

**A System Dynamics Approach to the Car
Ownership Trend in Taiwan Urban Areas**

by

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ABSTRACT

The economy in Taiwan grew rapidly in the last decade. This steep increase strongly affects its transportation system: the number of cars in the urban areas increased dramatically. Some studies forecasted that the number of car in Taiwan urban areas in 2000 will be three times of that in 1984. However, those studies did not consider the feedbacks from the traffic and parking conditions to the car ownership. In addition, some of the possible changes in the system environment are also not being considered, such as the increasing life expectancy of the car, the shortening car renewal period and the more and more attractive car purchasing loans policies. This study is an attempt to apply system dynamics methodology to analyze the trend with the inclusion of feedback and the above mentioned system environment changes. The results show that due to the feedbacks from the limited capacity of roadway and parking and the influence from the system environment, the number of cars in urban areas will only be doubled in the year of 2000. Although the data for this research were very limited, by using the system dynamics methodology we are able to have a better picture of the future trend of the car ownership in Taiwan.

INTRODUCTION

The economic growth in Taiwan, the Republic of China, in the last decade was very impressive. The per capita income increased about 8% per year [1]. This steep increase also affects the transportation system in Taiwan, especially in the urban areas. The number of cars increased dramatically; according to statistical data, there were only 2.9 cars per 1000 people in Taiwan in 1965 but increased to 64.6 cars per 1000 people in 1984 [2]. This car ownership index is much higher in the urban area such as Taipei and Kaohsiung which are the two largest cities in Taiwan. Based on car registration data in Taipei, the increasing rate of number of car last year was about 16% [3].

Some studies use statistical analyses, behavioral approaches and economic models to estimate the future trend of car ownership [e.g. 4,5,6,7]. They forecasted that the number of car in Taiwan urban areas in 2000 will be three times of that in 1984. However, those studies did not consider the feedbacks from the traffic and parking conditions to the car ownership. In addition, some of the possible changes in the system environment are also not being considered, such as the increasing life expectancy of the car, the shortening car renewal period and the more and more attractive car purchasing loans policies.

This study is an attempt to apply system dynamics methodology to analyze the trend with the inclusion of feedback and the above mentioned system environment changes. Our major objective is not to estimate the trend more precisely than those studies, but to show that the dynamic and contingent characteristics of this system and its environment significantly influence the future trend.

THE MODEL

As mentioned earlier, the higher per capita income in Taiwan will affect the condition of the transportation system in the urban area. Car, which is considered as the most convenient transportation mode, will be the main target for the people to purchase as their per capita income grows. The purchasing power is increased due to the higher per capita income and the attractive car loan policy which will also make the purchasing power even higher. The higher the purchasing power, the higher the demand to own a car and this will

increase the number of cars especially in the urban area. This condition, however is not favourable to the transportation system which is limited, or slowly expanded due to the limited space and other considerations. The traffic density in Taipei right now is so high that the increasing number of car will only create more traffic congestion. This condition will discourage people to drive or buy a car as their transportation mode. Basically, the high traffic density will urge the government to build more highways. But due to the limited space of urban area in Taiwan, constructing new highways are only about 3% per year [3]. These causal relationships are shown in Fig. 1.

More cars require more parking places. When the parking capacity is not enough to accomodate the parking demand, the searching time for parking increases dramatically and discourages the car purchasing behavior consequently. On the other hand, when the parking problem gets more serious, the government and some private company tend to build some off-street parking places to satisfy the needs. Nowadays most of the cars in Taiwan are still parked on the street [7]. However, when the volume/capacity ratio of traffic exceeds a certain level, in order to increase the road area for traffic, curb parkings are prohibited. The causal relationship between parking and the growth of cars is shown in Fig. 2.

The quality of car in Taiwan was quite improved after 1981 due to Japanese technology transfer which lengthen the average car expectancy and reduce the average car price accordingly. The high-income people tends to renew their car more frequently and the attractiveness of car loan policy will enhance the tendency as well. In addition, we have noticed that the society's peer pressure in Taiwan tends to shorten the average car renewal period. The more frequent car renewal will lower the price of second hand car and subsequently reduce the average car price. This description is shown causally in Fig. 3.

COMPUTER SIMULATION

BASE RUN

The simulation model is run from 1980 to 2000. Fig. 4 shows the result of the base run, in which we assume that the average car life

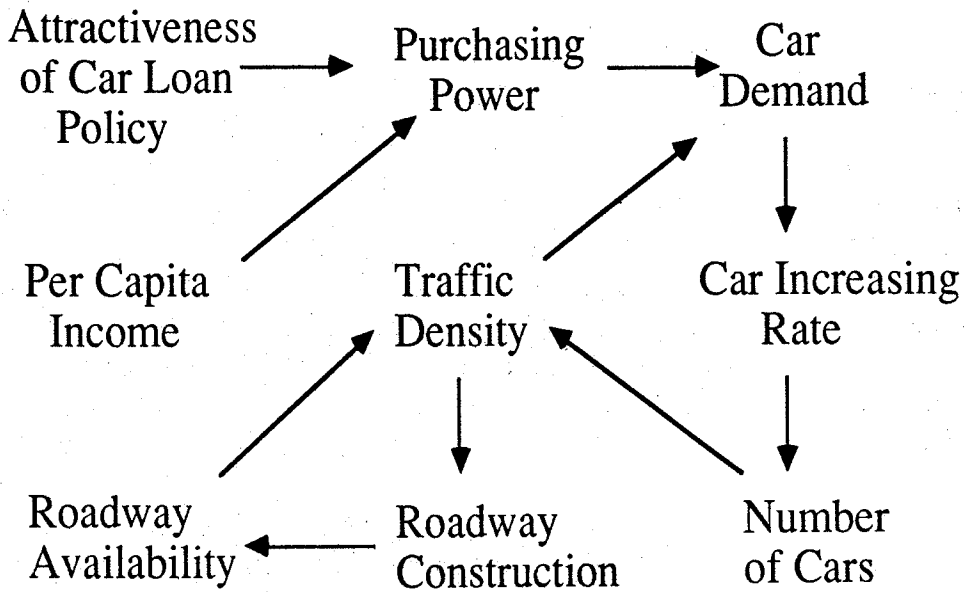


Fig. 1 Traffic-Related Causal Diagram

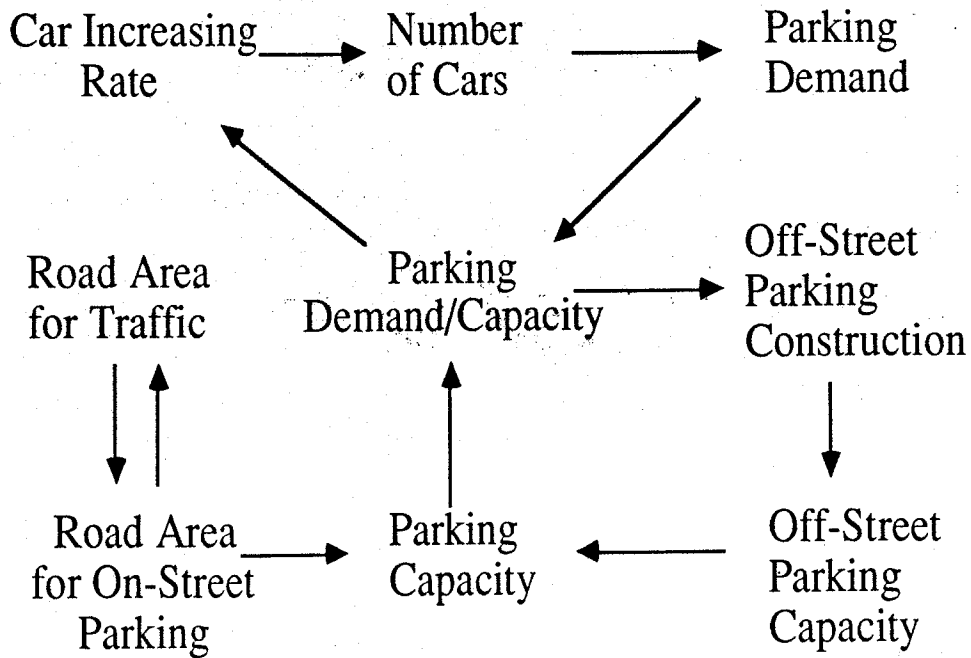


Fig. 2 Parking-Related Causal Diagram

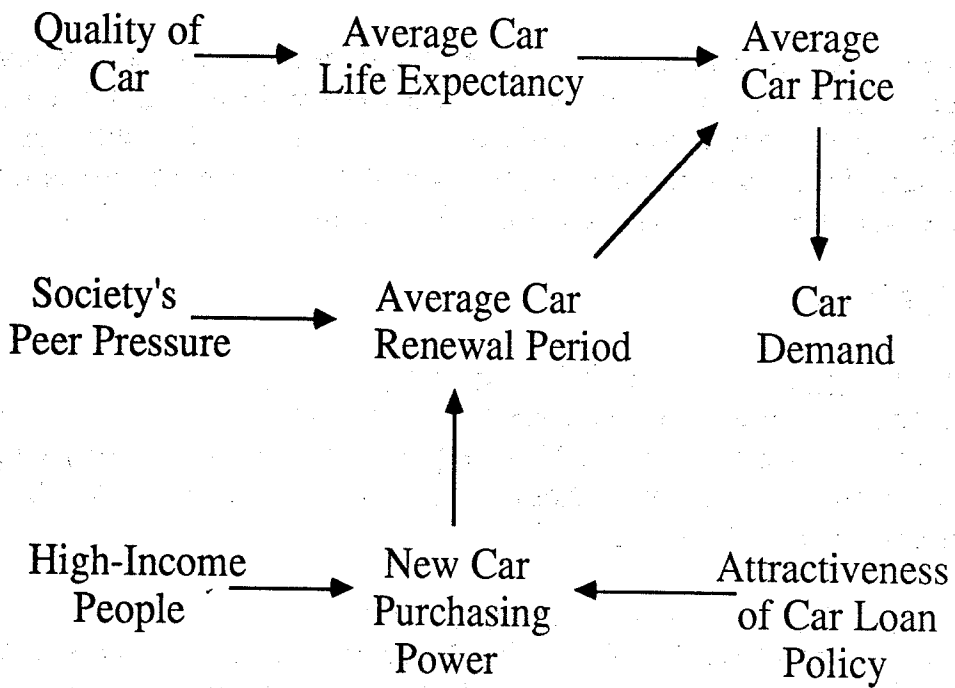


Fig. 3 The Influences of Life Expectancy and Renewal Period to Car Demand

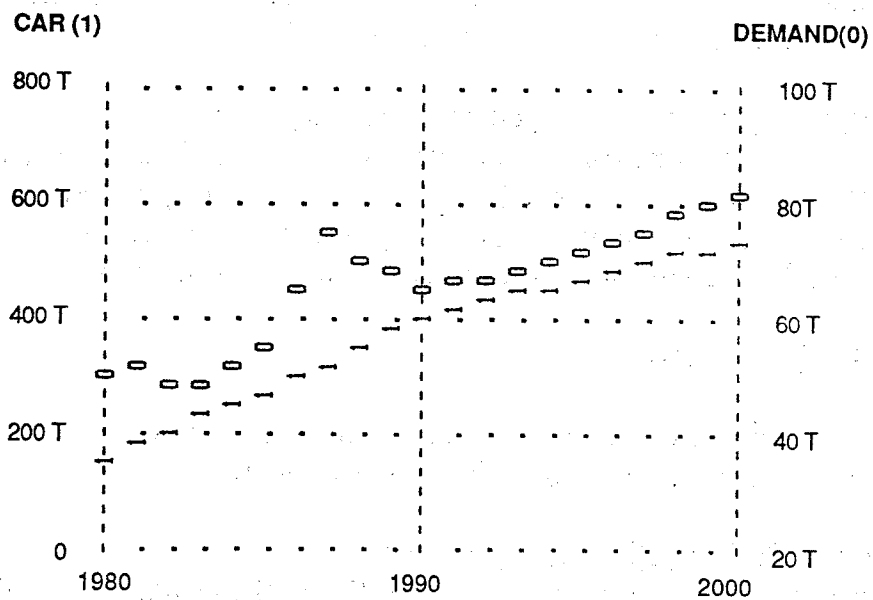


Fig. 4 Base Run

expectancy is a constant of 8 years and the average car renewal period is set to be 6 years. The car loan policy is assumed not significant enough to be considered. It can be seen that although the demand fluctuates, the number of car is still growing steadily and the total number of car will be about 540,000 in the year of 2000.

SCENARIOS

Scenario 1: Increasing Life Expectancy of the Car

Referring to Fig. 5, we can see that increasing life expectancy will increase the number of car. This happens because the cars stay longer before they are removed from its service. The estimate number of car in the year 2000 is 575,000.

Scenario 2: Shortening Car Renewal Period

It can be seen from Fig. 6 that the shortening car renewal period does not affect very much the number of cars as we compare with base run in Fig. 4.

Scenario 3: More Attractive Car Loan Policy

The car loan policy which started to be effective in the year of 1986 gives a sudden impact to the demand and the increasing rate of car, but the trend does not continue on its track as the demand of car are affected more by the limited growth of highways and parking spaces. The result of this scenario is shown in Fig. 7.

Scenario 4: Combination of Scenarios 1, 2 and 3

It can be seen from Fig. 8 that the impact of car loan policy is very effective at the time when this policy is just being introduced, and due to the higher car life expectancy, there will be more car in the year of 2000 (about 585,000) as compared with the base run.

POLICY TESTING

The following policy tests are conducted to scenario 4 only, since this scenario is considered as the most reasonable one.

Policy 1: Parking Place Enforcement

Government is considering to apply the parking policy -- "The car buyers are obliged to have a parking place before hand" -- in order to minimize the parking problem in the urban area. Most of the residential area in Taiwan has no parking area. Applying this policy

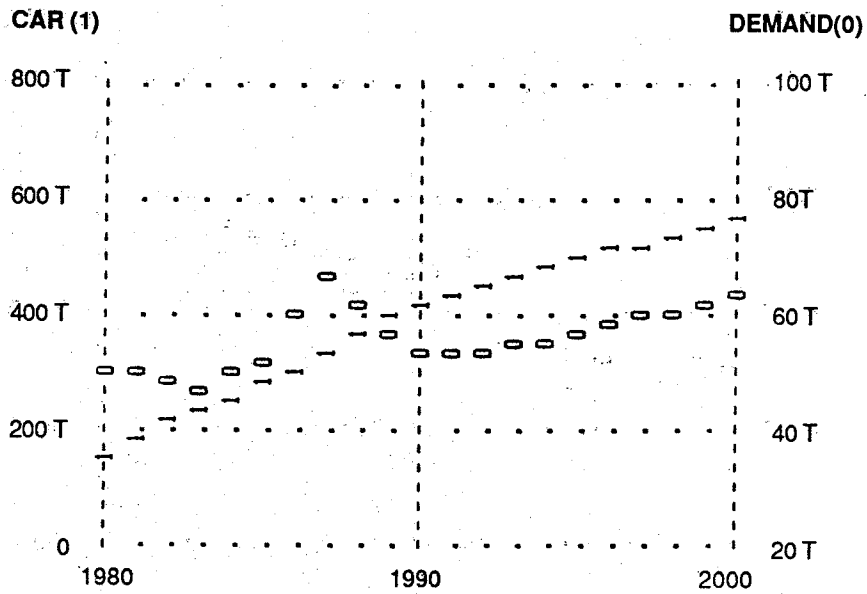


Fig. 5 Scenario 1 - Increasing Car Life Expectancy

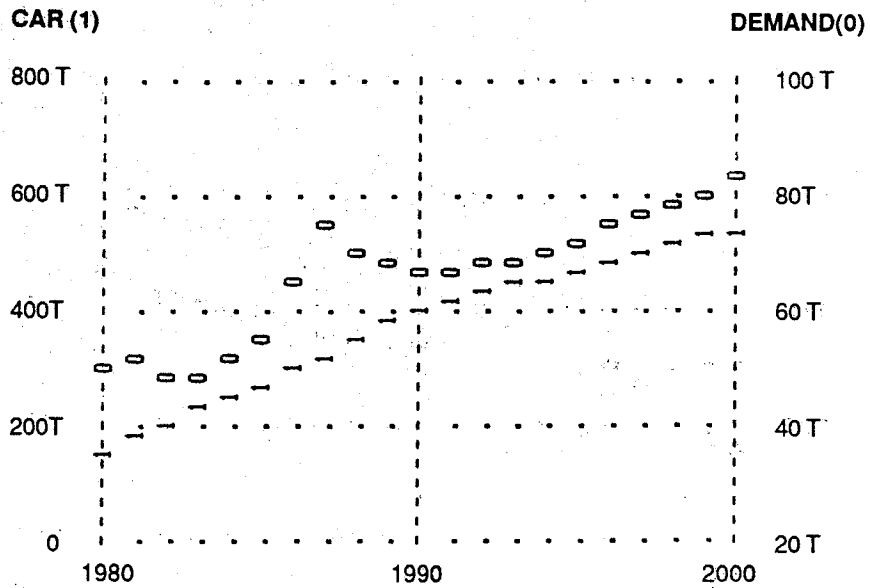


Fig. 6 Scenario 2 - Shortening Car Renewal Period

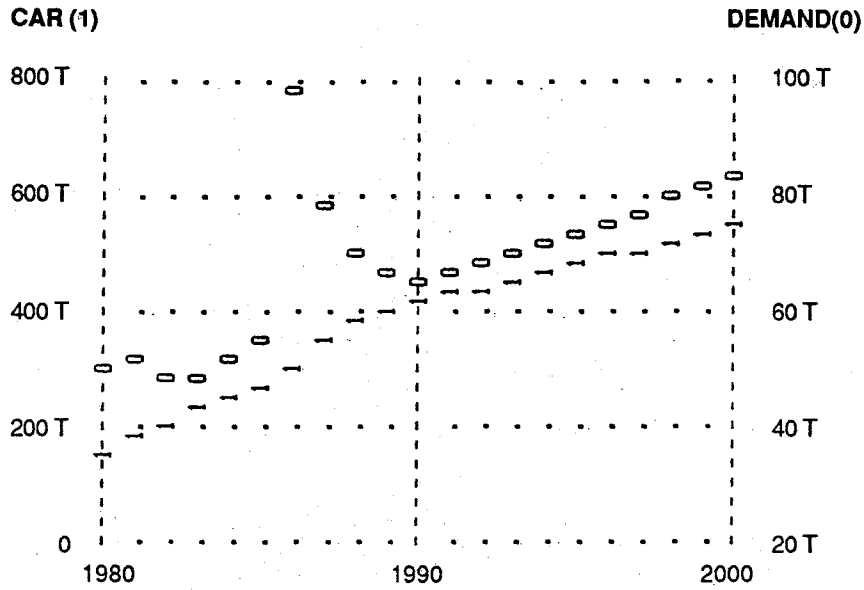


Fig. 7 Scenario 3 - More Attractive Car Loan Policy

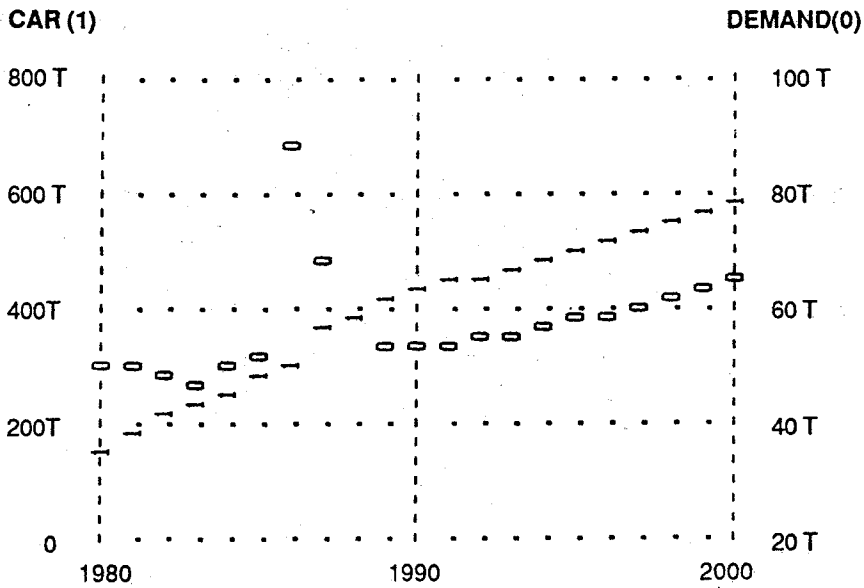


Fig. 8 Scenario 4 - Combination Scenarios 1,2 and 3

will make the people think twice before they buy a car. The costly land price in the urban area makes the parking place also expensive. Usually the price is as expensive as the car price itself. The high price of parking space really affects the car demand and the number of cars subsequently as shown in Fig. 9. Based on this policy, there will be only about 550,000 of car in the urban area.

Policy 2: Curb Parking Prohibition

When the volume/capacity of traffic exceeds a certain level, curb parkings are prohibited to increase the capacity of roadways for traffic. The result is shown in Fig. 10. This policy slightly affects the pattern of car demand and the number of cars as compared to Fig. 8. But the estimate number of car in the year 2000 is much higher, i.e. 634,000. This happens because the increasing rate of off-street parking is faster than the road construction.

Policy 3: Transportation System Management

Transportation System Management measures such as ridesharing, exclusive bus lane, staggered working hour, etc. might be applied in the future to avoid the traffic congestion in the urban area. This policy is intended to better use of the existing urban streets. From Fig. 11, it can be seen that the effect of this policy is not very significant (about 570,000 cars in 2000).

Policy 4: Combination of Policies 1, 2, and 3

Applying those three policies will reduce the demand significantly in 1988, but afterwards the trend does not vary that much as compared to Fig. 7. It is shown in Fig. 12 that applying all policies will not reduce the number of cars as much as policy 1 does, since policy 2 may attract more people to have cars.

DISCUSSIONS

As mentioned in the introduction, some studies forecasted that the number of car in Taiwan urban areas in 2000 will be three times of that in 1984. However, the above simulation results show that due to the feedbacks from the limited capacity of roadway and parking and the influence from the system environment, the number of cars in urban areas will only be doubled in the year of 2000.

Although the data for this research were very limited, by using the system dynamics methodology we are able to have a better

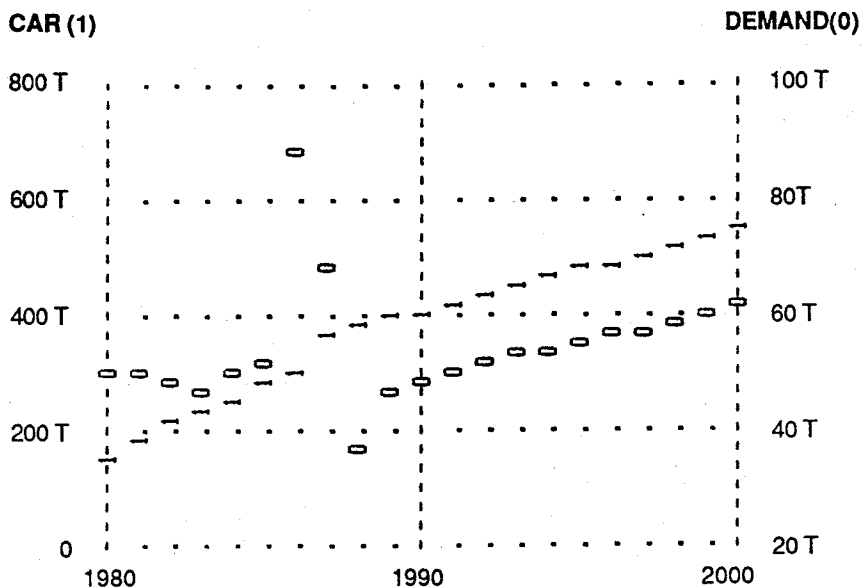


Fig. 9 Policy 1 - Parking Place Enforcement



Fig. 10 Policy 2 - Curb Parking Prohibition

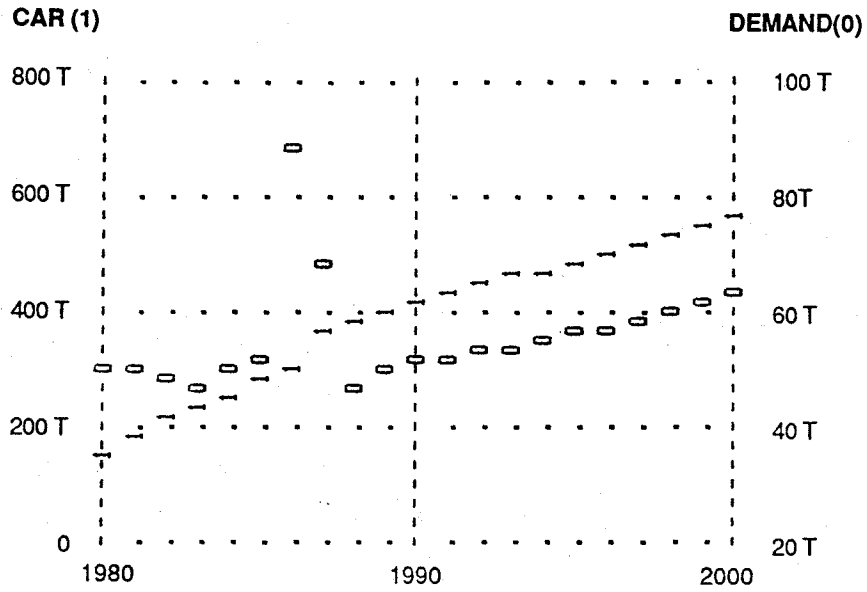


Fig. 11 Policy 3 - Transportation System Management

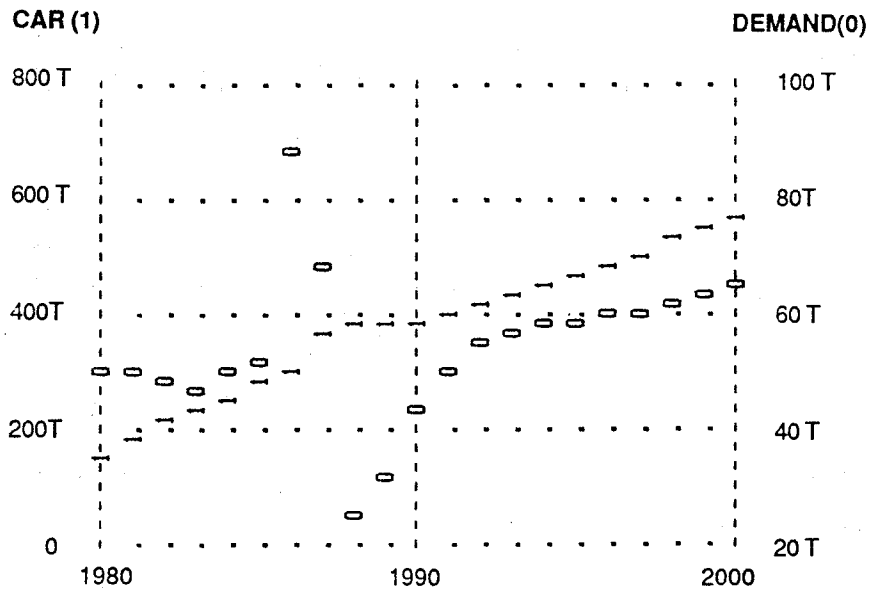


Fig. 12 Policy 4 - Combination of Policies 1,2 and 3

picture of the future trend of the car ownership in Taiwan. The model is far from complete and it is open for further studies.

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