

A System Dynamics Approach to Simulation of Tax Policy for Traditional and Internet Phone Services

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Abstract

Voice Over Internet Protocol (VOIP) is the fastest-growing market in the United States. VOIP technology provides telephone-like service without the restrictions of telecommunication regulations. State governments fear that more calls traveling over Internet protocol (IP) enabled phone services will impact on the heavily-taxed fixed line phone service, which means less tax revenue to support crucial public services. However, states are struggling with how to tax VOIP services and reduce the impact of VOIP development. In this paper, we build a system dynamics model to gain insight into interactions between the VOIP market, traditional phone market, and tax policy. Two tax policy tests reviewed in this paper show tax policy does not significantly affect market competition. In addition, we show government is able to collect sufficient funds when applying new tax policy. We believe the model can help policy makers find a better way to collect maximum tax revenue with less impact on the market.

Key word: System dynamics, Tax, VOIP, PSTN, Broadband, Telecommunications

1. Introduction

Technology development usually brings competition to the market. Some of these are “destructive technologies”, which can dramatically change market balance, such as the impact of information technology (IT) on knowledge dissemination, and Internet trade on purchasing behavior. In the telecommunications industry, telephony was the great “natural monopoly” of mid-20th century United States. Since 1950, the Federal Communications Commission (FCC) began a very “cautious” initiative to introduce competition into the telecommunications market to break up this monopoly situation (Faulhaber, 2001). With the development of VOIP, however, this legislative approach to changing market balance is being overtaken by the rapid development of this new destructive technology.

The FCC’s long-term strategy will be seriously disturbed by the new VOIP technology, because of the dramatic growth of customers for this service. According to a recent press release issued by Vonage Holdings Corporation (the first and the biggest VOIP company in

the United States), the company continues to add more than 15,000 lines per week. This means of course, that traditional phone companies may lose 15,000 customers per week (Vonage, 2005a). In addition, the total VOIP subscribers have grown from just 10,000 lines at the end of 2002 to 1,000,000 lines two years later (Dalrymple, 2005). We do not want to make the careless conclusion that VOIP will win this market war, but we can expect that a huge number of customers will move over to VOIP in the next few years.

Market competition is the nature of the business world. However, in the telecommunications market, states and local governments seem very concerned about this competition because there are no regulations governing VOIP services, which is of particular concern in the area of taxation policy. In fact, a U.S. district court recently barred the state of Minnesota applying telecommunication rules to VOIP companies (Sullivan 2004). So, on the one hand, governments fear their tax revenues will decline and affect the delivery of public services. On the other, governments also want to protect this infant technology. On December 03, 2004, President Bush extended until 2007 the Internet Tax Freedom Act (IFTA). This act stops governments imposing tax on Internet enabled activities, but VOIP was excluded. Although Senator Sununu and Congressman Pickering introduced versions of the "VOIP Regulatory Freedom Act of 2004", the legislation has not yet been reintroduced (CNET Networks 2005). In the near future, governments will find a way to impose tax on VOIP but the question is: Where is the balancing point? Until now, both sides of the debate have not compromised. No doubt, taxation of VOIP will be a critical and controversial issue to governments.

This paper is broken into three parts. We begin with a review of VOIP technology and current government policy, to understand the potential effects on the traditional phone market. We also consider the problem of telecommunications taxation on the traditional phone and emerging VOIP markets. Secondly, we describe the conceptual basis of our model and the base case simulation results. In the third section, we simulate different policy combinations and describe the results we find. It is hoped this model can provide valuable insight for policy makers.

2. A Review of the Issue

VOIP technology provides telephone-like service without the restriction of telecommunication regulations, particularly taxation. Local, state and federal governments argue that their tax revenues from telephone companies will decline because Internet Protocol (IP) phone services erode the traditional telephone market. In this section, we will review the issues relating to this problem.

2.1 VOIP Technology

VOIP is a technology that allows users to make phone calls via the Internet instead of regular phone lines. Because VOIP requires high speed Internet to ensure voice quality, its development was slow when it was first introduced in the mid-1990s (Sullivan, 2004). However, recently expansion of broadband Internet access has successfully improved quality and attracted more customers to adopt VOIP.

There are several types of VOIP services, PC to PC, PC to Phone¹, and Phone to Phone. All of the services allow users to call anyone who has a telephone number. Some of services also provide a physical phone number which allows others to call VOIP users (FCC 2004a). In the discussion of communications market competition, we focus on the customers who use VOIP with a physical number.

¹ Phone includes both traditional phone and Internet phone

2.2 Government attitude to VOIP technology

Government's attitudes to VOIP technology are formed from two points of view. One side wants to support VOIP development with less regulation. Chair Michael Powell has said that Internet-enabled services like VOIP should enjoy a "comprehensive, yet minimal, regulatory environment," to promote the development (Powell 2004). The other side prefers to impose regulations on the service. Most of those supporting this stance are local and state governments.

However, the FCC has announced a notice of proposed rulemaking to consider five public policy issues that may impact the obligations of VOIP service providers. These issues are: access charges, universal service fund fees, emergency 911 service, disability access, and public safety. Therefore, as we can see, the FCC will impose at least some regulation on VOIP providers and subscribers (Nagel and Lev, 2004).

2.3 Government regulation of telecommunications

Telecommunication is a comprehensively and heavily taxed service in the US, attracting taxes, fees, and surcharges on its services. These charges are not always fixed, with some fees adjusted each quarter. Moreover, fees are levied by various levels of government (federal, local and state), and by companies. Overall, 20% to 30% of each telephone bill is made up of taxes or fees (FCC, 2005b).

2.4 The current problem

Right now, Federal and State governments are still struggling with how to tax VOIP services. Several state governments want to apply telecommunication taxes on VOIP service providers. However, the FCC rejected this option because it defines VOIP as an information service, not a telephone service, and so cannot have telecommunication taxes applied to it. Some states, such as California, Ohio, and New York, have tried overturning this through appeal to circuit courts but have failed (CNET Network, 2005). Therefore, governments need to find a new way to tax VOIP enabled services, which will take time to achieve. Before new tax policy to VOIP released, we can expect tax revenue from telecommunications will continue to decline.

3. Model Description

3.1 Model purposes

At present, governments prefer to support Internet technology development, including IP phone technology. Unfortunately, the most important policy in this area, the Internet Tax Freedom Act (ITFA), signed by President Bush on Dec 03, 2004, bans taxing of Internet related technologies, but excludes VOIP. On the one hand, this policy should help the growth of broadband customers, which will increase the potential customers of VOIP. On the other hand, taxing VOIP may affect its development. In either case, the eventual affect of this new tax policy on VOIP development is still unknown. How does tax policy affect market competition? It is hard to find the truth of this controversial issue. Therefore, we will build a model to assist us to understand this complicated issue. There are four purposes in building this model.

1. To understand market competition between traditional phone companies and IP phone companies
2. To understand how current tax policy affects telephone market competition.
3. To understand the possible trend of declining tax revenues
4. To provide a method to test telephone tax policies

3.2 Target audiences

The target audience of this project are local, states, and federal government officers who are involved in the development of telecommunications regulations and taxation policy. These people can use the model to test various policy settings to assist with policy formulation. In addition, the audience also includes those people conducting market research for the telecommunications companies, who can use the simulation results to indicate to them the outcome of future changes.

3.3 Model boundaries

Our model is based on the specific situation in the United States, such as tax policy, regulations, and market competition. The model cannot be applied to other countries. However, some concepts and structure in the model may be useful for other countries when building similar models.

The time horizon for this model is the 30 years from 1990 to 2020. Since broadband and VOIP are recent developments, no long-term historical data is available. We decided, however, that the data from 1990 to 2005 should be long enough to see historical behaviors. In addition, due to the rapid growth of Internet technology and VOIP, a dramatic change has appeared in a short period of time and, therefore, we think 15 years should provide enough data on which to model the market.

The model focuses on the influence of tax policy on market competition between traditional telephone market and VOIP market. The model is designed to capture the basic behaviors but not increase its complexity. Therefore, some factors are ignored, such as the wireless phone market and the benefits to government of using VOIP. The factors we used in the model are listed in the table 1. The values of exogenous factors we listed can be adjusted in our simulation model which means policy makers can use their preferred values to test results.

Included		Excluded
Endogenous	Exogenous	
PSTN with no broadband household	PSTN tax (Policy test)	Wireless phone market International competition Price competition within PSTN service providers Benefits of VOIP to the governments
PSTN with broadband	VOIP tax (Policy test)	
PSTN price	Household growth normal	
VOIP household	PSTN growth normal	
VOIP price	Broadband household growth normal	
Broadband household		
Tax revenues		
US Household		
Broadband household		

Table 1. Model causes and excluded factors

3.4 Reference Modes and Preferred Behaviors

In the model, there is three reference modes: traditional phone subscribers, VOIP subscribers and tax revenues. Figure 1 shows the historical traditional phone subscribers since 1990 to 2004. The dotted line shows the possible behaviors without introduction of any new policy. Figure 2 shows the preferred behaviors if we introduce new policy after 2005. The preferred behavior is that the traditional phone companies do not stop losing subscribers, but there is a slowing down the rate of decline, in order to give policy makers more time to prepare new tax policy and traditional phone companies to adjust their business strategy.

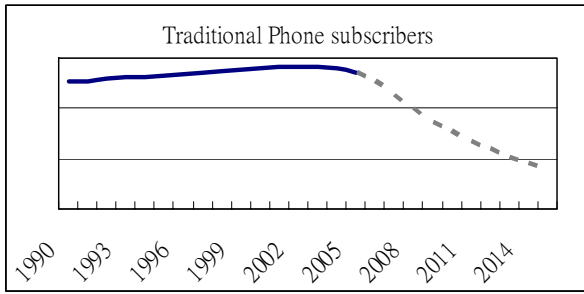


Figure 1. Reference mode of traditional phone subscribers

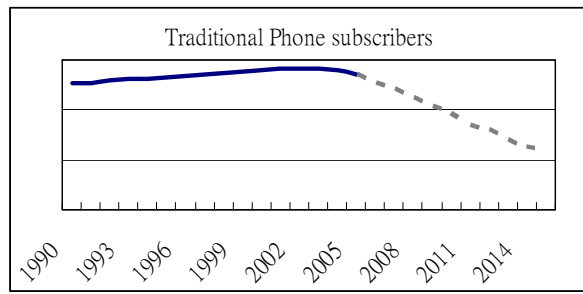


Figure 2. Preferred behaviors of traditional phone subscribers

In Figure 3 presents the historical data of VOIP subscribers for the three years since 2001. The graph shows the dramatic growth of these subscribers. We expect this trend will continue until market saturation is reached or new competitors enter the market. We also believe that tax policy will moderate its growth and therefore not suddenly cause disruption of the traditional telecommunications market, because this disruption to taxation revenues may cause social problems (figure 4).

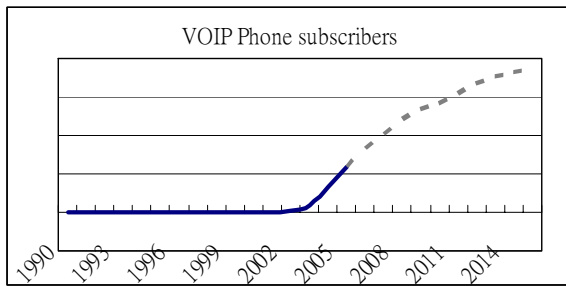


Figure 3. Reference mode of VOIP subscribers

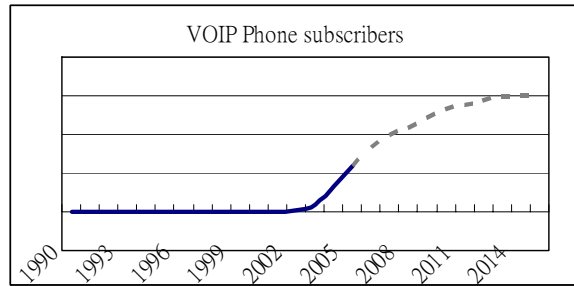


Figure 4. Preferred behaviors of VOIP subscribers

Figure 5 shows the tax revenues from the historical data since 1990 to 2004. However, this tax revenue may start to decline if no new tax policy is introduced to the VOIP services or traditional phone companies. We hope new policy can help to maintain tax revenue in a certain level without decline (Fig 6).

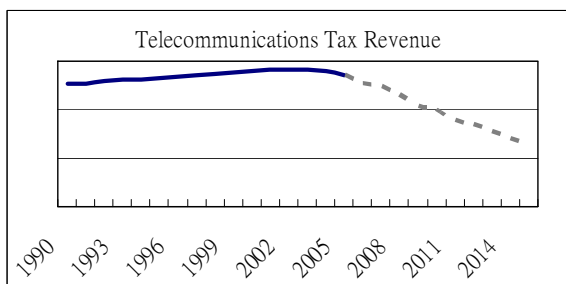


Figure 5. Reference mode of tax revenue

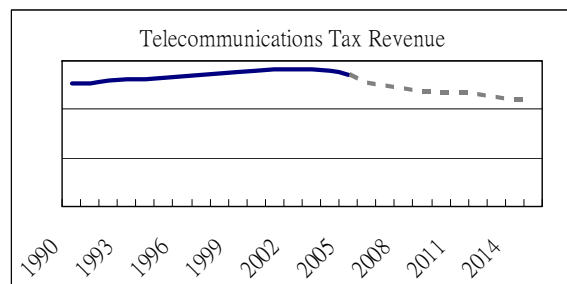


Figure 6. Preferred behaviors of tax revenue

3.5 Model concepts

The model includes two important concepts: success-to-successful archetype (figure 7) and escalation archetype (figure 9). These two archetypes have been discussed by Daniel Kim (1992) and Peter Senge (1990).

3.5.1 Success to successful archetype

Success to successful archetype suggests that the outcome of a situation largely depends on the support from the third party (Kim, 1992). For example, if A received more resources than

B, A has more chance of success. Because of A's success, he will gain more support from the company. In other words, B will get less resources, which reduces his chances of success (figure 7). This is important when government tries to find a win-win solution between government policy and market development. Sometimes, government ignores its negative effect on the market. In our model, this archetype can be applied to government policy to support VOIP development rather than traditional telecommunications.

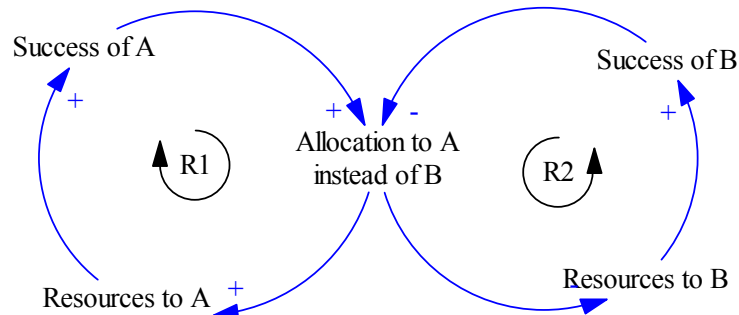


Figure 7. Success to Successful Archetype

VOIP and public switched telephone network (PSTN) both provide telephone services. VOIP is an Internet technology and government is trying to assist the development of these new-born technologies. In the loop R1, it shows that when VOIP gets more support from government, the cost to VOIP service providers decreases. This result leads to an increase in VOIP users and VOIP market continues to grow. On the other hand, the PSTN market declines because of less support from government (Fig 8). PSTN telephone companies have more regulations to follow, which increases their costs and the price to customers (R2 loop). In this case, we agree that government should give more support to VOIP. However, we also consider the shrinking of the traditional phone market. When should government withdraw its support? When is the best time to let the VOIP providers compete fairly? The model should help policy makers to answer these questions.

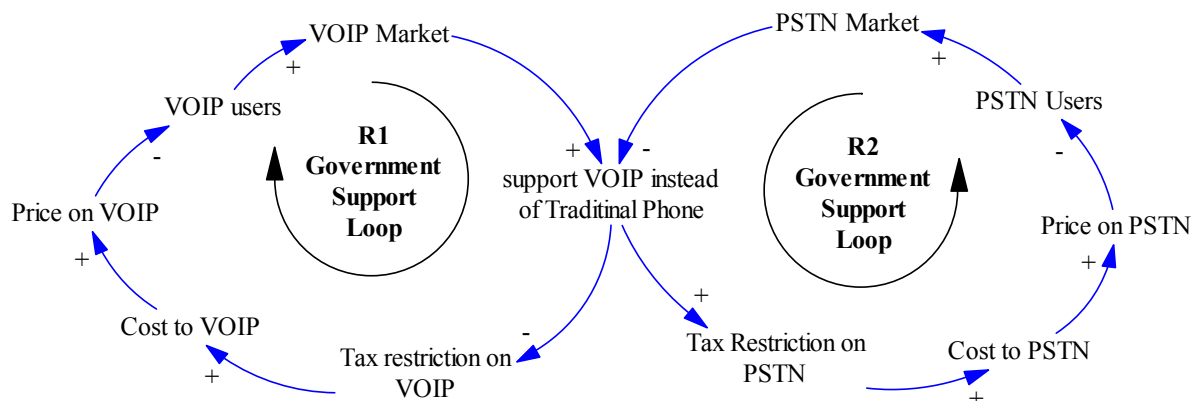


Figure 8. Government support to telecommunications market competition.

The model includes the other success to successful archetype. We think the most important factor of government support is tax policy. It directly influences the price of PSTN and VOIP services, and government tax revenues (fig 9). Theoretically, when VOIP gets more support and increases its market, government should get more tax revenue from VOIP instead of PSTN (R3 loop, R4 loop). However, there is currently no tax on VOIP services. Government wants to support VOIP but is also losing tax revenue. This is a issue between local, state and federal governments.

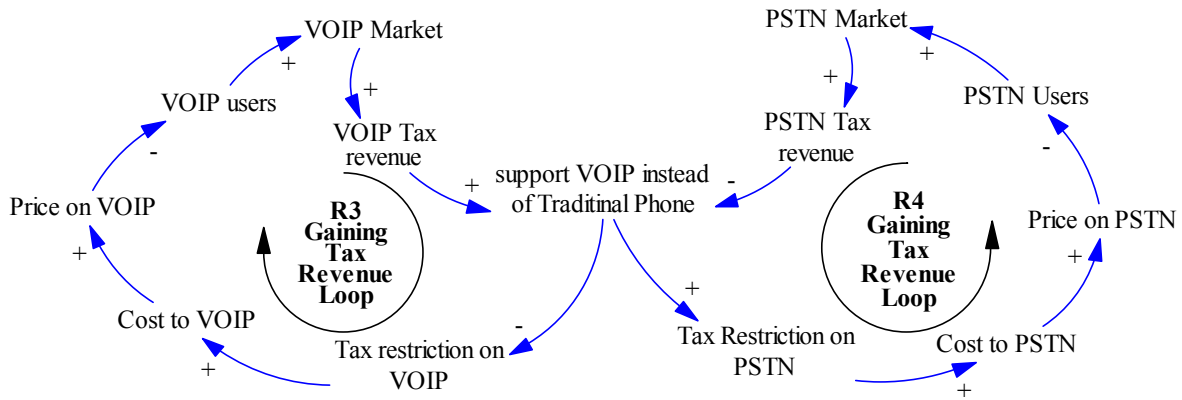


Figure 9. Government support to the tax revenues

3.5.2 Escalation archetype

The Escalation archetype suggests that two or more parties feel threatened by the actions of others. Party A tries to get things under control by adjusting its own processes. However, other parties also feel a threat from A's action and respond with their own strategy (figure 10). This interaction makes the problem more serious. The Cold War arms race between the United State and Soviets was an example of the escalation archetype. Both sides built more arms in order to respond to the perceived threat from the other. They never reached a balance by building more arms because the action from each side just resulted in the other side to build more arms. The other famous example of this archetype is price wars in the business world. According to the data we have found, we believe that price wars are happening in the telecommunications market.

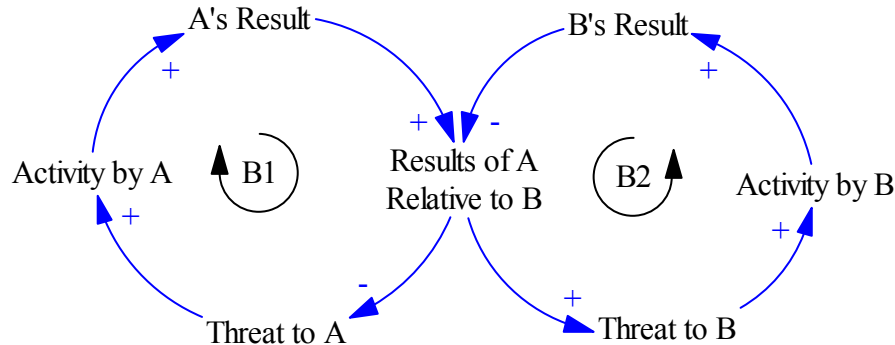


Figure 10. Escalation Archetype

Because both VOIP and PSTN provide telephone services, they have to share the same market, which means as one side gets more customers, the other side loses customers. The price war occurs when both sides want to attract more customers (figure 10). However in the real situation, PSTN service provides will continue to lose customers because the costs for VOIP service provides are always lower then PSTN service provides. When PSTN companies lower their price, VOIP service providers can respond with cheaper price. How long does it take to lose the majority of customers? The model should help to find this answer.

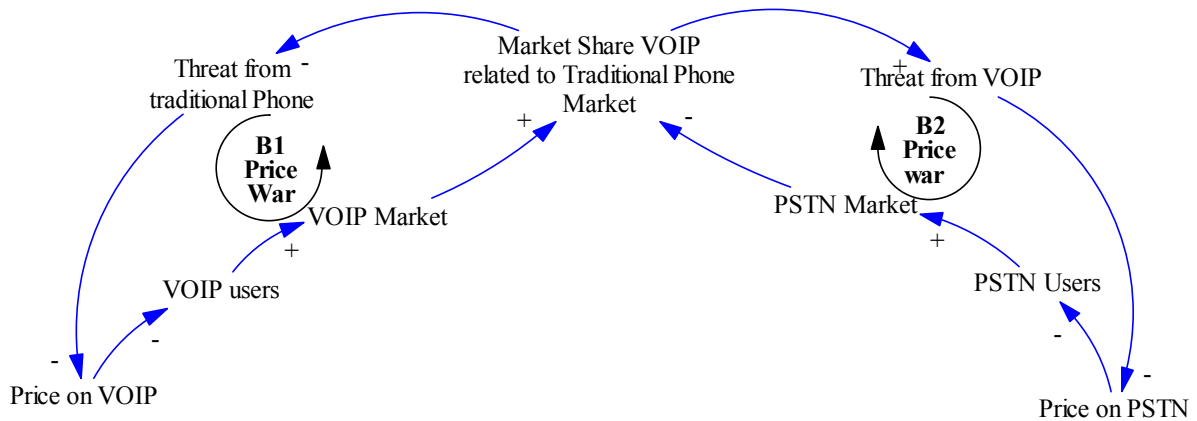


Figure 11. Price competition between VOIP and PSTN services

We constructed our base model on the above concepts. The main concept is described in the causal-loop diagram shown in figure 12. In the next section, we will describe in detail the various model sectors.

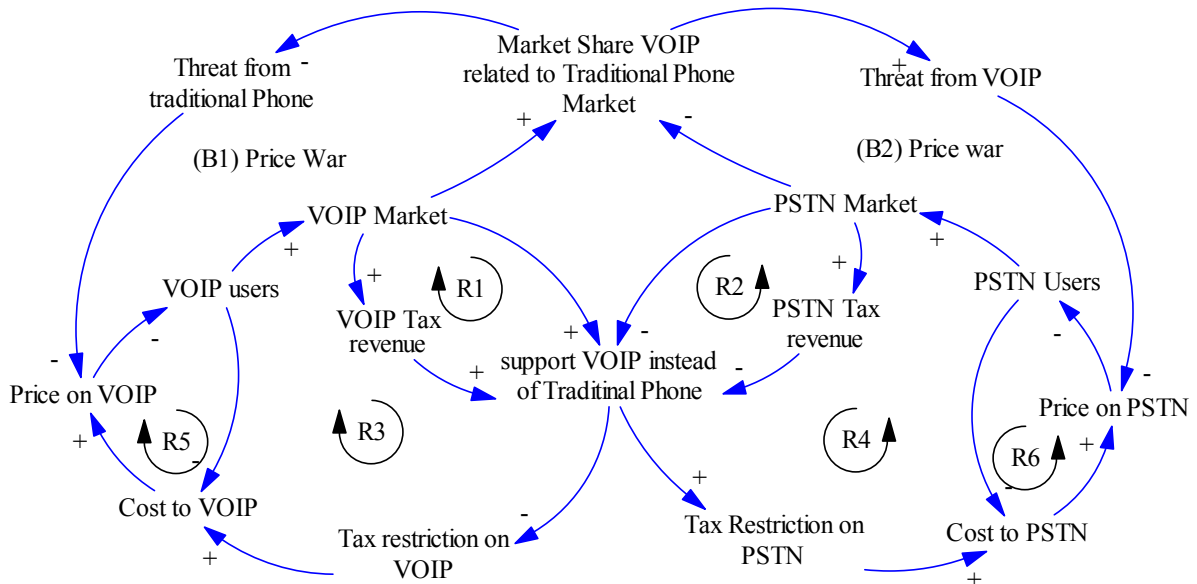


Figure 12. Casual-loop diagram

3.6 Model sectors

The model is separated into five sectors as below.

1. Broadband household sector (figure 13)
2. PSTN not broadband household and PSTN with broadband household sector (figure 14)
3. PSTN with broadband household and VOIP household market competition sector (figure 15, 16, 17)
4. Tax revenue sector (figure 18)
5. Tax policy test sector (figure 19)

3.6.1 Broadband household sector

Because VOIP service requires high speed Internet in order to maintain voice quality, we assume that only users who have broadband Internet access are potential VOIP customers. In

addition, one household usually applies for one broadband service. Therefore, our first step is to find out the population of broadband households.

From historical data, broadband households grew dramatically after 1999. Before then, only a few households had broadband service. To simulate this historical behavior, we built a “technology development” stock and a “ratio of broadband vs. total household” variable. Before 1999, “technology development” stock dominated the growth of broadband households, and limited the growth of broadband households because the technology was not mature enough. After 1999, “technology development” improves and attracts more broadband households. At this time, the “ratio of broadband vs. total household” begins to dominate the growth of broadband households. When the “ratio of broadband vs total household” is still small, it does not affect the growth. However, when the ratio becomes bigger, it will slow the growth.

The other idea in the sector is the “subscribing ratio”. In our assumptions, in the earlier period most people owned traditional phone services when they applied for broadband services. They changed to VOIP service later. This situation may change in the near future as some people may apply for broadband and VOIP service at the same time without owning a traditional phone service at all. The variable of “subscribing ratio” gives us a chance to adjust this ratio.

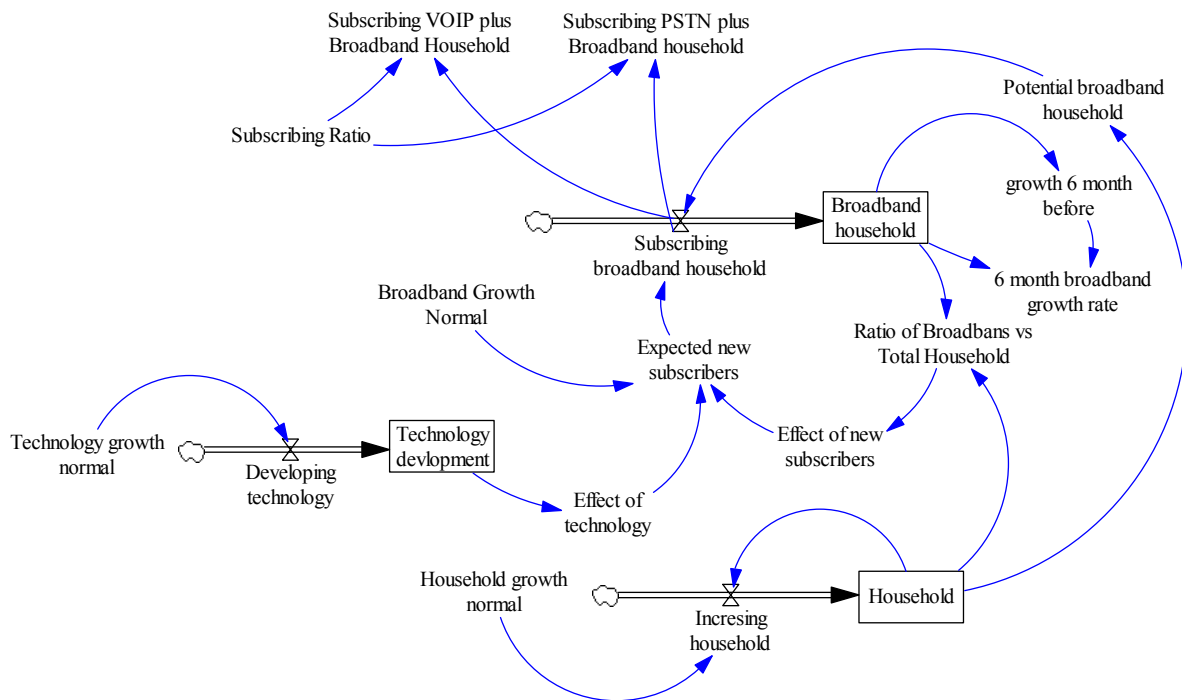


Figure 13 Broadband household sector

3.6.2 PSTN not broadband household and PSTN with broadband household sector

VOIP provides telephone-like service but requires high speed Internet to support its quality. Therefore, we need to distinguish the traditional phone users who also own broadband services and those who don't, because the competition between traditional phone service and VOIP only exist in the customers who own a broadband service. Therefore, we include in this sector two stocks, PSTN non-broadband households and PSTN plus broadband households. In addition, traditional phone services use lines to calculate users. We convert this to households in order to compute the market competition between the traditional phone market and VOIP.

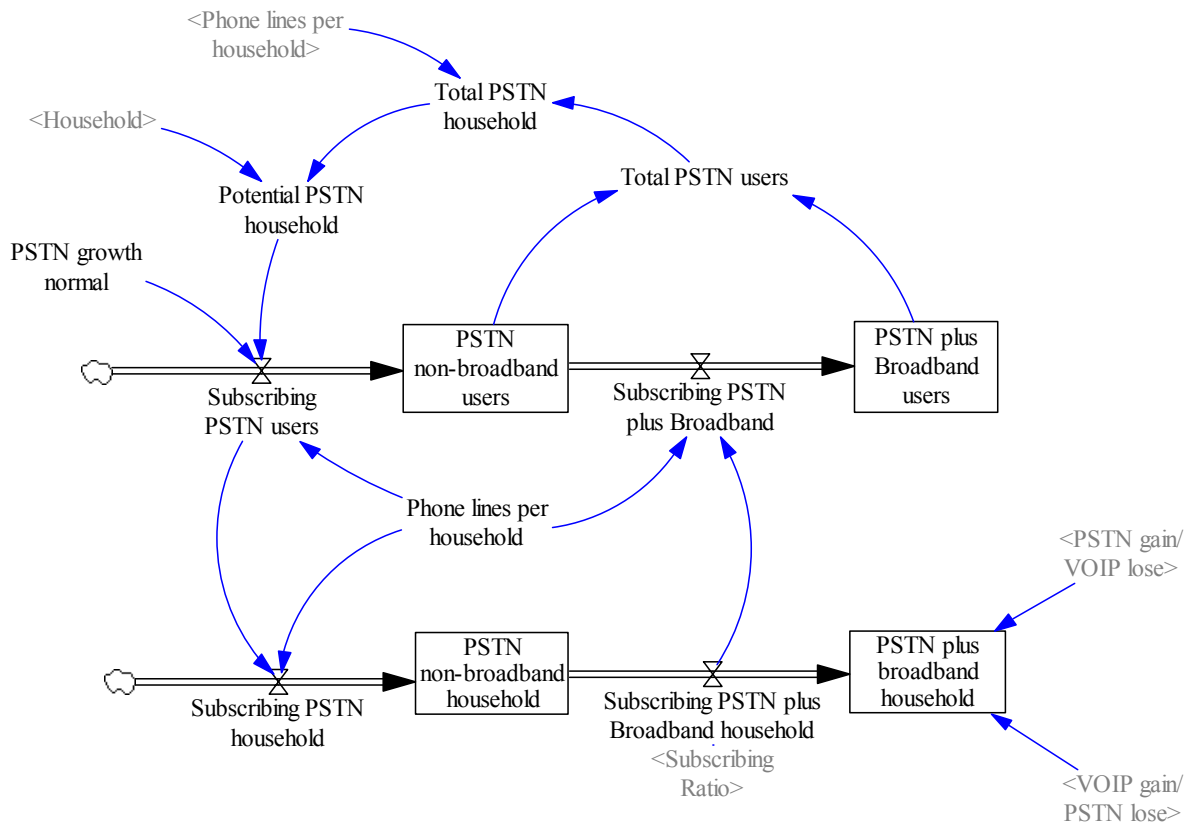


Figure 14. broadband and non-broadband users in the traditional phone market

3.6.3 PSTN with broadband household and VOIP household market competition sector

This sector presents the competition between the traditional phone market and VOIP. Because they share the same market, as one side gains customers, the other side loses customers. Figure 15 represents this situation. Customers either flow into “PSTN plus broadband household” stock or “VOIP X household” stock.

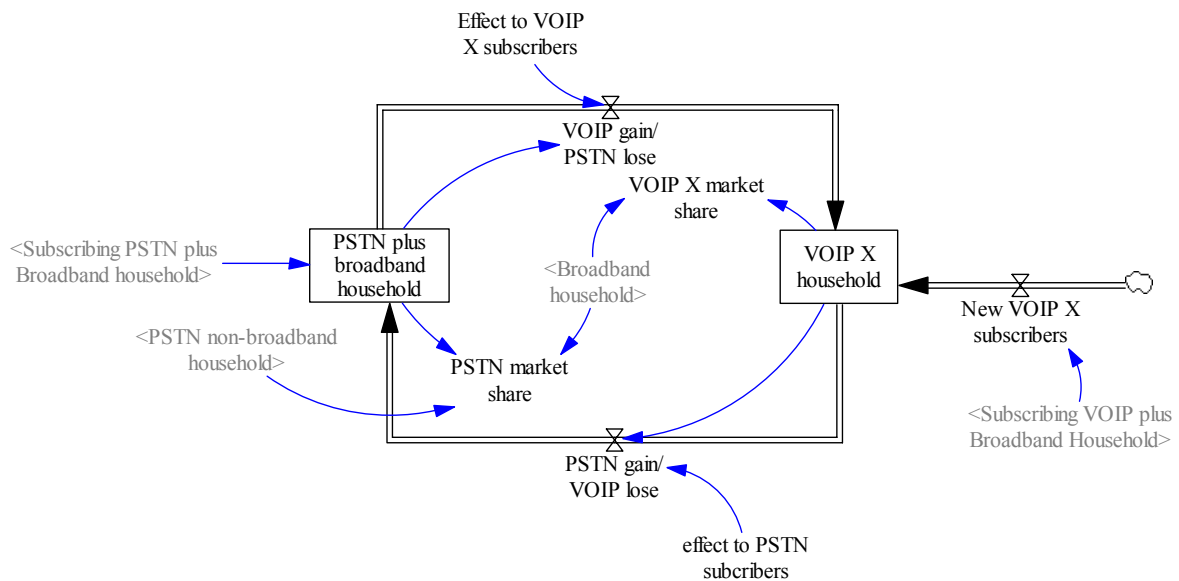


Figure 15. Market competition

Figure 16 shows two concepts: price adjustment strategy, and relationship between price and customer. The price adjustment strategy is based on the price war concept we mention above.

In the figure 16, it is shown that VOIP adjust their price depending on the price of traditional phone services, which is the variable of “gap between PSTN/VOIP. However, VOIP companies cannot lower its price indefinitely. It also needs to consider costs in order to find the maximum price they can adjust, “max adjustable VOIP X price”. Therefore, we assume price adjustment will depend on these two factors.

Price will affect how many customers adopt their services. We use a variable of “gap between PSTN/VOIP” to decide the ratio of customers who will change their service from traditional phone service to VOIP service. In addition, this sector also include two kind of tax policy, “VOIP tax \$ per P” and “VOIP tax rate %”. The detail description includes in the next sector. Figure 17 shows than same pattern as VOIP market in the figure 16.

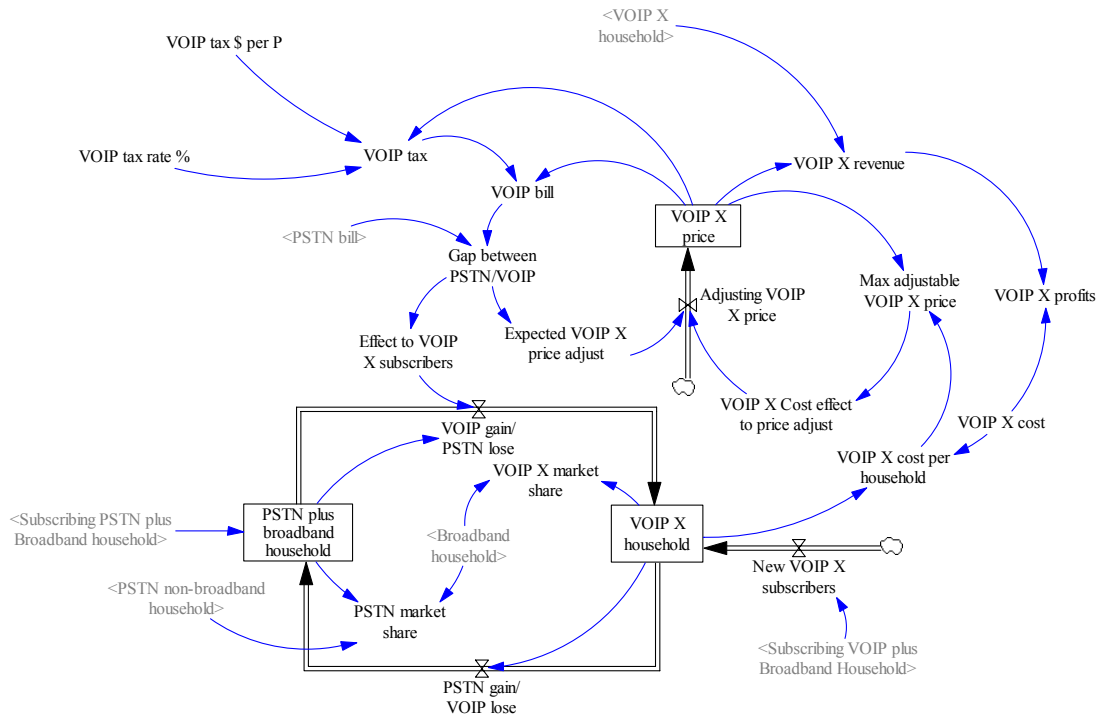


Figure 16. Market competition (VOIP)

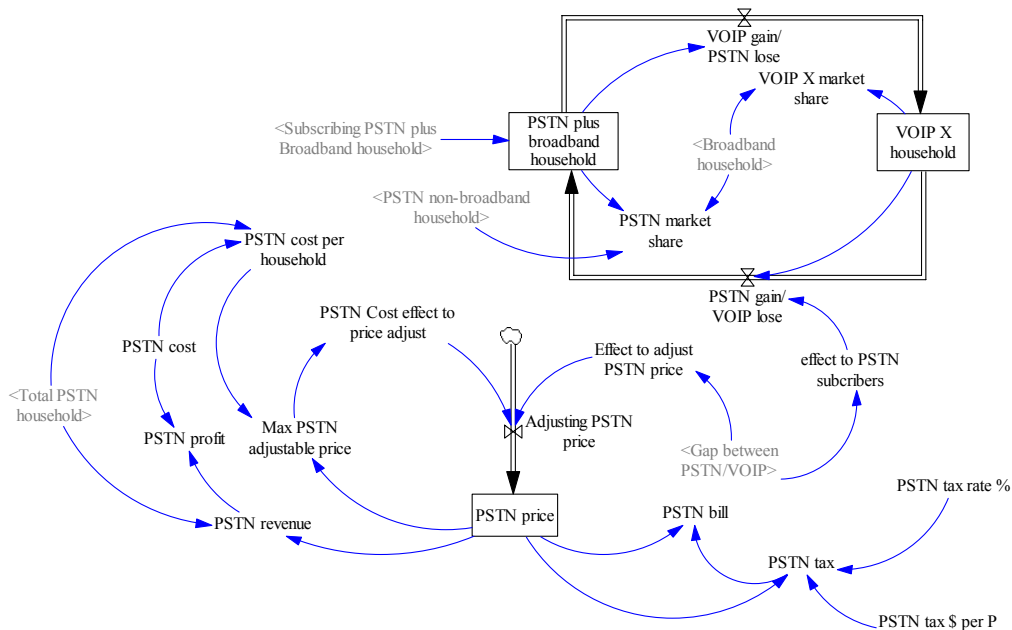


Figure 17. Market competition (traditional phone)

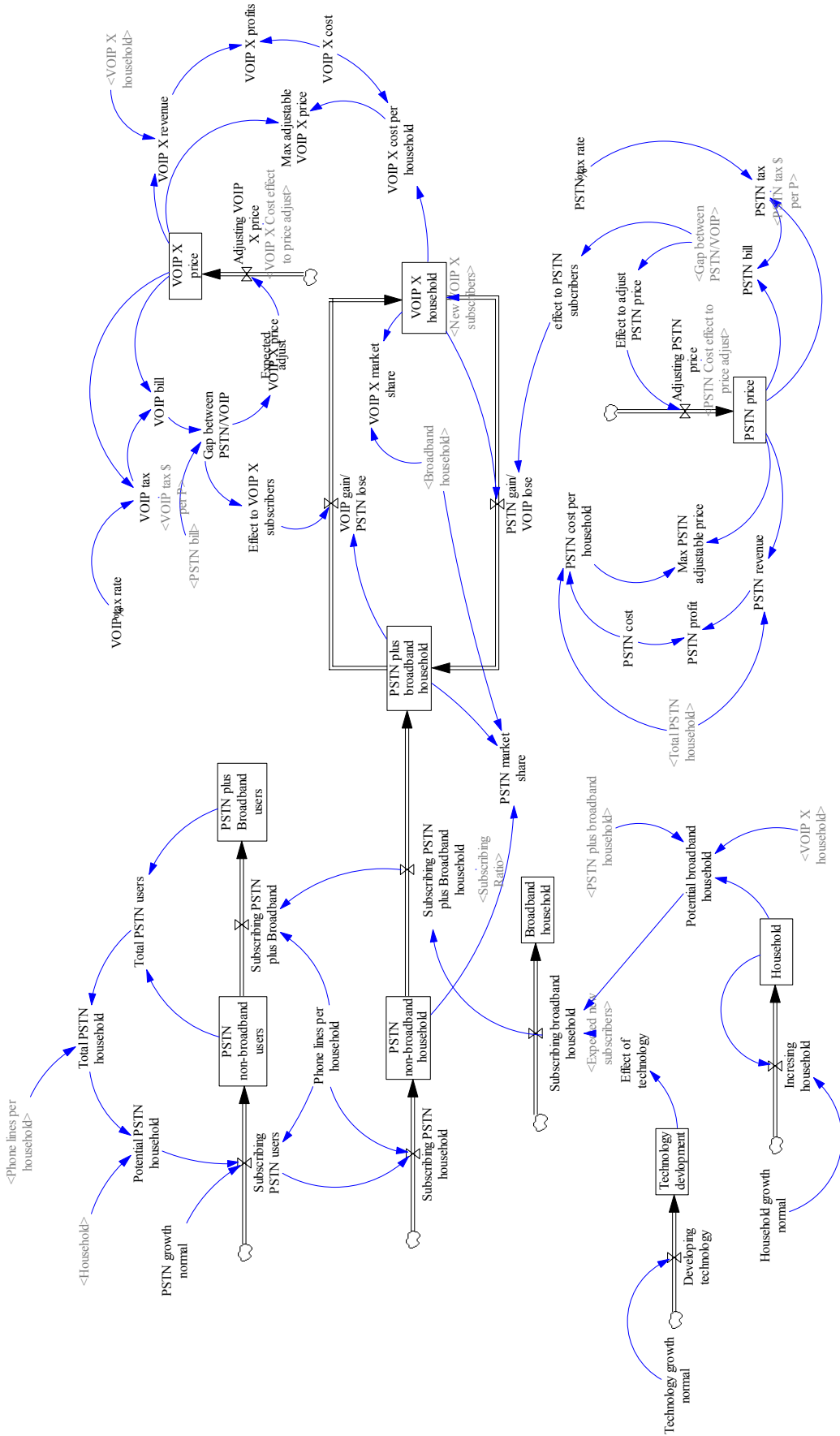


Figure 18. Model overview

3.6.4 Tax revenue sector

The purpose of this sector is to compute total tax revenue. This sector includes four tax policies, VOP tax \$ per P, VOIP tax rate %, PSTN tax \$ per P, and PSTN tax rate percentage (figure 19). Policy makers can try to combine different tax policy theories and see how total tax revenue changes over time. For each phone bill, tax per person will look like the equation below.

$$\text{"VOIP tax rate \%"} * \text{VOIP X price} + \text{VOIP X tax \$ per P}$$

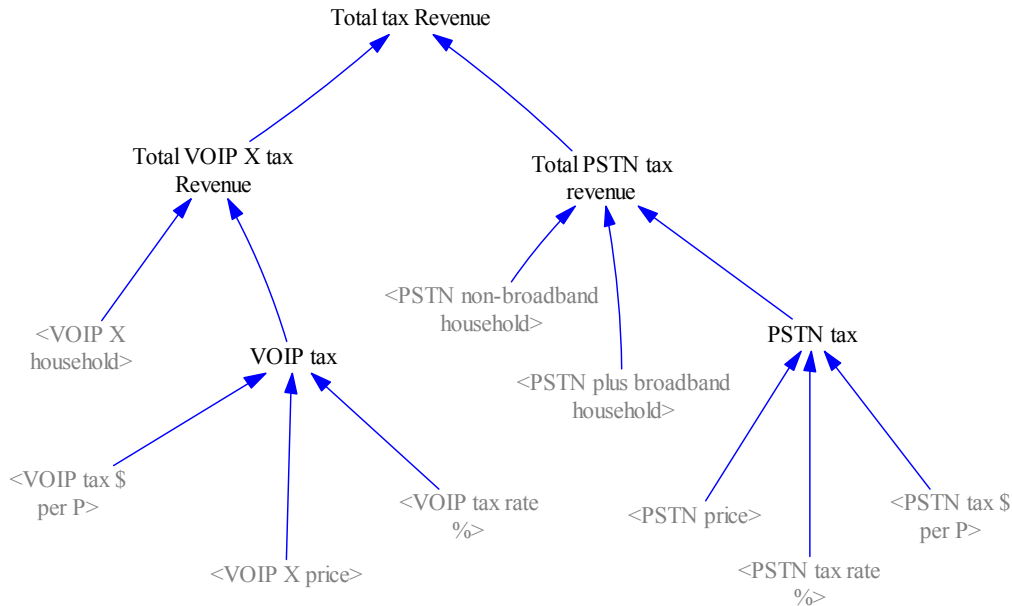


Figure 19. Tax revenue

3.6.5. Tax policy test sector

This sector allows users to test tax policy combinations. On the left side of the interface, both VOIP and PSTN include two kinds of tax policy strategies, “tax rate %” and “Tax \$ per P”. When using the “tax rate %”, the tax will be proportional to the phone bill. When using the “tax \$ per P”, the tax will be a fixed fee per person no matter what the phone bill is. After users adjust their policy, the simulation result will show in the middle of the interface. Through the graphs, users can see how their tax policy affects to the market competition and how much tax revenue they will gain. Users can gain further insight by trying more policy combinations.

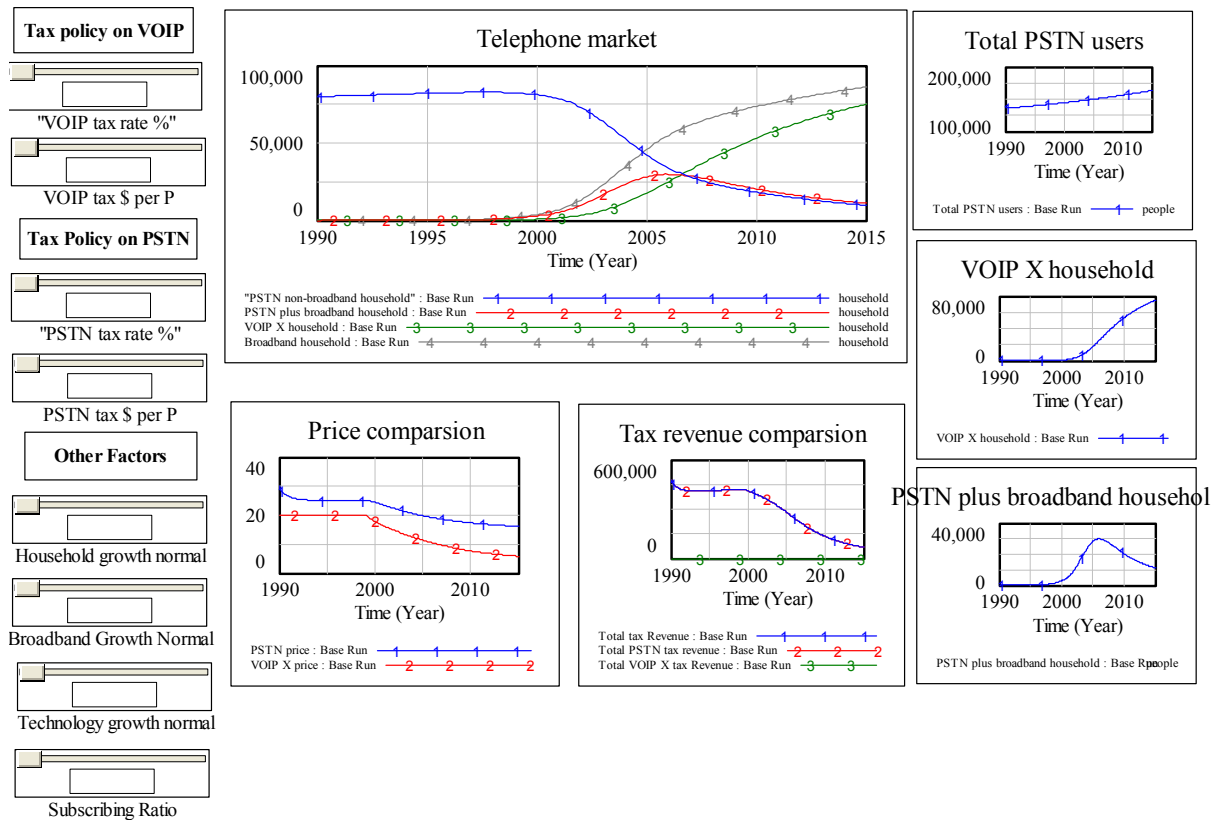


Figure 20. Policy test interface

3.7 Simulation results

In the first 15 years, the model plots the historical behaviors, such as VOIP market growth (figure 21) and the tax revenue decline (figure 22). Figure 21 shows how VOIP growth affects the PSTN with broadband household. It also shows how growth of broadband households affects the numbers of PSTN without broadband households. The growth in broadband households is so important because potential VOIP customers will depend on how many broadband users there are. Customers without broadband service will not be VOIP users.

Figure 22 shows the tax revenues decline when tax policy only applies to traditional phone companies. Therefore, when VOIP users increase and PSTN users decline, tax revenues start to decline. In the first 12 years, tax revenues stayed at a stable level. However, as VOIP grows, tax revenues start to decline. The simulation shows that tax revenues will continue to decline if governments do not introduce new tax policy to VOIP.

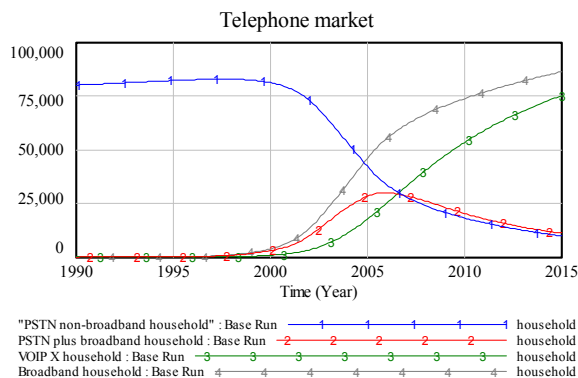


Figure 21. Population changes in each stock

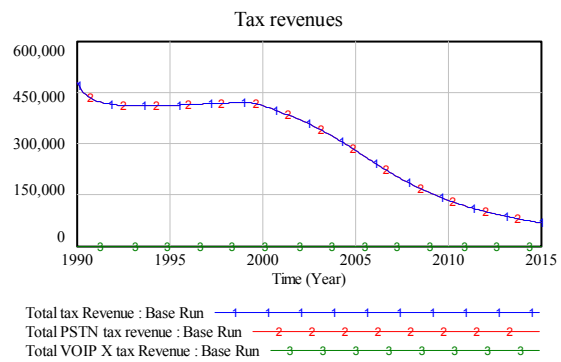


Figure 22. Tax revenues

In Figure 23 the price war between PSTN and VOIP is shown. When PSTN providers reduce price, VOIP providers will do the same immediately. However, because the cost to PSTN companies is higher than VOIP, the PSTN companies cannot offer a price lower than their cost. As a result, the price of VOIP will always be lower than PSTN. Therefore, PSTN companies continue to lose their customers.

In Figure 24, the market share between PSTN and VOIP companies is shown. Because they share the same market, when one side increases market share, the other side will reduce market share. However, one thing to note is the methods to calculate both markets are different. The PSTN market includes two types of customers: one has broadband service while the other does not. For the VOIP companies, the market is the people who have broadband service. Therefore, the total market for PSTN companies is larger than VOIP companies. The equations to calculate both market shares are listed below.

$$\text{PSTN market share} = \frac{\text{PSTN plus broadband household} + \text{"PSTN non-broadband household"}}{\text{Broadband household} + \text{"PSTN non-broadband household"}}$$

$$\text{VOIP X market share} = \frac{\text{VOIP X household}}{\text{Broadband household}}$$

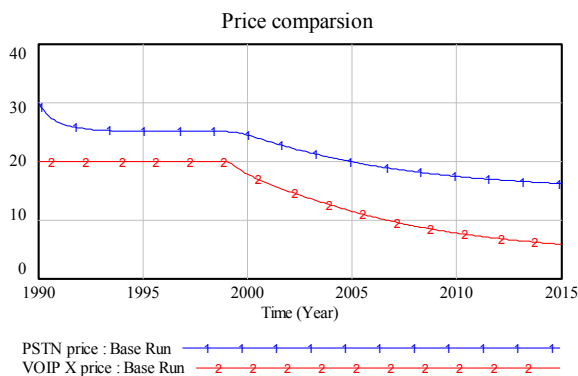


Figure 23. Price comparison

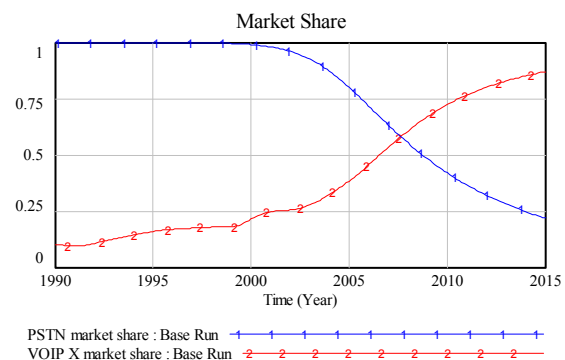


Figure 24. Market share.

4. Policy Test

We use the interface to test how new tax policies affect market competition and tax revenue. Below we list two policy tests. In the first test, new tax policy imposes 20% tax on VOIP bills after 2005 and the tax rate for the PSTN remains the same. In the second test, both PSTN and VOIP users will be charged \$5 dollars as the tax.

4.1 Impose 20% of VOIP bill after 2005

When applying 20% tax on the VOIP bill after 2005, VOIP price suddenly jumps but returns back to the price of the base run quickly (figure 25). In addition, total tax revenue increase but does not affect to the market competition (figure 26). Both PSTN and VOIP household still maintain similar growth as in the base run (figure 27, figure 28)

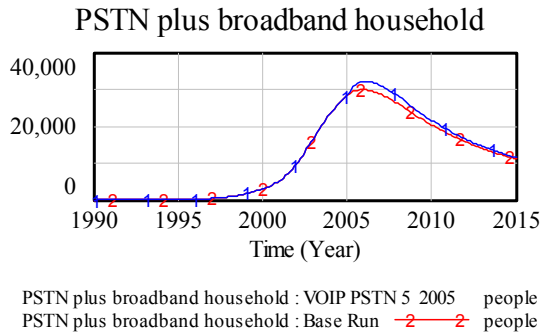


Figure 31. PSTN household (with broadband service)

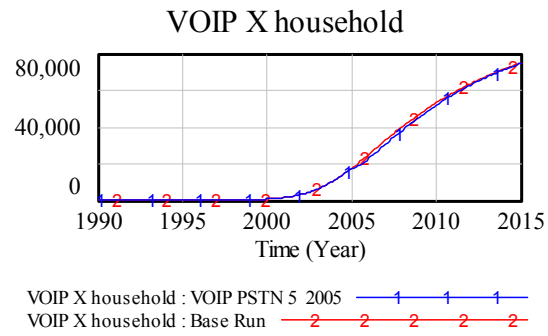


Figure 32. VOIP household

Through the two tests we make, we can make several conclusions.

1. Tax policy has little influence on market competition.
2. Traditional phone markets will continue to decline no matter what the tax policy is.
3. A fixed fee for tax can ensure stable tax revenue.

5. Conclusion

In the United States, VOIP has been considered one of the largest areas of investment in the telecommunications market, and government activity supports its development. However, VOIP growth causes decline in the traditional phone market and in government tax revenue. Governments are struggling with what the solution is. Our simulation model provides an efficient environment to assist policy makers to find a solution and assists as a decision making tool.

In the future, we would like to include market competition between VOIP providers. In addition, we would also like to introduce the wireless phone market into the model. We believe that after we expand our model, we can plot more precise behavior changes. In addition, the model cannot only help policy makers reach decisions, but also help companies to decide their business strategies.

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