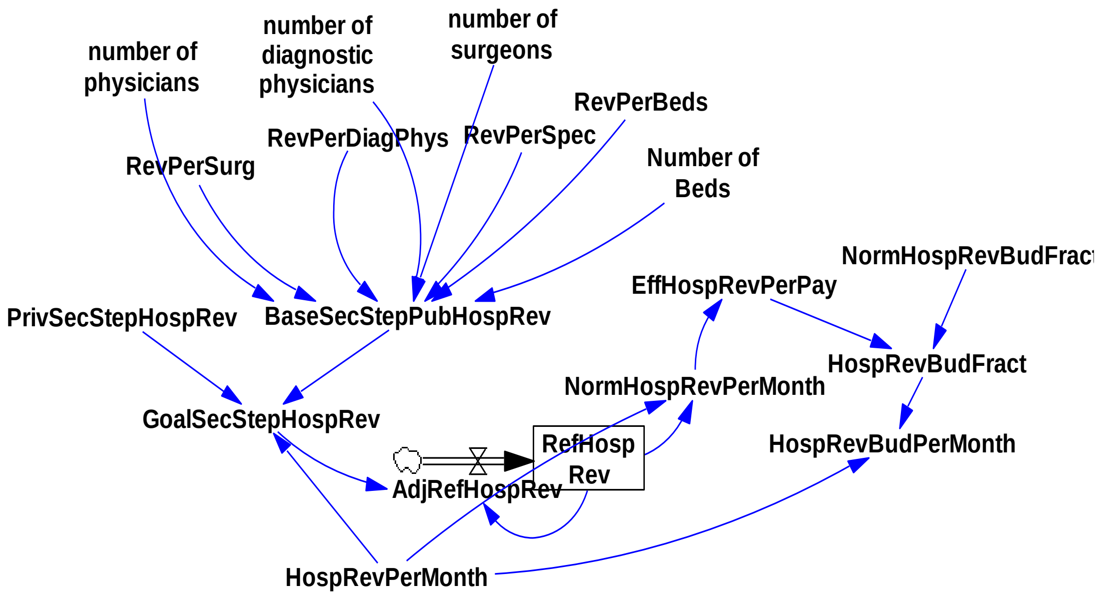

Figure 4.5.Hospital Revenue Calculation Structure.

4.5. Major Model Variables and Their Explanations

Major model variables and their definitions are presented in the table below:

Table 4.1. Major Model Variables and Their Explanations.

Variable	Definition	Type	Unit
ActExtExamDemSpec	Actual Examination Demand to Specialist Physicians Per Month	Converter	People/ Month
Chronic patients	Chronic Patients	Stock	People
ChronPatRemovRate	Chronic Patients Removal Rate	Flow	People/ Month
DiagPhyPerPointPerMonth	Diagnostic Physician Performance Points per Month	Converter	Points/ Month
DiagPhyPerRevPerMonth	Diagnostic Physician Performance Revenue Per Month	Converter	TL/ Month

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
DiagPhysProductivity	Diagnostic Physician Productivity	Converter	Tests/ Month
DiagPhysRevPerMonth	Diagnostic Physician Revenue Per Month	Converter	TL/ Month
EffAvailSpecActDem	Effect of Availability on Specialist Actual Demand	Converter	Dimension less
EffDiagPhysCrowd TSPT	Effect of Diagnostic Physician Crowding on TSPT	Converter	Dimension less
EffDiagPhysRevTSPT	Effect of Diagnostic Physician Revenue on TSPT	Converter	Dimension less
EffDiagPhysTSPT WrongDiagFract	Effect of Diagnostic Physician TSPT on Wrong Diagnose Fraction	Converter	Dimension less
EffHospRevSpecTSPE	Effect of Hospital Revenue on Specialist Physician TSPE	Converter	Dimension less
EffHospRevSurgTSPE	Effect of Hospital Revenue on Surgeon Physician TSPE	Converter	Dimension less
EffHosRevPerPay	Effect of Hospital Revenue on Performance Payments	Converter	Dimension less
EffInPatCrowdHosPer Month	Effect of In-Patient Crowding on Hospitalization per Month	Converter	Dimension less
EffSpecAppExam	Effect of Specialist Applications to Examination	Converter	Dimension less
EffSpecCrowdExtDem and	Effect of Specialist Crowding on External Demand	Converter	Dimension less
EffSpecCrowdTSPE	Effect of Specialist Crowding on Effect of Revenue on TSPE	Converter	Dimension less

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
EffSpecExamCrowd TSPE	Effect of Specialist Examination Crowding on TSPE	Converter	Dimension less
EffSpecRevHospFract	Effect of Specialist Revenue on Hospitalization Fraction	Converter	Dimension less
EffSpecRevTSPE	Effect of Specialist Revenue on TSPE	Converter	Dimension less
EffSpecTSPEChron PatRemTime	Effect of Specialist TSPE on Chronic Patients Removal Time	Converter	Dimension less
EffSpecTSPECorr DiagFract	Effect of Specialist TSPE on Correct Diagnose Fraction	Converter	Dimension less
EffSpecTSPECorr TreatFract	Effect of Specialist TSPE on Correct Treatment Fraction	Converter	Dimension less
EffSpecTSPEInTreat Fract	Effect of Specialist TSPE on Inadequate Treatment Fraction	Converter	Dimension less
EffSpecTSPEWrong DiagFract	Effect of Specialist TSPE on Wrong Diagnose Fraction	Converter	Dimension less
EffSpecTSPEWrong DiagFract	Effect of Specialist TSPE on Wrong Diagnose Fraction	Converter	Dimension less
EffSurgAppExam	Effect of Surgeon Patients Applications	Converter	Dimension less
EffSurgAppSurPer	Effect of Patients Applications to Surgeons	Converter	Dimension less
EffSurgAvExamExt Demand	Effect of Surgeon Availability on External Examination Demand	Converter	Dimension less
EffSurgCrowdEff SurgRevTSPE	Effect of Surgeon Crowding on Effect of Surgeon Revenue on TSPE	Converter	Dimension less
EffSurgCrowdExtDe mand	Effect of Surgeon Crowding on External Demand	Converter	Dimension less

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
EffSurgCrowdTSPE	Effect of Surgeon Examination Crowding on TSPE	Converter	Dimension less
EffSurgCrowdTSPS	Effect of Surgeon Crowding on TSPS	Converter	Dimension less
EffSurgRevSrgryFract	Effect of Surgeon Revenue on Surgery Referring Fraction	Converter	Dimension less
EffSurgRevSrgryTime	Effect of Surgeon Revenue on Surgery Time	Converter	Dimension less
EffSurgRevTSPS	Effect of Surgeon Revenue on TSPS	Converter	Dimension less
EffSurgTSPEChronPat RemovTime	Effect of Surgeon TSPE on Chronic Patients Removal Time	Converter	Dimension less
EffSurgTSPECorrDiag Fract	Effect of Surgeon TSPE on Correct Diagnose Fraction	Converter	Dimension less
EffSurgTSPECorr TreatFract	Effect of Surgeon TSPE on Correct Treatment Fraction	Converter	Dimension less
EffSurgTSPEInad TreatFract	Effect of Surgeon TSPE on Inadequate Treatment Fraction	Converter	Dimension less
EffSurgTSPEWrong DiagFract	Effect of Surgeon TSPE on Wrong Diagnose Fraction	Converter	Dimension less
EffSurgTSPEWrong TreatFract	Effect of Surgeon TSPE on Wrong Treatment Fraction	Converter	Dimension less
EffTestAppNumTest Perf	Effect of Tests Applications on Number of Tests Performed Per Month	Converter	Dimension less
EffTestCrowdEffDiag PhyRevTSPT	Effect of Tests Crowding on Effect of Diagnostic Physician Revenue on TSPT	Converter	Dimension less
EffTSPSCorrTreat Fract	Effect of TSPS on Correct Treatment Fraction	Converter	Dimension less
EffTSPSInadSurgFract	Effect of TSPS on Inadequate Surgery Fraction	Converter	Dimension less
EffTSPTCorrDiag Fract	Effect of TSPT on Correct Diagnose Fraction	Converter	Dimension less
DiagPhysGoal Revenue	Diagnostic Physician Goal Revenue	Converter	TL/Month
SecStepPubHosGoal	Second Step Public Hospital Goal Revenue	Converter	TL/Month
SpecGoalRevenue	Specialist Physician Goal Revenue	Converter	TL/Month
SurgGoalRevenue	Surgeon Physician Goal Revenue	Converter	TL/Month
HealthExpenditurPer Month	Health Expenditure Per Month	Converter	TL/Month
HosCapacityPerMonth	Hospital Capacity Per Month	Converter	People/ Month

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
HospRevPerMonth	Hospital Revenue Per Month	Converter	TL/Month
HospSpecVisTreatPat	Hospital Specialist Visits Per Treatable Patients	Converter	1/Month
HospSurgVisTreatPat	Hospital Surgeon Visits Per Treatable Patients	Converter	1/Month
HospVisChronPat	Hospital Visits Per Chronic Patients	Converter	1/Month
HospVisInadeTreat	Hospital Visits Per Inadequately Treatments	Converter	1/Month
HospVisPerMonth	Hospital Visits Per Month	Converter	Visits/ Month
HosRevBudPerMonth	Hospital Revolving Budget Per Month	Converter	TL/Month
HosVisDiagPatPer Month	Hospital Visits for Diagnostic Patients Per Month	Converter	1/month
Inadequate Surgeries	Inadequate Surgeries	Stock	People
InadSurgicalTreated Patients	Inadequately Surgical Treated Patients	Stock	People/ Month
InPatCrowd	In Patient Crowding	Converter	Dimension less
IntSpecExamDemPer Month	Internal Specialist Examination Demand Per Month	Converter	People/ Month
IntSurgExamDemPer Month	Internal Surgeon Examination Demand Per Month	Converter	People/ Month
MaxSpecExamCap	Maximum Specialist Examination Capacity	Converter	People/ Month
MaxSpecExamProduc Tivity	Maximum Specialist Examination Productivity	Converter	People/ Month/ Specialists
MaxSpecExtExamCap	Maximum Specialist External Examination Capacity	Converter	People/ Month
MaxSurgExamCapa city	Maximum Surgeon Examination Capacity	Converter	People/ Month
MaxSurgExamProduc tivity	Maximum Surgeon Examination Productivity	Converter	People/ Month/ Surgeons
New Chronic Patients	New Chronic Patients	Flow	People/ Month
NewSpecDiagPatRate	New Specialist Physicians Diagnostic Patients Rate	Flow	People/ Month
NewSurgDiagPatFract	New Surgeon Diagnostic Patients Fraction	Flow	People/ Month
NewSurgDiagPatRate	New Surgeon Diagnostic Patients Rate	Flow	People/ Month

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
NumMedPres	Number of Medicine Prescribed Per Month	Converter	Medicine/ Month
NumPatHospPer Month	Number of Patients Hospitalized Per Month	Converter	People/ Month
NumPatRefInPatCare	Number of Patients Referring to In-Patient Care	Converter	People/ Month
NumSrgryCanBePerf PerMonth	Number of Surgeries Can Be Performed Per Month	Converter	Surgery/ Month
NumSrgryPerfPer Month	Number of Surgeries Performed Per Month	Converter	Surgery/ Month
NumTestAnAppPer Month	Number of Tests Analysis Applications Per Month	Converter	Tests/ Month
NumTestCanBePerf PerMonth	Number of Test Can Be Performed Per Month	Converter	Tests/ Month
NumTestsPerPer Month	Number of Tests Performed Per Month	Converter	Tests/ Month
PatExamPerMonth	Patients Examined Per Month	Converter	People/ Month
PatExamSpecPerMont h	Patients Examined by Specialists Per Month	Converter	People/ Month
PatExamSurgPerMont h	Patients Examined By Surgeons Per Month	Converter	People/ Month
PerRevDiagPerMonth	Performance Revenue of Diagnostic Physician Per Month	Converter	TL/Month
PhysTotSalPerMonth	Physician Total Salary Per Month	Converter	TL/Month
PosSpecCorrDiagRate	Possible Specialist Correct Diagnose Rate	Converter	People/ Month
PosSpecReTreatPer Month	Possible Specialist Re-Treatment Per Month	Converter	People/ Month
PosSpecTreatPer Month	Possible Specialist Treatment Per Month	Converter	People/ Month
PosSpecWrongTreat PerMonth	Possible Specialist Wrong Treatment Per Month	Converter	People/ Month
PosSurgCorrDiagPer Month	Possible Surgeon Correct Diagnose Per Month	Converter	People/ Month
PosSurgCorrTreatPer Month	Possible Surgeon Correct Treatment Per Month	Converter	People/ Month
PosSurgReTreatPer Month	Possible Surgeon Re Treatment Per Month	Converter	People/ Month
PosSurgWrongDiag PerMonth	Possible Surgeon Wrong Diagnose Per Month	Converter	People/ Month
PosSurgWrongTreat PerMonth	Possible Wrong Treatment Per Month	Converter	People/ Month

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
PosSurgWrongDiag PerMonth	Possible Surgeon Wrong Diagnose Per Month	Converter	People/ Month
PriSecStepHosRev	Private Second Step Hospital Revenue	Converter	TL/Month
RefDiagPhysRevenue	Reference Diagnostic Physician Revenue	Stock	TL/Month
RefHospRev	Reference Hospital Revenue	Stock	TL/Month
RefSpecRevenue	Reference Specialist Physician Revenue	Stock	TL/Month
RefSurgRevenue	Reference Surgeon Revenue	Stock	TL/Month
RevBudgetFract	Revolving Budget Fraction	Converter	Dimension less
SpecCorrDiagRate	Specialist Correct Diagnose Rate	Flow	People/ Month
SpecCorrTreatRate	Specialist Correct Treatment Rate	Flow	People/ Month
SpecExamCapPer Month	Specialist Examination Capacity Per Month	Converter	People/ Month
SpecExamCrowd	Specialist Examination Crowding	Converter	Dimension less
SpecExamProd	Specialist Examination Productivity	Converter	People/ Month/ Physicians
SpecInadequate Treatments	Specialist Inadequate Treatments	Stock	People
SpecInadeTreatPat Rate	Specialist Inadequately Treated Patients Rate	Flow	People/ Month
SpecInadeTreatPer Exam	Specialist Inadequately Treated Patients Per Examination	Converter	Dimension less
SpecPatAppOther Hosp Rate	Specialist Patients Applying to Other Hospital Rate	Flow	People/ Month
SpecPerPoints	Specialist Performance Points	Converter	Points/ Month
SpecPerRevPer Month	Specialist Performance Revenue Per Month	Converter	TL/Month
SpecPubPriRevRatio	Specialist Public-Private Hospital Revenue Ratio	Converter	Dimension less
SpecReTreatment Rate	Specialist Re Treatment Rate		People/ Month
SpecRevPerMonth	Specialist Revenue Per Month	Converter	TL/Month
SpecTreatable Patients	Specialist Treatable Patients	Stock	People
SpecTreatable Patients with Diagnostic	Specialist Treatable Patients with Diagnostic	Stock	People

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
SpecTSPE	Specialist Time Spent Per Examination	Converter	Minutes/ People
SpecWrongDiagRate	Specialist Patients Wrong Diagnose Rate	Flow	People/ Month
SpecWrongTreatRate	Specialist Wrong Treatment Fraction	Flow	People/ Month
SurgActExtExamDemPerMonth	Surgeon Actual Examination Demand Per Month	Converter	People/ Month
SurgCorrDiagRate	Surgeon Correct Diagnose Rate	Flow	People/ Month
SurgCorrTreatRate	Surgeon Correct Treatment Rate	Flow	People/ Month
SurgCorrTreatRatio	Surgeon Correct Treatment Ratio	Converter	Dimension less
Surgery Crowding	Surgery Crowding Per Month	Converter	Dimension less
SurgExamCapPerMonth	Surgeon Examination Capacity Per Month	Converter	People/ Month
SurgExamCrowding	Surgeon Examination Crowding	Converter	Dimension less
SurgExamProd	Surgeon Examination Productivity	Converter	People/ Surgeons/ Month
Surgical Correction Rate	Surgery Patients Corrections Rate	Flow	People/ Month
SurgInadequate Treatments	Surgeon Inadequate Treatments	Stock	People/ Month
SurgInadeTreatPatRate	Surgeon Inadequately Treated Patients Rate	Flow	People/ Month
SurgInadeTreatPerExam Ratio	Surgeon Inadequate Treatments Per Examination Ration	Converter	Dimension less
SurgPatAppOtherHosp Rate	Surgery Patients Applying Other Hospital Rate	Flow	People/ Month
SurgPerPoints	Surgeon Performance Points	Converter	Points/ Month
SurgPerRevenue	Surgeon Total Performance Revenue	Converter	TL/Month
SurgPerRevPerMonth	Surgeon Performance Revenue Per Month	Converter	TL/Month
SurgReTreat Rate	Surgeon Re Treatment Rate	Flow	People/ Month
SurgRevPerMonth	Surgeon Reference Revenue Per Month	Converter	TL/Month
SurgSrgryProd	Surgeon Surgery Productivity	Converter	Surgery/ (Month* Surgeons)

Table 4.1. Major Model Variables and Their Explanations (cont.).

Variable	Definition	Type	Unit
SurgTreatable Patients	Surgeon Treatable Patients	Stock	People
Surgtreatable Patients with Diagnostic	Surgeon Treatable Patients With Diagnostic	Stock	People
SurgTSPE	Surgeon Time Spent Per Examination	Converter	Minutes/ People
SurgWrongDiagPer Month	Surgeon Wrong Diagnostic Patients Per Month	Flow	People/ Month
SurgWrongDiagRate	Surgeon Wrong Diagnose Rate	Flow	People/ Month
SurgWrongPerRatio	Wrong Surgery Ratio	Converter	Dimension less
SurgWrongTreatRate	Surgeons Wrong Treatment Rate	Flow	People/ Month
TestAnalysisPerDiag Physician	Tests Analysis Per Diagnostic Physician	Converter	Dimension less
TestsCrowding	Tests and Analysis Crowding	Converter	Dimension less
Time Spent Per Surgery	Time Spent Per Surgery	Converter	Minutes/ Surgery
TimeSpentPerTests	Time Spent Per Tests	Converter	Minutes/ Test
TotPerPoints	Total Performance Points	Converter	Points/ Month
TotSpecExamDem PerMonth	Total Specialist Examination Demand Per Month	Converter	People/ Month
TotSurgExamDem PerMonth	Total Surgeons' Examination Demand Per Month	Converter	People/ Month

5. DESCRIPTION OF THE MODEL

In this section major structures and variables are explained in detail.Model has sub-structures and they are allinterrelated. These relations are shown below in detail.In addition to this, model's main assumptions are presented.

5.1. TreatmentFormulations

The model has three treatment formulations:

- Specialist physicians' patient treatmentformulation,
- Surgeon physicians' treatment formulation,
- Re-surgical treatment formulation.

Details for these treatment formulations are presented in sub-sections below.

5.1.1. Specialists'-Surgeons' Treatment Formulation

One of the main structures in the model is specialist treatment structure. This structure represents diagnose and treatment process of special patients.Specialpatients need extra tests, analysis and more examinations rather than regular patients. They create more visits to hospital than regular patients and increase hospital crowding.Their medical problems have not been diagnosed yet, thus they are waiting for diagnoses.

As described in Chapter4, the examination demand is composed of external and internal demand. Internal demand is directly affected by external demand.Moreover, internal examination demand affects total examination demand and hospital examination crowding. Hospital crowding affects external demand with a delay.

Every month, 15% of actual external demand enters this treatment structure as patients andwait for treatment.This variable's nameis SpecTreatablePatients with Diagnostic. For patients whom apply for medical service of surgeon physicians are named as SurgTreatablePatients with Diagnostic. The stock-flow diagram of specialist physician patients' treatment structure is given in Figure 4.1.

Special patients pass through diagnose and treatment processes. Patients whom are waiting for diagnose activities have two routes. Either, they are correctly diagnosed and wait for further treatment; or physicians have wrong diagnosis on them and patients become a part of inadequate treatments. In addition to this, patients whom are correctly diagnosed but wrongly treated are inflow to inadequate treatments. Moreover, %15 of patients that been examined by specialist physicians are inflow for inadequate treatments. Before taking adequate treatments, they either wait for re-treatment activities from hospital or leave for another hospital to satisfy and meet health service needs.

All flows of this structure are affected by time spent for medical activity variables. These variables are as follow:

- Time spent per examination by specialist physicians,
- Time spent per examination by surgeons,
- Time spent per tests by diagnostic physicians.

Diagnose process of a patient is affected by time spent per examination and tests. If physicians spend more time per medical activities, the quality of health service will improve. As a result, more patients are diagnosed correctly and take sufficient medical treatment. However;if physicians giveless priority to the health quality, thenwrong diagnoses and insufficient treatments will increase.

Diagnose activity is highly related with physicians' eye examination and tests or analysis performed on patients. Diagnose activity results as correct diagnoses or wrong diagnoses. These two variables are flow variables in model. Each variableis affected by time spent per tests and examinations.

The relationship between time spent per tests on correct diagnose rate is expressed in Figure 5.1. There is a positive relationship between time spent per tests and correct diagnose fraction. If diagnostic physicians give more attention to each tests and analysis, better and more accurate test results are presented to physicians. Thus, they can provide more accurate diagnoses for patients.

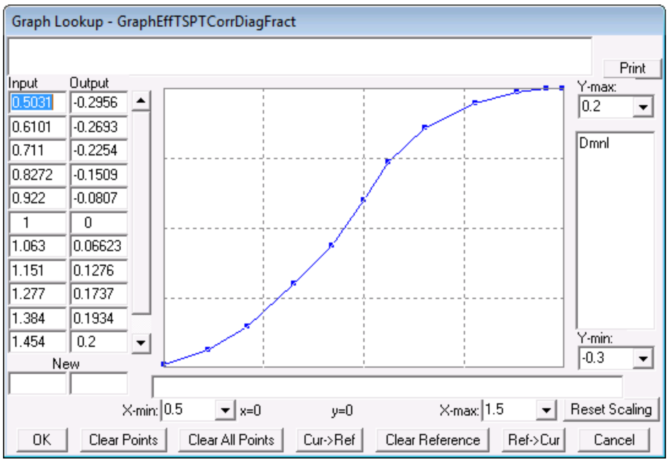

Figure 5.1. Effect of Time Spent Per Tests on Correct Diagnose Fraction.

Another factor that affects diagnose activity is time spent per examination. Eye examination is a key factor for correct diagnoses and analysis. When physicians spend longer time per examination, their diagnoses are more accurate.The relationship between time spent per examination and correct diagnose fraction is shown in Figure 5.2.

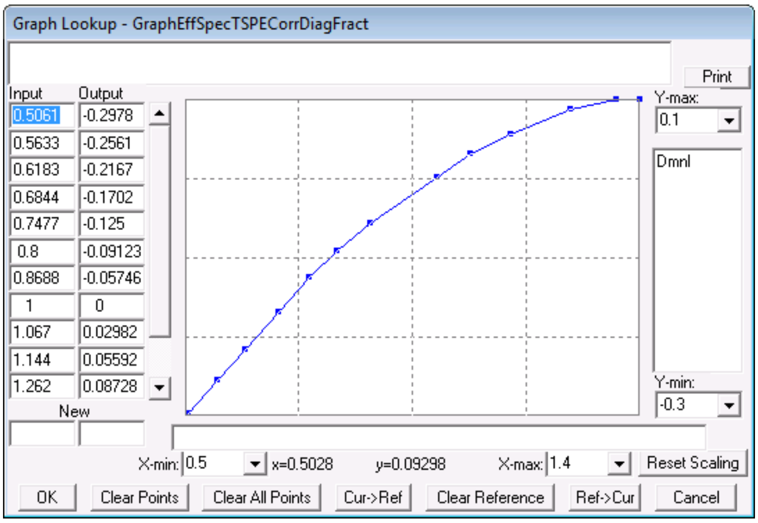

Figure 5.2. Effect of TSPE on Correct Diagnose Fraction.

Correct diagnose rate is a function of time spent per tests, examination andpossible correct diagnoses.

$$SpecCorrDiagRate = MIN(SpecTreatable\ Patients\ with\ Diagnostic * CorrSpecDiagFract, PosSpecCorrDiagRate) \tag{5.1}$$

$$CorrSpecDiagFract = NormSpecDiagFrac * (1 + DelEffTSPTCorrDiagFract + DelEffSpecTSPECorrDiagFract) \tag{5.2}$$

SpecCorrDiagRate represents correct diagnose rate for specialist physicians' patients. CorrSpecDiagFract is the correct diagnose fraction. Additive and multiplicative effect formulations are combined together for formulation of this variable.Wrong diagnose rate and wrong diagnose formulation is the reverse version of correct diagnose formulations. Details are presented in AppendixA.

Possible diagnose and treatments are included in model. What is meant by possible treatment or diagnose is that physicians can only treat or diagnose special patients as much as a certain percentage of their medical capacity. Since these patients are special with their medical needs, diagnoses and treatments are different from the average patients. They need more attention and effort. Possible rate formulations are given in the following equations. Fractions are constant variables and details about these variables are given in Appendix A.

$$PosCorrDiagRate = NumTestsPerfPerMonth * PosCorrDiagFract \tag{5.3}$$

$$PosWrongDiagRate = NumTestsPerfPerMonth * PosWrongDiagFract \tag{5.4}$$

5.1.2. Surgical Treatment Formulation

Surgical treatment formulationsinclude inadequate surgeries stock variable, its flows and its relations with other variables of the model. Surgical correction rate and surgery patients applying to other hospital rate are the outflow of this structure. Inflow of this structure is inadequate surgically treated patients.

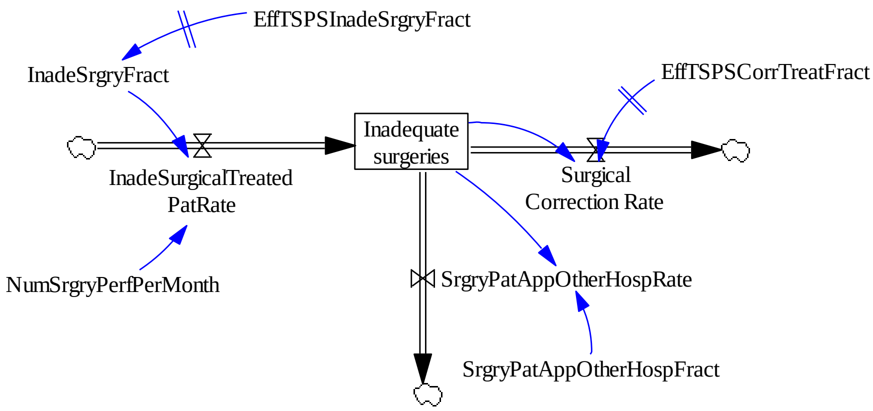

Figure 5.3.Surgical Treatment Structure.

Inadequate surgeries result as more admissions to surgery care. Surgery crowding increases pressure on surgeons for performing more surgery. In addition, revenue pressures lead surgeons to spend less time for surgery, perform more surgery. These pressures result as increases in surgery productivity and meanwhile decrease in surgery quality.

Inadequate surgically treated patients' rate is a function of number of surgeries performed per month and inadequate surgery fraction. Inadequate surgery fraction is affected by time spent per surgery. Time spent per surgery is critical for sufficient surgeries. If surgeons spend more time on surgery, complications due to surgery and wrong surgeries decrease as expected. The relationship between time spent per surgery and inadequate surgery fraction is presented in Figure 5.4.

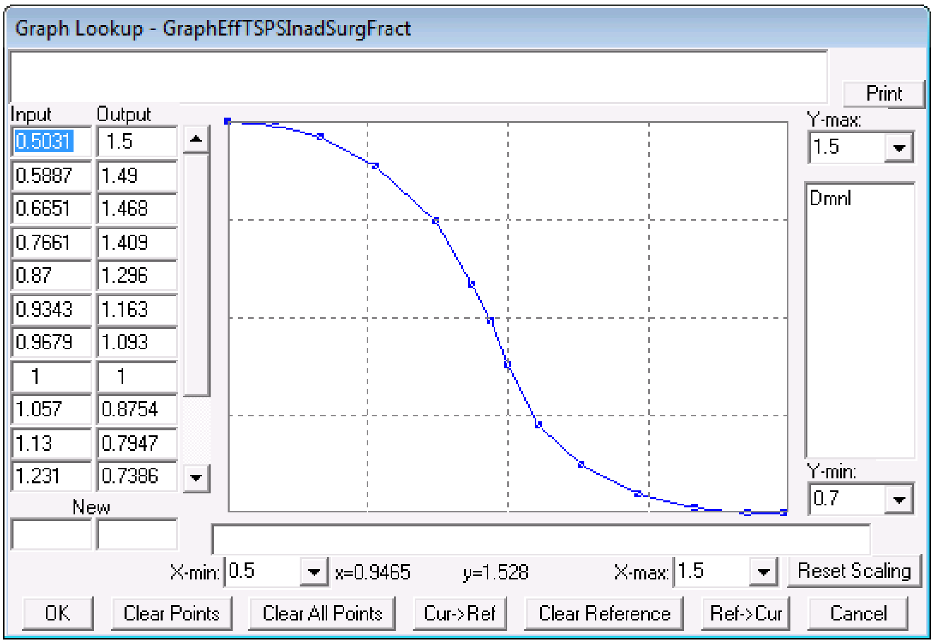

Figure 5.4. Effect of TSPS on Inadequate Surgery Fraction.

Surgical correction is a surgically treatment of patients whom are the results of inadequate surgeries. Inadequate surgery patients need surgical re-treatment and further medical operations. Thus, surgeons treat these patients by performing medical operations-surgeries. And,surgically treatment activity is a function of current inadequate surgeries and surgical treatment fraction. This fraction is affected by time spent per surgery. There is a positive relationship between surgical correction fraction and TSPS. When surgeons give more attentions to patients, spare more time per each surgery, permanent treatment rate may be better.The relationship between TSPS and surgically correct treatment fraction is displayed inFigure 5.5.

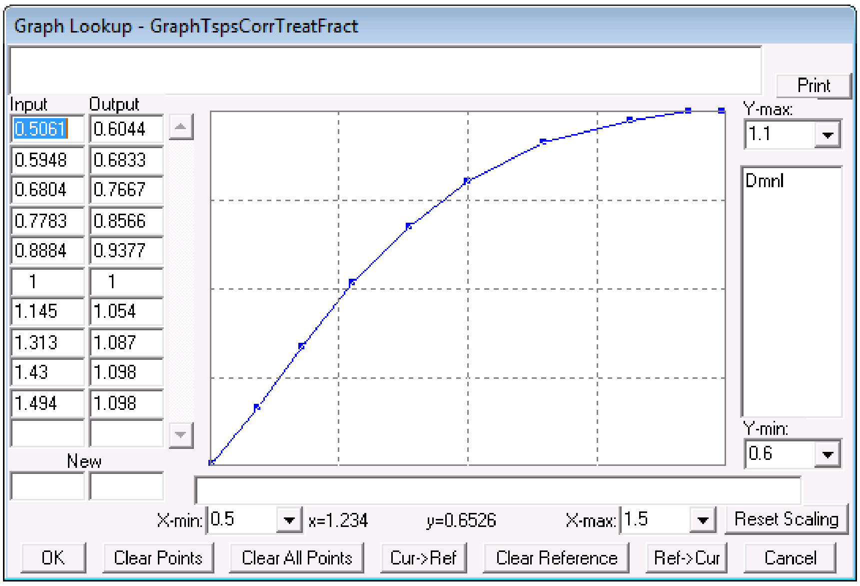

Figure 5.5.Effect of TSPS on Correct Treatment Fraction.

The following equations demonstrate the relationship between variables in surgically treatment structure. Inadequately treated patients are result of inadequate surgeries. Time spent per surgery is chosen as a quality indicator for surgery. Inadequate and surgical correction rate are dependent on surgery quality, thus TSPS. In addition, TSPS also affects surgery productivity thus, surgeon performance revenue. TSPS formulations are explained in detail in Section 5.6.3.

The resulting equations are:

$$InadSurgicalTreatedPatients = InadeSurgFract * NumSrgryPerfPerMonth \tag{5.5}$$

$$InadeSurgFract = NormInadeSurgFract * DelEffTSPSInadeqSrgryFract \tag{5.6}$$

$$\begin{aligned} Inadequate\ Surgeries \\ &= InadSurgicalTreatedPatients - SgryPatAppOtherHospRate \\ &- Surgical\ Correction\ Rate \end{aligned} \tag{5.7}$$

$$
\begin{aligned}
&Surgical\ Correction\ Rate \\
&\qquad = SrgryCorrTreatFract * Inadequate\ Surgeries \\
&\qquad * DelEffTSPSCorrTreat
\end{aligned}
\tag{5.8}
$$

$$
\begin{aligned}
&NumSrgryPerfPerMonth \\
&\qquad = EffSurgAppSurPer * NumSrgryCanBePerfPerMonth
\end{aligned}
\tag{5.9}
$$

$$
Surgery\ crowding = SurgPatAppPerMonth/NumSrgryCanBePerfPerMonth \tag{5.10}
$$

$$
NumSrgryCanBePerfPerMonth = Number\ of\ Surgeons * SurgSrgryProd \tag{5.11}
$$

$$
\begin{aligned}
&Time\ Spent\ Per\ Surgery \\
&\qquad = NormTimePerSurgery * (1 + DelEffSurgRevSurgTime \\
&\qquad + DelEffSurgCrowdTSPS)
\end{aligned}
\tag{5.12}
$$

$$
SurgSrgryProd = TotSurgTimePerSurgeons/Time\ Spent\ Per\ Surgery \tag{5.13}
$$

5.2.External-Internal Demand Formulation

Two different demand sources are included in model. One is external demand and the other one is internal demand. The internal demand is generated by the visits of patients who are still in treatment structure. Internal demand structure is affected by external demand. If health quality decreases, more patients are wrongly diagnosed and inadequately treated. Thus, internal demand increases. Increase in internal demand results as hospital crowding. Since hospital has limited capacity for medical activities, external demand decreases owing to increases hospital crowding.

One of the main effects in this formulation is effect of availability on actual external examination demand. Patients can generate examination visits to hospital with respect to its examination capacity. In order to include this assumption into the model, the following equations are used:

$$NormSpecExamAvail = PotExtExamDemSpec/MaxSpecExtExamCap \tag{5.14}$$

$$EffAvailSpecExtExamDem = F(NormSpecExamAvail) \tag{5.15}$$

Potential external examination demand represents patients whom are nearby hospital, able to make hospital visits and create medical service demand to hospital.Same as real-life implementation, potential examination demand is much bigger than health resources' capacity. Conversely, physicians or surgeons try to meet this health demand by performing more medical activities. On the other hand, when physicians or surgeons' examination capacity is higher than potential demand, then physicians are able to examine existing demand and not able to increase their performance revenue via performing more medical operations. The relationship between potential demand and maximum specialist examination capacity is shown in Figure5.6.

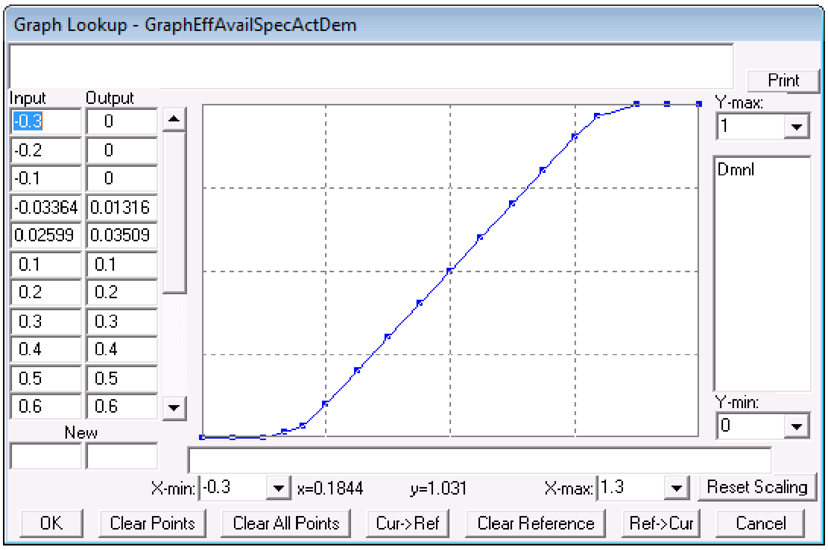

Figure 5.6. Effect of Specialist Availability on Actual Examination Demand.

Maximum specialist external examination capacity is the subtraction internal examination demand from maximum specialist examination demand. Specialist maximum examination capacity is calculated as divide of minimum examination time to the specialist physicians' total examination time. Minimum examination time per examination is assumed six minutes in model. Productivity formulation of examination activities are presented in Section 5.6.

In addition to effect of availability on external demand, hospital crowding also affects external demand. It is assumed that specialist examination crowding has a negative effect on external demand. If the crowding is far higher than the average, than the patients whom apply for medical service cannot get any treatment or examination. Lack of health service induces patients to seek other hospitals or health centers to fulfill medical needs.

$$SpecExamCrowd = TotSpecExamDemPerMonth/SpecExamCapPerMonth \tag{5.16}$$

$$EffSpcCrowdExtDem = F(SpecExamCrowd) \tag{5.17}$$

$$\begin{aligned} SpecActExtExamDem \\ &= EffAvailSpecExtExamDem * MaxSpecExtExamCap \\ &* DelEffSpecCrowdExtDem \end{aligned} \tag{5.18}$$

The following graph displays the relationship between examination crowding and external demand. As it can be seen from Figure 5.7, there is a negative relationship between crowding and external examination demand. If examination capacity is higher than demand then low crowding provoke more potential patients to apply to hospital for medical services.

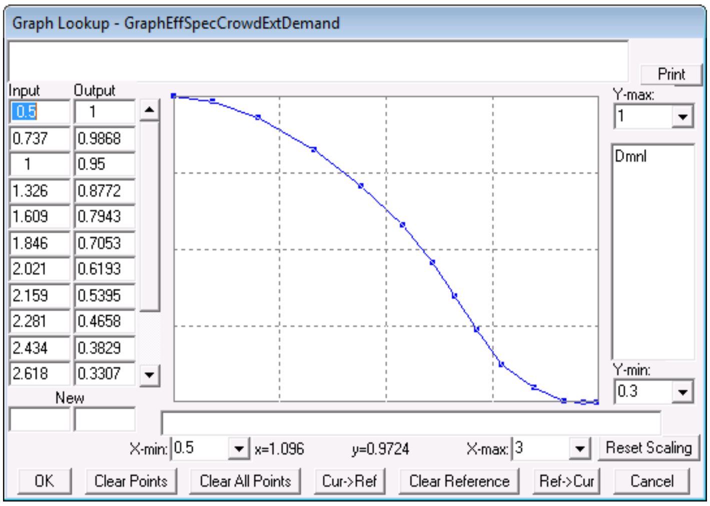

Figure 5.7. Effect of Crowding on External Demand

5.3. Physicians' Performance Revenue

Performance based payment system (PBPS) aims to improve health service quality and efficiency by paying additional payments to health employees. By the implementation of HTP, first studies over this payment system have been started. After the second half of 2003, PBPS was pilot in ten public hospitals. With feedbacks from the pilot implementation, performance evaluation criteria were improved. Corporate performance criteria are added into PBPS in 2005. The studies over management performance criteria and financial indicators were performed in 2006. PBPS is a dynamic policy application and from start it has been continuously improved depending on MOH strategic objectives. (Gazi, 2006)

According to the management science, performance management, which has been used in private sector corporates over the years, may be the wrong choice for public sector, especially if private sector's principles are followed without considering the attributes of public sector (Memiş, 2010). The main attribute and aim of public sector is to provide services for people without first priority on profits or revenue.

There is currently a great need to increase efficiency in public sector. And one of the sectors that open to improvement is healthcare. PBPS or P4P is one of the most common methods for improving quality and efficiency in private and public sectors.

In order to construct acceptable and sustainable performance system in public health sector, the following principles should be followed: measurable performance criteria, legality, openness and humanity (Bilgin 2004).

In 2004, the MOH and SSK signed protocol for common use of their health facilities, and in 2005, all SSK hospitals had been transferred to the MOH (Sulku, 2011). Since 2005, PBPS has been practice in all public health centers except university hospitals. The coverage percentage for PBPS implementation increased to %90. Since 2011, PBPS has been implemented in university hospitals.

Performance system has been performed with two instructions and three different models in these instructions (Memiş, 2010). In first instruction, rules and recommendations are for implementation into first step public health centers. These recommendations are for improving quality for health service and increasing proactive health activities. Physicians collect performance points owing to their medical performance. Due to their performance points, their revenue increases. In second instruction, model for second step public hospital and research hospitals are defined. These two models have common features but different implementation principles. In research and education hospitals, education and science activities are also recommended and rewarded. However, the opportunity to increase performance revenue by educational or research activities is far much lower than medical operations. Insufficient reward of educational and research activities may result as low health education quality and health service quality in long term.

One of the main constituent of PBPS is determination of 5300 medical operations' points. These medical operations which are performed by physicians are evaluated as their mental and physical contribution to health services. These medical operations are such as examination, hospital visit and surgery. Physicians collect performance points due to their medical performance and earn performance payments in return.

5.3.1. The Actual Physicians' Performance Revenue

Physicians' performance is measured directly from performance points that they collectby performing medical operations. Hospital performance point average is calculated by the arithmetic average of physicians' performance points and considering working days of physicians (Memiş, 2010).

Additional payments due to physicians' performance are based on the following factors:

- Physician's tittle
- Physician's task
- Working conditions and duration
- Contribution to health service
- Performance
- Full-time or part-time employee
- Examination
- Anesthesia, surgery
- Medical activities

Hospital employee revenue fraction is determined by their title, their tasks, their working conditions and duration and especially if they are working in risk hazardous places like radiology department. It is used for calculating indirect individual performance points.An individual performance point of health employee isthe multiplication of hospital employee fraction and hospital performance points' average.

All hospital employees' individual performance points (direct or indirect) are multiplied with freelance work fraction, active working days fraction and title fraction to find net performance revenue.If physicians work as part-time in public hospitals, and perform medical activities in private clinics, their net performance revenue is also multiplied with 0, 3. This performance point calculation is also used by government to induce physicians to work full-time in public hospitals. If physicians work as a full-time employee in public hospitals, then their performance revenue is multiplied by 1.

Performance based payment system provides direct performance revenue calculation of physicians and indirect performance revenue calculation of other health employees. Apart from this calculation method, system also includes reward mechanism to change performance revenue. Performance revenue is the multiplication of performance points of physician and unit revenue per points. Unit revenue per points is calculated by divide of total performance points to the net performance revenue.

5.3.2. Simplified Performance Revenue Formulation in the Model

In second step public hospitals, there are three main physicians groups: specialist physicians, surgeons and diagnostic physicians. For instance, specialist physicians are responsible for eye-examination and performing hospital visits to inpatients. In return, they collect performance points. In addition to these medical activities, surgeonsare able toperform surgeries and obtain performance payments due to these surgeries. Apart from specialist and surgeon physicians, diagnostic physicians perform tests and analysis and they collect performance points owing to these tests. There are also other employees in hospital who are responsible for managerial or other activities and having no direct impacts on health service quality. Thus, these employees and their performance revenue payments are not included into model.

Specialist physicians’ medical activities are eye-examination and hospital visit. They can spend less time per examination and perform more examination for improving their revenue. Moreover, they can refer more patients to in hospital care to make hospital visits and earn points due to these visits. According to medical activities’ point list, by performing an examination, physicians can obtain 20 points. Whereas, physicians can collect 40 points by making one hospital visits.

Surgeon physicians can also perform surgeries. Surgery performance points change between 75 and 4000. There are three types of surgeries: small surgeries, medium surgeries and large surgeries. For large surgeries, more than one surgeons and physicians participate in surgery operations and performance points are shared by the participants.

The interval and the average points of surgery types are displayed in Table 5.1.

Table 5.1. Surgery Types and Surgery Performance Points.

Surgery Type	Points	
	Interval	Average
A1	3000-5000	4000
A2	2000-2999	2500
A3	900-1999	1500
A	900-3000	2634
B	500-899	750
C	300-499	450
D	150-249	200
E	0-149	100

The surgery types and number of surgeries performed in second step public hospitals in Istanbul in 2009 are shown in Table 5.2.

Table 5.2. Surgery Types and Percentages.

Surgery Type	Number of Surgeries Performed	Percentage
A	3242	2.99%
B	15330	14.14%
C	34962	32.25%
D	26931	24.84%
E	27932	25.77%

Percentage of surgeries and performance points are taken into account for the average points per surgery. The weighted-average formulation is used for determining the average. And it is assumed that points per surgery in model are 400.

Diagnostic physicians can collect performance points due to tests and analysis they perform. Performance points per tests change from 4 points to 270 points. However, majority of test activities' points change between 7 and 20. Frequency of these tests and impacts on diagnose quality are taken into account and it is assumed that points per tests in model are 10 point points.

Current performance revenue formulation consists of direct and indirect performance revenue formulations. Direct formulations are used for calculating individual physician's performance revenue. Indirect formulations are used for calculation performance points of other health employees. These employees are like managers or clerks and they don't have any direct relations with patients or treatment structures. In order to obtain the simplicity, group based performance formulation is used. And the average of specialist physicians', surgeons' and diagnostic physicians' revenue is calculated using this perspective. The performance calculation structure is presented in Figure 4.5.The following formulations are used in model:

$$TotPerPoints = SpecPerPoints + SurgPerPoints + DiagPhyPerPoints \tag{5.19}$$

$$\begin{aligned} SpecPerPoints &\\ &= HospVisPerMonth * PointPerHosVis * (1 - SpecVisRatio) \\ &+ PatExamSpecPerMonth * PointsForExam \end{aligned} \tag{5.20}$$

$$\begin{aligned} SurgPerPoints &\\ &= HospVisPerMonth * PointPerHosVis * SpecVisRatio \\ &+ PatExamSurgPerMonth * PointsForExam + PoinsPerSurgery \\ &* NumSrgryPerfPerMonth \end{aligned} \tag{5.21}$$

$$DiagPhysPerPoints = NumTestsPerPerMonth * PointsPerTests \tag{5.22}$$

$$UnRevPerPoints = HosRevBudPerMonth/TotPerPoints \tag{5.23}$$

$$SpecPerRevenue = SpecPerPoints * UnRevPerPoints \tag{5.24}$$

$$SurgPerRevenue = SurgPerPoints * UnRevPerPoints \tag{5.25}$$

$$DiagPerRevenue = DiagPhysPerPoints * UnRevPerPoints \tag{5.26}$$

$$SpecPerRevPerMonth = SpecPerRevenue/Number\ of\ Specialists \tag{5.27}$$

$$SurgPerRevPerMonth = SurgPerRevenue/Number\ of\ Surgeons \tag{5.28}$$

$$DiagPhysRevPerMonth = DiagPhyPerRevene/Number\ of\ Diagnostic\ Physicians \tag{5.29}$$

5.4. Hospital Revenue-Revolving Budget

Hospital performance evaluation is accepted as suitable method by government. It has been used for the measurement of hospital performance since 2005. According to hospital's performance results, hospital revolving budget and hospital performance payments to its employees change.

5.4.1. The Actual Hospital Revolving Budget Formulation

In current performance revenue formulation in Turkey, hospital revolving budget is determined by corporate performance evaluation criteria and hospital revenue. Together with PBPS, hospitals can distribute 40% of their income to physicians when they achieve the best performance evaluation.

Corporate performance evaluation measurement is used to determine the performance of hospitals.Corporate performance evaluation is added into PBPS since 2005. With this implementation, government aims to increase health service quality and maintain it. MOH corporate performance measurement methods can be summarizedbyfour main points.

- Clinical health services
- Hospital quality criteria
- Physical and health process auditing
- Patients' and patients' relevant satisfaction surveys

5.4.1.1. Clinical Health Services Fraction.Crowding in health centers is a critical problem for Turkey. First step public health centers have been insufficient for meeting health demand. As a result, unmet health admissions increase health service crowding in clinics further. In order to meet the abundant health demand, physicians are induced to perform more medical operations. And in order to measure the medical performance, clinical health service fraction has been used since 2005. Number of physicians (ability to perform examination) per clinic examination room is used as a qualityindicator for meeting health demand. If this fraction is bigger, then it represents the success of meeting health demand, increase in time spent per examination and decrease in waiting time for medical service (Health Transition Program Series-2, 2006).

$$ClinicalServiceFract = Number\ of\ physicians/Number\ of\ clinic\ examination\ rooms \tag{5.30}$$

5.4.1.2. Hospital Quality Criteria Fraction.An evaluation form has been used in order to measurethe hospital health service quality. This form consists of 100 criteria which are commonly accepted by the international accredited centers. Hospitals are evaluated considering these criteria. This fraction provides feedbacks from customer of health sector and gives hospital management opportunities to improve health quality (Health Transition Program Series-2, 2006).

5.4.1.3. Physical Place and Process Evaluation Fraction.Management of health in every city evaluates hospitals with evaluation form. This form measures the hospitals' physical condition, infrastructure and presentation of health service (Health Transition Program Series-2, 2006).

5.4.1.4. Patients and Patients'Relevant Satisfaction Survey Fraction.Two surveys are carried out for inpatients and out-patients of hospital. Patients and patients' relatives are included intothe evaluation process. Together with this evaluation, it can be found that which factors patients give more importance and how they perceive government policies and decisions on healthcare (Health Transition Program Series-2, 2006).

These four fractions' average is used to determine corporate performance fraction. And this fraction changes between 0 and 1. If hospital's corporate performance is one then, health quality and productivity is the highest and hospital management can allocate 40% of hospital revenue hospital's employees.

$$CorporatePerfFraction = (PatientSatFract + PhysicialCondFract + HospQualityFrac + ClinicalServiceFract)/4 \tag{5.31}$$

$$HospRevPerPay = CorporatePerfFract * RevolBudgetFract * HospRevPerMonth \tag{5.32}$$

To sum up, every hospital can allocate their %40 of revenues to the physicians (revolving budget fraction). MOH evaluates each hospital by considering the four quality indicators above. Hospital performance evaluation's scale is between 0 and 1. For example, if the hospital performance is calculated as 0.8 then this hospital can allocate 0.32 of revenues to its employees.

5.4.2. Hospital Revolving Budget Formulation in the Model

Financial performance is the most important part of evaluation. If hospitals cannot cover their expenses, then allocating additional payments to their employees is not possible. Corporate evaluation factors have impacts on hospital revolving budget only ifhospital revenue is sufficient. Thus, hospital revolving budget is directly influenced by hospital financial performance in model.

The relationship between hospital financial performance and hospital revolving budget is positive. This relationship is displayed in Figure 5.8 below.

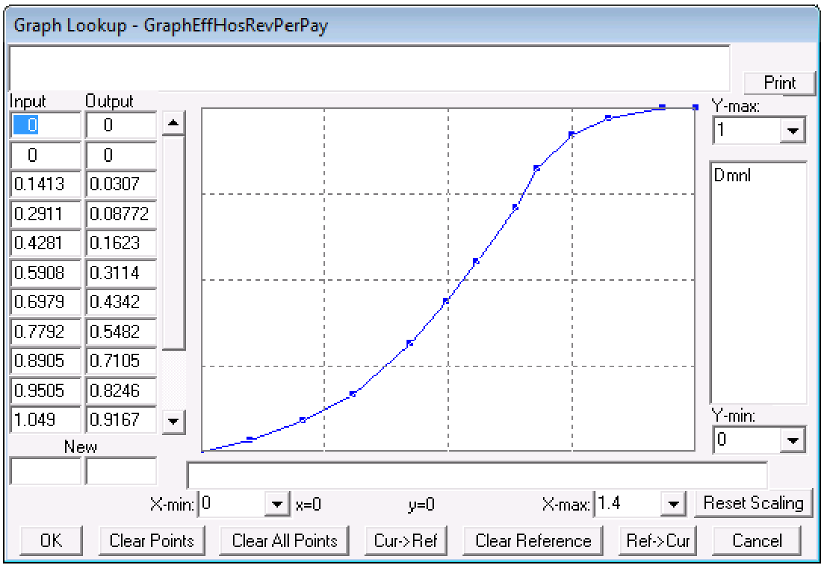

Figure 5.8. Effect of Hospitals' Financial Performance on Performance Payments.

The following effect formulationsare used to describe this relationship:

$$RevBudgetFract = EffHospRevPerPay * NormRevBudFract \tag{5.33}$$

$$EffHospRevPerPay = f(NormHospRev) \tag{5.34}$$

$$NormHospRev = HospRevPerMonth/RefHospRev \tag{5.35}$$

In order to model only the related aspect of real system, four fractions for evaluating the hospital's corporate performance is modified and areference revenue formulation is added into model. And this variable is calculated by hospital resources, private sector second step public hospital base revenue and public second step hospital base revenue. By referencerevenue formulations, three of four corporate performance fractions are simplified and integrated into model. However; patients' satisfaction fraction is not directly included into model.

To evaluatea hospital's financial performance, hospital revenue is compared with other second-step public hospital revenue and second-step private hospital revenue. Base second step hospital revenue is calculated as a function of hospital physical resources, health employees and medical operations.

Referencerevenue formulation is the weighted average of hospital current revenue, base public hospital revenue and private hospital revenue. Weight of hospital revenue is higher than other variables' weight, because it represents the average of all second step public hospitals and it has greater effect of calculation of goal hospital revenue.

The following equations are used in reference hospital revenue formulation:

$$
\begin{aligned}
BaseSecStepPubHospRev &= Number\ of\ physicians * RevPhysSpec + Number\ of\ surgeons \\
&* RevPerSurg + Number\ of\ diagnostic\ physcians * RevPeriagPhys \\
&+ Number\ of\ Beds * RevPerBeds
\end{aligned}
\tag{5.36}
$$

$$
\begin{aligned}
SecStepHospGoalRev &= BaseSecStepPubHospRev * 0.2 + PrivSetepHospRev * 0.2 \\
&+ HospRevPerMonth * 0.6
\end{aligned}
\tag{5.37}
$$

$$
PrivSecStepHospRev = BaseSecStepPubHospRev * 1.5 \tag{5.38}
$$

5.5. Time Spent Per Medical Activity

Time spent per medical activity is essential for quality of health service provided. Medical activities in model:

- Examination
- Surgery
- Test-analysis

Details are illustrated in sub-sections below.

5.5.1. Time Spent Per Examination

Time spent per examination is one of the most important variables in the model. In order to provide sufficient diagnoses and treatments, time is vital. If physicians spend more time on examinations, they can spend more time for taking information about patient's complaints. With the aid of better knowledge and understanding of patient's complaint, physicians may make more accurate diagnoses and provide adequate treatments.

It is assumed in the model that time spent per examination is affected by physicians' and hospitals' revenue concerns and examination crowding. The formulation of this variable in model is the combination of additive-multiplicative effect formulation. If physician's revenue is lower than the reference, than the physician may feel a revenue pressure and an obligation to produce more examinations to collect more performance points. If physician's revenue is higher than the reference, than the physicians may focus on making more accurate diagnoses and correct treatments. The effect of physicians' revenue has greater effect on TSPE than hospital revenue concern.

Hospital revenue is important to describe the effects on TSPE. Hospital revenue is strictly related to medical operations that been performed in hospital. Thus, hospitals which have lower revenue than average, feel bankrupt pressure on themselves. Their managers seek ways to increase hospital revenue. Thus, they induce physicians to spend less time on examinations to increase productivity and examinations. The relationships between physician revenue-TSPE and hospital revenue-TSPE are displayed in Figure 5.9.

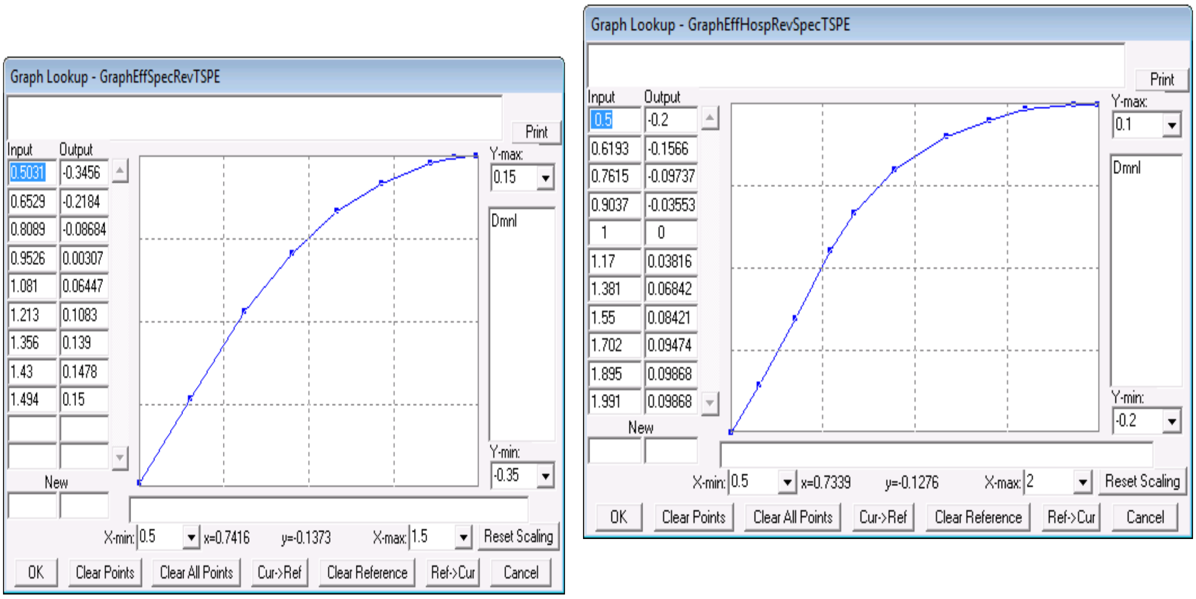

Figure 5.9. Effect of Specialist and Hospital Revenue on TSPE.

Time spent per examination is also affected by crowding. Crowding is a function of examination demand and examination capacity. There is a negative relationship between crowding and TSPE. If crowding is higher than reference, physicians feel pressure of meeting the examination demand. Thus, they spend less time on examination; give second priority to health service quality. By decreasing TSPE, physicians can examine more patients and gain better performance revenue. The following graph displays the relationship between specialist examination crowding and TSPE.

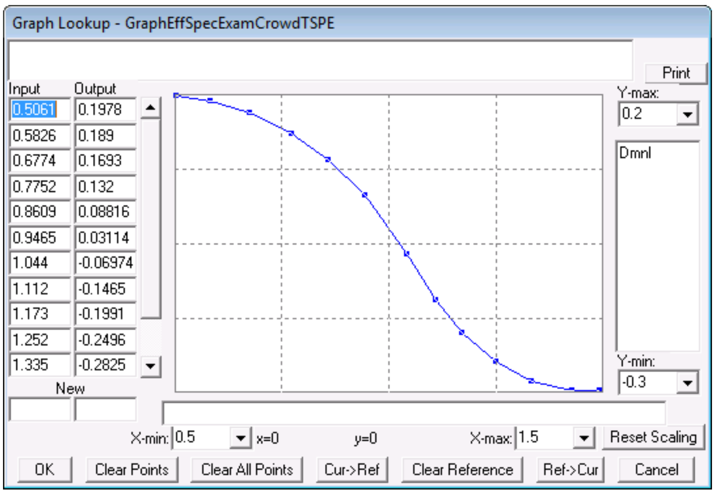

Figure 5.10. Effect of Specialist Examination Crowding on TSPE.

The resulting equation is:

$$SpecTSPE = NormalSpecTSPE * (1 + DelEffHosRevSpecTSPE + DelEffSpecExamCrowdTSPE + DelEffSpecRevTSPE) \tag{5.39}$$

5.5.2. Time Spent Per Tests/Analysis

Time spent per tests (TSPT) /analysis is affected by tests crowding and diagnostic physicians' revenue concern. The formulation of this variable in model is the combination of an additive-multiplicative effect formulation.

There is a positive relationship between diagnostic physicians' revenue and TSPT. If diagnostic physicians satisfy with their revenue, they spend more time per tests-analysis and give absolute priority to tests/analysis quality. While diagnostic physicians' revenue is lower than their expectation, they may try to improve their revenue by performing more tests. Similar to specialist / surgeon physicians' reaction, diagnostic physicians decrease TSPT and try to increase their productivity. The following graph shows the relationship between diagnostic physicians' revenue and TSPT.

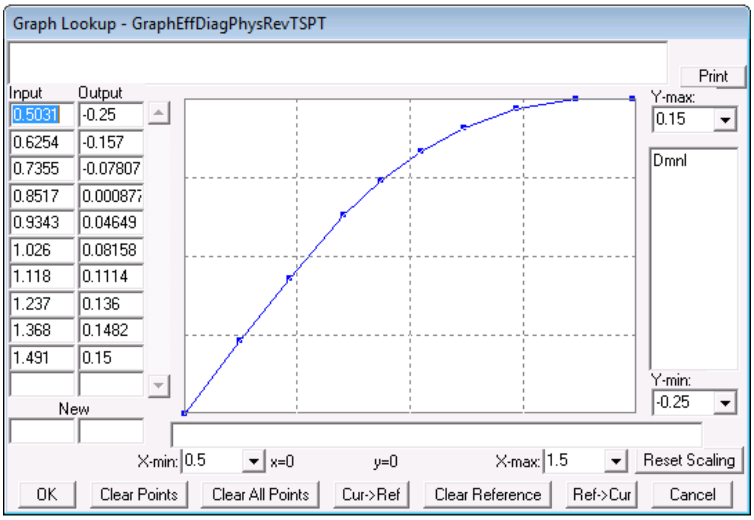

Figure 5.11. Effect of Diagnostic Physicians' Revenue on TSPT.

On the other hand there is a negative relationship between tests crowding and TSPT. If crowding is higher, diagnostic physicians may feel a pressure of meeting the test demand. Thus, they spend less time on tests; give second priority to sufficient analysis and tests. By decreasing TSPT, diagnostic physicians perform more tests and analysis and collect more performance points. According to their performance points, diagnostic physicians are able to improve their revenue. However, decreasing tests and analysis quality have adverse effects on health service quality. Insufficient tests result as wrong diagnoses and inadequate treatments. In long term, more admissions increase crowding due to insufficient diagnoses.

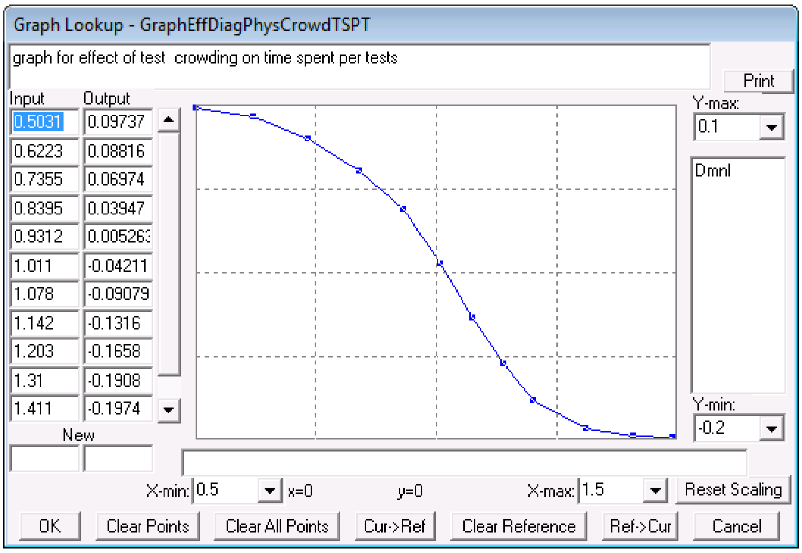

Figure 5.12. Effect of Tests/Analysis Crowding on Time Spent Per Tests.

The resulting equation is:

$$TimeSpentPerTests = NormTimeTSPT * (1 + DelEffDiagPhysRevTSPT + DelEffDiagPhysCrowdTSPT) \tag{5.40}$$

5.5.3. Time Spent Per Surgery

Time spent per surgery (TSPS) is a function of surgery crowding pressure and revenue pressure of surgeons. If crowding increases, surgeons start to spend less time for surgeries for meeting the surgery demand. Another factor affecting TSPS is surgeons' revenue. After P4P system, surgeons are able to increase their revenue by performing more medical operations. Their options are surgery, examination and hospital visits. By performing more surgery, surgeons can improve their performance points, thus their performance revenue.

Surgeons' revenue has positive impact on surgery quality. If surgeons satisfy with their revenue, then their concern for their revenue is low. Without revenue pressure, surgeons give absolute priority to surgery quality and spend more time per surgery. The relationship between surgeon revenue and TSPS is presented in Figure 5.13.

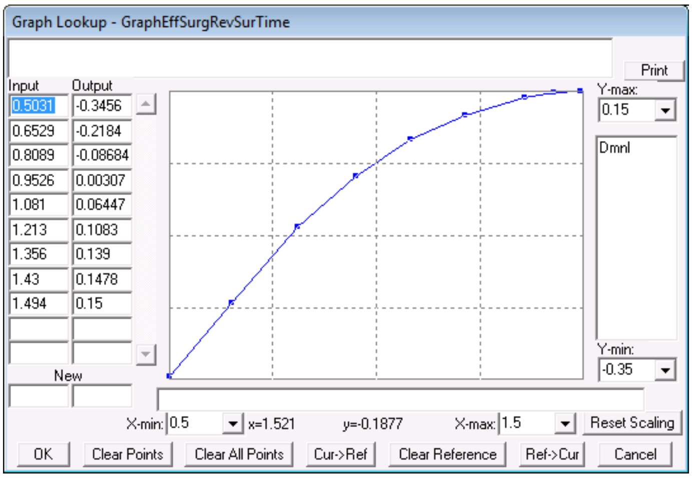

Figure 5.13. Effect of Surgeons' Revenue on TSPS.

Surgery crowding has a negative impact on TSPS. If crowding is higher, they spend less time per surgery; give second priority to sufficient surgeries. By decreasing TSPS, surgeons can perform more surgery and meet surgery demand. Conversely, they reduce surgery quality and increase insufficient surgeries. Furthermore, more admissions are stem from insufficient surgeries increase surgery crowding.

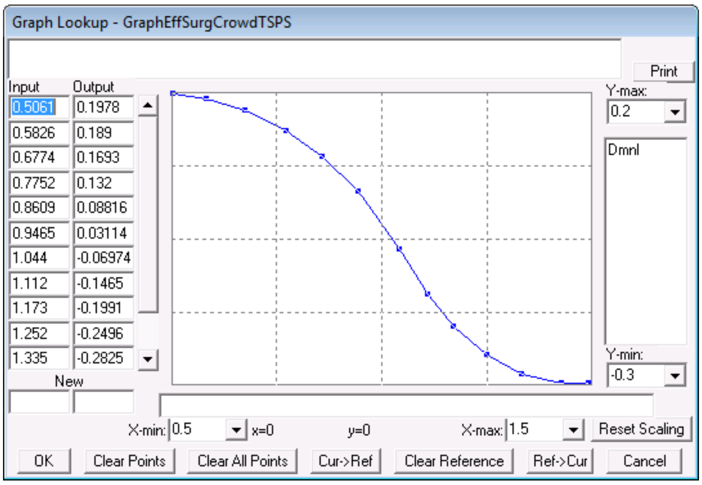

Figure 5.14. Effect of Surgery Crowding on TSPS.

The resulting equation is:

$$
\begin{aligned}
&Time\ Spent\ Per\ Surgery \\
&\qquad = NormTimePerSurgery * (1 + DelEffSurgRevSurgTime \\
&\qquad + DelEffSurgCrowdTSPS)
\end{aligned}
\tag{5.40}
$$

5.6. Productivity Formulations

Productivity formulations are used to calculate examination, tests and surgery productivity. Time spent per medical activity has negative impact on productivity. By spending more time on medical activity, health productivity decreases.

5.6.1. Examination Productivity

Examination or eye-examination is one of the most important activities in treatment structures. Every patients first make visit to hospital and are examined by physicians. Quality of examination affects diagnose and treatment activity from the start.

Specialist physicians' total work time is transformed into minute scale in model. Normal time per eye-examination is assumed ten minutes. Considering time spent per examination by specialist physicians, their productivity changes. Specialist physicians also spend time per hospital visits. These visits compensate approximately %10 of their total work time. Thus, time allocated for examination by specialists (TimeAllExamSpec) is determined as %90 of their total working time. However, surgeons also have to allocate time for surgery. Consequently, they allocate lesser time per examinations than specialist physicians. Time allocated to examination by surgeons is assumed to 60% of their total work-time. Apart from allocation time to examination activity, formulations and structure of productivity for surgeons are similar to specialist physicians in model.

Total examination demand composes of internal and external demand. Details for demand structure are shared in Section 5.2. Examination demand creates crowding in hospital. Due to examination capacity, physicians try to meet health demand by performing examinations. Fuzzy-min formulation is used to construct the relationship between health demand and examination capacity. The productivity calculation structure is shown in Figure 5.15.

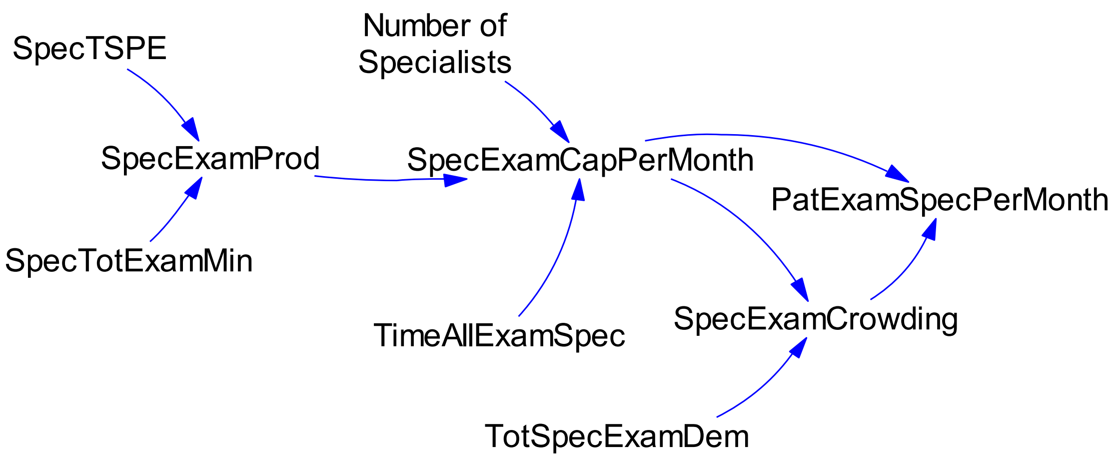

Figure 5.15. Examination Productivity Calculation Structure.

The resulting equations are:

$$SpecExamProd = SpecTotExamMin/SpecTSPE \tag{5.42}$$

$$SpecExamCapPerMonth = SpecExamProd * Number\ of\ Specialists * TimeAllExamSpec$$

(5.43)

$$SpecExamCrowd = TotSpecExamDemPerMonth/SpecExamCapPerMonth$$

(5.41)

$$EffSpecAppExam = F\ (SpecExamCrowd)$$

(5.42)

$$PatExamSpecPerMonth = SpecEamCapPerMonth * EffSpecAppExam$$

(5.43)

5.6.2. Tests and Analysis Productivity

Tests and analysis activities are important part of diagnosis process. Specialist or surgeons make proper medical decisions due to tests and analysis perform by diagnostic physicians. Thus, quality of tests activities isessential for sufficient treatments.

Time spent per tests (TSPT) is assumed ten minutes in model. Details are explained in Section 5.5. Fuzzy-min formulation is used to construct relationship between test's demand and tests and analysis capacity.

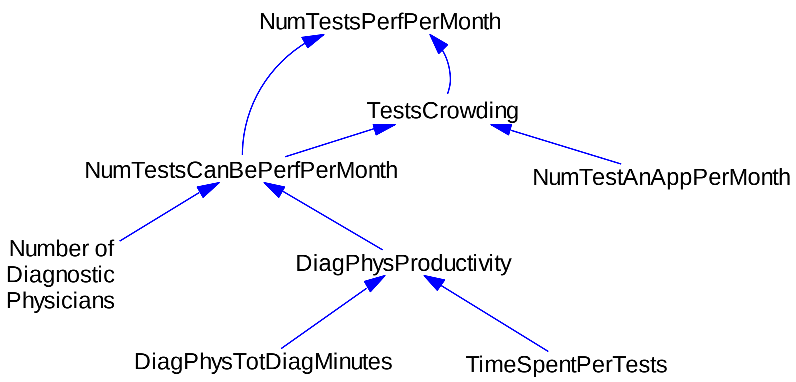

Figure5.16. Tests and Analysis Productivity Calculation Structure.

The resulting equations are:

$$DiagPhysProductivity = DiagPhysTotDiagMinutes/TimeSpentPerTests$$

(5.47)

$$NumTestCanBePerfPerMonth = DiagPhysProductivity * Number\ of\ Diagnostic\ Physicians \tag{5.48}$$

$$TestsCrowding = NumTestAnAppPerMonth / NumTestCanBePerfPerMonth \tag{5.49}$$

$$NumTestsPerfPerMonth = EffTestAppNumTestPerf * NumTestCanBePerfPerMonth \tag{5.50}$$

5.6.3. Surgery Productivity

Time spent per surgery is a critical factor for surgery quality and patients' health. By decreasing TSPS, surgeons are able to meet surgery demand and improve their performance revenue.

Normal TSPS is assumed one hundred and twenty minutes in model. This is a basic time required for surgery which is between C and B type. Details are explained in Section 5.5. Fuzzy-min formulation is used to construct relationship between surgery demand and surgery capacity. Surgery productivity calculation structure is displayed in Figure 5.17.

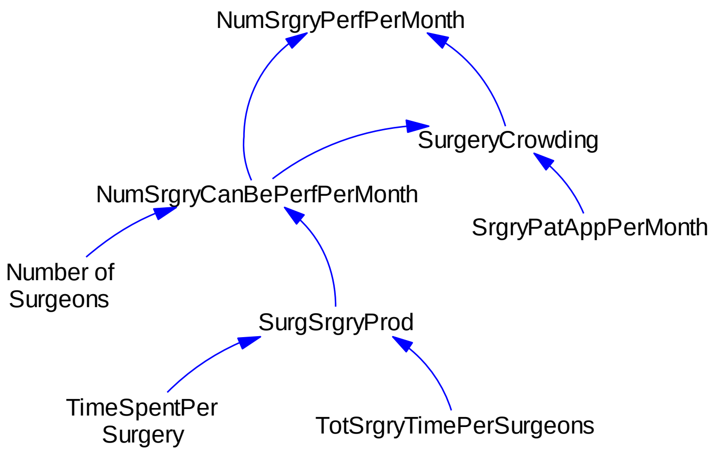

Figure 5.17. Surgery Productivity Calculation Structure.

The resulting equations:

$$SurgSrgryProd = TotSurTimePerSurgeons/Time\ Spent\ Per\ Surgery \tag{5.51}$$

$$NumSrgryCanBePerfPerMonth = Number\ of\ Surgeons * SurgSrgryProd \tag{5.52}$$

$$SurgeryCrowding = SurgPatAppPerMonth/NumSrgryCanBePerfPerMonth \tag{5.53}$$

$$EffSurgAppSurPer=F(SurgeryCrowding) \tag{5.54}$$

$$NumSrgryPerfPerMonth = EffSurgAppSurPr * NumSrgryCanBePerfPerMonth \tag{5.55}$$

6. ANALYSIS AND VALIDATION OF THE MODEL

Vensim PLE 5.11A is used in order to build the model and carrying out simulation experiments. Time step is selected as 1/8 months. Time unit is month. Time horizon is selected as 48 months, between 2005 and 2009. The integration method is selected as Euler method.

In this section, behavior of base run will be analyzed. In the validation section, the experiments run in order to test the validity of model will be summarized. In addition to this, main extreme runs are illustrated in this section.

6.1. Analysis of Base Behavior

Performance based payment system has changed physicians’ approach to health quality in medical activities. Together with revenue concerns and hospitals’ pressures, physicians have started to decrease time per medical activity and increase their productivity, thus their revenue. In the base run, physicians’ revenue is lower than their revenue expectation. Hospital crowding is higher than normal and there is an abundant demand for examination and surgery. Physicians who work in private hospitals earn much higher than physicians who work in public hospitals.

In order to increase their revenue and to meet health demand, physicians spend less time per medical activity. As it can be seen in Figure 6.1, time spent per examination and surgery decrease within 30 months. This is a result of revenue concerns and hospital examination crowding. Physicians tend to spend less time on medical activities to increase their revenue.

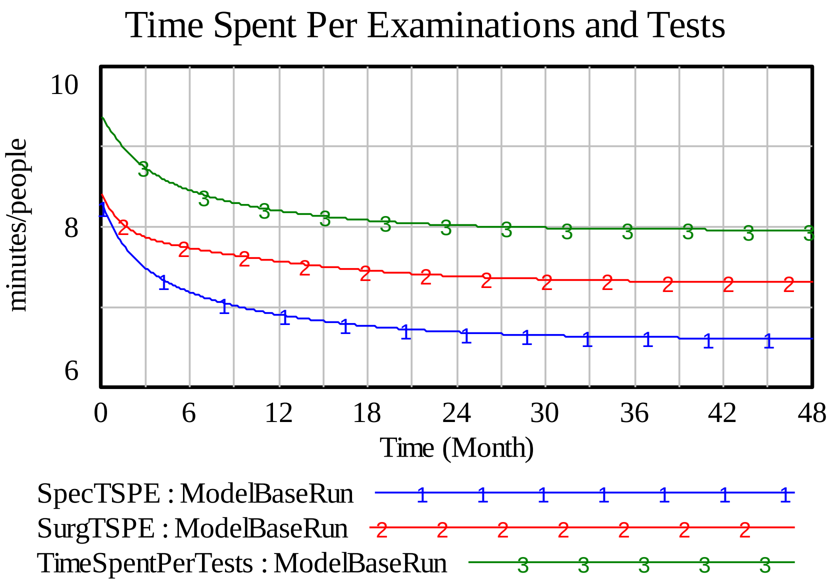

Figure 6.1.Time Spent Per Examinations and Tests.

As seen in Figure 6.2, inadequate treatment stock (SpecInadequate Treatments) reaches its new high equilibrium level in 30 months. Inadequate treatments increase due to decreases in health quality indicators like TSPE. Treatable patients and treatable patients are stable due to slow changes in flow variables of in Figure 6.3.

In Figure 6.4, it can be seen that PBPS has negative impact on quality indicators. Due to spending less time on medical activities, correct treatment and diagnose ratios decrease as expected.

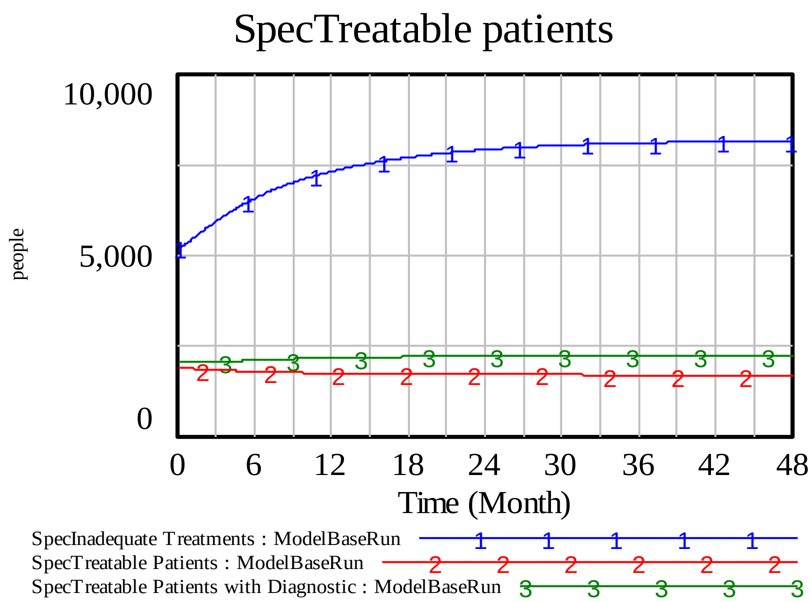

Figure 6.2.Treatment Structure-Specialist Physician Main Stocks.

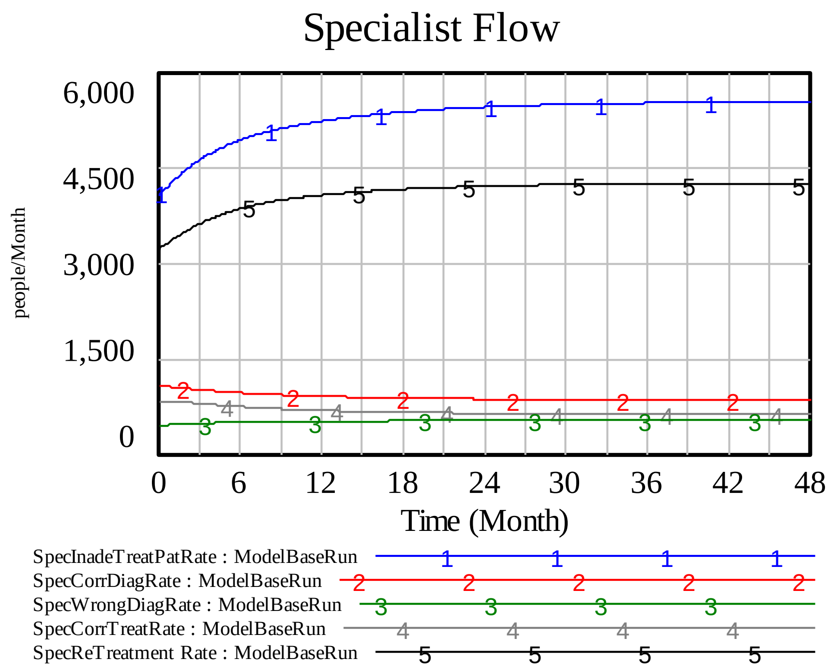

Figure 6.3.Treatment Structure-Specialist Physicians Main Flows.

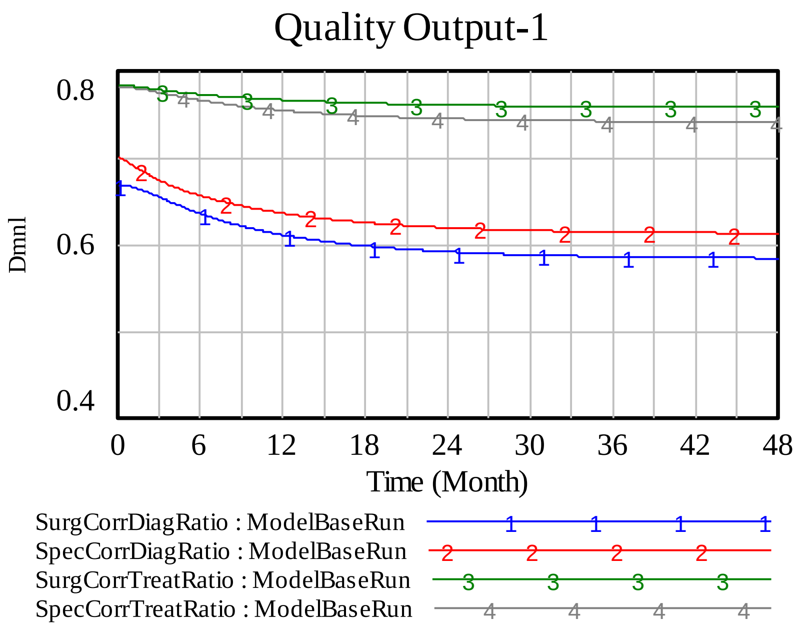

Figure 6.4.Correct – Wrong Diagnose and Treatment Ratio.

PBPS also has adverse effects on surgery quality. Surgeons try to decrease TSPS to meet surgery demand and improve their performance revenue. However, inadequate surgeries increasedue to the low surgery quality. Insufficient surgery patients make more visits to hospital for re-treatment. Consequently, surgery crowding increases as expected. With revenue and crowding pressures, surgeons may try to reduce TSPS more. In Figure 6.5, it can be interpreted that, PBPS has negative impact on surgery quality and TSPS.

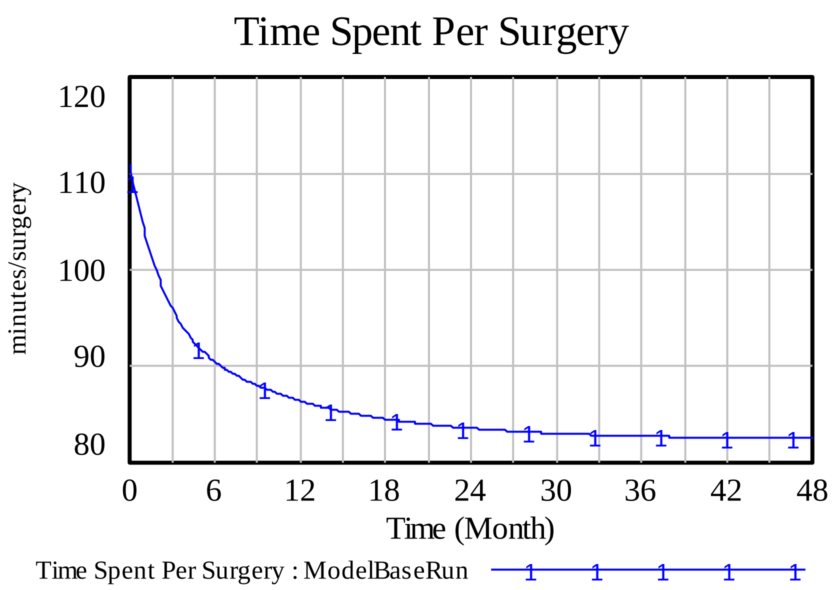

Figure 6.5.Time Spent Per Surgery.

In Figure 6.6 and Figure 6.7, it can be interpreted that, low surgery quality results as increase in inadequate surgeries and wrong surgery treatment ratio.

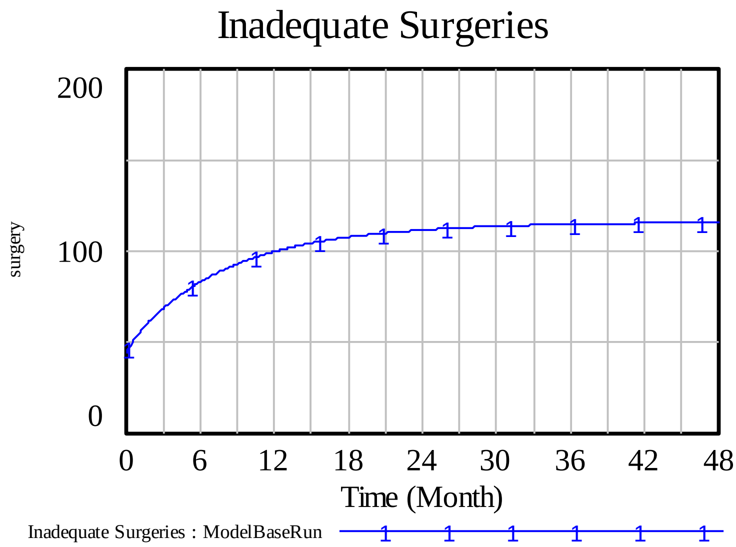

Figure 6.6.Inadequate Surgeries.

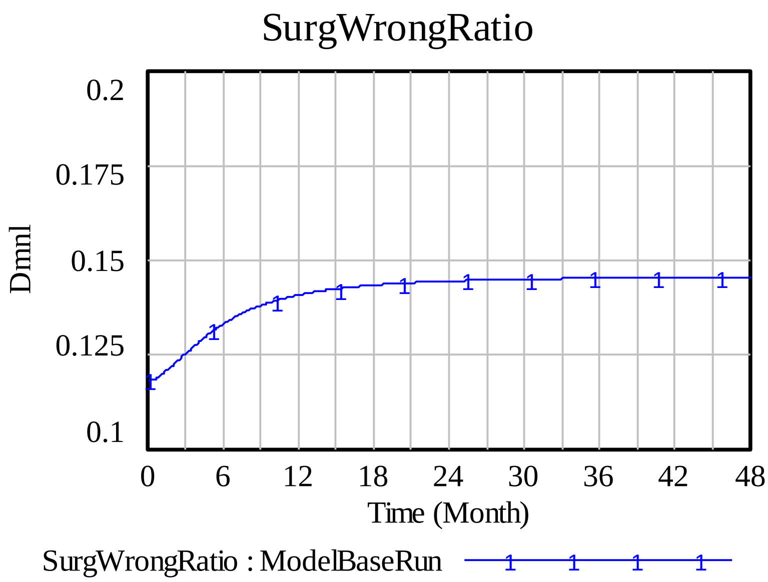

Figure 6.7.Wrong Surgery Ratio.

6.2. Validation of the Model

The aim of model validation is to assure that the model is an acceptable description of the real system with respect to the dynamic problem (Barlas, 1996). Model validation is executed in two steps: structure and behavior validity.

6.2.1. Structure Validity

Structure test is to check whether the structure of a model is a meaningful description of the real relations that exists in the problem (Barlas, 1996). There are two types of structure tests: direct structure tests and indirect structure tests.

Direct structure tests evaluate the validity of the model structure by direct comparison of real system structure. Parameter and variable confirmation, dimensional consistency and extreme condition tests are included in direct structure testing (Barlas, 1996).

In the model, all parameters and variables have real-life counterparts. The model is dimensionally consistent in all equations. All model variables and their dimensions are presented in Table 4.1. All model equations pass extreme condition tests.

6.2.1.1. Extreme Condition Tests.

Extreme Condition 1: Number of specialist physician is very high: Number of specialist physician, which is 20 in base run, is set to 200. Examination capacity increases because of the sufficient health resources. Due to the high number of physicians in hospital, performance revenue's share per physician decreases. However, physicians don't have opportunity to increase their performance revenue without sufficient demand. Since, potential external examination demand stays in base run value, effect of physicians' revenue concern on time diminishes. In Figure 6.8, it can be seen that, time spent per examination increases in first six months. Then it starts to decrease due to the effect of undiagnosed patients. The reason is the number of diagnostic physicians stay in base run value and high increase in number of specialist physicians make diagnostic physicians insufficient for tests and analysis.

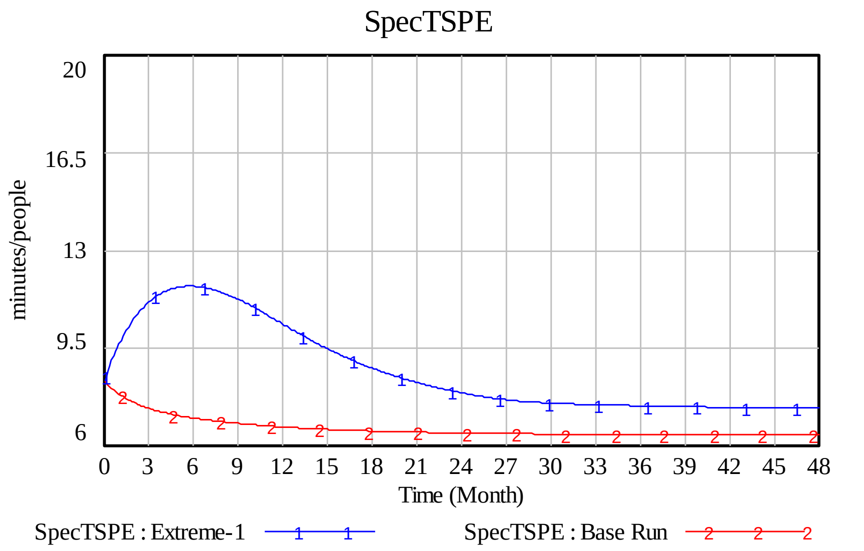

Figure 6.8.Extreme Condition-1: Time Spent per Examination by Specialist Physicians.

Extreme Condition 2: Number of physician is very low: Number of physician is set to 1. Expected behavioris increase in examination crowding. Crowding increases in first fifteen months. Since it has a negative impact on external demand, fewer patients make visits to hospital.After fifteen months, external demand starts to decrease via hospital crowding. Due to decreases in total demand, the effect of examination crowding on TSPE reduces. As a result, physician has opportunity to spare more time per patients. Between fifteen and twenty month, TSPE increases owing tothe lower pressures of crowding and physicians’ revenue.

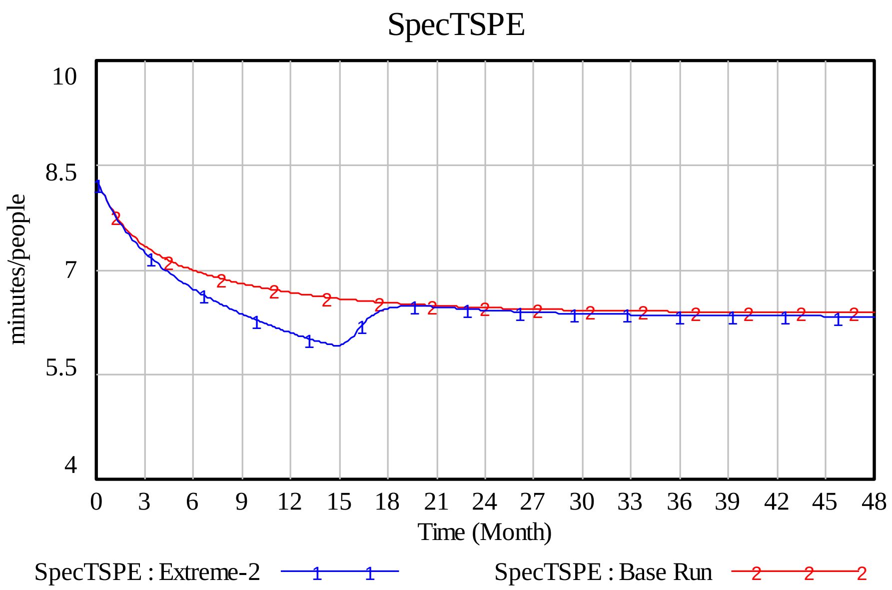

Figure 6.9.Extreme Condition-2: Specialist Physician TSPE.

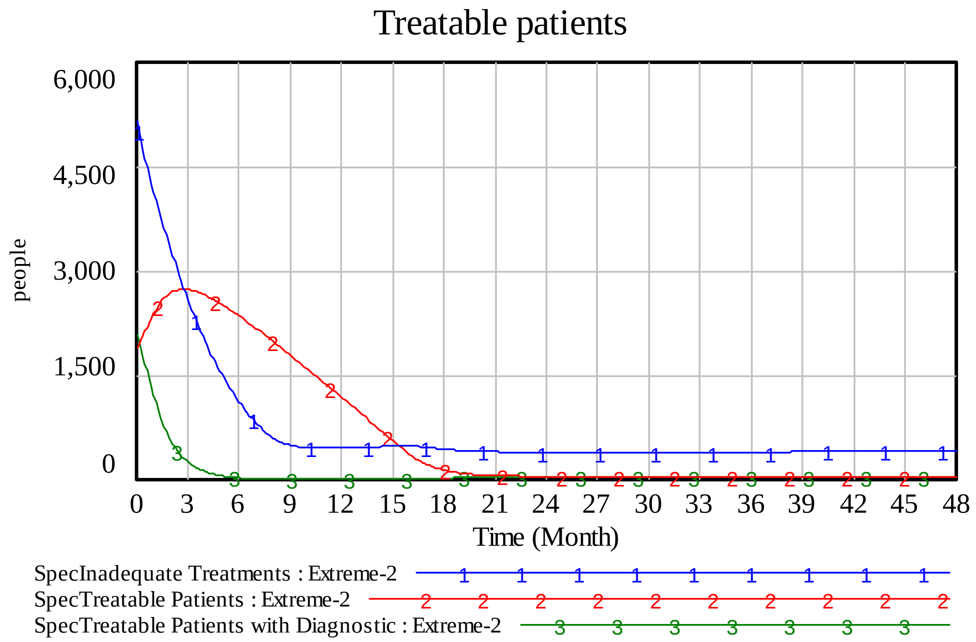

Figure 6.10.Extreme Condition-2:Specialist Treatable Patients.

Extreme Condition 3: Very low performance point: Performance point per examination is set to 1 which is 20 in base run. Due to decreases in performance revenue, physicians' revenue concerns increase. Thus, they try to improve their income by decreasing TSPE. Once they start to spend less time per examination, health quality decreases. Inadequate treatments increase by the lack of sufficient health service quality.

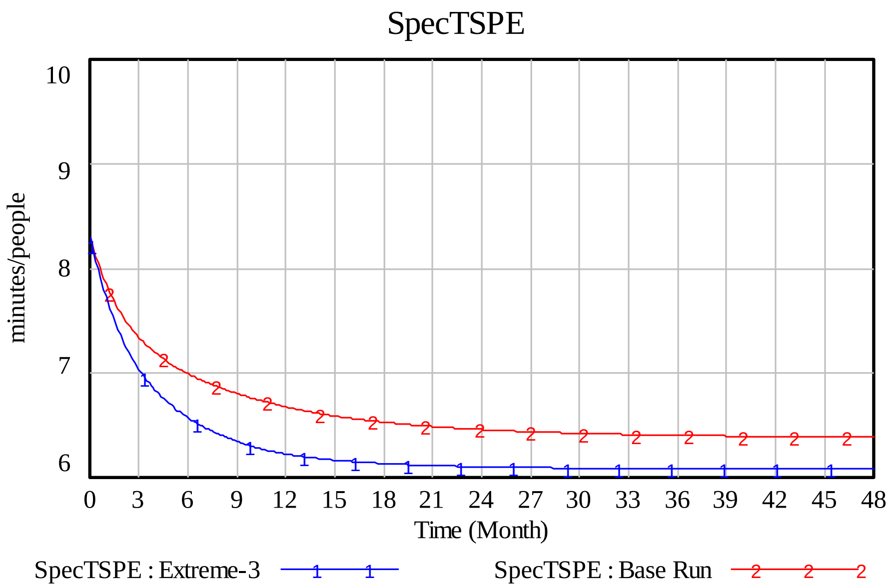

Figure 6.11. Extreme Condition-3:Specialist Physicians' TSPE.

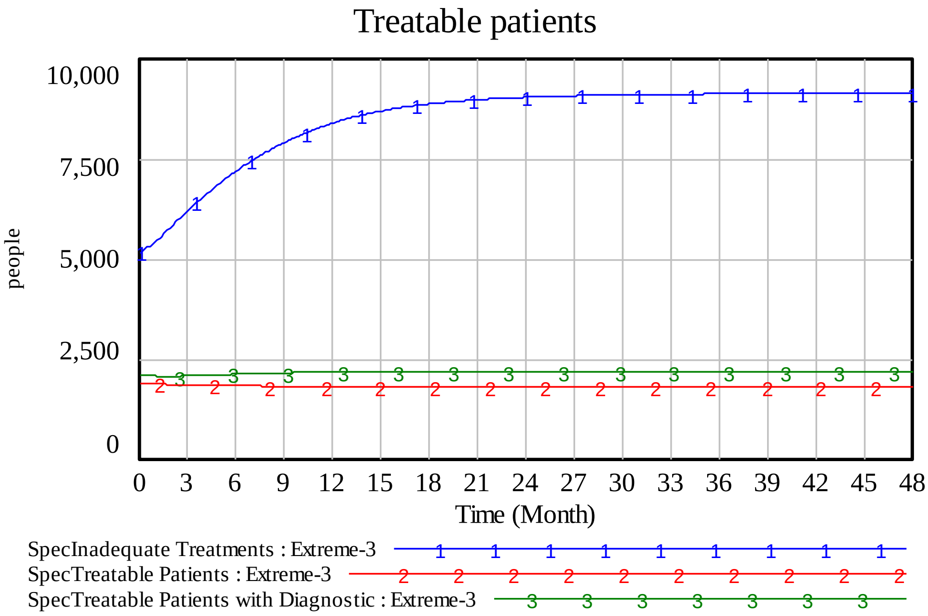

Figure6.12.Extreme Condition-3:SpecialistPhysician Treatable Patients.

Extreme Condition 4: High performance point: Performance point per examination is set to 100 in this extreme run. Physicians can earn same performance revenue by lesser medical activities. When, their revenue increases, their reference revenue increases too. As a result, revenue concerns of physicians increase. They try to improve their revenue by giving less priorityto health quality. Yet, it provides better quality results comparing with base runby lower revenue concerns.

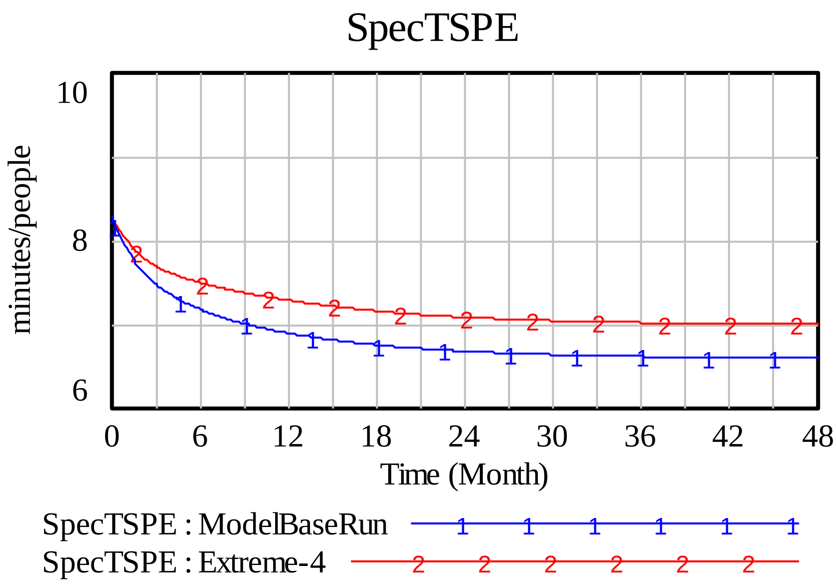

Figure 6.13.Extreme Condition 4: Specialist Physician TSPE.

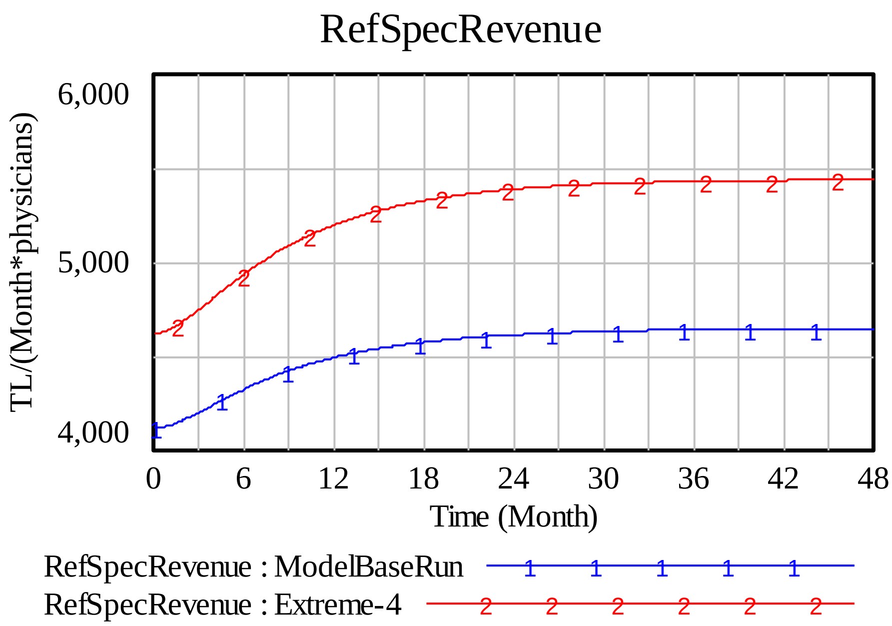

Figure 6.14.Extreme Condition 4:Reference Specialist Physician’s Revenue.

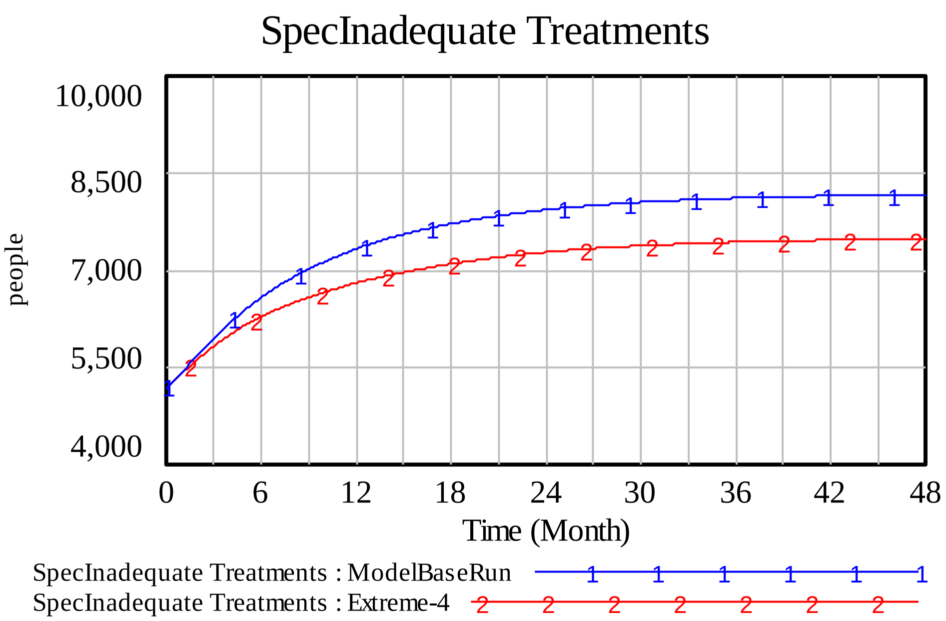

Figure 6.15.Extreme Condition 4:Specialist Inadequate Treatments.

Extreme Condition 5: Very low diagnostic physician resources: Number of diagnostic physician is set to 1. Tests and analysis crowding increases, because the number of diagnostic physicians is inadequate to meet tests demand.As a result, undiagnosed patients increase and tests/analysis crowding increases further. Thus diagnostic physicians start to decrease TSPS for meeting tests demand. Consequently, time spent per tests decreases much higher than base run.

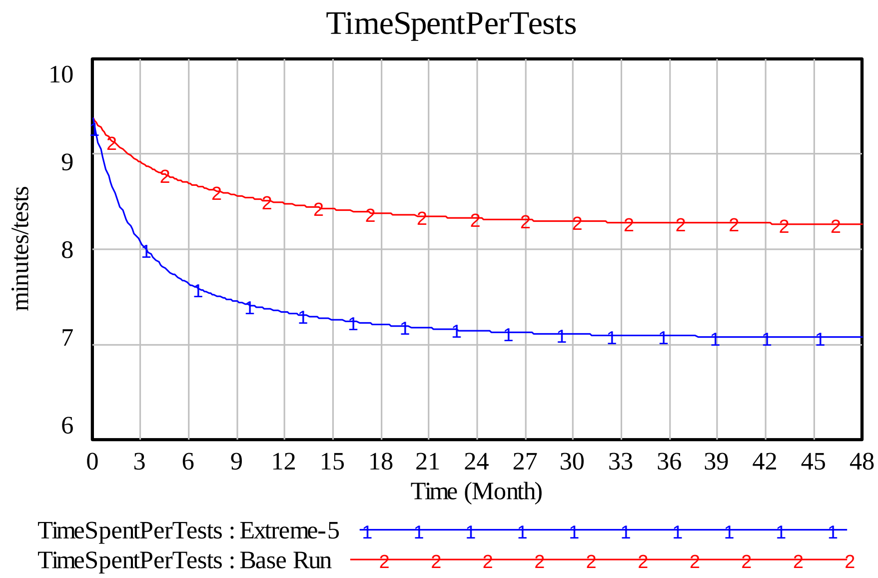

Figure 6.16.Extreme Condition 5:Time Spent per Tests.

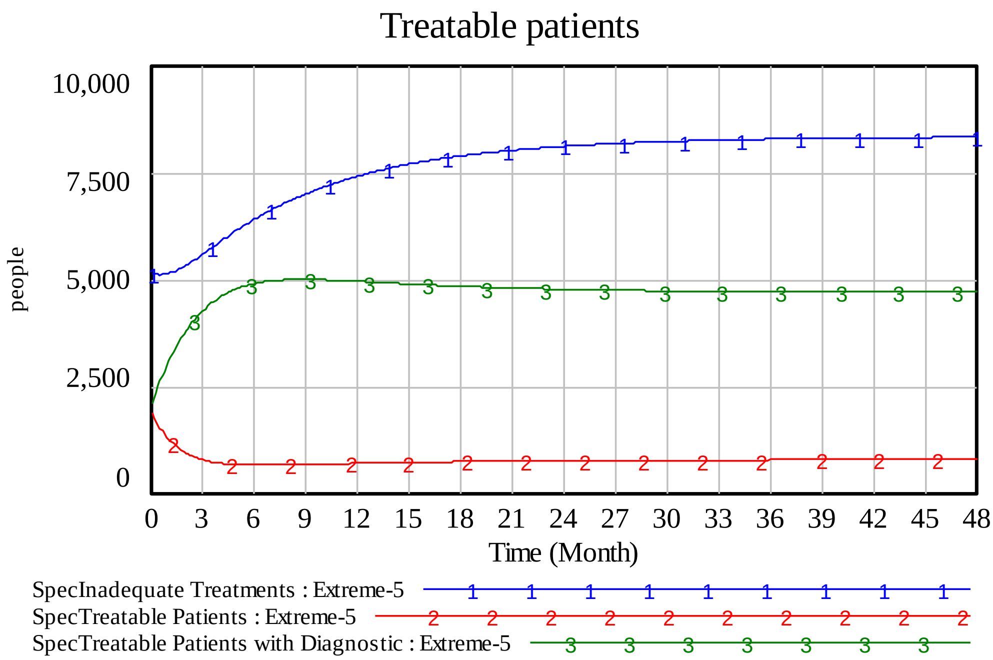

Figure 6.17.Extreme Condition 5:Specialists Treatable Patients.

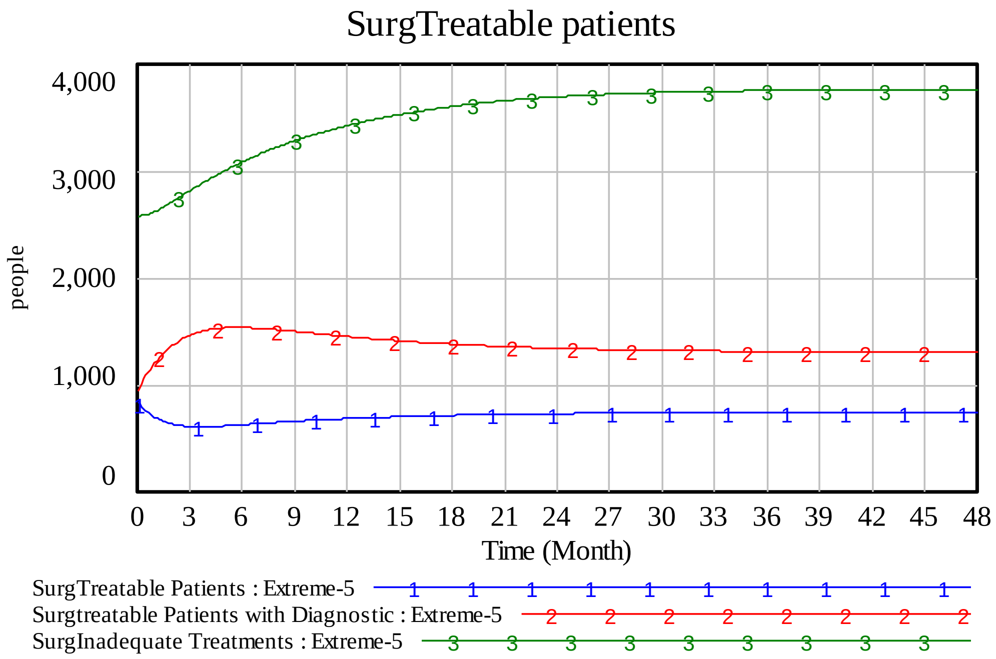

Figure 6.18.Extreme Condition 5:Surgeons Treatable Patients.

Extreme Condition 6: Very high number of diagnostic physicians: Number of diagnostic physicians is set to 50. Since tests crowding is lower than base run, diagnostic physicians feel less crowding pressure on themselves. However, revenue concerns of physicians remain same. In addition, due to the lack of demand, physicians do not have opportunity for increasing their revenue by decreasing TSPT. In Figure 6.19, increases in time spent per tests can be seen.

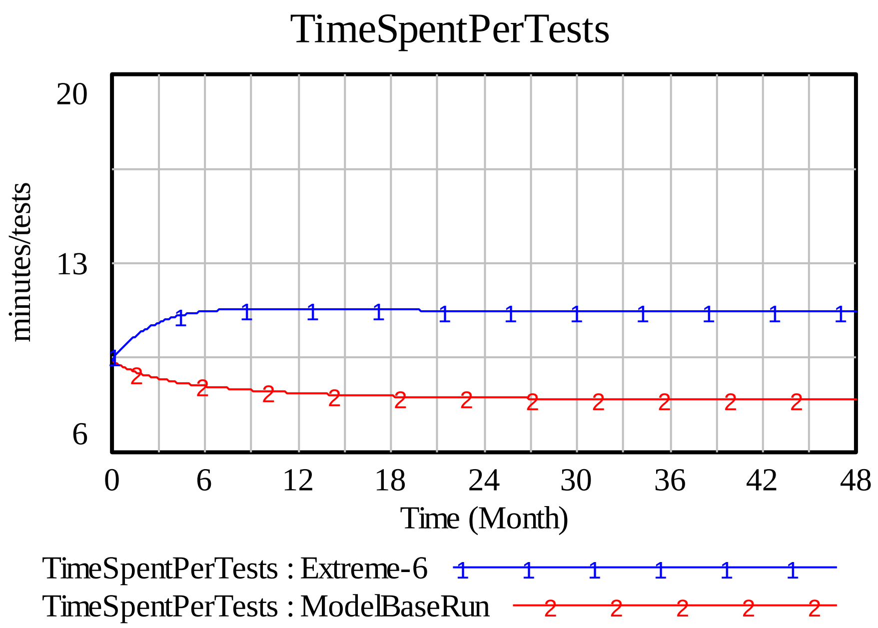

Figure 6.19. Extreme Condition 6: Time Spent per Tests.

Extreme Condition 7: Insufficient external demand: Potential examination demand to specialist physicians and surgeons are set to 0. Internal demand decreases because ofthe lack of external demand. Crowding pressure on physicians reduces. However, medical operations also decrease due to insufficient health demand. Thus, financial performance of hospital becomes inadequate to supplement physicians with satisfactory additional income. Performance revenues for physicians diminish as expected.All stock variables decrease from base run levels and stabilize in equilibrium values. It can be seen in Figure 6.20 and Figure 6.21.

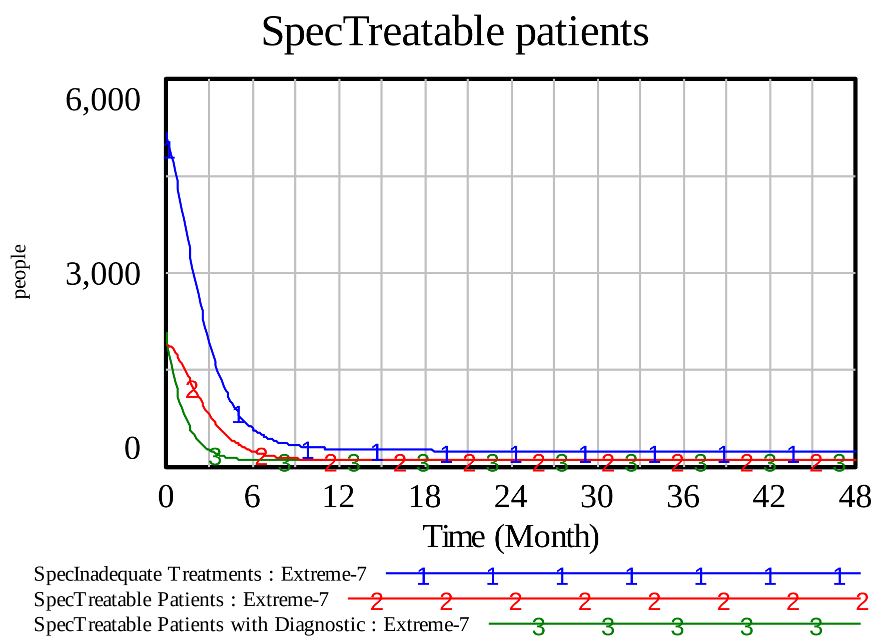

Figure 6.20.Extreme Condition 7:Specialist Physicians'Treatable Patients.

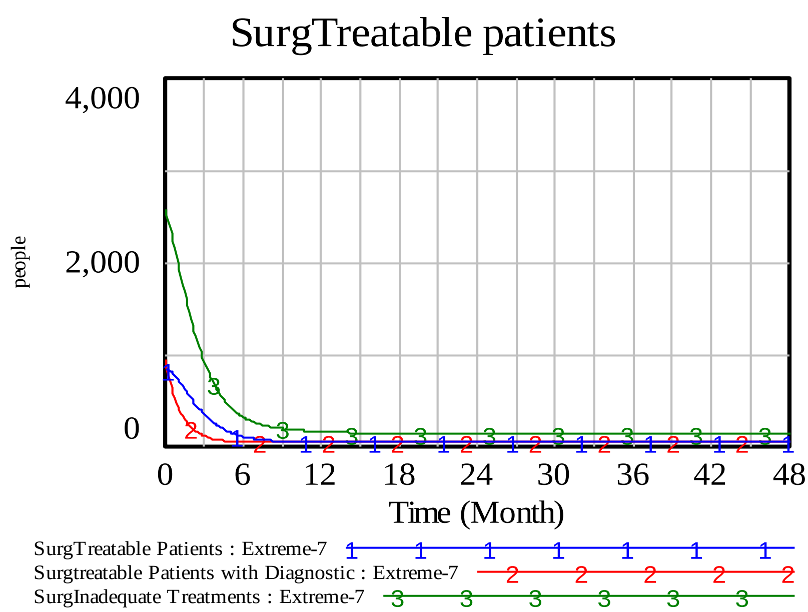

Figure 6.21.Extreme Condition 7:Surgeons Treatable Patients.

Due to the lack of examination demand, time spent per medical activities increase as expected. The results are presented in Figure 6.22 and Figure 6.23.

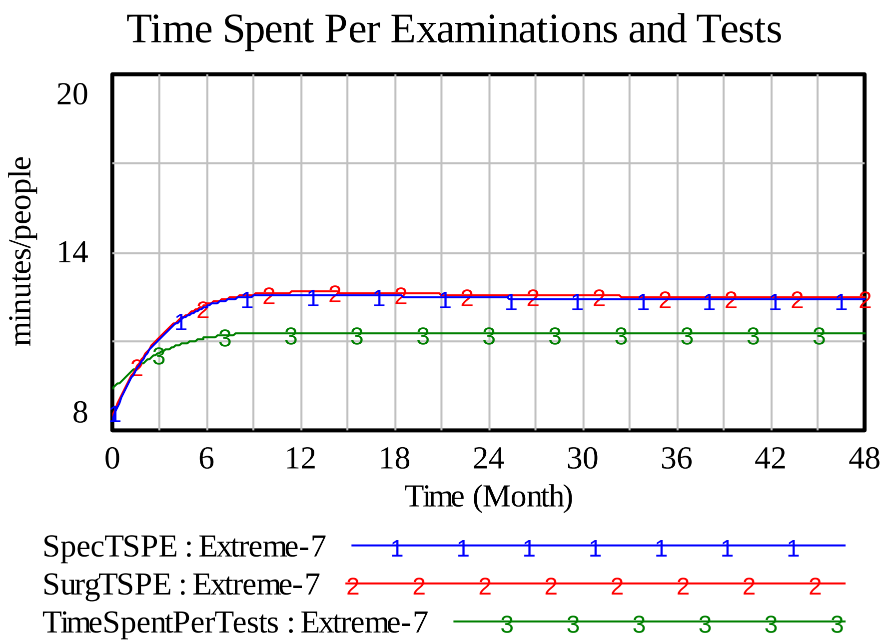

Figure 6.22.Extreme Condition 7:Time Spent Per Medical Activity.

Moreover, since physicians cannot increase additional income by performing more medical activities, their income decreases by the reason of low performance revenue.

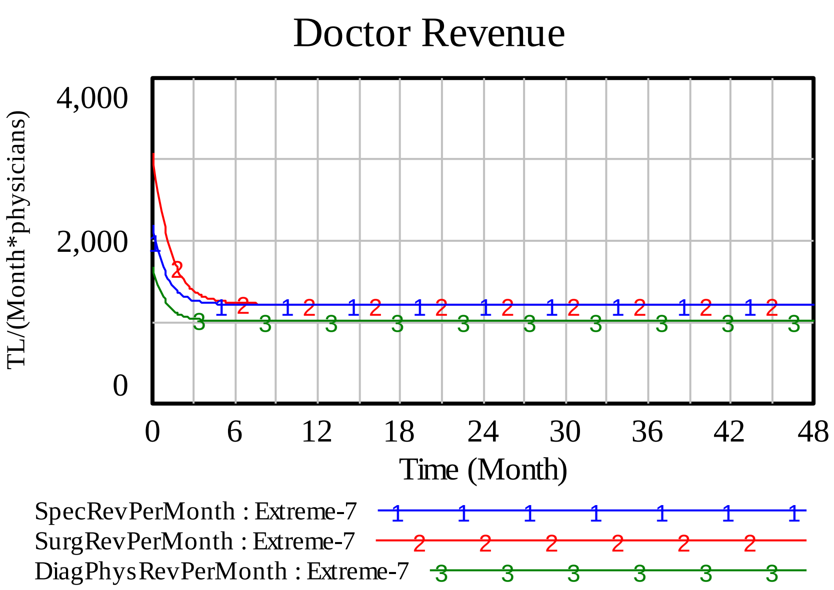

Figure 6.23.Extreme Condition 7:Physicians’ Revenue.

6.2.2. Behavior Validity

Ifsufficient confidence in the validity of model structure has been built by performing validity tests, one can start to apply certain tests designed to measure how accurately the model can reproduce major behavior patterns of real system. What is meant by behavior validity is pattern prediction (periods, frequencies, trends, phase lags and amplitudes) rather than point prediction (Barlas, 1996).

Limited real data is used for comparing the model behaviors and patterns of real system. In order to exclude the mergingeffects of SSK hospitals and MOH Hospitals, time interval is selected between 2005 and 2009.

Real data is limited for our study. There is no available data for TSPE or other quality indicators. But we can guess the real system behavior by looking into the patterns in other health statistics over the years since PBPS implementation.

<u>6.2.2.1. Physicians' Revenue.</u>If the physician's revenue is lower than reference revenue, physician's revenue concern can increase and physician may spend less time per examination. In base run, physicians' revenue is lower than their reference revenue.The following graph shows the comparison of the average physician's revenue and physician's revenue real data. Real data is taken from Turkey Health Statistical Yearbook 2011 First year, physicians' revenue increases as expected. After the first year, due to changes in government policies and fluctuations in inflation rates result as oscillations in physicians' revenue. Real data and model results are compatible.

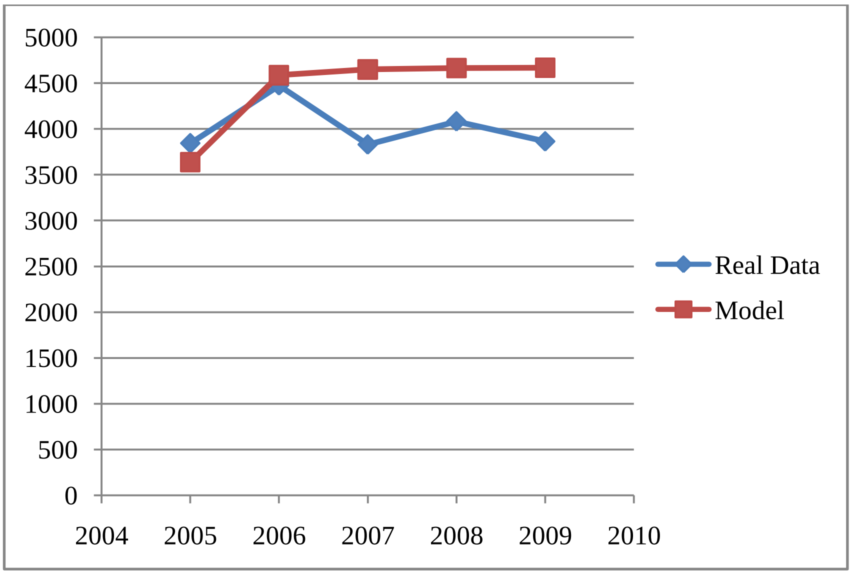

Figure 6.24.Physicians’ Revenue.

<u>6.2.2.2. Patients Examined by Specialist Physicians.</u>Patients examined by specialist physicians have increased since PBPS. Physicians try to improve their income by increasing their productivity. Real data is taken from local second-step public hospital in Istanbul.As it can be seen from Figure 6.25, the real data and model is well-matched.

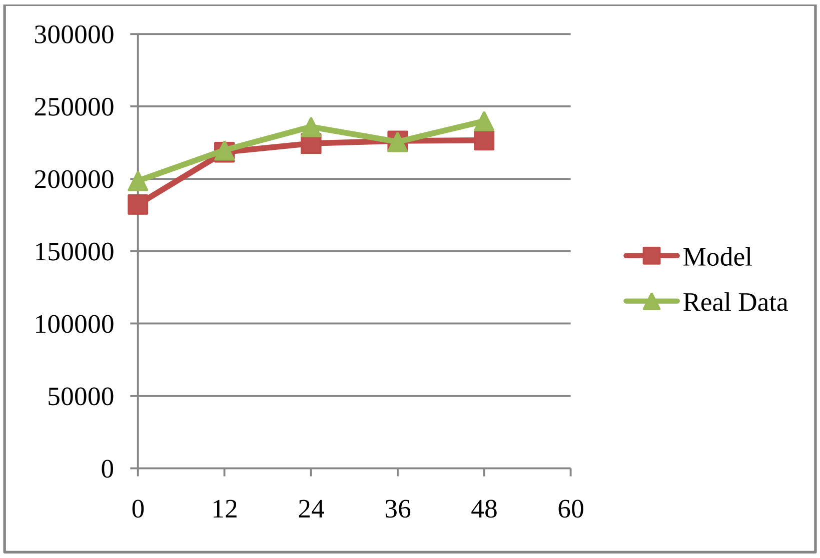

Figure 6.25.Patients Examined by Specialist Physicians.

<u>6.2.2.3. Number of Tests Performed per Month.</u>In order to increase productivity and the resource utilization in healthcare, government encourage physicians to refer more patients to tests and perform more medical activities. Moreover, hospital’s revenue can increase by

tests activities. Consequently, more test activities are induced and expected to increase. Real data is taken from second step public hospital in Istanbul. Due to their required time and performance points, real data is modified. The following graph displays change in model and real-life behavior. The model and real data is well-matched

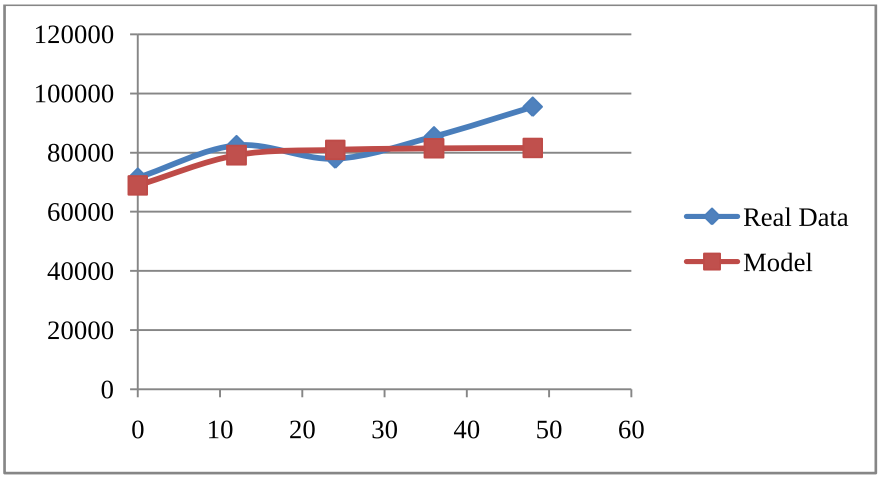

Figure 6.26. Number of tests performed per month.

6.2.2.4. Number of Surgeries Performed per Month.One of the most influenced medical activities via PBPS is surgery. In order to increase productivity, more unnecessary surgeries are induced. Changes in model and real-life behavior are shown in Figure 6.27. Real life and model's behavior is well-matched.

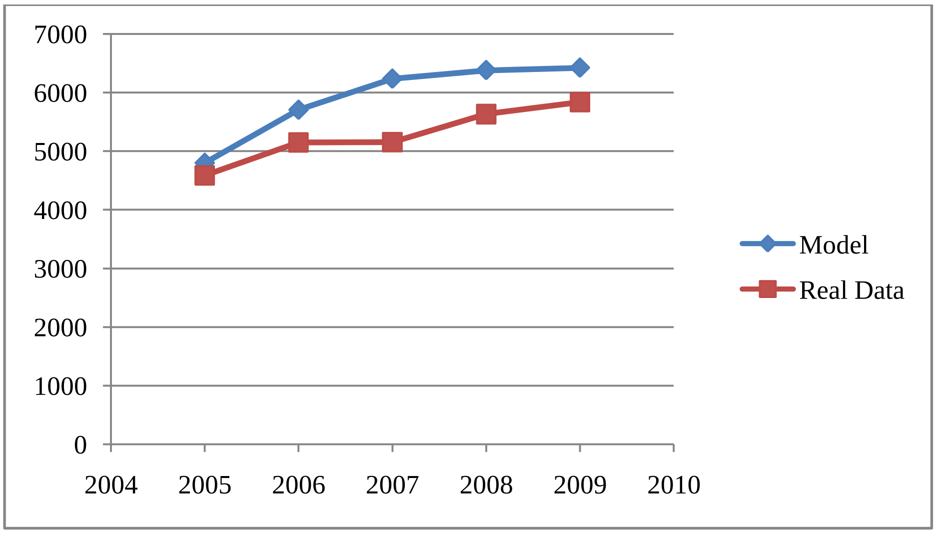

Figure 6.27.Number of surgeries performed per month.

7. SENSITIVITY ANALYSIS

Behavior sensitivity testing includes finding those parameters to which the model behavior is highly sensitive and questioning if the real system would generate similar sensitivity with respect same parameters (Barlas, 1996). Brief summary of sensitivity analysis is presented in this section. Sensitivity of these three variables' which is expected to be responsible for system's behavior is analyzed.

7.1. SensitivityAnalysis on Number of Specialist Physicians

In the base run, number of specialist physicians is assumed to be 20. Itis changed from 10 to 50 in sensitivity runs. From the results, it can be seen that, there is a positive relationship between health quality and health resources.

When number of physicians increase, more patients can be examined, more patients-visits can be performedby physicians and hospital revenue increases with respected to the growth in number of medical operations. However, at the same time, physicians' share from revolving budget reduces.

In Run A, number of physicians is insufficient to meet examination demand. In addition to this, unmet demand creates more hospital visits and increase crowding further. As a result, physicians try to meet health demand by decreasing TSPE.

In Run D, number of physicians is adequate for meeting health demand. However, number of diagnostic physicians is insufficient for tests applications. Accordingly, patients whom are waiting for diagnose increases. Undiagnosed patients make more visits to hospital and increase hospital crowding further. In addition to this, physicians' revenue is lower than their expectations with low share from revolving budget. After three months, examination capacity cannot met health demand and with the pressure of increasing crowding and revenue; specialist physicians start to decrease TSPE for meeting demand.

Number of Specialist Physicians:

- Run A:10 physician
- Run B:20 physician
- Run C:30 physician
- Run D:50 physician

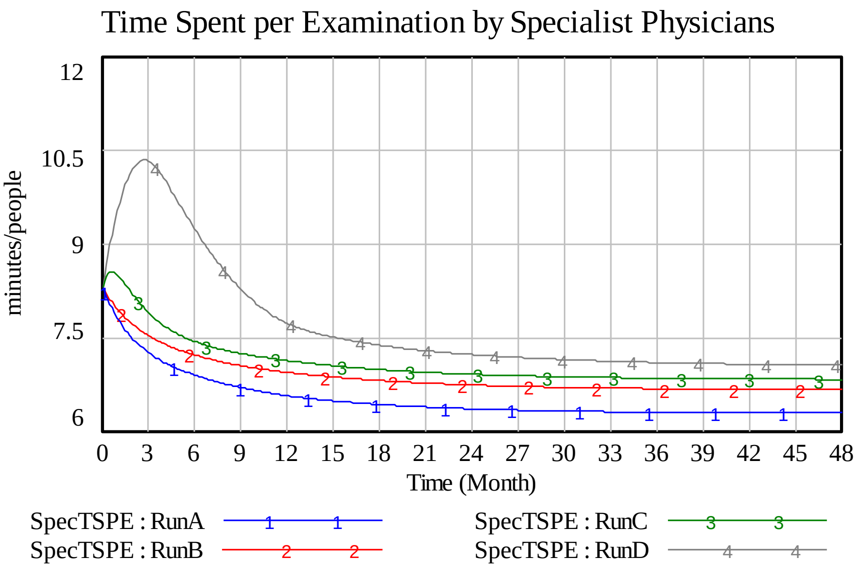

Figure 7.1.Time Spent Per Examination.

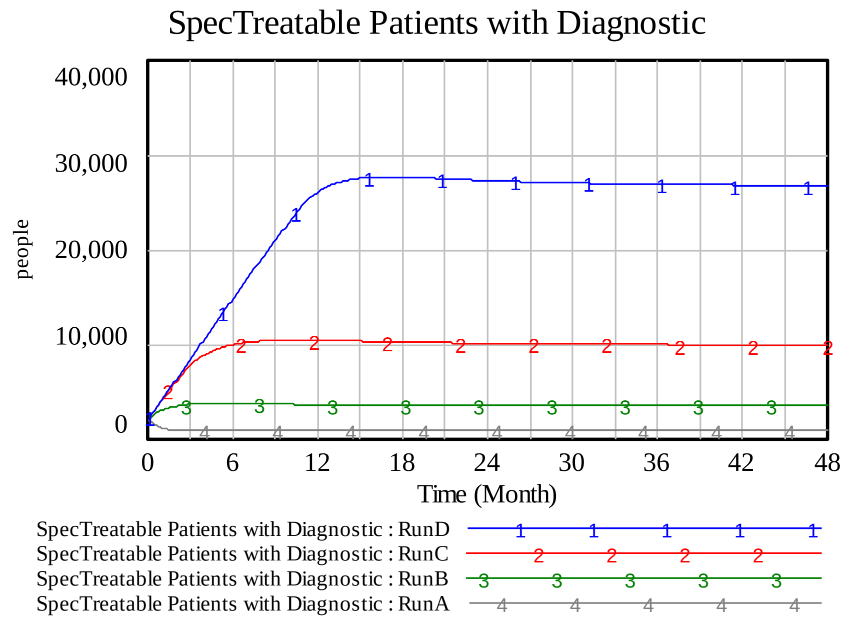

Figure 7.2.Specialist Physicians Treatable Patients with Diagnostic.

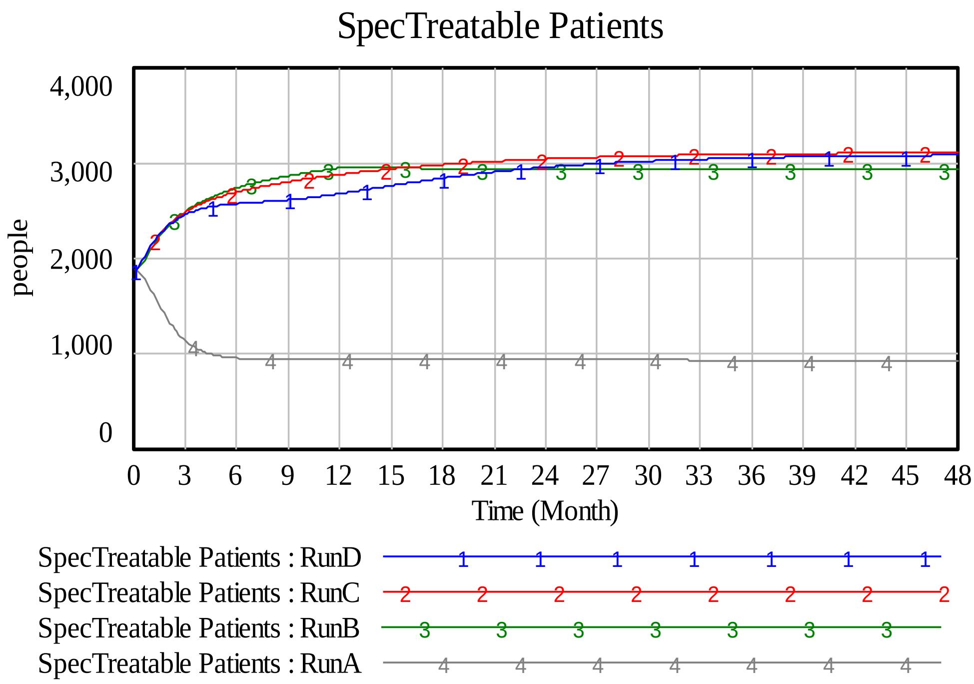

Figure 7.3Treatable Patients.

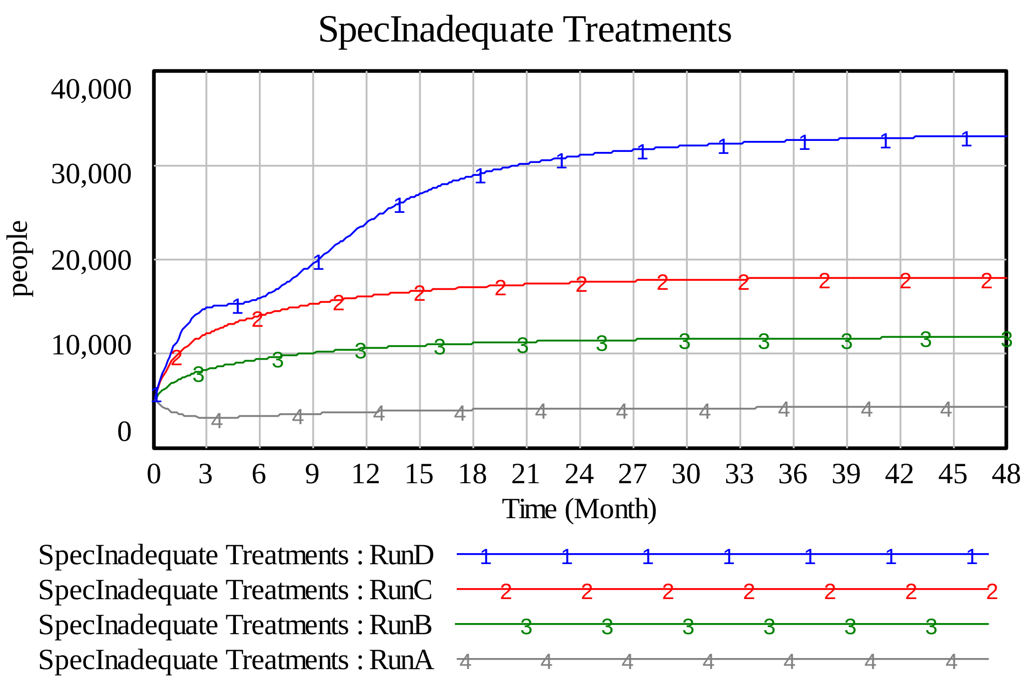

Figure 7.4.Inadequate Treatments.

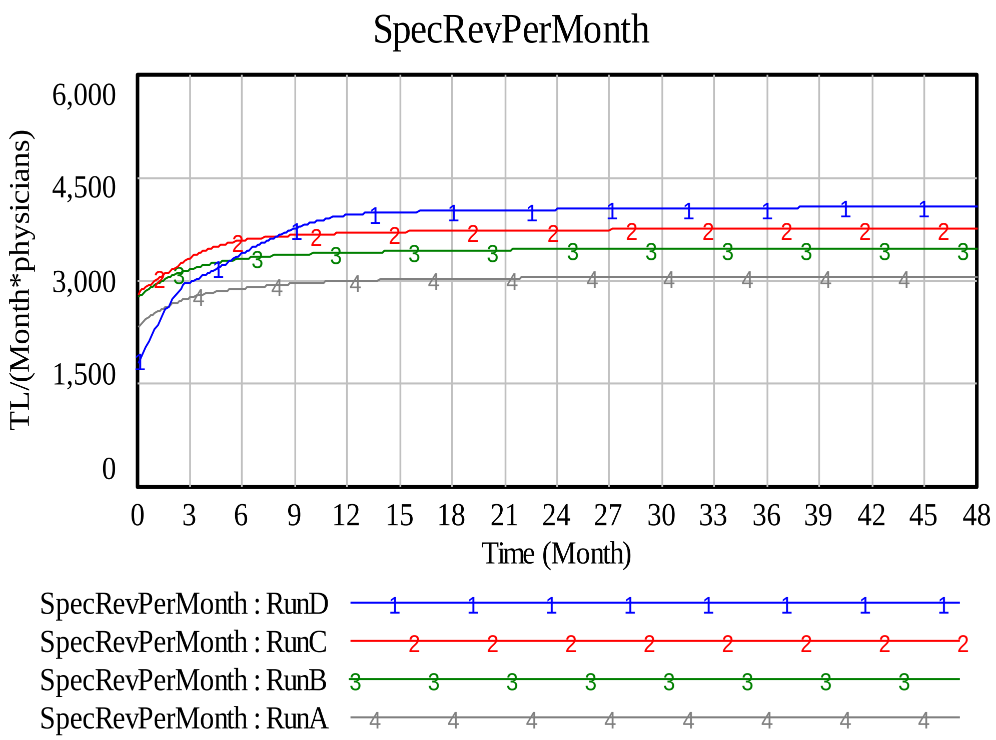

Figure 7.5.Specialist Physician Revenue per Month.

7.2. Sensitivity Analysis on Performance Point per Examination

Performance point per examination is 20 point/people in base run. In order to examine changes in dynamics of model with respect to changes in points per examination, the following runs are simulated:

- RunE: 10 Point/people
- Run F:30 Point/people
- RunG:5 Point/people
- Run H:50 Point/ people

It can be interpreted from the results that there is a positive relationship between points per examination and health quality. If points per examination increase from the base run value, physicians spend more time per examination and perform lower medical activities as a result of low revenue concerns. However; when physicians' revenue increases, their reference revenue increases proportionally. With the crowding pressure, physicians have to spend less time per examination and still health quality is adversely affected. This can be seen in behaviors in RunF and RunH.

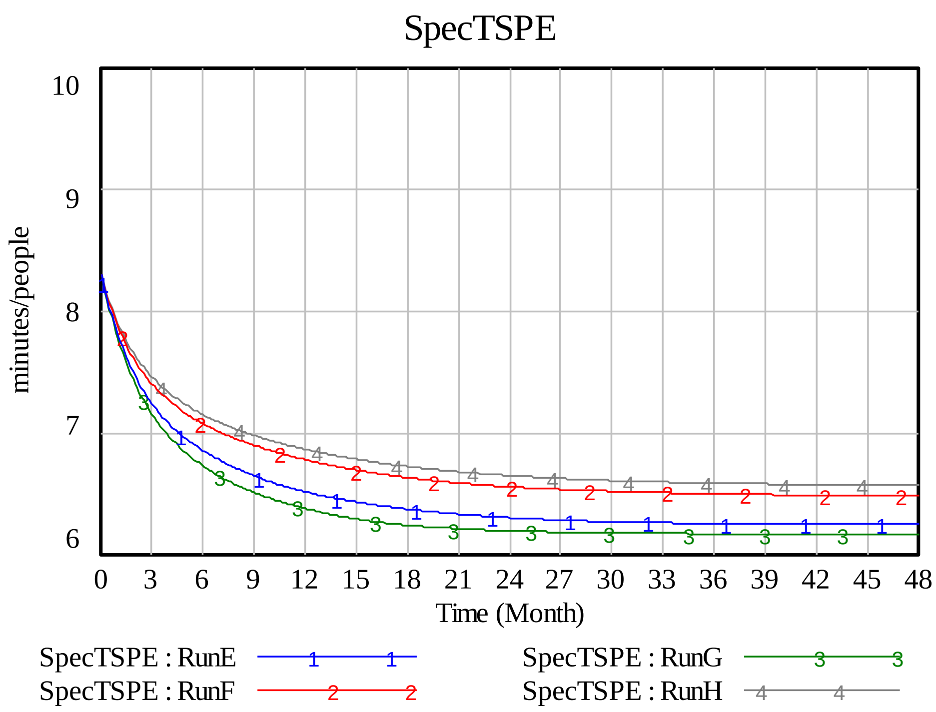

Figure 7.6.Time Spent per Examination by Specialist Physicians.

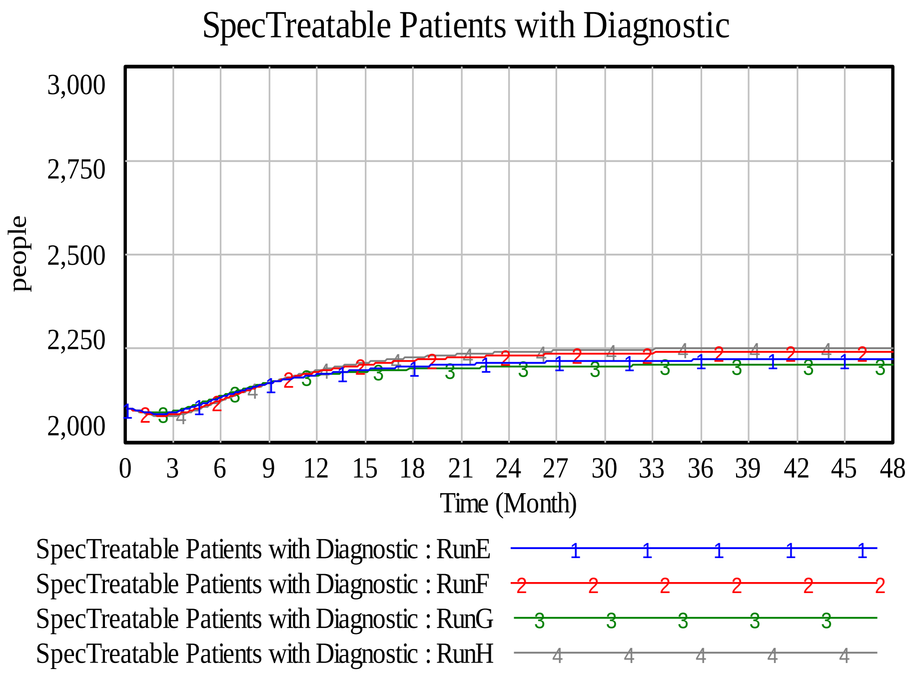

Figure 7.7.Specialist Physicians Treatable Patients with Diagnostic.

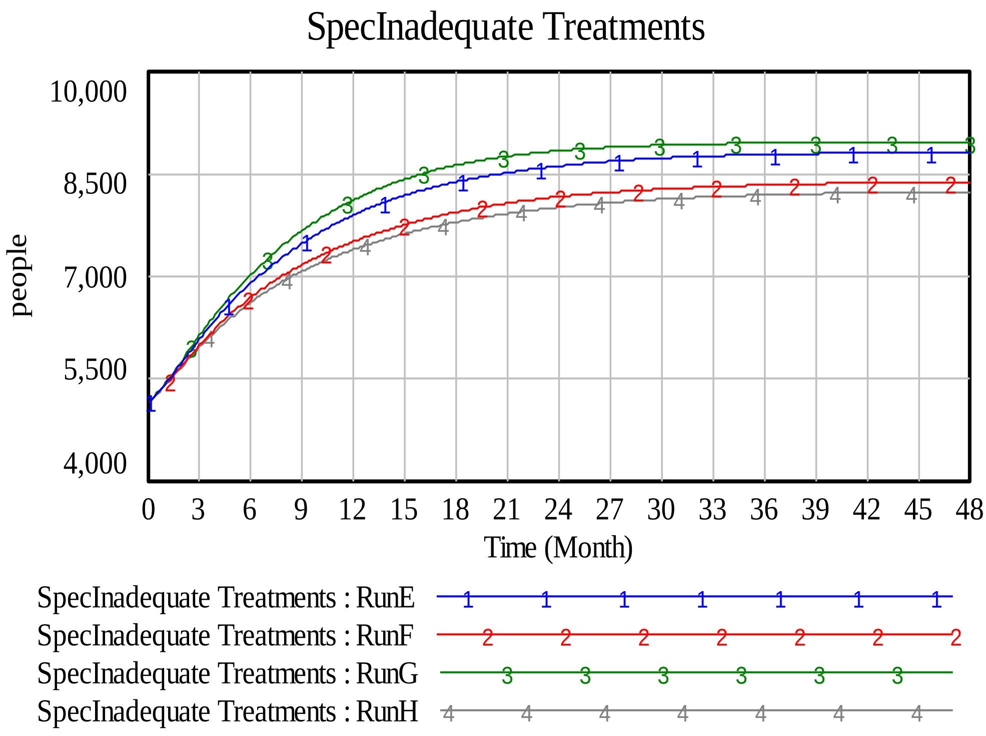

Figure 7.8.Specialist Physicians' Inadequate Treatments.

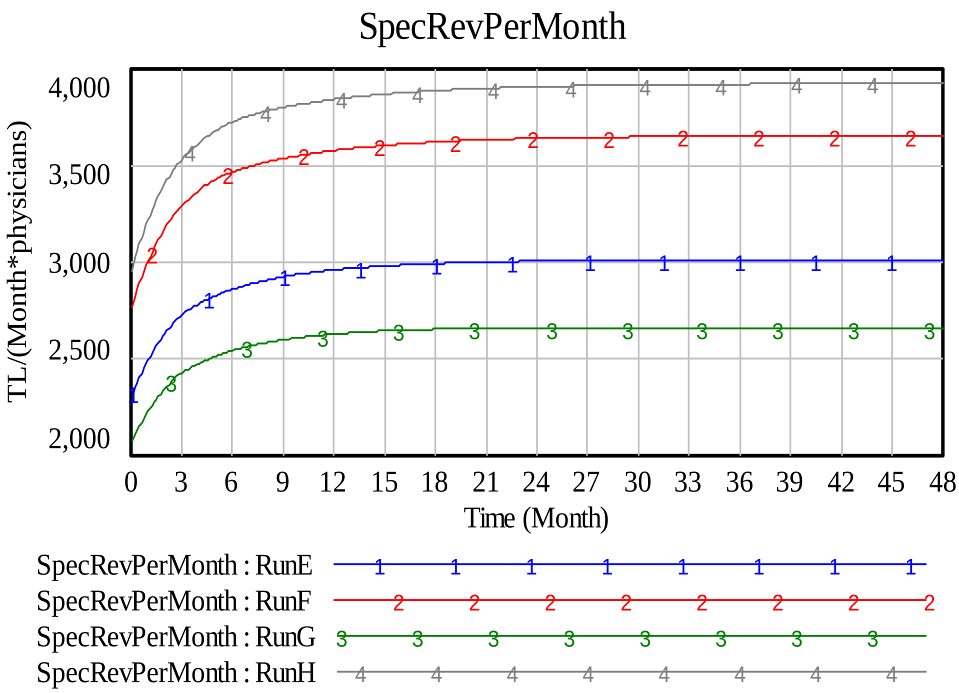

Figure 7.9.Specialist Revenue per Month.

7.3. Sensitivity Analysis on Net Revenue per Examination

Net revenue per examination is 10 TL in the base run. In order to examine changes in dynamics of model with respect to changes in net revenue per examination, following runs are simulated.

- Run I: 5 TL/people
- Run J : 15 TL/people
- Run K : 25 TL/people
- Run L : 30 TL/ people

With the high incentives per medical activities, both hospitals and physicians feel less revenue pressures. They give absolute priority on health service quality. However, if physicians' revenue increases, their reference revenue increases proportionally. Consequently, even in high incentivized policies, physicians try to maintain and increase their income. As can be seen from Figure, in RunL, that net revenue per examination is the third time bigger than baserun, however; physicians still try to increase their revenue by decreasing TSPE.

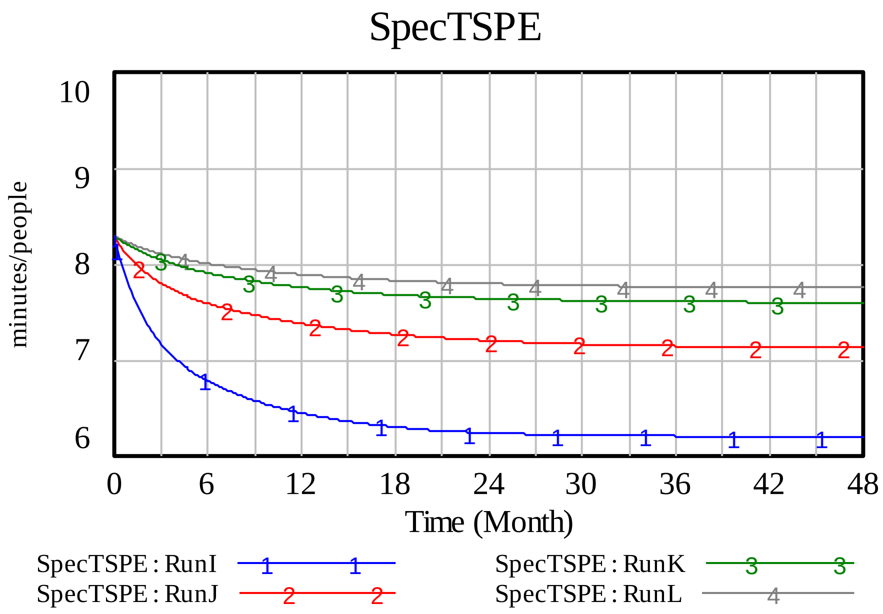

Figure 7.10.Time Spent per Examination by Specialist Physicians.

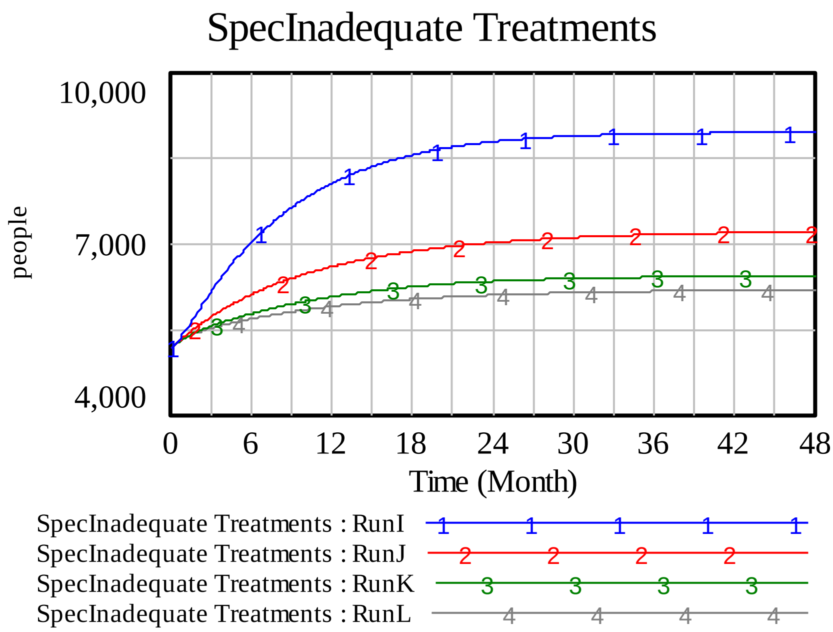

Figure 7.11.Specialists’ Inadequate Treatments.

7.4. Sensitivity Analysis on Private Hospital Specialist Physicians' Revenue

Private physicians' revenue is important reference for physicians' satisfaction in public hospitals. Physicians try to improve their revenue and earn better salaries like private hospitals' physicians. In order to study physicians reactions to private hospitals' physicians' income, the following runs are simulated:

- RunM:3000 TL/Month
- RunN:6000 TL/Month
- RunO:12000 TL/Month
- RunP: 18000 TL/Month

As can be seen from Figure 7.12, physicians try to increase their revenue much more when private physicians' revenue is higher than Base run. Conversely, health quality is affected adversely when physicians' revenue concern is high owing to the private physicians' revenue. In Figure 7.13 and Figure 7.14, it can be interpreted that, the relationship between net revenue per examination and health quality is positive. Inadequate treatments increase due to decreases in TSPE.

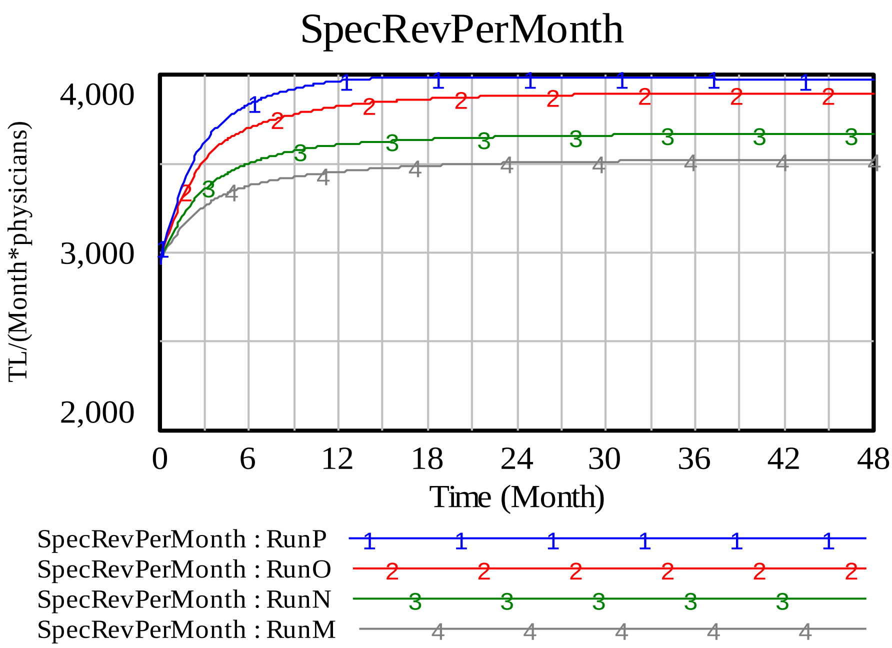

Figure 7.12.Specialist Physicians' Revenue per month.

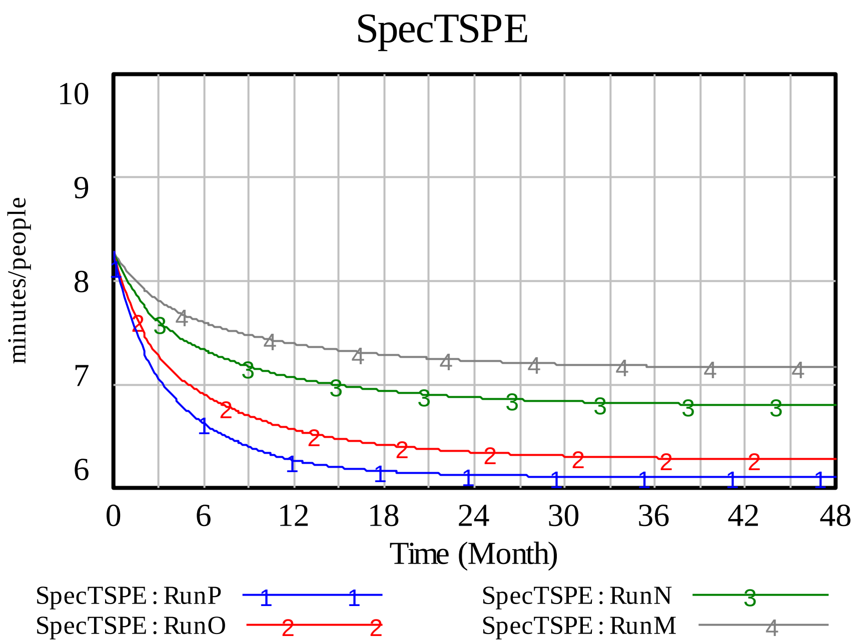

Figure 7.13.Time spent per examination by specialists.

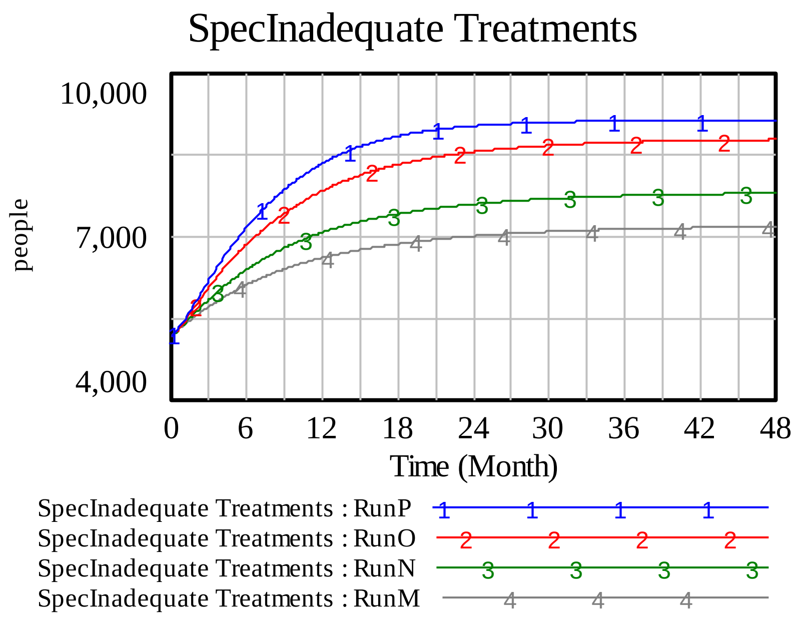

Figure 7.14.Inadequate Treatments.

8.SCENARIO ANALYSIS

8.1. High Incentive for Performance, Adequate Demand, Adequate Physicians

In this scenario, government's primary goal is to improve health service quality. Adequate health budget give MOH flexibility to carry out their performance program.

In order to reach this goal, first government increases health employee resources. Main expectation is to meet the health demand and increase health productivity. Since there is abundant demand, increases in health employee's numbers would not close the gap between health demand and capacity. Moreover, increases in physicians' revenue also increase their reference revenue in time. Thus, crowding and revenue concerns tend physicians to decrease TSPE and to give second priority on healthcare quality. The policy does not yield the desired outcomes, due to compensating feedback loops in the system.

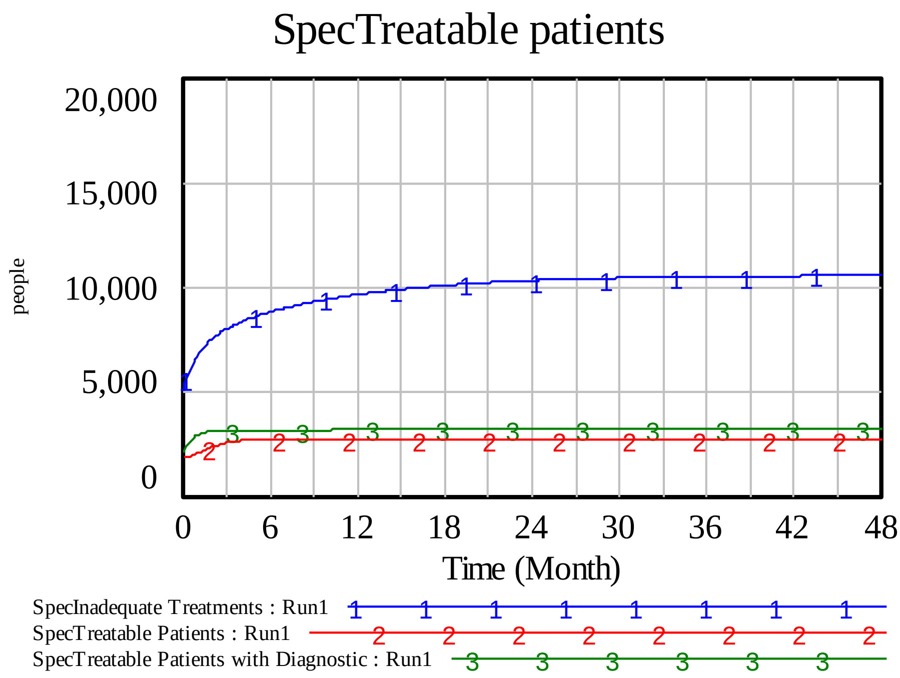

Figure 8.1.Specialist Physicians' Patient Stocks.

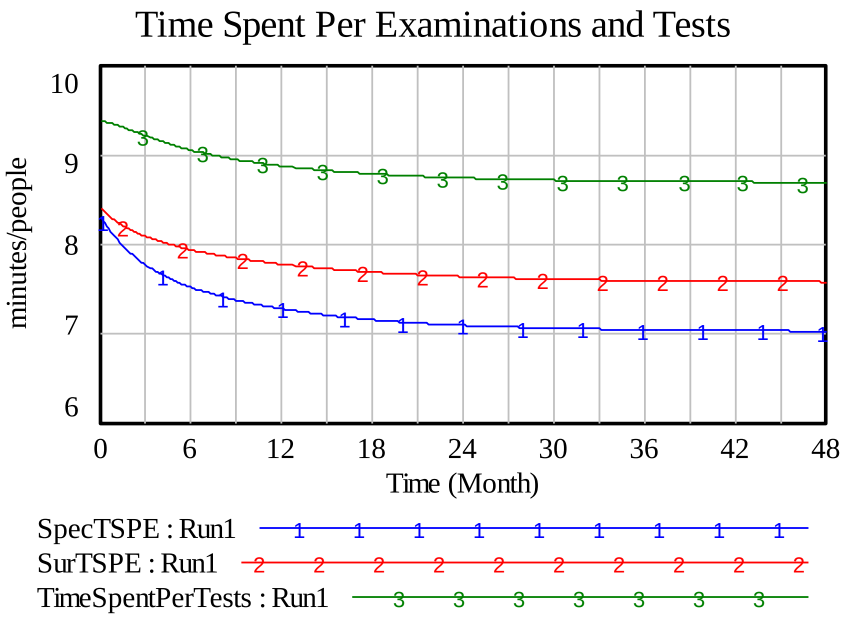

Figure 8.2.Time Spent per Examinations and Tests.

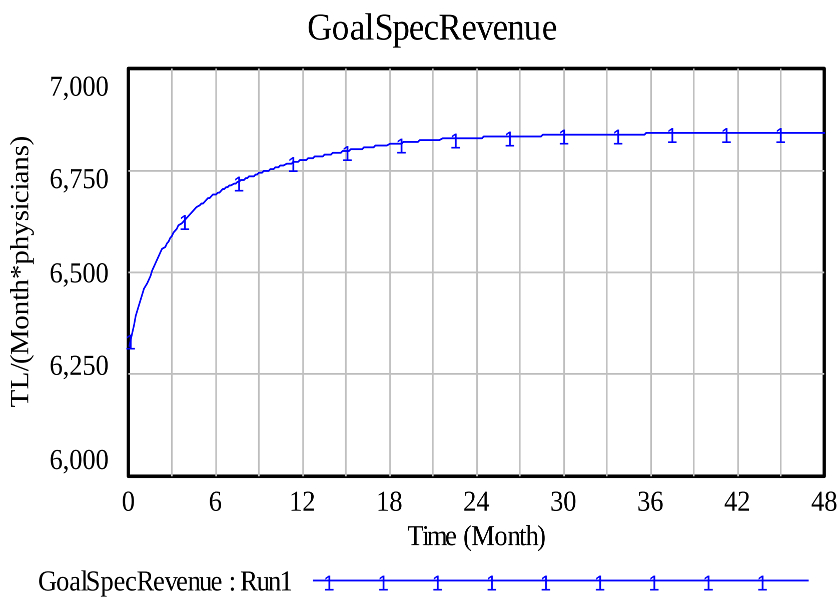

Figure 8.3.Specialists’ Goal Revenue.

8.2. Economic Crisis-Budget Cuts

In this scenario, government faces a big economic crisis. MOH cannot provide high incentives for medical activities anymore. Due to decreases in performance payments, physicians prefer working in private sector. As a result, public health employees are lower than that in base model. Moreover, private hospitals increase the physicians' base revenue to increase their productivity and market share.

Since the performance revenue of physicians is far lower than that in the base run, physician's revenue pressure is expected to be high. Moreover, decreases in health resources do not solve the unmet health demand problem. As a result, examination and surgery crowding increases due to inadequate number of health employees.

In Figure 8.4, it can be seen that time spent per examinations and tests decreases due to increases in crowding and revenue concern of hospital and physician. Physicians can increase their revenue by improving their productivity.

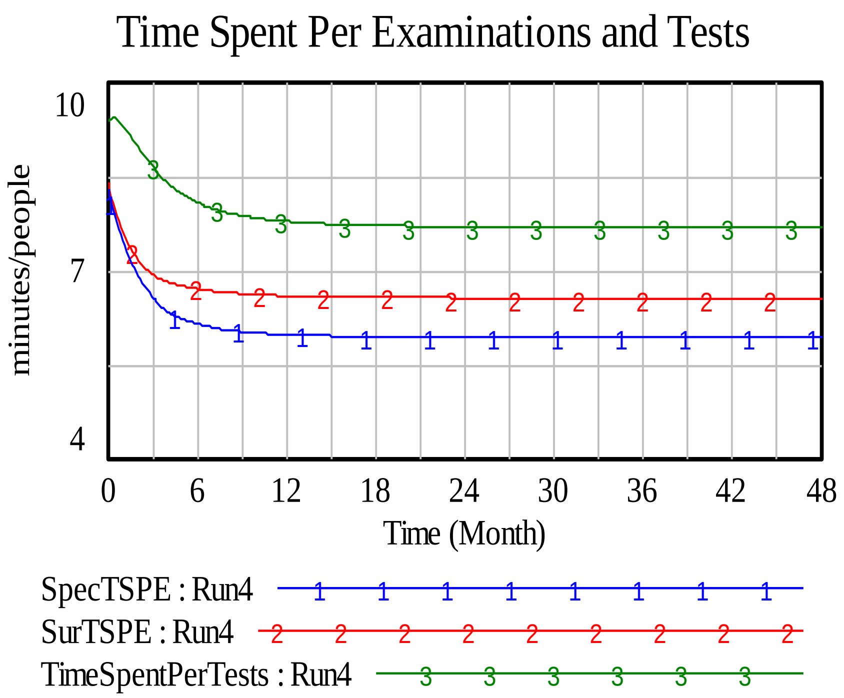

Figure 8.4.Time Spent Per Examinations and Tests.

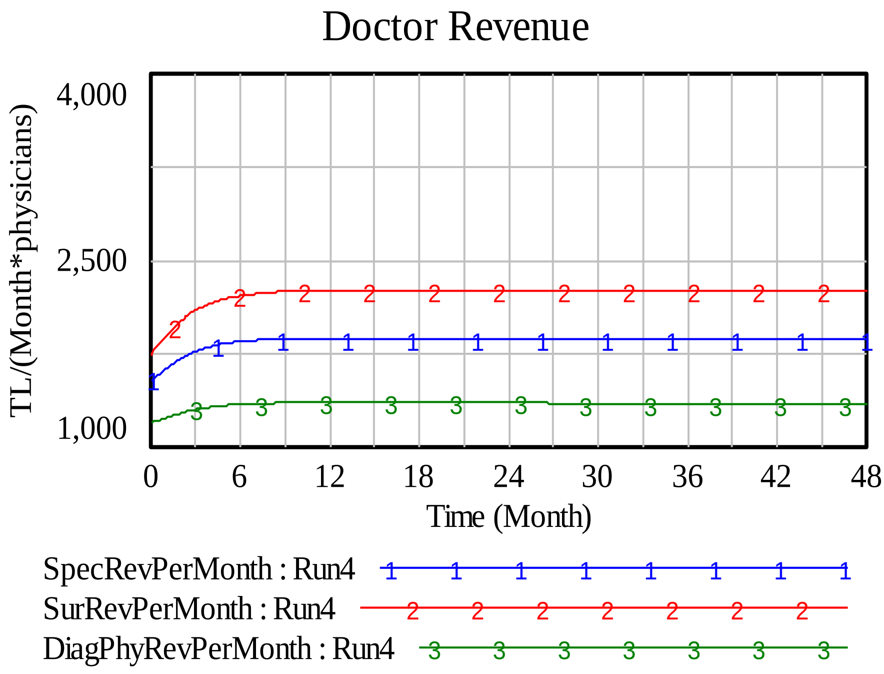

Figure 8.5.Physicians' Revenue.

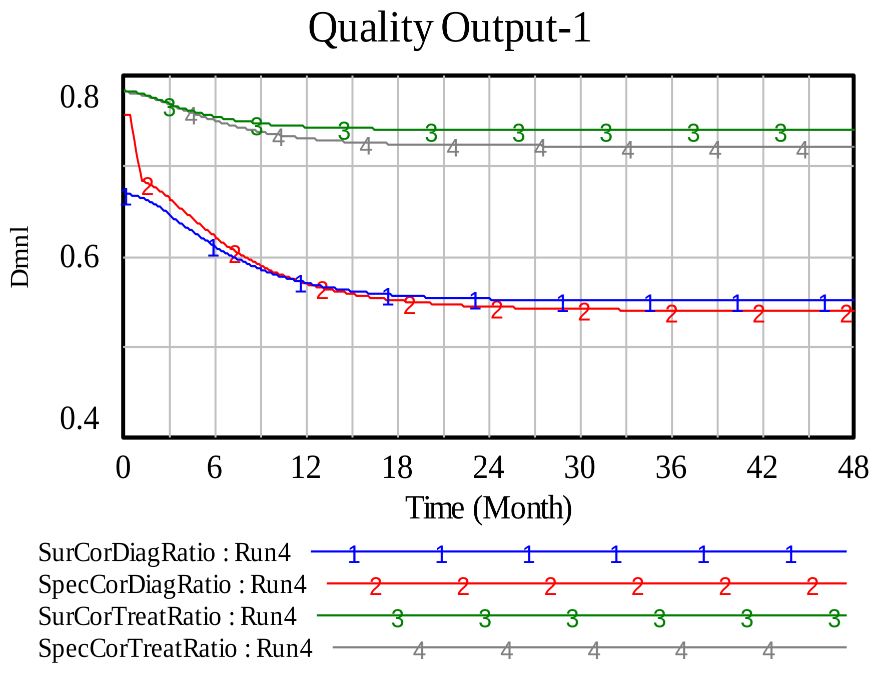

Figure 8.6.Correct Treatment / Diagnose Ratios.

8.3. No PBPS at all

If payment system is not based on medical performance of physicians, they still have revenue pressure but they don't have opportunity to improve their performance for increasing their revenue.

In this scenario, the effects of PBPS are excluded from model. Physicians' productivity is only affected by hospital crowding. Due to the hospital crowding, physicians may spend less time per examinations.

Although physicians' revenue is lower than their goal revenue, they can't increase their revenue by performing more medical activities. These behaviors can be seen in Figure 8.7 and Figure 8.8.

There is no significant changes are observed in this scenario. Absence of revenue-related effects excludes the adverse effects of PBPS on quality indicators. This can be seen in Figure 8.9.

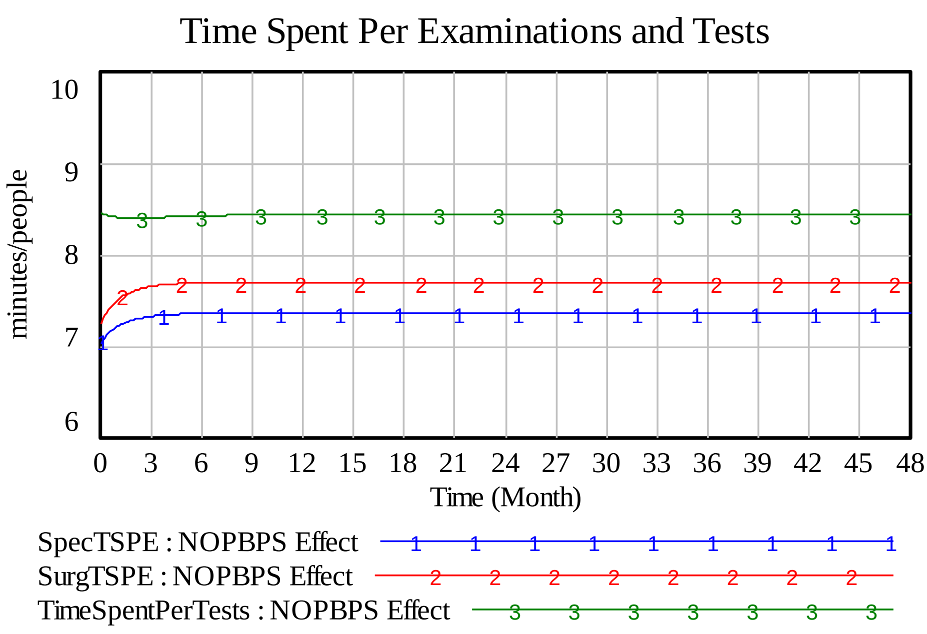

Figure 8.7.Time Spent per Examination and Tests.

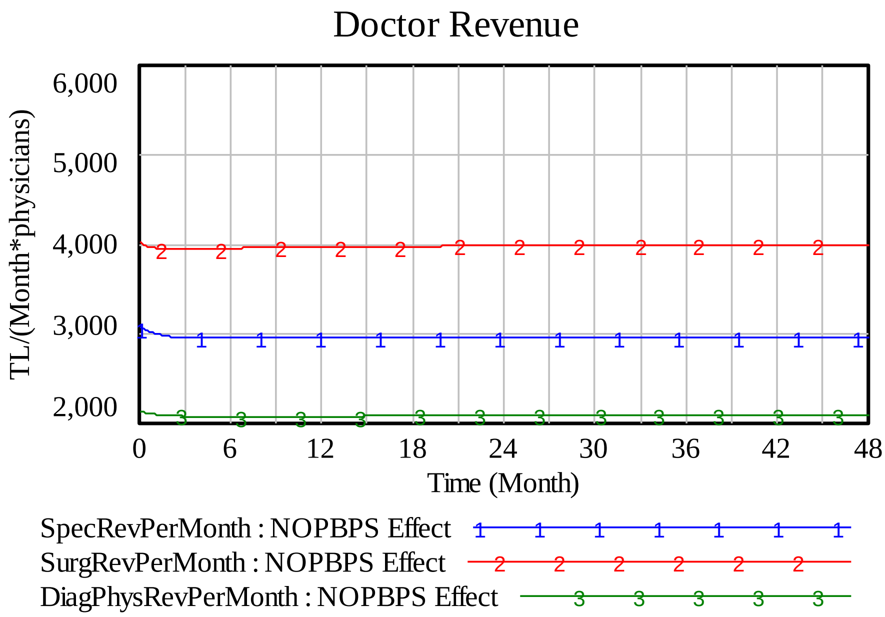

Figure 8.8.Physicians' Revenue.

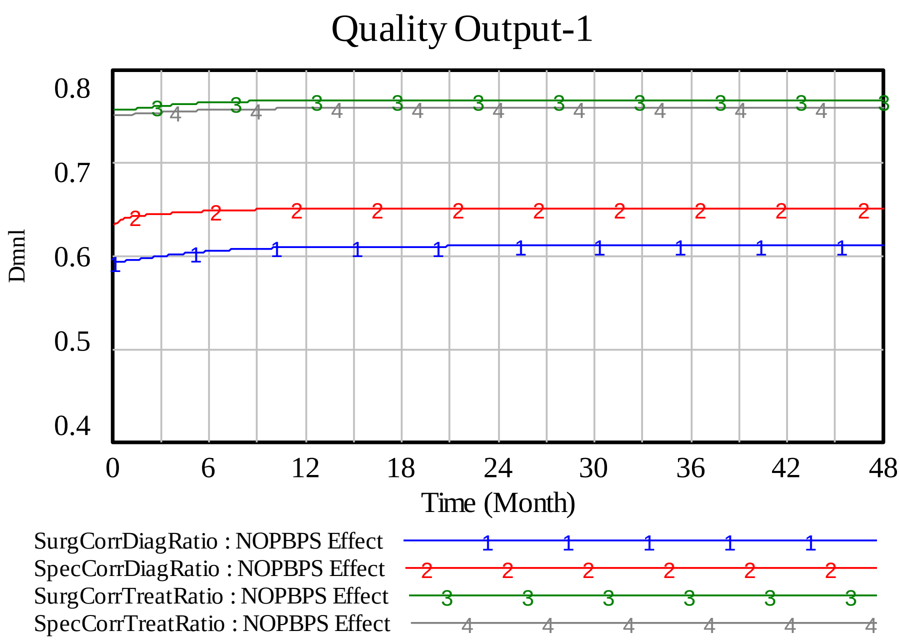

Figure 8.9.Correct Diagnose / Treatment Ratios.

8.4. Abundant Demand-Inadequate Specialist Physicians

In this scenario, number of physicians is decreased from 20 to 10. Hospital examination crowding increases as expected. Physicians experience the pressures of revenue and crowding. As a result, they try to increase their productivity by decreasing TSPE. This behavior can be seen in Figure 8.10.

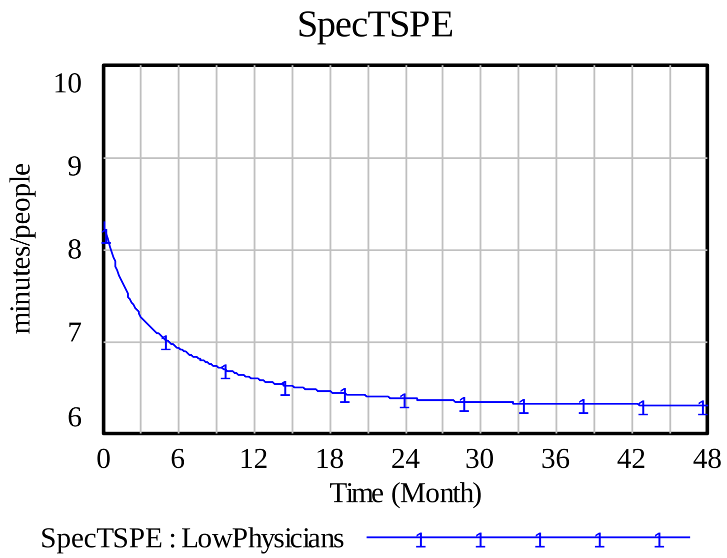

Figure 8.10.Specialist Time Spent Per Examination.

By performing more medical activities, physicians increase their revenue, which can be seen in Figure 8.11.

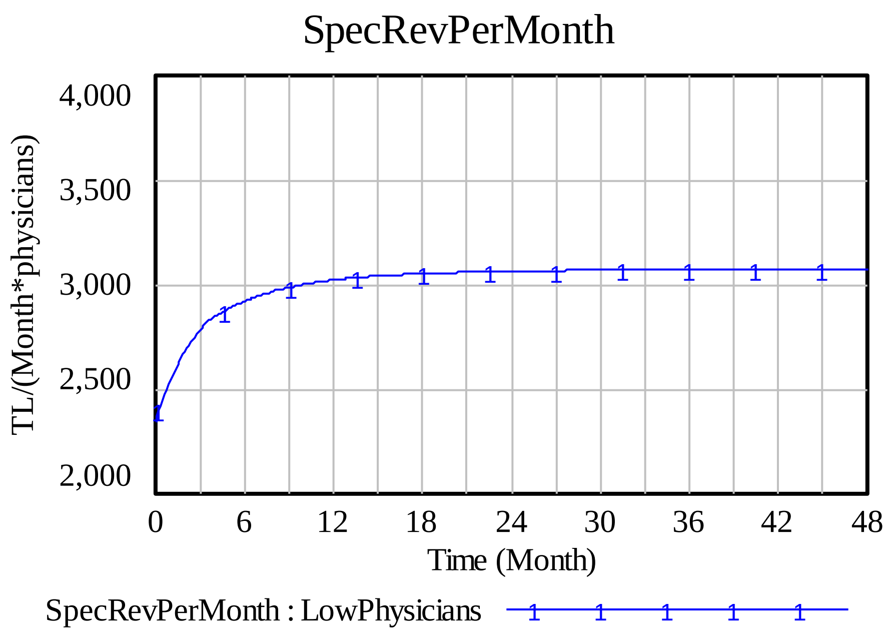

Figure 8.11.Specialist Physicians’ Revenue per Month.

8.5. Inadequate Demand-Low Performance Payments

In this scenario, there is inadequate demand for examination. Potential external examination demand to physicians is decreased to 3000 people/month. In addition to this, performance point per examination is decreased to 10 points/examination.

Although, specialist physicians' revenue is far lower than their reference revenue, they do not have opportunity to increase their income by examining more patients. The reason behind this situation is inadequate examination demand. Thus, time spent per examination doesn't decrease as a result of specialist's revenue concern, as expected. This behavior can be seen in Figure 8.12.

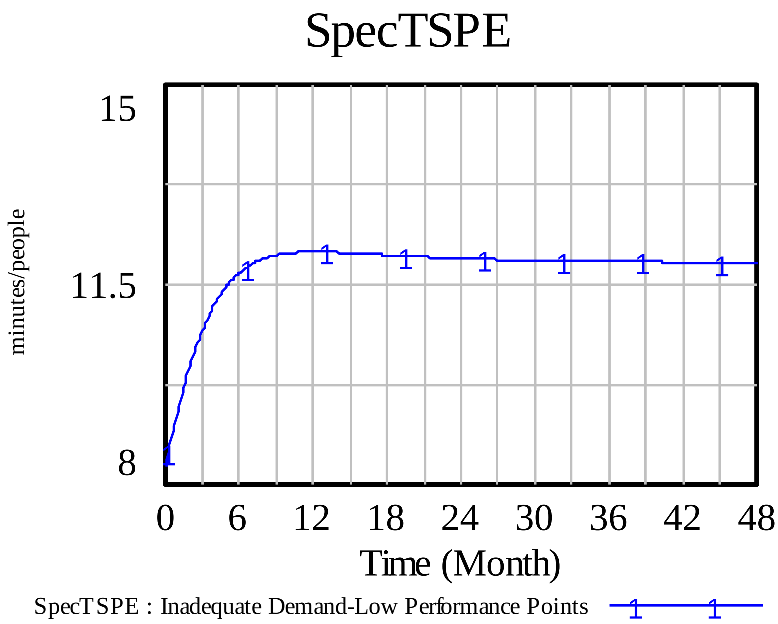

Figure 8.12.Time Spent per Examination by Specialist Physicians.

9. CONCLUSIONS

The aim of this study is to investigate dynamic impacts of performance based payment system(PBPS) on health service outputs. PBPS implementation in Turkey considers public health centers as revenue generating places. In order to meet health demand and increase medical productivity, PBPS has been active in second step public hospitals since 2004. Considering the long implementation history and share in medical operations, second step public hospital is selected and a model that represents the dynamic effects of PBPS on these hospitals and physicians is built.

Physicians' revenue and their response to government policies are related. With PBPS, physicians have a chance to improve their living standards by obtaining more performance revenue. If physicians already earn satisfactory salaries, then quality variables are expected to be positive with PBPS. In the base run, time spent per examination, performance points for medical activities, health resources and external demand are seen as main factors affecting the system behavior. According to simulation runs, there is a negative relationship with physician's revenue and health service quality, because of the fact that physician's revenue is strongly based on his/her productivity.

In scenario analysis, when physicians' revenue concern is high, physicians tend to spend less time per medical activity (examination, diagnostic and treatment) in order to increase their revenue. Quality indicators decrease as can be predicted. Inadequate treatment stocks increase and reach relatively high equilibrium values in 30 months. In another scenario, government decides to decrease the health expenditures and cut down performance points per medical activities. However, there is abundant demand for medical service and physicians can increase their productivity to increase their revenues. Therefore, inadequate and low quality treatments result, as well as crowding in hospitals. Efforts to decrease health expenditures end in failure because of the very structure of payment system.

To sum, this study is an initial effort for understanding dynamic effects of PBPS and presents base model for further studies. As further research, the relationships and competitions between public and private health sectors can be explicitly modeled and investigated. Moreover, a university hospital model may be built for investigating the impacts of PBPS on university hospitals. Thus, the effects of hospital revenue on educational and research activities may also be investigated.

APPENDIX A: MODEL EQUATIONS

ActExtExamDemSpec=MaxSpecExtExamCap*EffAvailSpecActDem*DelEfSpecCrowdExtDem{ People/Month}

AdjEffDiagPhysCrowdTSPT=(EffDiagPhysCrowdTSPT-DelEffDiagPhysCrowdTSPT) /DelTimeEff DiagPhysCrowdTSPT {Dmnl/Month}

AdjEffDiagPhysRevTSPT=(EffDiagPhysRevTSPT-DelEffDiagPhysRevTSPT)/DelTimeEff DiagPhysRevTSPT {Dmnl/Month}

AdjEffDiagPhysTSPTWrongDiagFract=EffDiagPhysTSPTWrongDiagFract-DelEffDiagPhysTSPTWrongDiagFract)/DelTimeEffDiagTSPTWrongDiagFract {Dmnl/Month}

AdjEffHospRevSpecTSPE=(EffHospRevSpecTSPE-DelEffHosRevSpecTSPE)/DelTimeEff HosRev SpecTSPE {Dmnl/Month}

AdjEffHospRevSurgTSPE=(EffHospRevSurgTSPE-DelEffHospRevSurgTSPE)/DelTimeEffHosp RevSurgTSPE {Dmnl/Month}

AdjEffSpecCrowdExtDemand=(EffSpecCrowdExtDemand-DelEfSpecCrowdExtDem)/ DelTimeEff SpecCrowdExtDemand {Dmnl/Month}

AdjEffSpecExamCrowdTSPE=(EffSpecExamCrowdTSPE-DelEffSpecExamCrowdTSPE)/ DelTime EffSpecExamCrowdTSPE {Dmnl/Month}

AdjEffSpecRevHospFract=(EffSpecRevHospFract-DelEffSpecRevHospFract)/ DelTimeEffSpecRev HospFract {Dmnl/Month}

AdjEffSpecRevTSPE=(EffSpecRevTSPE-DelEffSpecRevTSPE)/DelTimeEffSpecRevTSPE {Dmnl/ Month}

AdjEffSpecTSPEChronPatRemovTime=(EffSpecTSPEChrPatRemTime–DelEffSpecTSPEChronPatRemovTime)/DelTimeEffSpecTSPEChronPatRemovTime {Dmnl/Month}

AdjEffSpecTSPECorrDiagFract=(EffSpecTSPECorrDiagFract-DelEffSpecTSPECorrDiagFract)/ Del TimeEffSpecTSPECorrDiagFract {Dmnl/Month}

AdjEffSpecTSPECorTreatFract=(EffSpecTSPECorrTreatFract-DelEffSpecTSPECorTreatFract) /Del TimeEffSpecTSPECorrTreatFract {Dmnl/Month}

AdjEffSpecTSPEInTreatFract=(EffSpecTSPEInTreatFract-DelEffSpecTSPEIn TreatFract)/DelTime EffSpecTSPEInTreatFract {Dmnl/Month}

AdjEffSpecTSPEWrongDiagFract=(EffSpecTSPEWrongDiagFract-DelEffSpecTSPEWrongDiagFract)/DelTimeEffSpecTSPEWrongDiagFract {Dmnl/Month}

AdjEffSpecWrongDiagFract=(EffSpecWrongDiagFract-DelEffSpecWrongDiagFract)/DelTime Eff SpecWrongDiagFract {Dmnl/Month}

AdjEffSurgCrowdExtDemand=(EffSurgCrowdExtDemand-DelEffSurgCrowdExtDemand) /DelTime EffSurgCrowdExtDemand {Dmnl/Month}

AdjEffSurgCrowdTSPE=(EffSurgCrowdTSPE-DelEffSurgCrowdTSPE)/DelTimeEffSurgCrowdTSPE {Dmnl/Month}

AdjEffSurgCrowdTSPS=(EffSurgCrowdTSPS-DelEffSurgCrowdTSPS)/DelTimeEffSurgCrowdTSPS {Dmnl/Month}

AdjEffSurgRevSurFract=(EffSurgRevSurFract-DelEffSurgRevSurgFract)/DelTimeEffSurgRevSurg Fract {Dmnl/Month}

AdjEffSurgRevTSPS=(EffSurgRevTSPS-DelEffSurRevTSPS)/DelTimeEffSurgRevTSPS {Dmnl/ Month}

AdjEffSurgTSPEChonPatRemovTime=(EffSurgTSPEChronPatRemovTime-DelEffSurgTSPEChronPatRemovTime)/DelTimeEffSurgTSPEChPatRemTime {Dmnl/Month}

AdjEffSurgTSPECorrTreatFract=(EffSurgTSPECorrTreatFract-DelEffSurgTSPECorrTreatFract)/ DelTimeEffSurgTSPECorrTreatFract {Dmnl/Month}

AdjEffSurgTSPEInadTreatFract=(EffSurgTSPEInadTreatFract-DelEffSurgTSPEInAdTreatFract) /DelTimeEffSurgTSPEInadTreatFract {Dmnl/Month}

AdjEffSurgTSPEWrongDiagFract=(EffSurgTSPEWrongDiagFract-DelEffSurgTSPEWrongDiagFract)/DelTimeEffSurgTSPEWrongDiagFract {Dmnl/Month}

AdjEffSurgTSPEWrongTreatFract=(EffSurgTSPEWrongTreatFract-DelEffSurgTSPEWrongTreatFract)/DelTimeEffSurgTSPEWrongTreatFract {Dmnl/Month}

AdjEffSurRevSurgTime=(EffSurgRevSurgTime-DelEffSurgRevSurgTime)/DelTime EffSurRevSurg Time {Dmnl/Month}

AdjEffSurTSPECorrDiagFract=(EffSurgTSPECorrDiagFract-DelEffSurgTSPECorrDiagFract) /Del TimeEffSurgTSPECorrDiagFract {Dmnl/Month}

AdjEffTSPSCorrTreat=(EffTSPSCorrTreatFract-DelEffTSPSCorrTreat)/DelTimeEffTSPSCorrTreat {Dmnl/Month}

AdjEffTSPTCorrDiagFract=(EffTSPTCorrDiagFract-

DelEffTSPTCorrDiagFract)/DelTimeEff TSPT CorrDiagFract {Dmnl/Month}

AdjRefDiagPhysRevenue=(GoalDiagPhysRevenue-

RefDiagPhysRevenue)/DelTimeRefDiagPhys Revenue{TL/Month/physicians/Month}

AdjRefSurgRev=(GoalSurgRevenue-RefSurgRevenue)/DelTimeRefSurgRev

{TL/Month/surgeons/ Month}

AdjRevHosRev=(GoalSecStepPubHos-

RefHospRev)/DelTimeRefHospRev{TL/Month/Month}

AdjRevSpecRev=(SpecGoalRevenue-RefSpecRevenue)/DelTimeRevSpecRevenue

{TL/(Month* Month*physicians)}

AdjSurgInadeqSrgry=(EffTSPSInadSurgFract

DelEffTSPSInadeqSrgryFract)/DelTimeEffTSPSInad SurFract {Dmnl/Month}

BasePubHosDiagPhysRev=3000 { TL/Month/physicians}

BasePubHospSurgRev=5000 {TL/Month/surgeons}

BasePubHosSpecRevenue=4000 {TL/Month/physicians}

BaseSecStepPubHosRev=HosBedCapacity*RevPerBeds+NumberofDiagnosticPhysicians*

RevPerDiagPhys+NumberofSpecialists*RevPerSpec+RevPerSur*NumberofSurgeons

{TL/Month}

Chronic patients= INTEG (New Chronic Patients-ChronPatRemovRate,3007.01) {people}

ChronPatRemovRate=Chronic patients/ChronPatRemovTime {people/Month}

ChronPatRemovTime= 6 {Month}

DelTimeEffDiagPhysCrowdTSPT=3 {Month}

DelTimeEffDiagPhysRevTSPT=6 {Month}

DelTimeEffDiagTSPTWrongDiagFract=4 {Month}

DelTimeEffHospRevSurgTSPE=8 {Month}

DelTimeEffHosRevSpecTSPE=8 {Month}

DelTimeEffSpecExamCrowdTSPE=3 {Month}

DelTimeEffSpecRevHospFract=6 {Month}

DelTimeEffSpecRevTSPE=9 {Month}

DelTimeEffSpecTSPEChronPatRemovTime=3 {Month}

DelTimeEffSpecTSPECorrDiagFract=3 {Month}

DelTimeEffSpecTSPECorrTreatFract=4 {Month}

DelTimeEffSpecTSPEInTreatFract=3 {Month}

DelTimeEffSpecTSPEWrongDiagFract=4 {Month}

DelTimeEffSpecWrongDiagFract=10 {Month}

DelTimeEffSurgCrowdExtDemand=3 {Month}

DelTimeEffSurgCrowdTSPE=3 {Month}

DelTimeEffSurgCrowdTSPS=4 {Month}

DelTimeEffSurgRevSurgFract=6 {Month}

DelTimeEffSurgRevTSPS=9 {Month}

DelTimeEffSurgTSPEChPatRemTime=3 {Month}

DelTimeEffSurgTSPECorrDiagFract=4 {Month}

DelTimeEffSurgTSPECorrTreatFract=3 {Month}

DelTimeEffSurgTSPEInadTreatFract=6 {Month}

DelTimeEffSurgTSPEWrongDiagFract=4 {Month}

DelTimeEffSurgTSPEWrongTreatFract=3 {Month}

DelTimeEffSurRevSurgTime=6 {Month}

DelTimeEffTSPSCorrTreat=4 {Month}

DelTimeEffTSPSInadSurFract=4 {Month}

DelTimeEffTSPTCorrDiagFract=4 {Month}

DelTimeEfSpecCrowdExtDemand=3 {Month}

DelTimeRefDiagPhysRevenue=6 {Month}

DelTimeRefHospRev=6 {Month}

DelTimeRefSurgRev=6 {Month}

DelTimeRevSpecRevenue=6 {Month}

DiagPhyPerPointPerMonth=NumTestsPerPerMonth*PointsPerTests {Points/Month}

DiagPhyPerRevPerMonth=DiagPhyPerPointPerMonth*UnRevPerPoints {TL/Month}

DiagPhysFixedSalary=1000 {TL/(Month*physicians)}

DiagPhysProductivity=DiagPhysTotDiagMinutes/TimeSpentPerTests {tests/(Month*physicians)}

DiagPhysRevPerMonth=DiagPhysFixedSalary+PerRevDiagPerMonth {TL/(Month*physicians)}

DiagPhysTotDiagMinutes=10875.6 { minutes/(Month*physicians)}

EffAvailSpecActDem=lookupextrapolate(GraphEffAvailSpecActDem,NormSpecExamAvail){Dmnl}

EffDiagPhysCrowdTSPT=lookupextrapolate(GraphEffDiagPhysCrowdTSPT,TestsCrowding){Dmnl}

EffDiagPhysRevTSPT=lookupextrapolate(GraphEffDiagPhysRevTSPT,NormDiagPhysRev Per Month)* EffTestCrowdEffDiagPhyRevTSPT} {Dmnl}

EffDiagPhysTSPTWrongDiagFract=lookupextrapolate(GraphEffDiagTSPTWrongDiagFract,NormTSPT)

EffHospRevSpecTSPE=lookupextrapolate(GraphEffHospRevSpecTSPE,NormHospRev)* EffSpec CrowdRTSPE {Dmnl}

EffHospRevSurgTSPE=lookup extrapolate(GraphEffHospRevSurTSPE,NormHospRev)*EffSurgCrowd EffSurgRevTSPE {Dmnl}

EffHosRevPerPay=lookup extrapolate(GraphEffHosRevPerPay,NormHospRev) {Dmnl}

EffInPatCrowdHosPerMonth=lookupextrapolate(GraphEffInPatCrowdHosPerMonth,InPatCrowd) {Dmnl}

EffSpecAppExam=lookupextrapolate(GraphEffSpecAppExa,SpecExamCrowd) {Dmnl}

EffSpecCrowdExtDemand=lookupextrapolate(GraphEffSpecCrowdExtDemand,SpecExamCrowd) {Dmnl}

EffSpecCrowdRTSPE=lookupextrapolate(GraphEffSpecCrowdRTSPE,SpecExamCrowd) {Dmnl}

EffSpecExamCrowdTSPE=lookupextrapolate(GraphEffSpecExamCrowdTSPE,SpecExamCrowd) {Dmnl}

EffSpecRevHospFract=lookup extrapolate(GraphEffSpecRevHosFract,NormSpecRevenue) {Dmnl}

EffSpecRevTSPE=lookupextrapolate(GraphEffSpecRevTSPE,NormSpecRevenue)*EffSpecCrowdRTSPE{Dmnl}

EffSpecTSPEChrPatRemTime=lookupextrapolate(GraphEffSpecTSPEChronPatRemovTime, NormSpec TSPE) {Dmnl}

EffSpecTSPECorrDiagFract=lookupextrapolate(GraphEffSpecTSPECorrDiagFract,NormSpecTSPE) {Dmnl}

EffSpecTSPECorrTreatFract=lookupextrapolate(GraphEffSpecTSPECorTreFract,NormSpecTSPE) {Dmnl}

EffSpecTSPEInTreatFract=lookupextrapolate(GraphEffSpecTSPEInTreatFract,NormSpecTSPE) {Dmnl}

EffSpecTSPEWrongDiagFract=lookupextrapolate(GraphEffSpecTSPEWrongDiagFract,NormSpecTSPE) {Dmnl}

EffSpecWrongDiagFract=lookupextrapolate(GraphEffSpecWrongDiagFract,NormTSPT) {Dmnl}

EffSurgAppExam=lookupextrapolate(GraphSurgExamCrowding,SurgExamCrowding) {Dmnl}

EffSurgAppSurPer=lookupextrapolate(GraphEffSurgAppSurPer,Surgerycrowding) {Dmnl}

EffSurgAvExamExtDemand=lookupextrapolate(GraphEffSurgAvExamExtDemand,NormSurgExamAv) {Dmnl}

EffSurgCrowdEffSurgRevTSPE=lookupextrapolate(GraphEffSurgCrowdEffSurgRevTSPE,SurgExamCrowding) {Dmnl}

EffSurgCrowdExtDemand=lookupextrapolate(GraphEffSurgCrowdExtDemand,SurgExamCrowding) {Dmnl}

EffSurgCrowdTSPE=lookupextrapolate(GraphEffSurgCrowdTSPE,SurgExamCrowding) {Dmnl}

EffSurgCrowdTSPS=lookupextrapolate(GraphEffSurgCrowdTSPS,Surgerycrowding) {Dmnl}

EffSurgRevSurFract=lookupextrapolate(GraphEffSurgRevSurgFract,NormSurgPerRev) {Dmnl}

EffSurgRevSurgTime=lookupextrapolate(GraphEffSurgRevSurTime,NormSurgPerRev) {Dmnl}

EffSurgRevTSPS=lookupextrapolate(GraphEffSurgRevTSPS,NormSurgPerRev)*EffSurgCrowdEffSurg RevTSPE {Dmnl}

EffSurgTSPEChronPatRemovTime=lookupextrapolate(GraphEffSurgTSPEChronPatRemovTime,Norm SurgTSPE) {Dmnl}

EffSurgTSPECorrDiagFract=lookupextrapolate(GraphEffSurgTSPECorrDiagFract,NormSurgTSPE) {Dmnl}

EffSurgTSPECorrTreatFract=lookupextrapolate(GraphEffSurgTSPECorrTreatFract,NormSurgTSPE) {Dmnl}

EffSurgTSPEInadTreatFract=lookupextrapolate(GraphEffSurgTSPEInadTreatFract,NormSurgTSPE) {Dmnl}

EffSurgTSPEWrongDiagFract=lookupextrapolate(GraphEffSurgTSPEWrongDiagFract,NormSurgTSPE) {Dmnl}

EffSurgTSPEWrongTreatFract=lookupextrapolate(GraphEffSurgTSPEWrongTreatFract,NormSurg TSPE) {Dmnl}

EffTestAppNumTestPerf=lookupextrapolate(GraphEffTestAppNumTestPerf,TestsCrowding) {Dmnl}

EffTestCrowdEffDiagPhyRevTSPT=lookupextrapolate(GraphEffTestAnCrowdTSPT,TestsCrowding) {Dmnl}

EffTSPSCorrTreatFract=lookupextrapolate(GraphTspsCorrTreatFract,NormTSPS) {Dmnl}

EffTSPSInadSurgFract=lookupextrapolate(GraphEffTSPSInadSurgFract,NormTSPS) {Dmnl}

EffTSPTCorrDiagFract=lookupextrapolate(GraphEffTSPTCorrDiagFract,NormTSPT) {Dmnl}

FINAL TIME = 48 {Month}

DiagPhysGoalRevenue=PriDiagPhysRev*0.2+BasePubHosDiagPhysRev*0.2+DiagPhysRevPerMonth* 0.6 {TL/(Month*physicians)}

SecStepPubHosGoal=HospRevPerMonth*0.6+PriSecStepHosRev*0.2+BaseSecStepPubHosRev*0.2{TL/Month}

SurgGoalRevenue=BasePubHospSurgRev*0.2+PriSurgRevenue*0.2+SurgRevPerMonth* 0.6 {TL/(Month*surgeons)}

GraphEffAvailSpecActDem([(-0.3,0)-(1.3,1)],(-0.3,0),(-0.2,0),(-0.1,0),(0.0336392, 0.0131579),(0.0259939,0.0350877),(0.1,0.1),(0.2,0.2),(0.3,0.3),(0.4,0.4),(0.5,0.5),(0.6,0.6),(0.7,0.7),(0.8,0.8), (0.9,0.9),(0.977064,0.964912),(1.1,1),(1.2,1),(1.3,1)){ Dmnl}

GraphEffDiagPhysCrowdTSPT([(0.5,-0.2)(1.5,0.1)],(0.503058,0.0973684),(0.622324, 0.0881579), (0.735474,0.0697368),(0.83945,0.0394737),(0.931193,0.00526316),(1.0107,-0.0421053),(1.07798,-0.0907895),(1.1422,-0.131579),(1.20336,-0.165789),(1.3104,-0.190789),(1.41131,-0.197368), (1.49388,-0.198684)) { Dmnl}

GraphEffDiagPhysRevTSPT([(0.5,-0.25)-(1.5,0.15)],(0.503058,-0.25),(0.625382,-0.157018).(0.735474,-0.0780702),(0.851682,0.000877197),(0.934251,0.0464912),(1.02599,0.081579),
(1.11774,0.111404),(1.237,0.135965),(1.3685,0.148246),(1.49083,0.15)) { Dmnl}

GraphEffDiagTSPTWrongDiagFract([(0.5,-0.2)-(1.5,0.3)],(0.506116,0.297807),(0.585627,0.295614),(0.66208,0.282456),(0.744648,0.25614),(0.857798,0.188158),(0.934251,0.0960526),(1,0),(1.06881,-0.0815789),(1.1422,-0.134211),(1.24924,-0.175877),(1.38379,-0.197807),(1.49388,-0.2)) { Dmnl}

GraphEffHospRevSpecTSPE([(0.5,-0.2)-(2,0.1)],(0.5,-0.2),(0.619266,-0.156579),(0.761468,-0.0973684),(0.90367,-0.0355263),(1,0),(1.16972,0.0381579),(1.38073,0.0684211),(1.55046,0.0842105),(1.70183,0.0947368),(1.8945,0.0986842),(1.99083,0.0986842)) { Dmnl}

GraphEffHospRevSurTSPE([(0.5,-0.2)-(2,0.1)],(0.5,-0.2),(0.619266,-0.156579),(0.761468,-0.0973684),(0.90367,0.0355263),(1,0),(1.16972,0.0381579),(1.38073,0.0684211),(1.55046,0.0842105), (1.70183,0.0947368),(1.8945,0.0986842),(1.99083,0.0986842)) { Dmnl}

GraphEffHosRevPerPay([(0,0)-(1.4,1)],(0,0),(0,0),(0.141284,0.0307018),(0.291131,0.0877193),(0.428135,0.162281),(0.590826,0.311404),(0.697859,0.434211),(0.779205,0.548246),(0.89052,0.710526),(0.950459,0.824561),(1.04893,0.916667),(1.15596,0.969298),(1.31009,1),(1.4,1)) { Dmnl}

GraphEffInPatCrowdHosPerMonth([(0,0)-(1.4,1)],(0,0),(0,0),(0.1,0.1),(0.25,0.25),(0.4,0.4),(0.65,0.65),(0.8,0.8),(0.916208,0.890351),(1,0.95),(1.10031,0.97807),(1.25,1),(1.4,1)) { Dmnl}

GraphEffSpecAppExa([(0,0)-(1.4,1)],(0,0),(0,0),(0.1,0.1),(0.25,0.25),(0.4,0.4),(0.65,0.65),(0.8,0.8), (0.916208,0.890351),(1,0.95),(1.10031,0.97807),(1.25,1),(1.4,1)) { Dmnl}

GraphEffSpecCrowdExtDemand([(0.5,0.3)-(3,1)],(0.5,1),(0.737003,0.986842),(1,0.95),(1.32569,0.877193),(1.60856,0.794298),(1.84557,0.705263),(2.02141,0.619298),(2.15902,0.539474),(2.28135,0.465789),(2.43425,0.382895),(2.61774,0.330702),(2.79358,0.30307),(2.90826,0.3),(2.99235,0.3)) { Dmnl}

GraphEffSpecCrowdRTSPE([(0.5,-0.006)-(1.5,1)],(0.5,0),(0.6,0),(0.7,0),(0.8,0),(0.894495,0),(1,0),(1.02905,0.0292982),(1.05046,0.2455),(1.06575,0.488175),(1.0841,0.739675),(1.12385,0.960289),(1.15443,0.986763),(1.2,1),(1.3,1),(1.4,1),(1.5,1)) { Dmnl}

GraphEffSpecExamCrowdTSPE([(0.5,0.3)(1.5,0.2)],(0.506116,0.197807),(0.582569,0.189035),(0.67737,0.169298),(0.775229,0.132018),(0.860856,0.0881579),(0.946483,0.0311403),(1.04434,-0.0697368),(1.11162,-0.146491),(1.17278,-0.199123),(1.25229,-0.249561),(1.33486,-0.282456), (1.42661,-0.297807),(1.49388,-0.297807)) { Dmnl}

GraphEffSpecRevHosFract([(0.5,0.8)(1.5,1.4)],(0.503058,1.4),(0.567278,1.38684),(0.655963,1.35),(0.738532,1.30263),(0.814985,1.24474),(0.882263,1.17105),(0.949541,1.08158),(1,1),(1.03517,0.923684),(1.07798,0.878947),(1.14832,0.847368),(1.25841,0.823684),(1.35627,0.81),(1.44495,0.8),(1.49388,0.8)) { Dmnl}

GraphEffSpecRevTSPE([(0.5,-0.35)-(1.5,0.15)],(0.503058,-0.345614),(0.652905,-0.218421),(0.808869,0.0868421),(0.952599,0.00307018),(1.08104,0.0644737),(1.21254,0.108333), (1.35627,0.139035), (1.42966,0.147807),(1.49388,0.15)) { Dmnl}

GraphEffSpecTSPEChrPatRemovTime([(0,0.9)-(2,1.1)],(0.0122324,1.09825),(0.207951,1.09649),(0.35474,1.09123),(0.501529,1.08421),(0.623853,1.07193),(0.752294,1.05088),(0.868502,1.0307),(1,1),(1.10092,0.972807),(1.22324,0.951754),(1.36391,0.933333),(1.52294,0.918421),(1.68807,0.905263),(1.83486,0.9),(1.99388,0.9)) { Dmnl}

GraphEffSpecTSPECorrDiagFract([(0.5,-0.3)-(1.4,0.1)],(0.506116,-0.297807),(0.563303,-0.25614),(0.618349,-0.216667),(0.684404,-0.170175),(0.747706,-0.125),(0.8,-0.0912281),(0.868807,-0.0574561),(1,0),(1.06697,0.0298246),(1.14404,0.0559211),(1.26239,0.0872807), (1.35596, 0.1),(1.4,0.1)) { Dmnl}

GraphEffSpecTSPECorTreFract([(0.5,0.6)-(1.5,1.1)],(0.506116,0.604386),(0.594801,0.683333),(0.680428,0.766667),(0.778287,0.856579),(0.888379,0.937719),(1,1),(1.14526,1.05395),(1.31346,1.08684),(1.42966,1.09781),(1.49388,1.09781)) { Dmnl}

GraphEffSpecTSPEInTreatFract([(0.5,0.7)(1.5,1.5)],(0.503058,1.5),(0.588685,1.49),(0.665138,1.46842),(0.766055,1.40877),(0.870031,1.29649),(0.934251,1.16316),(0.96789,1.09298),(1,1),(1.05657,0.875439),(1.12997,0.794737),(1.23089,0.738596),(1.33486,0.707018),(1.42661,0.7),(1.49388,0.7)) {Dmnl}

GraphEffSpecTSPEWrongDiagFract([(0.7,0.9)-(1.3,1.3)],(0.701835,1.3),(0.753211,1.29298),(0.808257,1.26667),(0.866972,1.22281),(0.927523,1.15088),(0.966055,1.0807),(1,1),(1.04128,0.950877),(1.08899,0.92807),(1.14771,0.912281),(1.2211,0.903509),(1.2945,0.901754)) {Dmnl}

GraphEffSpecWrongDiagFract([(0.5,-0.2)-(1.5,0.3)],(0.506116,0.297807),(0.585627,0.295614),(0.66208,0.282456),(0.744648,0.25614),(0.857798,0.188158),(0.934251,0.0960526),(1,0),(1.06881,-0.0815789),(1.1422,-0.134211),(1.24924,-0.175877),(1.38379,-0.197807),(1.49388,-0.2)) {Dmnl}

GraphEffSurgAppSurPer([(0,0)(1.4,1)],(0,0),(0,0),(0.1,0.1),(0.25,0.25),(0.4,0.4),(0.65,0.65),(0.8,0.8),(0.916208,0.890351),(1,0.95),(1.10031,0.97807),(1.25,1),(1.4,1)) {Dmnl}

GraphEffSurgAvExamExtDemand([(-0.3,0)-(1.3,1)],(-0.3,0),(-0.2,0),(-0.1,0),(-0.0336392, 0.0131579),(0.0259939,0.0350877),(0.1,0.1),(0.2,0.2),(0.3,0.3),(0.4,0.4),(0.5,0.5),(0.6,0.6),(0.7,0.7),(0.8,0.8),(0.9,0.9),(0.977064,0.964912),(1.1,1),(1.2,1),(1.3,1)) {Dmnl}

GraphEffSurgCrowdEffSurgRevTSPE([(0.5,-0.006) (1.5,1)],(0.5,0),(0.6,0),(0.7,0), (0.8,0),(0.894495,0),(1,0),(1.02905,0.0292982),(1.05046,0.2455),(1.06575,0.488175),(1.0841,0.739675),(1.12385,0.960289),(1.15443,0.986763),(1.2,1),(1.3,1),(1.4,1),(1.5,1)) {Dmnl}

GraphEffSurgCrowdExtDemand((0.5,0.3)-(3,1)],(0.5,1),(0.737003,0.986842),(1,0.95),(1.32569,0.877193),(1.60856,0.794298),(1.84557,0.705263),(2.02141,0.619298),(2.15902,0.539474),(2.28135,0.465789),(2.43425,0.382895),(2.61774,0.330702),(2.79358, 0.30307),(2.90826,0.3),(2.99235,0.3)) {Dmnl}

GraphEffSurgCrowdTSPE([(0.5,-0.3)-(1.5,0.2)],(0.506116,0.197807),(0.610092,0.182456),(0.689602,0.162719),(0.775229,0.132018),(0.863914,0.0925439),(0.946483,0.0311403),(1.04434,0.0697368),(1.11162,-0.146491),(1.17278,-0.199123),(1.25229,-0.249561),(1.33486,-0.282456),(1.42661,-0.297807),(1.49388,-0.297807)) { Dmnl}

GraphEffSurgCrowdTSPS([(0.5,-0.3)-(1.5,0.2)],(0.506116,0.197807),(0.582569,0.189035),(0.67737,0.169298),(0.775229,0.132018),(0.860856,0.0881579),(0.946483,0.0311403),(1.04434,-0.0697368),(1.11162,-0.146491),(1.17278,-0.199123),(1.25229,-0.249561),(1.33486,-0.282456),(1.42661,-0.297807),(1.49388,-0.297807)) { Dmnl}

GraphEffSurgRevSurgFract([(0.5,0.75)-(1.5,1.5)],(0.503058,1.49715),(0.631498, 1.48684),(0.698777,1.47039),(0.781346,1.42763),(0.85474,1.35855),(0.909786,1.27303),(0.940367,1.20395),(0.977064,1.10855),(1,1),(1.02599,0.930921),(1.07492,0.878289),(1.14526,0.832237),(1.23089,0.789474),(1.34404,0.759868),(1.42661,0.753289),(1.49388,0.753289)){ Dmnl}

GraphEffSurgRevSurTime([(0.5,-0.35)-(1.5,0.15)],(0.503058,-0.345614),(0.652905,-0.218421), (0.808869,-0.0868421),(0.952599,0.00307018),(1.08104 ,0.0644737),(1.21254, 0.108333), (1.35627,0.139035),(1.42966,0.147807),(1.49388,0.15)) { Dmnl}

GraphEffSurgRevTSPS([(0.5,-0.35)-(1.5,0.15)],(0.503058,-0.345614),(0.652905,-0.218421),(0.808869,0.0868421),(0.952599,0.00307018),(1.08104,0.0644737),(1.21254,0.108333), (1.35627, 0.139035), (1.42966,0.147807),(1.49388,0.15)) { Dmnl}

GraphEffSurgTSPEChronPatRemovTime([(0,0.9)-(2,1.1)],(0.0122324,1.09825),(0.17737,1.09474),(0.366972,1.08509),(0.501529,1.07719),(0.629969,1.06579),(0.752294, 1.05088),(0.868502,1.0307),(1,1),(1.10092,0.972807),(1.22324,0.951754),(1.36391,0.9333 33),(1.52294,0.918421),(1.68807,0.905263),(1.83486,0.9),(1.99388,0.9)) {Dmnl}

GraphEffSurgTSPECorrDiagFract([(0.5,-0.3)-(1.4,0.1)],(0.506116,-0.297807),(0.618349,-0.216667), (0.747706,-0.125),(0.868807,-0.0574561),(1,0),(1.14404,0.0559211),(1.26239,0.0872807),(1.35596, 0.1),(1.4,0.1)) {Dmnl}

GraphEffSurgTSPECorrTreatFract([(0.5,0.6)-(1.5,1.1)],(0.506116,0.604386),(0.594801,0.683333),(0.680428,0.766667),(0.778287,0.856579),(0.888379,0.937719),(1,1),(1.14526,1.05395),(1.31346,1.08684),(1.42966,1.09781),(1.49388,1.09781)){Dmnl}

GraphEffSurgTSPEInadTreatFract([(0.5,0.7)-(1.5,1.5)],(0.503058,1.5),(0.588685,1.49),(0.665138,1.47544),(0.772171,1.41579),(0.870031,1.29649),(0.934251,1.16316),(0.96789,1.09298),(1,1),(1.05657,0.875439),(1.12997,0.794737),(1.23089,0.738596),(1.33486,0.707 018),(1.42661,0.7),(1.49388,0.7)) {Dmnl}

GraphEffSurgTSPEWrongDiagFract([(0.5,-0.2)-(1.5,0.3)],(0.506116,0.297807),(0.582569,0.291228),(0.655963,0.280263),(0.747706,0.247368),(0.836391,0.190351),(0.9 34251,0.0960526),(1,0),(1.0688,-0.0815789),(1.1422,-0.142982),(1.24924,-0.175877),(1.38379,-0.197807),(1.49388,-0.195614)) {Dmnl}

GraphEffSurgTSPEWrongTreatFract([(0.7,0.9)(1.3,1.3)],(0.701835,1.3),(0.753211,1.2929 8),(0.802752,1.27018),(0.846789,1.24211),(0.888991,1.20702),(0.920183,1.17544),(0.947 706,1.12105),(0.966055,1.0807),(1,1),(1.04128,0.950877),(1.08899,0.92807),(1.14771,0.9 12281),(1.2211,0.903509),(1.2945,0.901754)) {Dmnl}

GraphEffTestAnCrowdTSPT([(0.5,-0.006)-(1.5,1)],(0.5,0),(0.6,0),(0.7,0),(0.8,0),(0.894495,0),(1,0),(1.02905,0.0292982),(1.05046,0.2455),(1.06575,0.488175),(1.0841,0.7 39675),(1.12385,0.960289),(1.15443,0.986763),(1.2,1),(1.3,1),(1.4,1),(1.5,1)) {Dmnl}

GraphEffTestAppNumTestPerf([(0,0)-(1.4,1)],(0,0),(0.1,0.1),(0.25,0.25),(0.4,0.4),(0.55,0.55),(0.7,0.7),(0.85,0.85),(1,0.95),(1.100 31,0.97807),(1.25,1),(1.4,1)){ Dmnl}

GraphEffTSPSInadSurgFract([(0.5,0.7)-(1.5,1.5)],(0.503058,1.5),(0.588685,1.49),(0.665138,1.46842),(0.766055,1.40877),(0.870031,1.29649),(0.934251,1.16316),(0.96789,1.09298),(1,1),(1.05657,0.875439),(1.12997,0.794737),(1.23089,0.738596),(1.33486,0.707 018),(1.42661,0.7),(1.49388,0.7)) { Dmnl}

GraphEffTSPTCorrDiagFract([(0.5,-0.3)-(1.5,0.2)],(0.503058,-0.295614),(0.610092,-0.269298),(0.711009,-0.225439),(0.827217,-0.150877),(0.922018,-

0.0807018),(1,0),(1.06269,0.0662281),(1.15138,0.127632),(1.27676,0.173684),(1.38379,0.193421),(1.45413,0.2),(1.49694,0.2)) { Dmnl}
GraphSurgExamCrowding([(0,0)(1.4,1)],(0,0),(0,0),(0.1,0.1),(0.25,0.25),(0.4,0.4),(0.65,0.65),(0.8,0.8),(0.916208,0.890351),(1,0.95),(1.10031,0.97807),(1.25,1),(1.4,1)) { Dmnl}
GraphTspsCorrTreatFract([(0.5,0.6)-(1.5,1.1)],(0.506116,0.604386),(0.594801,0.683333),(0.680428,0.766667),(0.778287,0.856579),(0.888379,0.937719),(1,1),(1.14526,1.05395),(1.31346,1.08684),(1.42966,1.09781),(1.49388,1.09781)) { Dmnl}
HealthExpenditurPerMonth= NumMedPres*UnCostMedic+UnCostTests*NumTestsPerPerMonth+NumPatHospPerMonth*UnCostHosp+UnCostSurg*NumSrgryPerfPerMonth+PatExamPerMonth*UnCostExam+PhysTotSalPerMonth { TL/Month}
HosBedCapacity=200 {people}
HosCapacityPerMonth=HosBedCapacity/LengthOfStay {people/Month}
HospRevPerMonth=NetRevPerExam*PatExamPerMonth+NumTestsPerPerMonth*NetRevTest+NetRevSurg*NumSrgryPerfPerMonth+NetRevPerHosp*NumPatHospPerMonth {TL/Month}
HospSpecVisTrePat=1 {1/Month}
HospSurgVisTrePat=1 {1/Month}
HospVisChronPat=0.3 {1/Month}
HospVisInadeTreat=0.5 {1/Month}
HospVisPerMonth=NumPatHospPerMonth*VisPerInPatients {visits/Month}
HosRevBudPerMonth=HospRevPerMonth*RevBudgetFract {TL/Month}
HosVisDiagPatPerMonth=3 {1/Month}
Inadequate Surgeries= INTEG (InadSurgicalTreatedPatients-SrgryPatAppOtherHospRate-Surgical Correction Rate,44) {surgery}
InadeSurgFract=NormInadeSurgFract*DelEffTSPSInadeqSrgryFract { Dmnl}
InadSurgicalTreatedPatients=InadeSurgFract*NumSrgryPerfPerMonth{surgery/Month}
INITIAL TIME = 0 {Month}
InPatCareFract=NormInPatCareFract*DelEffSpecRevHospFract{Dmnl}
InPatCrowd=NumPatRefInPatCare/HosCapacityPerMonth {Dmnl}
IntSpecExamDemPerMonth=SpecChronFract*Chronic patients*HospVisChronPat+SpecTreatable Patients*HospSpecVisTrePat+SpecTreatable Patients with Diagnostic*HosVisDiagPatPerMonth +SpecInadequate Treatments*HospVisInadeTreat{people/Month}

IntSurgExamDemPerMonth=Chronic patients*SurgChronFract*HospVisChronPat+HosVisDiag Pat PerMonth*Surgtreatable Patients with Diagnostic+SurgInadequate Treatments* HospVis InadeTreat+SurgTreatable Patients*HospSurgVisTrePat{people/Month}

LengthOfStay=NormLengthOfStay {Month}

MaxSpecExamCap=Number of Specialists*MaxSpecExamProd{ people/Month}

MaxSpecExamProd=SpecTotExamMin/MinSpecTSPE {people/Month/physicians}

MaxSpecExtExamCap=MaxSpecExamCap-IntSpecExamDemPerMonth {people/Month}

MaxSurgExamCapacity=MaxSurgExamProductivity*NumberofSurgeons-IntSurgExamDem PerMonth{people/Month}

MaxSurgExamProductivity=SurgTotExamMinutePerMonth/MinSurTSPE {people/Month/surgeons}

MedicPerExam=3 {medicine/people}

MedPerSur=4 {medicine/surgery}

MedPerTestAn=0.3 {medicine/tests}

MinSpecTSPE=6 {minutes/people}

MinSurTSPE=6 {minutes/people}

NetRevPerExam=10 {TL/people}

NetRevPerHosp=50 {TL/people}

NetRevSurg=150 {TL/surgery}

NetRevTest=10 {TL/tests}

New Chronic Patients=400 { people/Month}

NewSpecDiagPatFract=0.15{Dmnl}

NewSpecDiagPatRate=ActExtExamDemSpec*NewSpecDiagPatFract {people/Month}

NewSurgDiagPaFract=0.15{Dmnl}

NewSurgDiagPatRate=SurgActExtExamDemPerMonth*NewSurgDiagPatFract {people/Month}

NormalSpecTSPE=10 {minutes/people}

NormChronPatRemTime=7 { Month}

NormDiagPhysRevPerMonth=DiagPhysRevPerMonth/RefDiagPhysRevenue {Dmnl}

NormHospRev=HospRevPerMonth/RefHospRev{Dmnl}

NormInadeSurgFract=0.1{Dmnl}

NormInadTreatFract=0.2 {Dmnl}

NormInPatCareFract=0.015{Dmnl}

NormLengthOfStay=0.25{Month}

NormRevBudFract=0.4{Dmnl}

NormSpecCorrTreatFract=0.5{1/Month}

NormSpecDiagFrac=0.6 {1/Month}

NormSpecExamAvail=PotExtExamDemSpec/MaxSpecExtExamCap{Dmnl}

NormSpecRevenue=SpecRevPerMonth/RefSpecRevenue{Dmnl}

NormSpecTSPE=SpecTSPE/NormalSpecTSPE{Dmnl}

NormSpecWrongDiagFract=0.2 {1/Month}

NormSpecWrongTreatFract=0.1 {1/Month}

NormSurgCorrDiagFract=0.6 {1/Month}

NormSurgCorrTreatFract=0.5 {1/Month}

NormSurgExamAv=PotSurExtExamDemPerMonth/MaxSurgExamCapacity{Dmnl}

NormSurgPerRev=SurgRevPerMonth/RefSurgRevenue{Dmnl}

NormSurgTSPE=SurgTSPE/NormTimeSurgTSPE{Dmnl}

NormSurgWrongTreatFract=0.1 {1/Month}

NormTimePerSurgery=120 {minutes/surgery}

NormTimeSurgTSPE=10{minutes/people}

NormTimeTSPT=10{minutes/tests}

NormTSPS=Time Spent Per Surgery/NormTimePerSurgery{Dmnl}

NormTSPT=TimeSpentPerTests/NormTimeTSPT{Dmnl}

Number of Diagnostic Physicians=5{physicians}

Number of Specialists=20 {physicians]

Number of Surgeons=15 {surgeons}

NumMedPres=MedicPerExam*PatExamPerMonth+NumSrgryPerfPerMonth*MedPerSur+ NumTestsPerPerMonth*MedPerTestAn {medicine/Month}

NumPatHospPerMonth=EffInPatCrowdHosPerMonth*HosCapacityPerMonth {people/Month}

NumPatRefInPatCare=NumSrgryPerfPerMonth*SurgInPatRefFract+PatExamSpecPerMonth*InPatCareFract {people/Month}

NumSpecExamPerPhys=PatExamSpecPerMonth/Number of Specialists {people/(Month*physicians)}

NumSrgryCanBePerfPerMonth=Number of Surgeons*SurgSrgryProd {surgery/Month}

NumSrgryPerfPerMonth=EffSurgAppSurPer*NumSrgryCanBePerfPerMonth {surgery/Month}

NumSurExamPerSurgeons=PatExamSurgPerMonth/NumberofSurgeons{people/(Month*surgeons)}

NumTestAnAppPerMonth=PatExamPerMonth*TestAnalysisFract {tests/Month}

NumTestCanBePerfPerMonth=DiagPhysProductivity*Number of Diagnostic Physicians {tests/ Month}

NumTestPerMonthPerDiagPhys=NumTestsPerPerMonth/NumberofDiagnosticPhysicians {tests/Month/physicians}

NumTestsPerPerMonth=EffTestAppNumTestPerf*NumTestCanBePerfPerMonth {tests/Month}

PatExamPerMonth=PatExamSpecPerMonth+PatExamSurgPerMonth {people/Month}

PatExamSpecPerMonth=SpecExamCapPerMonth*EffSpecAppExam {people/Month}

PatExamSurgPerMonth=EffSurgAppExam*SurgExamCapPerMonth {people/Month}

PerRevDiagPerMonth=DiagPhyPerRevPerMonth/NumberofDiagnosticPhysicians {TL/(Month* physicians)}

PhysTotSalPerMonth=DiagPhysRevPerMonth*Number of Diagnostic Physicians+Number of Specialists*SpecRevPerMonth+Number of Surgeons*SurgRevPerMonth {TL/Month

PointPerHosVis=40{points/visits}

PointsForExam=20{points/people}

PointsPerSurgery=400{points/surgery}

PointsPerTests=10{points/tests}

PosReTreatFract=0.4{Dmnl}

PosSpecCorrDiagFract=0.25 people/tests

PosSpecCorrDiagRate=NumTestsPerPerMonth*PosSpecCorrDiagFract {people/Month}

PosSpecCorrTreatFract=0.15{Dmnl}

PosSpecReTreatFract= 0.4{Dmnl}

PosSpecReTreatPerMonth=PatExamSpecPerMonth*PosSpecReTreatFract {people/Month}

PosSpecTreatPerMonth=PatExamSpecPerMonth*PosSpecCorrTreatFract{ people/Month}

PosSpecWrongDiagFract=0.08 {people/tests}

PosSpecWrongTreatFract=0.05 {Dmnl}

PosSpecWrongTreatPerMonth=PatExamSpecPerMonth*PosSpecWrongTreatFract {people/Month}

PosSurgCorrDiagFract=0.25 {people/tests}

PosSurgCorrDiagPerMonth=NumTestsPerPerMonth*PosSurgCorrDiagFract {people/Month}

PosSurgCorrTreatFract=0.15 {Dmnl}

PosSurgCorrTreatPerMonth=PatExamSurgPerMonth*PosSurgCorrTreatFract {people/Month}

PosSurgReTreatPerMonth=PatExamSurgPerMonth*PosReTreatFract {people/Month}

PosSurgWrongDiagFract=0.1{ people/tests}

PosSurgWrongDiagPerMonth=NumTestsPerPerMonth*PosSurgWrongDiagFract {people/Month}

PosSurgWrongTreatFract=0.15 {Dmnl}

PosSurgWrongTreatPerMonth=PatExamSurgPerMonth*PosSurgWrongTreatFract {people/Month}

PosWrongDiagPerMonth=NumTestsPerPerMonth*PosSpecWrongDiagFract{people/ Month}

PotExtExamDemSpec=30000 {people/Month}

PotSurExtExamDemPerMonth=20000 {people/Month}

PriDiagPhysRev=5000 {TL/(Month*physicians)}

PriSecStepHosRev=BaseSecStepPubHosRev*1.5 {TL/Month}

PriSpecRevenue=8000 {TL/Month/physicians}

PriSurgRevenue=9000 {TL/Month/surgeons}

RefDiagPhysRevenue= INTEG (AdjRefDiagPhysRevenue, DiagPhysGoal Revenue){TL/Month /physicians}

RefHospRev= INTEG (AdjRevHosRev, SecStepPubHosGoal) {TL/Month}

RefSpecRevenue= INTEG (AdjRevSpecRev,SpecGoalRevenue) {TL/Month/physicians}

RefSurgRevenue= INTEG (AdjRefSurgRev, SurgGoalRevenue) {TL/Month/surgeons}

RevBudgetFract=EffHosRevPerPay*NormRevBudFract {Dmnl}

RevPerBeds=1500 {TL/people/Month}

RevPerDiagPhys=3000 {TL/physicians/Month}

RevPerSpec=5000 {TL/physicians/Month}

RevPerSur=7000 {TL/surgeons/Month}

SpecAppOthHsptFract=0.25 {1/Month}

SpecChronFract=0.6 {Dmnl}

SpecCorrDiagRate=MIN(SpecTreatablePatientswithDiagnostic*CorrSpecDiagFrac, PosSpecCorr Diag Rate) { people/Month}

SpecCorrDiagRatio=SpecCorrDiagRate/(SpecCorrDiagRate+SpecWrongDiagRate) {Dmnl}

SpecCorrTreatFract=DelEffSpecTSPECorTreFract*NormSpecCorrTreatFract {1/Month}

SpecCorrTreatRate=MIN(SpecTreatable Patients*SpecCorrTreatFract, PosSpecTreatPer Month)) { people/Month}

SpecCorrTreatRatio=SpecCorrTreatRate/(SpecCorrTreatRate+SpecWrongTreatRate) {Dmnl}

SpecExamCapPerMonth=SpecExamProd*NumberofSpecialists*TimeAllExamSpec{people/Month}

SpecExamCrowd=TotSpecExamDemPerMonth/SpecExamCapPerMonth {Dmnl}

SpecExamProd=SpecTotExamMin/SpecTSPE {people/Month/physicians}

SpecFixedSalary=1200 {TL/(Month*physicians)}

SpecGoalRevenue=BasePubHosSpecRevenue*0.2+PriSpecRevenue*0.2+SpecRevPerMonth*0.6{TL/Month/physicians}

SpecInadequate Treatments=INTEG(SpecInadeTreatPatRate+SpecWrongDiagRate+ Spec WrongTreatRate SpecReTreatment Rate-SpecPatAppOtherHosp Rate,5159) {people}

SpecInadeTreatPatRate=PatExamSpecPerMonth*SpecInTreatFract {people/Month}

SpecInadeTreatPerExam=SpecInadeTreatPatRate/PatExamSpecPerMonth {Dmnl}

SpecInTreatFract=NormInadTreatFract*DelEffSpecTSPEInTreatFract{Dmnl}

SpecPatAppOtherHosp Rate=SpecAppOthHsptFract*SpecInadequate Treatments {people/Month}

SpecPatSurgRefFract=0.01 {surgery/people}

SpecPerPoints=HospVisPerMonth*PointPerHosVis*(1-SpecVisRatio)+ PatExamSpecPerMonth* PointsForExam points/Month

SpecPerRevenue=SpecPerPoints*UnRevPerPoints {TL/Month}

SpecPerRevPerMonth= SpecPerRevenue/Number of Specialists { TL/Month/physicians}

SpecPubPriRevRatio=SpecRevPerMonth/PriSpecRevenue{Dmnl}

SpecReTreatFract=0.7 {Dmnl}

SpecReTreatment Rate=MIN(SpecInadequate Treatments*DelEffSpecTSPECorTreFract*Spec ReTreatFract,PosSpecReTreatPerMonth) {people/Month}

SpecRevPerMonth=SpecFixedSalary+SpecPerRevPerMonth {TL/(Month*physicians)}

SpecTotExamMin=7000 {minutes/Month/physicians}

SpecTreatable Patients= INTEG (SpecCorrDiagRate-SpecCorrTreatRate-SpecWrong Treat Rate, 1882.42) {people}

SpecTreatablePatientswithDiagnostic= INTEG (NewSpecDiagPatRate-SpecCorrDiagRate-Spec WrongDiagRate,2089.87) {people}

SpecTSPE=NormalSpecTSPE*(1+DelEffHosRevSpecTSPE+DelEffSpecExamCrowdTSPE+DelEffSpecRevTSPE){minutes/people}

SpecVisRatio=0.7{Dmnl}

SpecWrongDiagFract=NormSpecWrongDiagFract*(1+DelEffSpecWrongDiagFract+DelEffDiagPhysTSPTWrongDiagFract) {1/Month}

SpecWrongDiagRate=MIN(SpecWrongDiagFract*SpecTreatable Patients with Diagnostic, PosWrongDiagPerMonth) {people/Month}

SpecWrongTreatRate=MIN(DelEffSpecTSPEWrongDiagFract*NormSpecWrongTreatFract*SpecTreatable Patients,PosSpecWrongTreatPerMonth) {people/Month}

SrgryCorrTreatFract=0.75 {1/Month}

SrgryPatAppOtherHospRate=SurgPatAppOtherHospFract*Inadequate Surgeries{surgery/Month}

SurgActExtExamDemPerMonth=EffSurgAvExamExtDemand*MaxSurgExamCapacity*DelEffSurgCrowdExtDemand {people/Month}

SurgAppOtherHospFract=0.25 {1/Month}

SurgChronFract=0.4 {Dmnl}

SurgCorrDiagFract=NormSurgCorrDiagFract*(1+DelEffSurgTSPECorrDiagFract+DelEffTSPTCorrDiagFract) {1/Month}

SurgCorrDiagRate=MIN(Surgtreatable Patients with Diagnostic*SurgCorrDiagFract, PosSurg Corr DiagPerMonth) {people/Month}

SurgCorrDiagRatio=SurgCorrDiagRate/(SurgCorrDiagRate+SurgWrongDiagRate) {Dmnl}

SurgCorrTreatFract=DelEffSurgTSPECorrTreatFract*NormSurgCorrTreatFract {1/Month}

SurgCorrTreatRate=MIN(SurgTreatable Patients*SurgCorrTreatFract,PosSurgCorrTreatPerMonth) {people/Month}

SurgCorrTreatRatio=SurgCorrTreatRate/(SurgCorrTreatRate+SurgWrongTreatRate) {Dmnl}

Surgery crowding=SurgPatAppPerMonth/NumSrgryCanBePerfPerMonth{Dmnl}

SurgExamCapPerMonth=Number of Surgeons*SurgExamProd {people/Month}

SurgExamCrowding=TotSurgExamDemPerMonth/SurgExamCapPerMonth{Dmnl}

SurgExamProd=SurgTotExamMinutePerMonth/SurgTSPE {people/(surgeons*Month)}

SurgFixedSalary=1200 {TL/(Month*surgeons)}

SurgicalCorrectionRate=SrgryCorrTreatFract*Inadequate Surgeries*DelEffTSPSCorrTreat {surgery/Month}

SurgInadeFract=0.2{Dmnl}

SurgInadequate Treatments= INTEG (SurgInadeTreatPatRate+SurgWrongTreatRate+ SurgWrong DiagRate-SurgPatAppOtherHosp Rate-SurgReTreat Rate,2582.14) {people}

SurgInadeTreatPatRate=DelEffSurgTSPEInAdTreatFract*PatExamSurgPerMonth*SurgInadeFract {people/Month}

SurgInadeTreatPerExam Ratio=SurgInadeTreatPatRate/PatExamSurgPerMonth{Dmnl}

SurgInPatRefFract=0.95{people/surgery}

SurgPatAppOtherHospRate=SurgInadequateTreatments*SurgAppOtherHospFract {people/Month}

SurgPatAppOtherHospFract=0.25{Dmnl/Month}

SurgPatAppPerMonth=DelEffSurgRevSurgFract*SurgPatRevSurFract*SurgTreatable Patients+PatExamSpecPerMonth*SpecPatSurgRefFract+VisInadSurgPat*Inadequate Surgeries {surgery/Month}

SurgPatRevSurFract=0.35 {surgery/(people*Month)}

SurgPerPoints=HospVisPerMonth*PointPerHosVis*SpecVisRatio+PatExamSurgPerMonth*PointsForExam+PointsPerSurgery*NumSrgryPerfPerMonth {points/Month}

SurgPerRevenue=SurgPerPoints*UnRevPerPoints {TL/Month}

SurgPerRevPerMonth=SurgPerRevenue/Number of Surgeons {TL/(Month*surgeons)}

SurgReTreat Rate=MIN(SurgReTreatFract*SurgInadequate Treatments* DelEffSurgTSPECorrTreatFract,PosSurgReTreatPerMonth) {people/Month}

SurgReTreatFract=0.7 {1/Month}

SurgRevPerMonth=SurgFixedSalary+SurgPerRevPerMonth {TL/(Month*surgeons)}

SurgSrgryProd=TotSurTimePerSurgeons/TimeSpentPerSurgery {surgery/Month/surgeons}

SurgTotExamMinutePerMonth=4320 {minutes/Month/surgeons}

SurgTreatable Patients= INTEG (SurgCorrDiagRate-SurgCorrTreatRate-SurgWrongTreatRate, 842.449) {people}

SurgtreatablePatients with Diagnostic= INTEG (NewSurgDiagPatRate-SurgCorrDiagRate-Surg WrongDiagRate,937.298) {people}

SurgTSPE=NormTimeSurgTSPE*(1+DelEffSurgCrowdTSPE+DelEffHospRevSurgTSPE +DelEffSurRevTSPS) {minutes/people}

SurgWrongDiagFract=0.2 {1/Month}

SurgWrongDiagPerMonth=SurgWrongDiagFract*(1+DelEffSurgTSPEWrongDiagFract+ DelEffDiagPhysTSPTWrongDiagFract) {Dmnl/Month}

SurgWrongDiagRate=MIN(Surgtreatable Patients with Diagnostic* SurgWrongDiagPer Month,PosSurgWrongDiagPerMonth) {people/Month}

SurgWrongRatio=InadSurgicalTreatedPatients/NumSrgryPerfPerMonth{Dmnl}

SurgWrongTreatFract=DelEffSurgTSPEWrongTreatFract*NormSurgWrongTreatFract {1/Month}

SurgWrongTreatRate=MIN(SurgTreatablePatients*SurgWrongTreatFract,PosSurgWrongT reatPerMonth) {people/Month}

TestAnalysisFract=0.3 {tests/people}

TestAnPerDiagPhysician=NumTestsPerPerMonth/NumberofDiagnosticPhysicians{tests/(Month *physicians)}

TestsCrowding=NumTestAnAppPerMonth/NumTestCanBePerfPerMonth {Dmnl}

TimeSpentPerSurgery =NormTimePerSurgery* (1+DelEffSurgRevSurgTime +DelEffSurg Crowd TSPS) {minutes/surgery}

TIME STEP = 0.125 {Month}

TimeAllExamSpec=0.9{Dmnl}

TimeSpentPerTests=NormTimeTSPT*(1+DelEffDiagPhysRevTSPT+DelEffDiagPhys CrowdTSPT){minutes/tests}

TotPerPoints=SpecPerPoints+SurgPerPoints+DiagPhyPerPointPerMonth{points/Month}

TotSpecExamDemPerMonth=IntSpecExamDemPerMonth+ActExtExamDemSpec {people/Month}

TotSurgExamDemPerMonth=IntSurgExamDemPerMonth+SurgActExtExamDemPerMonth {people/Month}

TotSurTimePerSurgeons= 3000 {minutes/surgery}

UnCostExam=10 {TL/people}

UnCostHosp= 50 {TL/people}

UnCostMedic=3 {TL/medicine}

UnCostSurg=500 {TL/surgery}

UnCostTests=30 {TL/tests}

UnRevPerPoints=HosRevBudPerMonth/TotPerPoints {TL/points}

VisInadSurgPat=2 {1/Month}

VisPerInPatients=10 {visits/people}

APPENDIX B: CAUSAL LOOP DIAGRAMS

Main Causal Loop Diagram:

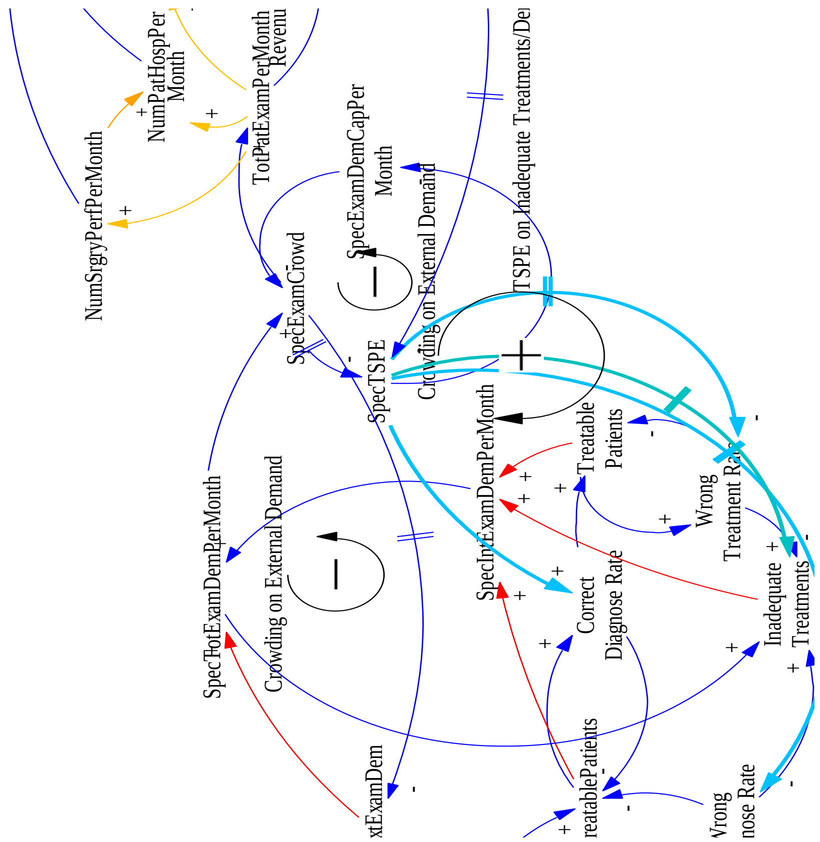

Figure B.1. Main Causal Loop Diagram of the Model.

Causal Loop-1

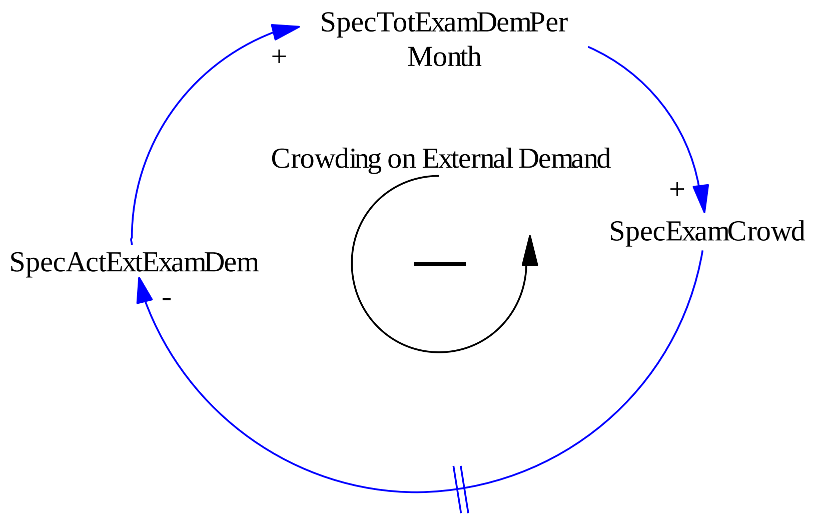

Figure B.2. Causal Loop Diagram for Effect of Crowding on External Demand.

Causal Loop-2

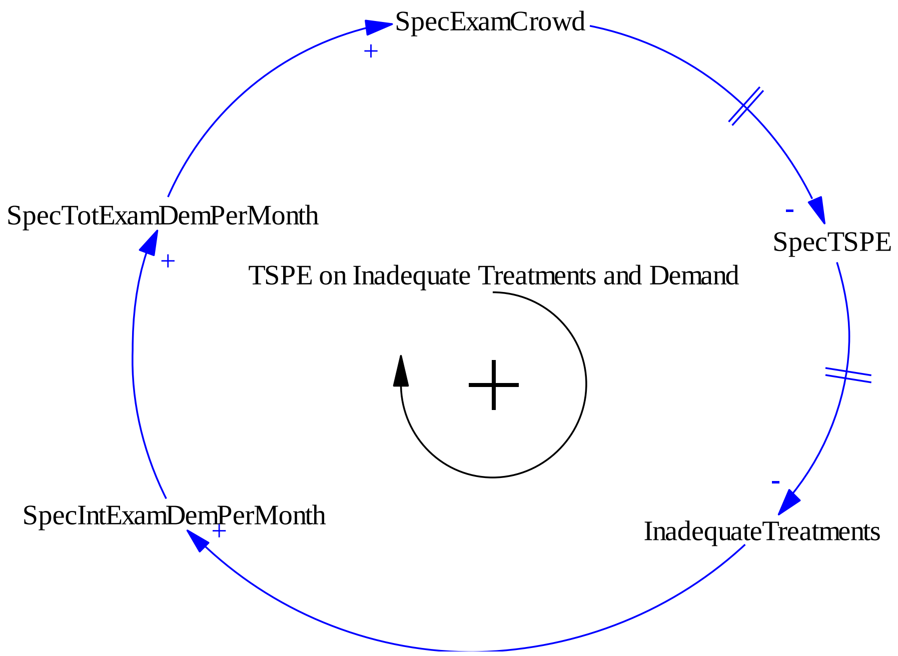

Figure B.3. Causal Loop Diagram for Effect of TSPE on Inadequate Treatments.

Causal Loop-3

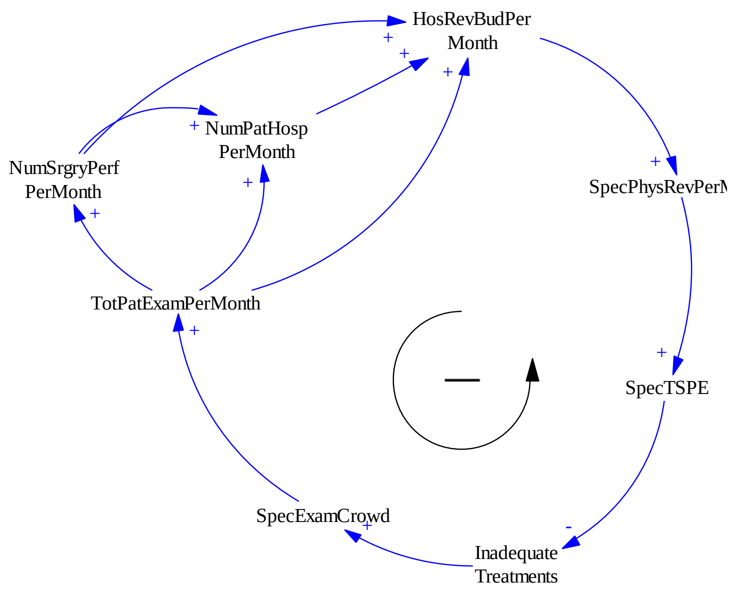

Figure B.4. Causal Loop Diagram for Effect of Physicians' Revenue on Quality.

Causal Loop 4

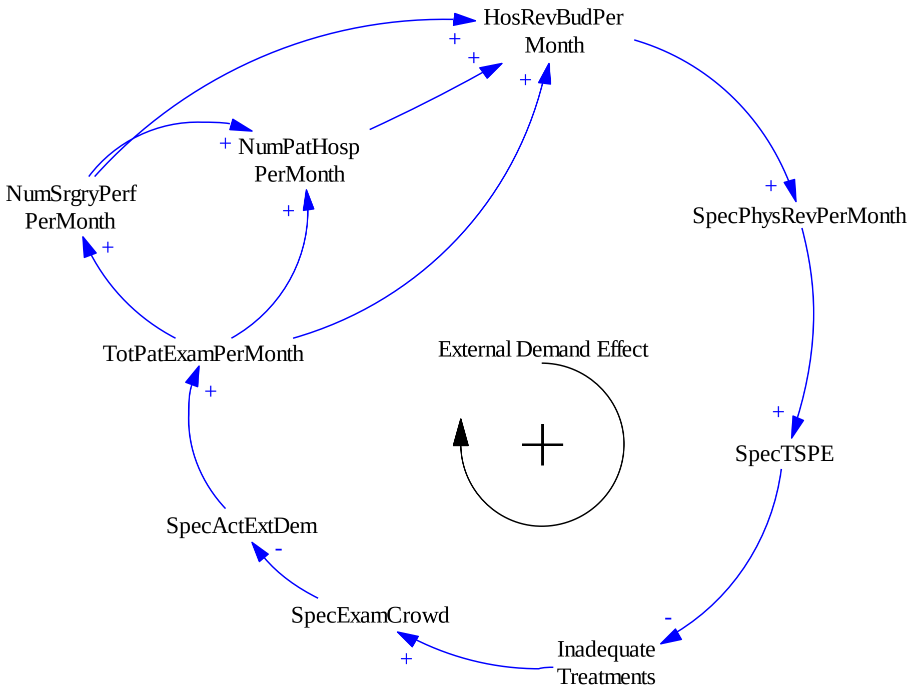

Figure B.5. Causal Loop Diagram for Effect of Physicians' Revenue on Ext-Demand.

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