APPLICATIONS OF A TELECOM SECTOR MODEL FOR ESTABLISHING AND VALIDATING TELECOM POLICIES AND STRATEGIES

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Abstract

This article describes applications of a system dynamics model of the telecom sector to the definition and validation of telecom policies and strategies in developing countries. This describes several cases where this model has been used to solve problematic and complex behavior found in the telecom sector, such as saving telecom operators from bankruptcy, validating a new structure for three telecom operators, defining and validating universal service policies, and validating tax policies for the telecom sector.

Introduction

This paper shows different applications of a system dynamics model to the resolution of problematic and complex behavior still found in the telecom sector of developing countries. The telecommunications sector has several positive externalities and feedback loops that trigger the diffusion of its services, the adoption of subscribers, and the collection of revenues (Ramos *et al.* 2010). However, in spite of that, there are still several operators within this profitable sector that face bankruptcy or economic loses.

This article shows the application of system dynamics to the definition and validation of strategies in order to improve the performance of two government-owned telecom operators in developing countries. In these cases, the poor planning previously applied had led to the failure of their operational and financial performances. The one case corresponds to a fixed telecom operator, which had been experiencing loses over the past years of this study, and the other a mobile operator that had been declared in bankruptcy after several years of not seeing profits since its creation.

The economic crises that face many countries worldwide obligate their governments to find new sources of funding to balance their respective budgets. One common mechanism is to increase tax revenues by imposing new taxes, especially to sectors considered sumptuary and that generate very high levels of revenues. Telecommunications is commonly considered a very profitable sector, but in some cases, it has been mistakenly considered a sumptuary one.

This paper also describes the validation of a tax rate applied to the telecom sector, specifically investigates the impact of applying a tax rate to the cellular telephone traffic. It has been observed that telecommunications generate a significant fraction of the GDP in most countries, which makes it attractive for new taxes and fees. On the other hand, telecommunications are actually used as a luxury in some few cases, but in most cases, these are utilized for increasing the productivity and the welfare of the population (Hudson 1984; The ITU-D Focus Group 7 2000).

Several unsuccessful universal service policies have been applied in developing countries in past years (Ramos *et al.* 2010). Universal service can be defined by the provision of “universal” availability of connections to individual households from public telecommunication networks, with non-discriminatory and affordable prices (Hank and McCarthy 2000). An alternative to universal service is “universal access”, which is defined by a situation where every person has a reasonable means of access to a public telecom network (Cain and Macdonald 1991).

This work is also used to validate the design of a new proposed universal service policy. This policy defines a variable universal service rate that impose a higher universal service fee to fixed telephone operators with low capacity in rural areas and a lower universal service fee to operators with higher capacity in rural areas. It was found that this policy fails on achieving the goal of reducing the urban-rural telecom gap. However, it was shown by this investigation that this policy might be effective on reducing cream skimming in fixed telephony.

The simulations carried by this model helped identifying counterproductive behavior, incomplete policy definitions, and the causes of failure of the proposed telecom policies and strategies. For instance, counterproductive behavior was found after simulating a tax policy for the telecom sector, because it reduced the total collected telecom taxes in the long term. The incomplete policies showed the lack of complementary strategies to increase the probability of implementation success. These deficient policies include the procedure to merge three telecom operators, and the new proposed universal service policy.

Finally, a telecom strategy transformed a cellular company into a mobile virtual network operator (MVNO), which allowed leasing telecom capacity to other mobile operators. This implementation was supposed to save the operator from bankruptcy by improving the number of subscribers and the economic resources in the short term. The underlying causes of the failure of this policy were also found through the simulations of the model.

A System Dynamics Model of the Telecom Sector

The model sectors and their interactions are shown in Figure 1. These sectors are grouped according to the functions they perform (Ramos *et al.* 2010).

Telephone Demand represents the subscribers with telephone lines and the unmet demand, which is composed of subscribers in the waiting list and potential subscribers willing to pay the monthly rental fee (Warren 2002). The subscribers in the waiting list are connected to a rate, which depends on the telephone capacity (Jensen *et al.* 2002; Ros and Banerjee 2000).

Telephone Deployment represents the process of deployment of new telephone lines, which is a function of the economic resources available, the number of subscribers in the waiting list, the current telephone capacity, and the number of telephone lines being deployed (Lyneis 1980).

Telephone Traffic represents the level of usage of the telephone network as a function of the price, income per capita of the population, the current telephone density, and the telecom penetration in the region (Kayani and Dymond 1997; Shapiro and Varian 1999).

The Financial Resources sector accumulates the economic resources used in the expansion of telecom infrastructure. This sector depends on the number of subscribers, the telephone traffic, the price of the service, the operating costs, and the amount of money invested in telecom infrastructure (Kayani and Dymond 1997).

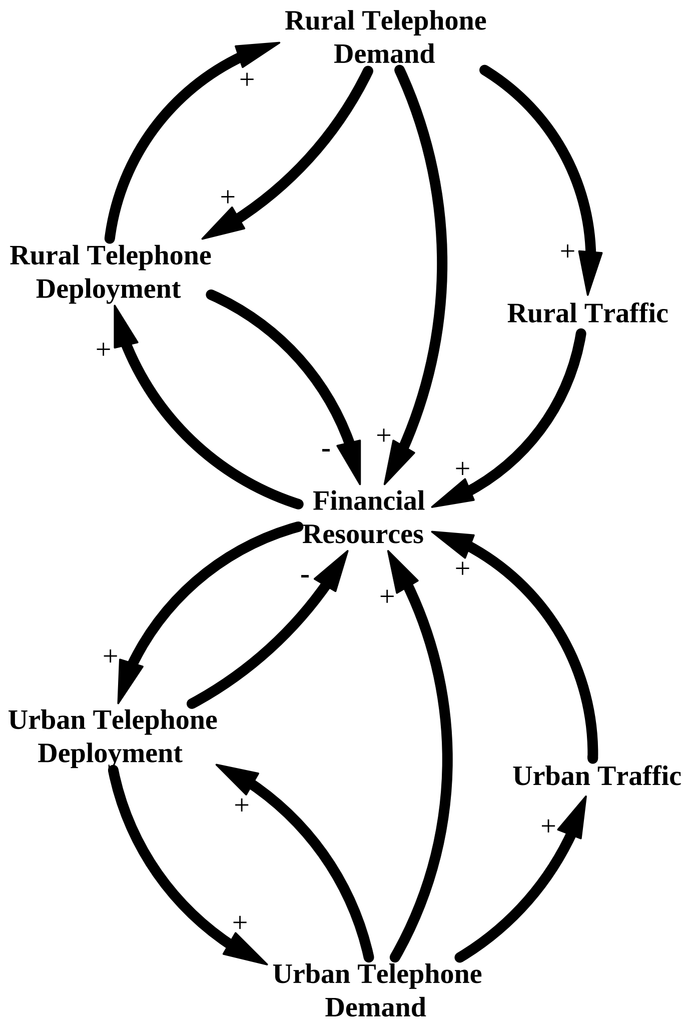

Figure 1. A simplified sector map of the Telecom Sector Model (Ramos *et al.* 2010)

Real Applications of the Telecom Model

The basic model described in the previous section has been extended and modified to validate and define different policies and strategies applied to the telecom sector of developing countries. The five telecom policies and strategies being tested and analyzed are described as follows.

1. Defining Strategies to Save a Mobile Operator from Bankruptcy.

The mobile operator under analysis was government-owned and the smallest one of a developing country. This operator has been losing money since its creation, and the growth of mobile subscribers in the recent months has been lower than before, in spite of that the company was recently transformed into a mobile virtual network operator (MVNO). It is important to note that this operator was also the last one to enter into the mobile competing market.

The main determinants of growth or stagnation were attributed to the network externality of the competing mobile operators, the installed capacity of the network, the distribution channels, the advertising of the operator, and the operating costs. The causal structure of the growth of the referenced mobile operator is described in Figure 2.

As observed in positive feedback loop 1 of Figure 2, the economic resources and the MVNO implementation increase the installed capacity of the mobile operator, which improves the coverage of the network. The better coverage of the network improves the demand of the mobile service, increasing the number of subscribers. The higher number of subscribers increases the economic resources of the mobile operator. Finally, the subscribers adopted by the operator are also a function of the distribution channels and advertising.

On the other hand, as it can be seen in negative feedback loop 4 in Figure 2, the increase of the installed capacity raises the operating costs, which reduces the economic resources of the company. In addition, the positive feedback loop 2 in the same figure indicates that a higher number of subscribers increase the network externality of the mobile operator. This tends to reduce the subscribers from other mobile operators. On the other hand, the higher number of subscribers from other operators increases their network externality, reducing the subscribers from our mobile operator.

The following strategies were tested in the model sequentially and in an aggregated manner:

1. Price reduction
2. Increase of distribution channels
3. Higher investment on advertising.
4. Reduction of operating costs.

The base case is observed in line 1 of Figures 3 and 4. These strategies were implemented in month 54.

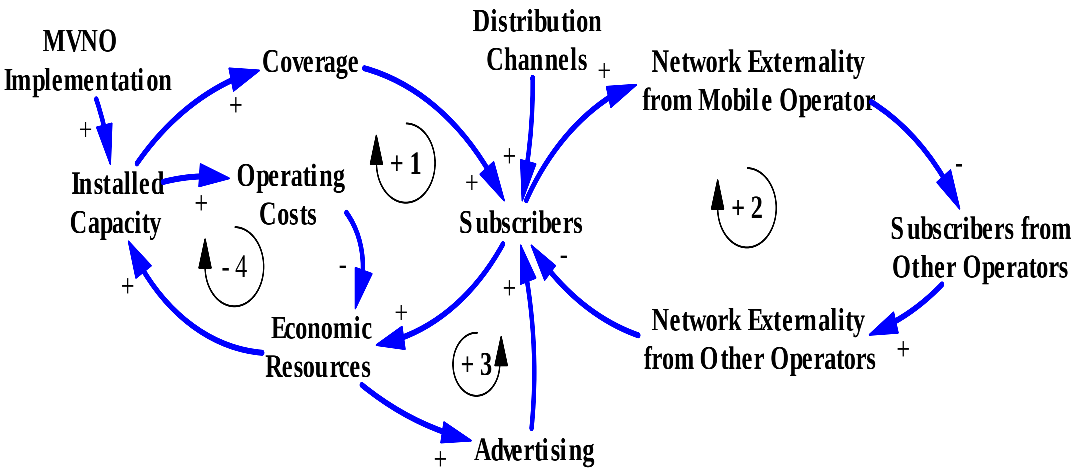

Figure 2. The causal structure of the growth of the mobile operator

The price reduction was a common strategy implemented by the mobile operator in order to improve its market share. However, this price strategy was shown to improve the demand and the number of subscribers, as observed in line 2 of Figure 3, in a lower proportion than the reduction of the price. This led to the reduction of the economic resources in the short to middle term, as observed in line 2 of Figure 4, which is a counterproductive result.

One year before this investigation, the mobile operator became a MVNO without observing since then, a significant improvement on its financial, operational, and market performance. The main reason for the failure of the MVNO implementation that was found was the lack of distribution channels and a low level of investment in advertising, as shown in feedback loop 1 of Figure 2. It was also proved through the simulations that in spite that the MVNO implementation increased the installed capacity of the operator, it was not appropriately accompanied with an increase on the number of distribution channels and more investment on advertising.

The increase of the distribution channels represented in line 3 and the improvement of advertising in line 4 of Figures 3 and 4 were strongly recommended because they improved the performance of the system. It was shown by the simulations that they improved the number of subscribers and the economic resources of the mobile operator as shown in Figures 3 and 4 respectively.

The reduction of operating costs by increasing efficiency tends to improve the economic resources of the mobile operator, as shown in feedback loop 4 of Figure 2. This situation increases the advertising even more, raising the number of subscribers as shown in line 5 of Figure 3. The higher number of subscribers tends to improve the economic resources of the operator. However, more investment on advertising end reducing a little bit the economic resources in spite of more subscribers, as shown in line 5 of Figure 4.

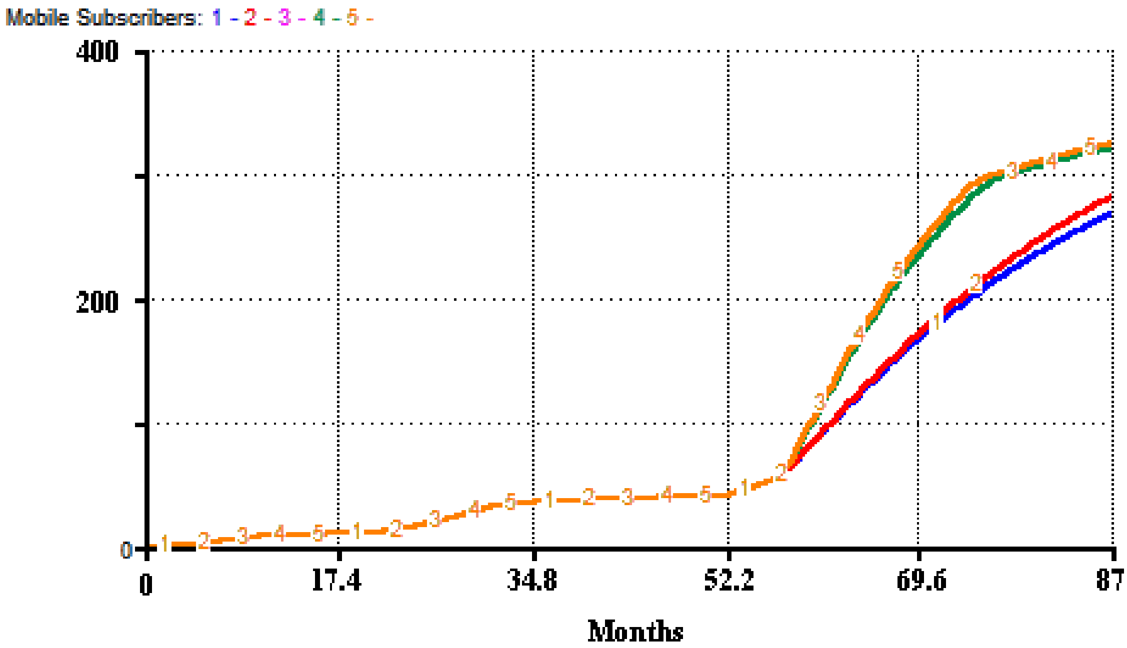

Figure 3. Subscribers for Different Strategies of the Mobile Operator

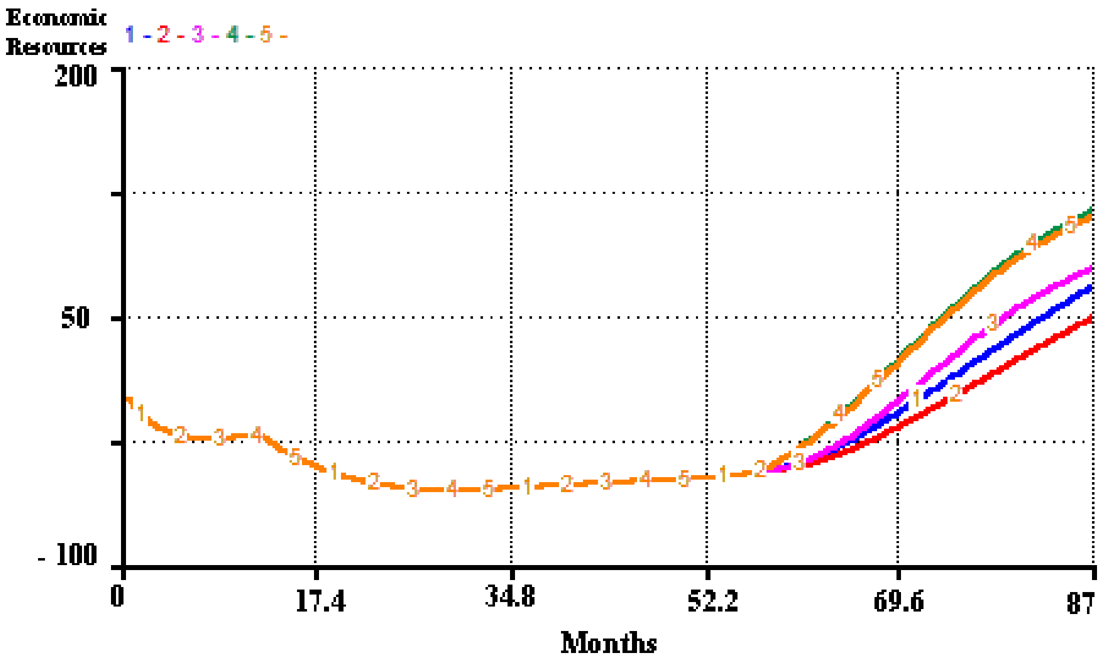

Figure 4. Economic Resources for Different Strategies of the Mobile Operator

2. Defining Strategies to Improve the Performance of a Fixed Telecom Operator.

There were two main government-owned fixed telecom operators serving a different region of the same developing country. The company under analysis was the second largest and has been losing money in most of the previous years, in spite of a significant number of urban subscribers. It is important to note that the average revenue per user (ARPU) has been reducing through the years, however its value is still considered high. In addition, the revenue from international traffic is considerably lower than previous years.

The main determinants of growth or stagnation were attributed to the network externality of the operator, the installed capacity of the network, and the operating costs. The causal structure of the system is described in Figure 5. As observed in positive feedback loop 5 in this figure, the economic resources increase the installed capacity of the operator, which improves the connection rate and the number of subscribers. The higher number of subscribers raises the economic resources of the company.

On the other hand, the negative feedback loop 7 in Figure 5 shows that the increase of economic resources improves later the installed capacity of the operator raising its operating costs, which in turn reduces the economic resources of the company. Finally, the higher number of subscribers improves the network externality of the operator, which increases the demand, the connection rate, and the number of subscribers, as seen in positive feedback loop 6 in the same figure.

The following strategies were tested sequentially, in an aggregated manner, in the model:

1. The use of wireless access technology
2. Reengineering of capacity implementation process
3. Reduction of installation prices
4. Reduction of operating costs

The base case is observed in line 1 of Figures 6, 7, and 8. These strategies were implemented in month 78.

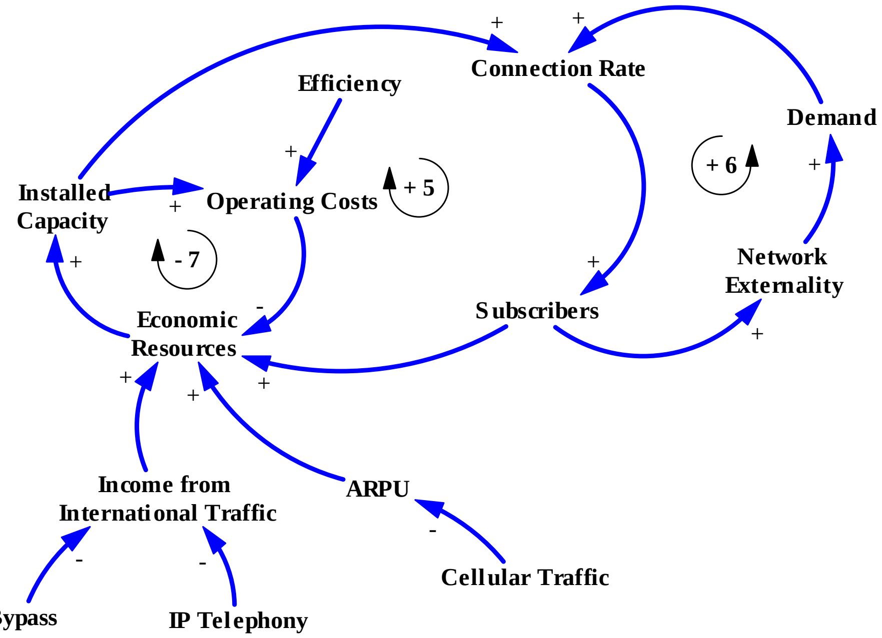

Figure 5. The causal structure of the growth of the fixed telecom operator

It is already known that wireless technology reduces the costs of telecom infrastructure and the implementation delays, which tends to improve the installed capacity, as observed in positive feedback loop 5 in Figure 5. This situation was also shown by the simulations, since wireless technology implementation considerably improved the number of subscribers and the economic resources of the operator, as observed in line 2 of Figures 6 and 7 respectively.

The reengineering of the capacity implementation process allows reducing the delays incurred in the causal relation between the economic resources and installed capacity, as shown in positive feedback loop 5 of Figure 5. It was seen through the simulations that this strategy was able to improve the number of subscribers, the economic resources, and the installed capacity of the fixed telecom operator, as seen in line 3 of Figures 6, 7 and 8.

The reduction of installation prices was intended to improve the demand and the number of subscribers of the service. It was observed through the simulations, that the improvement of demand produced by this strategy was not able to increase the connection rate and the number of subscribers, as observed in line 4 of Figure 6. It happened because the connection rate also depends on the installed capacity and the economic resources of the operator, as observed in positive feedback loop 5 of Figure 5, which practically remained constant as can be seen in line 4 of Figures 8 and 7 respectively.

The reduction of operating costs considerably improved the economic resources and the installed capacity of the telecom company in the short term, as observed in line 5 of Figures 7 and 8. This improvement on economic resources was able to considerably increase the installed capacity and the number of subscribers, as indicated in positive feedback loop 5 of Figure 5. The substantial improvement in the number of subscribers achieved by this strategy in the simulations is shown in line 5 of Figure 6.

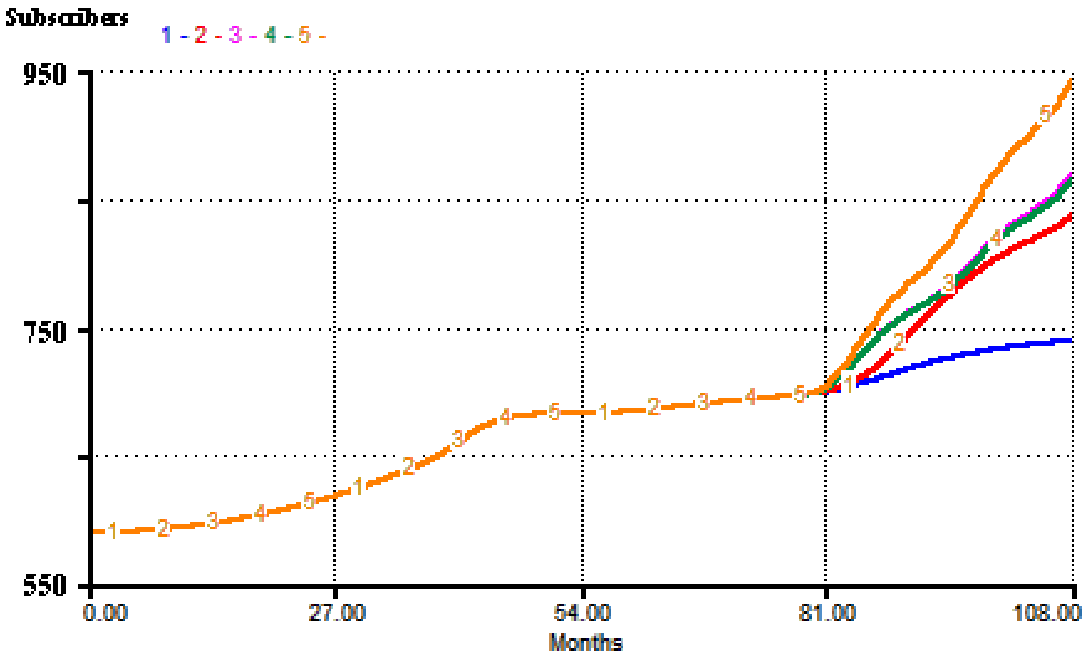

Figure 6. Subscribers for Different Strategies of the Fixed Operator

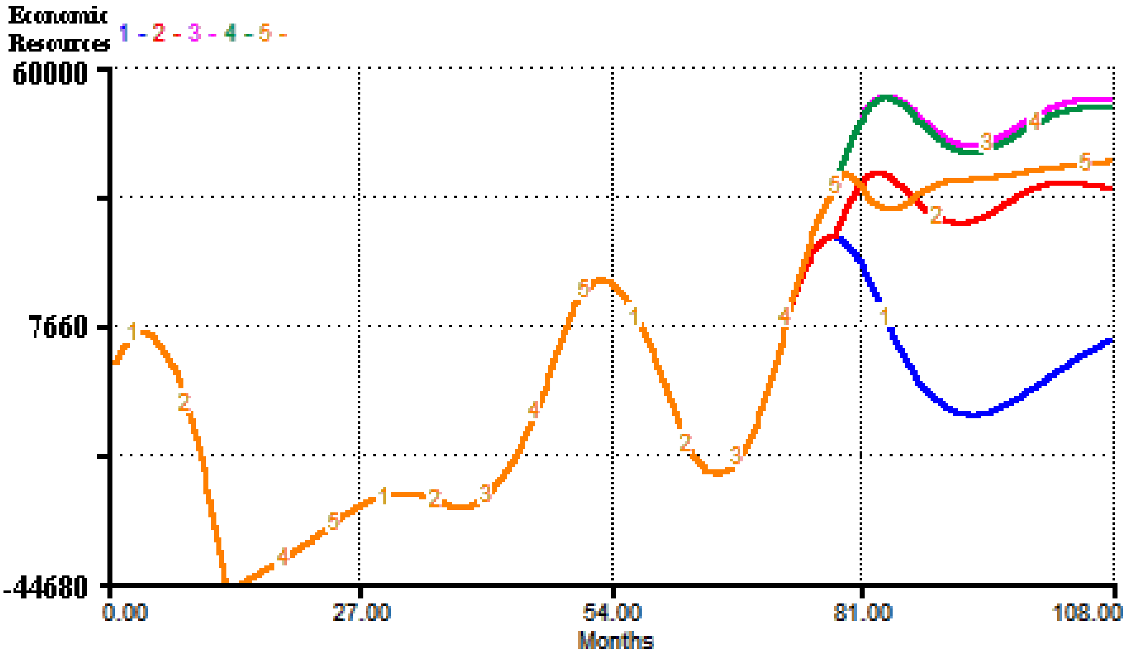

Figure 7. Economic Resources for Different Strategies of the Fixed Operator

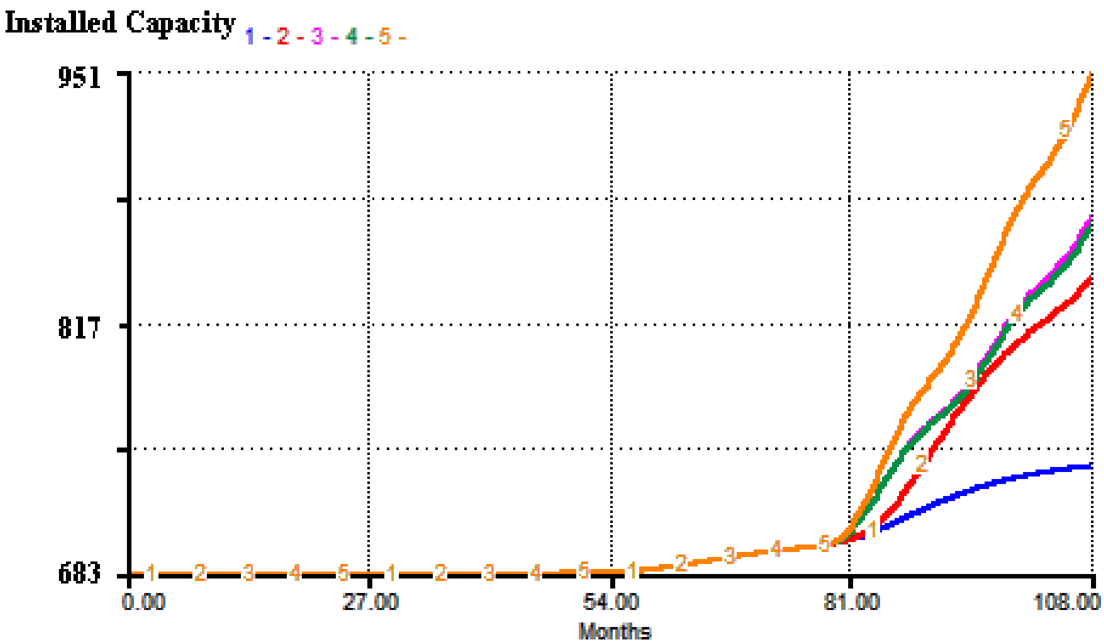

Figure 8. Installed Capacity for Different Strategies of the Fixed Operator

3. Validating the Merging Process of Three Telecom Operators.

The final strategy proposed to improve the performance of the previous government-owned mobile and fixed telecom operators was to merge these two companies with the remaining government-owned fixed telecom operator, which was the only one generating economic profits.

In addition, the national fixed telephone density had not improved in the previous years, and was relatively low compared with the mean values of the countries in the region. In addition, the urban-rural fixed telephone gap has not been reduced in spite of the existence of universal service policies in place in the country.

The purpose for merging the telecom companies was to guarantee universal service under economic and social profitability, with affordable prices and national coverage. The causal structure of the mobile and fixed telecom operators being merged are similar to those shown in Figures 2 and 5 respectively.

The base case of the simulations is observed in line 1 of Figures 9, 10 and 11. It was also considered that the merging process was implemented in month 78. The direct impacts identified after merging the three telecom operators were achieving scale economies for infrastructure implementation, increasing the number of distribution channels for a merged service, and a better investment distribution, when using aggregated economic resources. The performance achieved by the merged telecom operator after the simulations was a considerable increase of the fixed and mobile telecom subscribers, and the improvement of the aggregated economic resources, as observed in line 2 of Figures 9, 10 and 11 respectively.

In addition to validate the merging process of the three telecom operators, some additional recommendations were made in order to successfully implement this process. Among these recommendations was the reduction of the operating costs by improving the operational efficiency. This strategy was able to improve the economic resources of the merged operator and the number of fixed subscribers, as shown in line 3 of Figures 11 and 9 respectively. The mobile subscribers were not improved since the mobile service remained under the same MVNO scheme.

The use of new business models for integrated wired and wireless services was another recommendation made to successfully implement the merging process. This strategy consisted on providing a more appealing and integrated wireless and wired services to the fixed telephone subscribers with the main purpose of increasing the number mobile clients of the merged company. It was shown through the simulations that this strategy was able to improve the fixed and mobile subscribers and the economic resources of the merged operator, as observed in line 4 of Figures 9, 10 and 11 respectively.

The use of wireless technologies in rural areas was the final recommendation made and was also implemented in the model. The simulations showed that this strategy was able to improve the number of fixed subscribers and the economic resources of the merged operator, as can be seen in the line 5 of Figures 9 and 11.

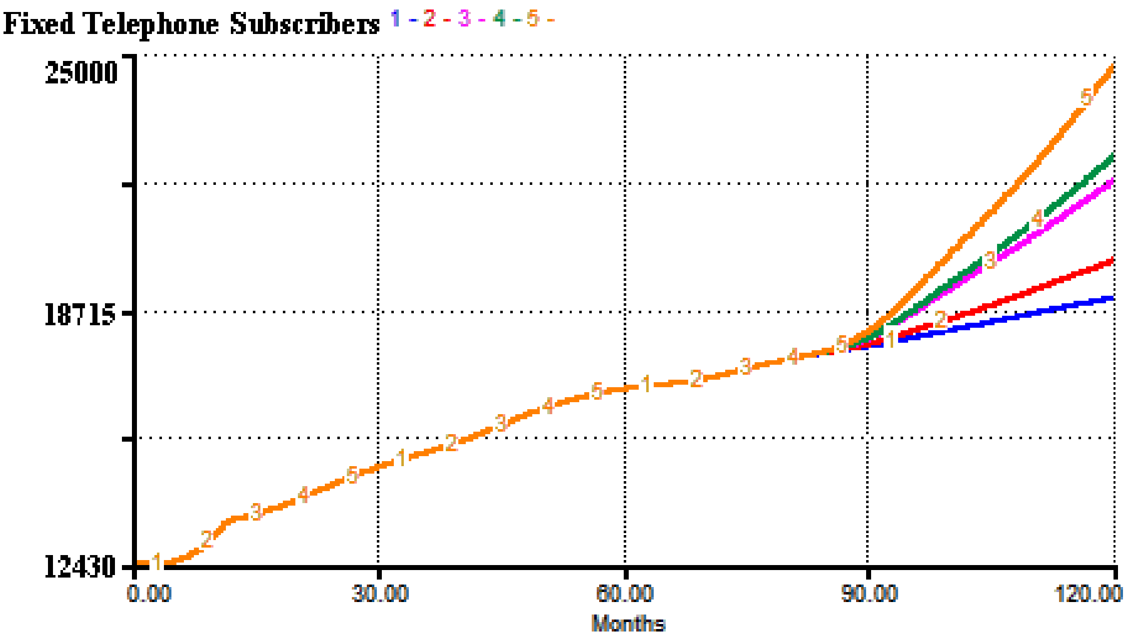

Figure 9. Fixed Subscribers for Different Strategies of the Merged Operator

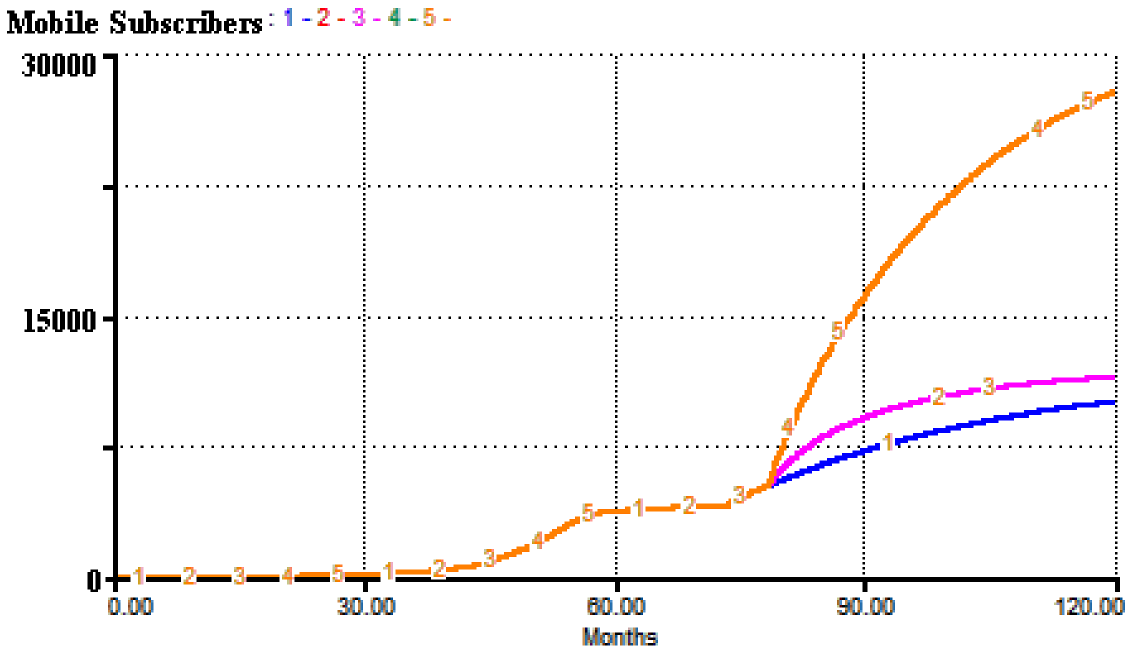

Figure 10. Mobile Subscribers for Different Strategies of the Merged Operator

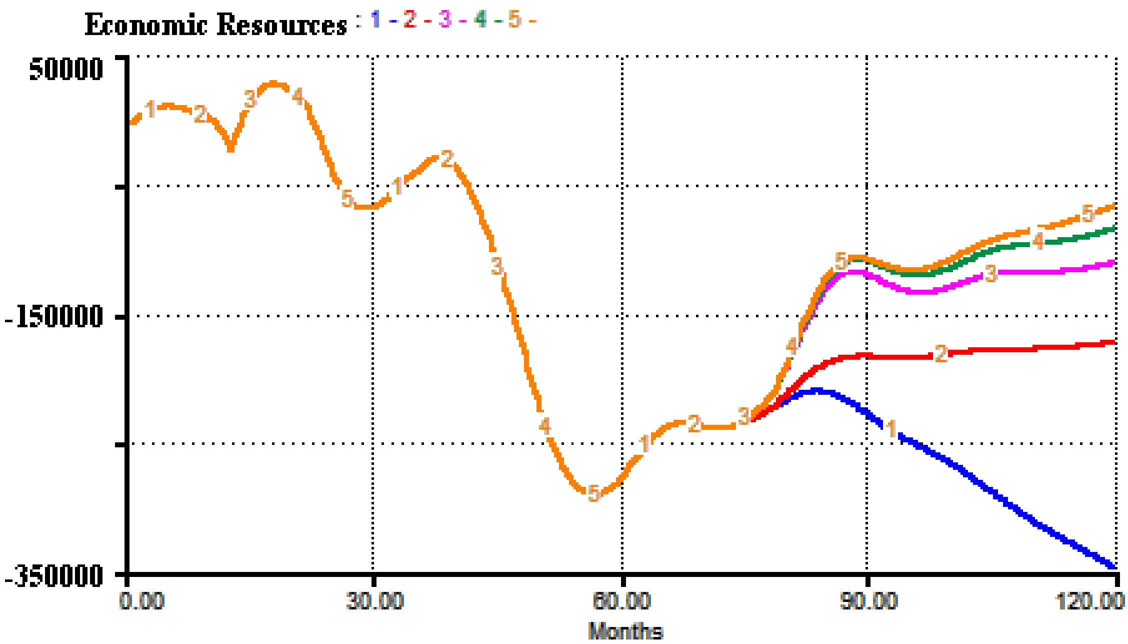

Figure 11. Economic Resources for Different Strategies of the Merged Operator

4. Validating a New Universal Service Policy.

The proposed policy under analysis consisted of a variable rate for the universal service fee, which should be charged to the fixed telecom operators of the country. The two main purposes behind this variable percentage were to increase the universal service fund and to reduce cream skimming of profitable subscribers in urban areas. The universal service fee contributed by each fixed operator was calculated as the product between the revenue from its service operation, and this universal service rate represented as a percentage.

Under this new universal service policy, the fixed telecom operators that were focusing mostly in high-income urban areas clients should be charged a higher universal service rate, and operators that were investing considerable resources to the expansion of fixed telephone services in rural areas should be charged a lower universal service rate. Then, this universal service fee was defined as a decreasing linear function of the rural and urban-low income telephone density. The rural and urban-low income telephone density was calculated as the proportion of the operator total capacity implemented in rural and urban-low income areas.

The causal structure of the system is shown in Figure 12. In this figure is observed two fixed telecom operators, operator 1 and operator 2. The operator 1 invests on the rural and low-income urban network besides the urban profitable network, and the operator 2 only on profitable urban areas. The operator 1 and operator 2 contribute to the universal service fund, which is invested on telecenters and infrastructure to deliver Internet connectivity for public elementary schools.

In Figure 12, it is also observed the cream skimming process in profitable urban areas. The operator 2 is doing cream skimming because only invests in high-income urban areas, as shown in positive feedback loop 11, reducing the number of profitable urban subscribers from operator 1.

In addition, this causal structure shows the causal relationships behind the implementation of this variable universal service rate. The higher the urban telephone density, the higher the universal service rate, as shown in negative feedback loops 9 and 12 of Figure 12, and the lower the rural and low-income urban telephone density, the higher the universal service rate, as shown in positive feedback loop 10 in the same figure.

In addition, the feedback loops 9, 10 and 12 show how the universal service fee reduces the economic resources of the telecom operator, which are used to increase telecom capacity and the number of urban and rural subscribers of the operators.

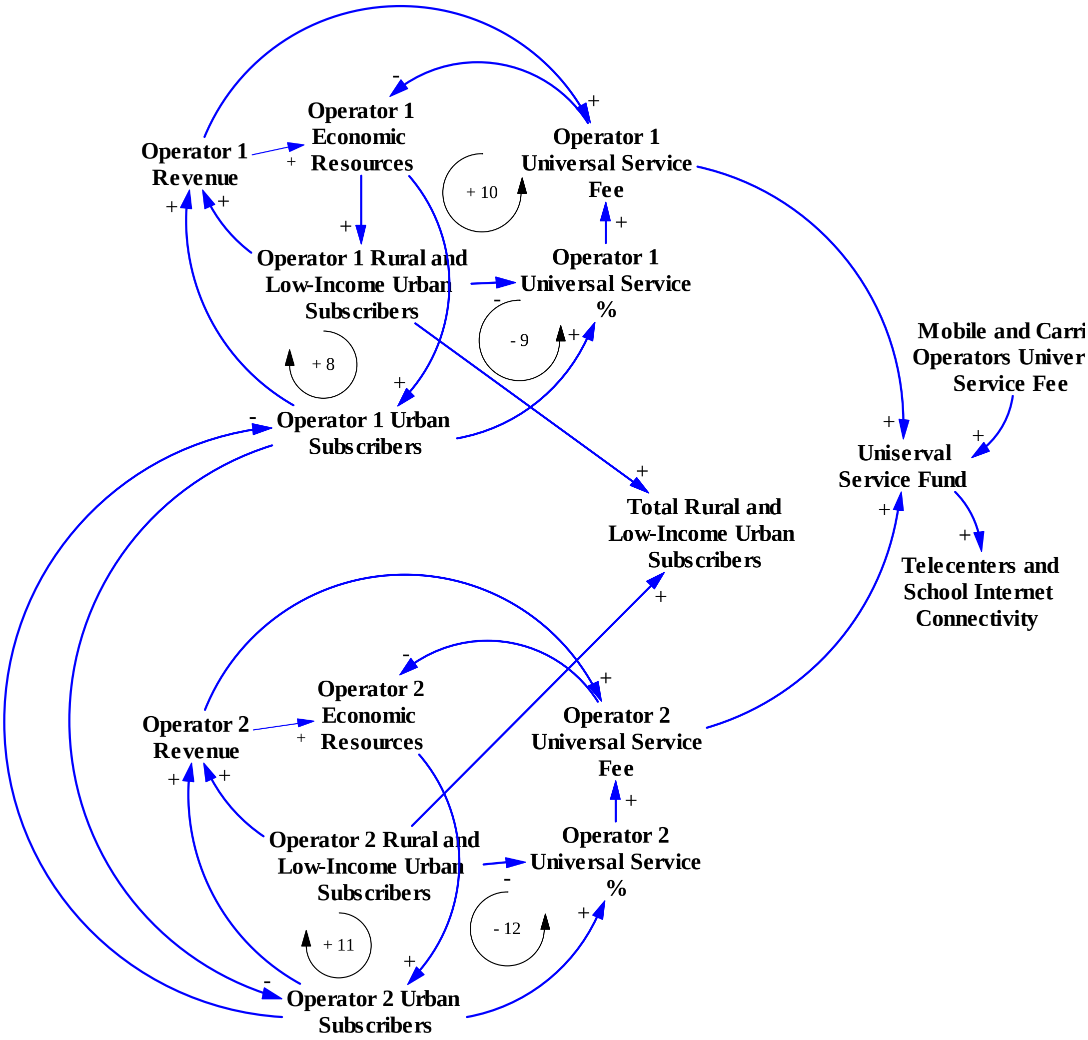

Figure 12. The causal structure of the impact of a universal service variable rate

The model was simulated combining this universal service variable rate with other universal service policies. The base case of the simulations is observed in line 1 of Figures 13 and 14. It was also considered that these policies were implemented in month 108. The implementation of the universal service variable rate alone was able to considerably raise the universal service fund collected from the fixed telecom operators, as can be seen in the causal structure of Figure 12. However, this policy did not improve the rural telecom capacity, as observed in line 2 of Figure 13, and did not close the urban-rural telecom gap.

On the other hand, this policy was able to reduce the number of profitable urban subscribers from operators focused mostly on these types of clients, and transferred them to the operators that have been also investing in rural areas, reducing the so-called cream skimming. An important aspect of this policy implementation is that the total number of urban subscribers did not reduce, as can be seen in line 2 of Figure 14.

The combination of this universal service variable rate with two different universal service obligations is also simulated using the model. The first universal service obligation implemented by the model mandated the fixed telecom operators to invest four percent of its new telecom capacity in rural and low-income urban areas. This implementation reduced the number of rural subscribers and improved the number of urban subscribers, as observed in line 3 of Figures 13 and 14 respectively, which is a counterproductive result. This happened basically because this level of investment in rural areas is lower than the investment being actually made by the type of operator number one in Figure 12.

The second universal service obligation combined with this universal service variable rate, mandated the fixed telecom operators to invest nine percent of its new telecom capacity in rural and low-income urban areas. This implementation improved a little bit the number of rural subscribers while at the same keeps the same number of urban subscribers, as shown in line 4 of Figures 13 and 14 respectively. This improvement is achieved because the level of investment in rural areas is equivalent to the one being actually made by the type of operator number one in Figure 12.

Finally, if the last combination of universal service variable rate with universal service obligation also considers investing fifty percent of the total universal service fund in rural and low-income urban areas, a considerable improvement in the number of rural subscribers is achieved, as can be seen in line 5 of Figure 13. However, the total number of urban subscribers still remains the same, as observed in line 5 of Figure 14.

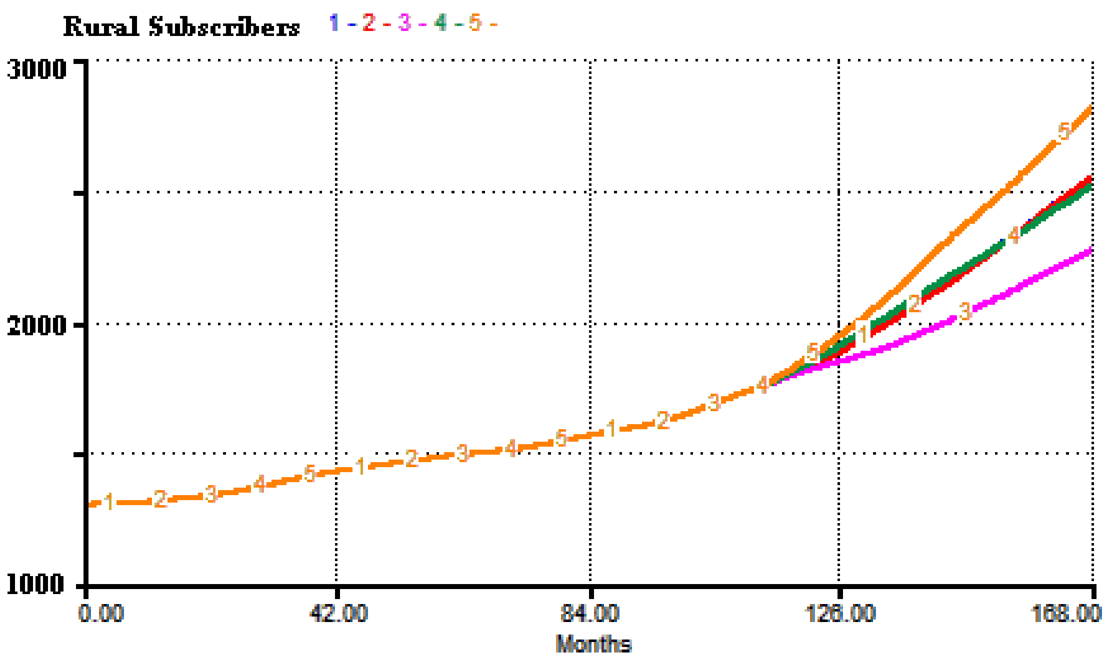

Figure 13. Rural Subscribers for Different Implementations of the Universal Service Variable Rate

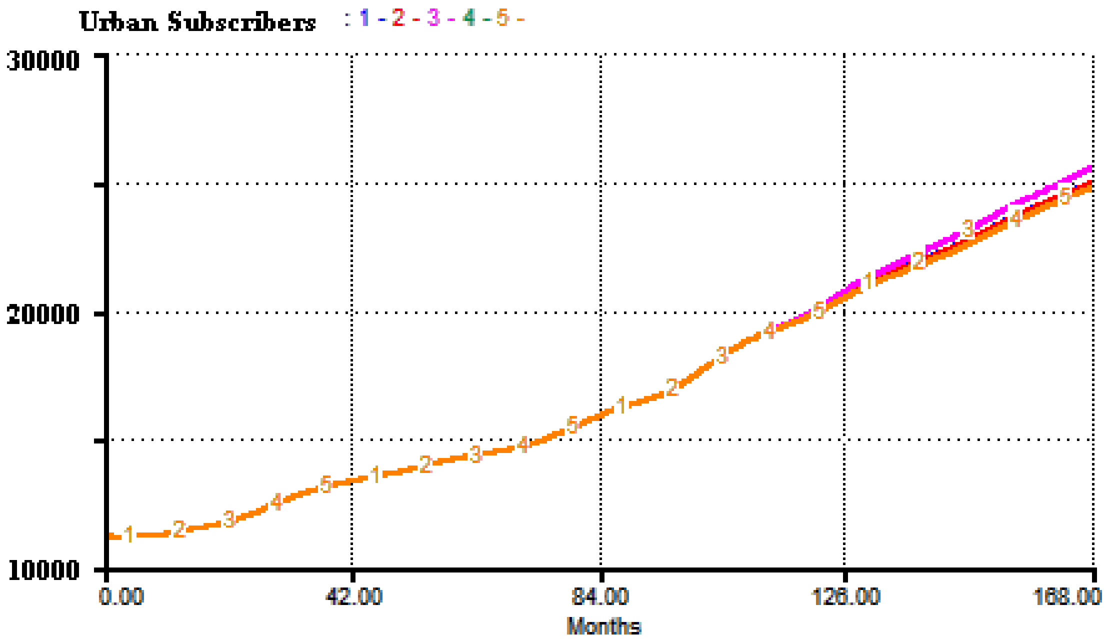

Figure 14. Urban Subscribers for Different Implementations of the Universal Service Variable Rate

5. Validating a Tax Policy for the Telecom Sector.

The economic crisis worldwide affected the economic resources of the country, and a tax rate to the cellular phone calls was proposed in order to raise its fiscal revenue and investment budget. This cellular tax was intended to be applied to the generated cellular traffic, and was calculated as the product of this proposed cellular traffic tax rate with the revenue generated from the cellular traffic.

The causal structure of the impact of a cellular traffic tax is shown in Figure 15. It can be seen in the negative feedback loop 14, that the cellular traffic tax rate increases the cellular traffic tax and the total collected cellular taxes. On the other hand, the total cellular taxes reduce the cellular operator profit, which is used to improve telecom capacity and later the revenue of the mobile operator. Additionally, it is observed in negative feedback loop 16 that the reduction of the operator profit also tends to reduce the income tax and the total collected taxes from the operator.

It can also be seen in negative feedback loop 15 of Figure 15 that total collected taxes are also increased by the value added tax, which depends on the cellular revenue and cellular capacity. Finally, the cellular revenue tends to improve the operator profit as observed in positive feedback loop 13.

It was shown by the simulations that the application of a cellular traffic tax rate increases the collected cellular traffic tax, and the total collected cellular taxes at the beginning. However, this reduces the cellular operator profit and the operator income tax, which reduces the total collected cellular taxes in the long term, in spite of an increase on the cellular traffic tax. In other words, it was found by this investigation that the implementation of a cellular traffic tax rate yields counterproductive results.

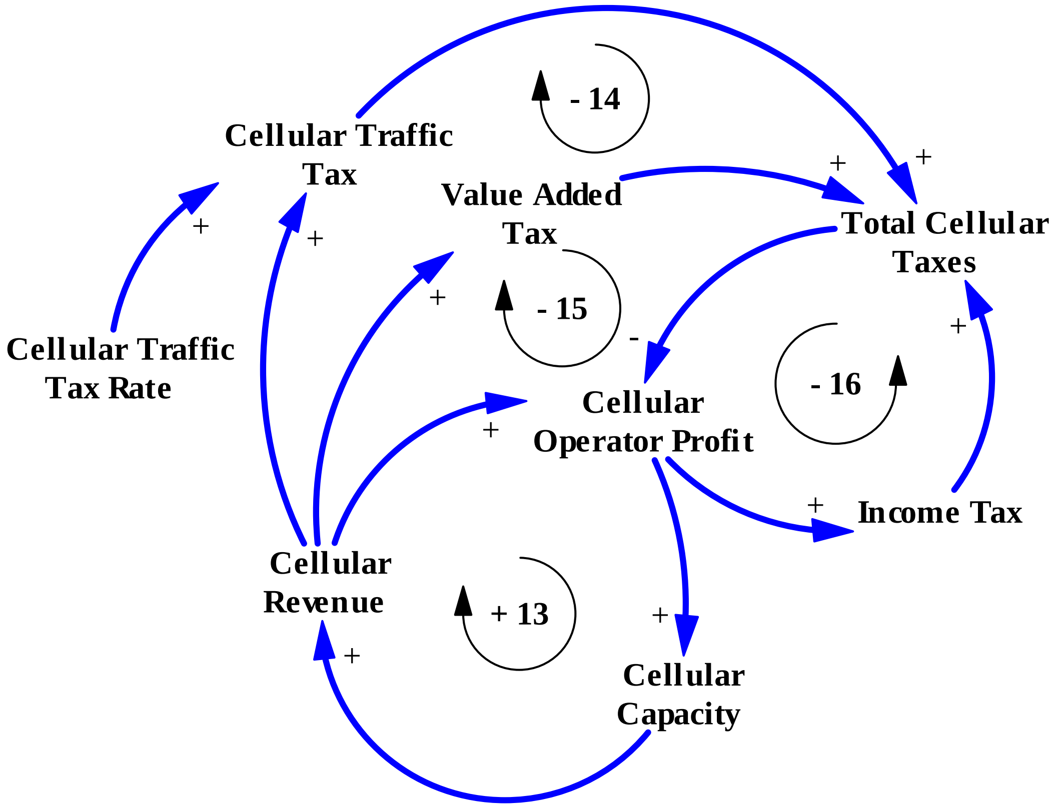

Figure 15. The causal structure of the impact of a cellular traffic tax

Conclusions

This telecom model was extended to test, design, and validate several telecom policies and strategies in a country. This article shows real applications of the model and its effectiveness to find counterproductive behavior, deficient policies, and actual causes of policy implementation failure in the telecom sector.

It was concluded after the simulations that implementing a cellular traffic tax rate produces counterproductive results, and implementing a MVNO strategy could also be counterproductive, if this is not accompanied by appropriate complementary strategies.

The strategy of merging three telecom operators and a proposed universal service policy were found to be deficient, through the simulations of the model.

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