Structural policies to address induced travel demand by road construction.

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Abstract

Nowadays in developed countries road construction is no longer an exclusive policy to reduce congestion because evidence has been found of how new roads enhance car use. This phenomenon is known as induced travel demand (ITD) in which new roads induce increases in the number of kilometers traveled by vehicles. However, in spite of available evidence about ITD we have not found works that discuss ITD in urban contexts of some Latin American (LA) countries wherein road construction is still used to reduce traffic congestion. This suggests that although ITD has already been studied and debated abroad, there has not been a full appropriation of this knowledge at the LA level. In this paper we want to provide policy insights of the dynamic effects of public transport and congestion pricing, two mobility policies widely discussed in LA countries, on ITD within urban contexts where road construction is still necessary to guarantee connectivity. These insights are based on a system dynamics model whose feedback untangles the structural complexity underlying ITD and allows evaluating the effects of above-mentioned policies on it. The model proposed can be conceived as useful simulation tool that can support decision-making processes that LA policy makers could face.

Key words: Induced travel demand, public transport, congestion pricing, system dynamics, public policy, dynamic modeling.

Introduction

Nowadays countries in Europe, Asia, North America and Oceania have adopted a new transport planning paradigm (NTPP)[1] to address traffic congestion that is named smart congestion relief (Litman, 2015a). In those countries, road construction is no longer an exclusive policy to reduce congestion because evidence has been found of how new roads enhance car use. Econometric works have corroborated a positive correlation between road construction and motorized travel demand in which new roads, measured as linear kilometers, induce increases in the number of kilometers traveled by vehicles (Noland and Lem, 2002; Hansen, 1995). This phenomenon is known as induced travel demand (ITD), and it rebuts the effectiveness of road construction as single and sufficient policy to deal with traffic congestion (Ladd, 2012).

In Latin America few countries have implemented comprehensive strategies to adopt the NTPP with the exception of Brazil and Chile that have already done this. The old transport planning paradigm (OTPP), in which road construction seeks to improve mobility maximizing motor vehicle travel speeds, has prevailed as predominant approach in the remaining countries (Ortuzar, 2015; Rivasplata, 2013). In urban contexts of those countries rapid urban sprawl, high population growth, raised motorization rates and increased traffic congestion together with a lack of road infrastructure to guarantee connectivity have promoted a perceived need of more roads among transport policy makers. Consequently, public policy has been focused on investing more money to supply new and better roads that both fulfil the gap of infrastructure and improve traffic conditions.

However, in spite of available evidence about ITD in developed countries we have not found works that discuss ITD and evaluate its potential implications in urban contexts of Latin American countries wherein road construction, beyond the role of policy that provides connectivity, is still used to reduce traffic congestion. This suggests that although ITD has already been studied and debated abroad, there has not been a full appropriation of this knowledge at the Latin American level. In this paper we want to provide policy insights of the dynamic effects of high quality public transport congestion pricing, two mobility policies widely discussed in Latin American countries, on ITD. These insights are based on a system dynamics model whose feedback structure untangles

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[1] NTPP seeks to improve overall accessibility rather than motorized travel speeds. Besides, the NTPP takes into account multiple modes of transport and no only private vehicles.

the structural complexity underlying ITD and allows evaluating the effects of above-mentioned policies on this phenomenon.

Bibliographic review

Several works have approached ITD with econometric models that use elasticities as measure to estimate how much motorized travel demand can be induced by new roads (Litman, 2015b; Handy, 2014; Currie and Delbosc, 2010; Özuysal and Tanyel, 2008; Noland, 2004; Noland and Lem, 2002). Those models are built with forecasting purposes to match sets of outputs between specified ranges of accuracy without claims of causality in their structure (Barlas, 1996). They do not focus on providing structural explanations of the counterintuitive behavior in which mobility tends to be saturated despite building new roads.

ITD is a phenomenon already measured and corroborated but not structurally explained at all. Some authors have dealt with causation through Granger test and instrumental variables in least squares of two and three stages (Melo et al., 2012; Hymel et al., 2010; Özuysal and Tanyel, 2008; Cervero and Hansen, 2002; Cervero and Hansen, 2000; Noland and Cowart, 2000). However, these techniques do not deepen the structural complexity underlying ITD. Questions about causal links between motorized travel demand and road construction require a look beyond the linear relationship between kilometers traveled and kilometers built. To do this, it is needed to approach ITD with a systemic perspective to suggest sizing up this phenomenon, placing it in a wide enough context, and thinking about it as a system.

With system dynamics (SD) is possible to formulate statements of how ITD actually works. A SD approach offers to represent the complexity underlying ITD with feedback loops, non-linear relationships and delays, which are tools that fit better with characteristics of ITD, if it is assumed as a social phenomenon of transport that involves people behavior and the way in which they travel, instead of assuming a reductionist thinking that approaches in isolation the linear cause-effect relationship between kilometers traveled and kilometers built.

Shepherd (2014) set out a review of 50 peer-reviewed journal papers since 1994 that have used SD in transportation modeling. He categorized them by area of application and provided a summary of each paper. The fields of application range from fuel vehicles, supply chain management affecting transport, highway maintenance, strategic policy, airport infrastructure to airline business cycles. In the area of strategic policy, he reviewed the works of Pfaffenbichler et al. (2010) and Pfaffenbichler (2011) who introduced the concepts underlying the MARS LUTI model. That model discusses what the majority of car users, transport planners and politicians assume as true in the old transport planning paradigm: reducing congestion by permanently road construction is an effective policy that improves mobility. Those authors state that every time road capacity is increased, traffic volumes will go up and settle around previous levels of congestion. This is in accordance with Elias (2006) and Sterman (2000) who previously had discussed the unintended consequences of new roads on traffic.

Summarizing, we did a bibliographic review that covers the time period between 1992 and 2016. All papers reviewed were made under an econometric approach wherein elasticities are the main measures to quantify ITD. Though some works described in the paragraph above have stated structural explanations to the counterintuitive behavior in which mobility tends to be saturated despite building new roads, we did not find papers with a "causal-descriptive" or system dynamics approach that model and discuss explicitly ITD. This can suggest a lack of "white-box" models with causal hypothesis to explain the structural complexity of this phenomenon based on available statistical evidence provided by econometric works.

Method

System dynamics (SD) is a methodology based on feedback control theory equipped with mathematical simulation models by computer, which uses linear and non-linear differential equations. Jay Forrester at Massachusetts Institute of Technology developed this approach in the 1960s. Since then, it has been employed to deal with complex issues in various fields such as urban dynamics (Forrester, 1969), business and management (Sterman, 2000), education and learning (Andrade et al., 2014; Forrester, 1994), economy and environment (Ford, 1999). The purpose of SD in these areas has focused on explaining structurally and modelling complex phenomena represented as systems for understanding their behavior over time.

To build a system dynamics model involves an iterative process. In the progress from one-step to the next, the modeler moves backward and forward through each methodological tool that SD offers to create a model as abstraction of a real phenomenon (Sterman, 2000). For this paper, we assumed these methodological tools as a set of languages in which each of them represents a particular view of the model (Andrade et al., 2001). This methodological assumption corresponds to the modelling methodology of "five languages" proposed by Andrade et al. (2001) that is shown in Figure 1. The model was built with Evolución 4.5[2], a software platform created by SIMON[3] research group at Universidad Industrial de Santander (Colombia) to develop system dynamics models.

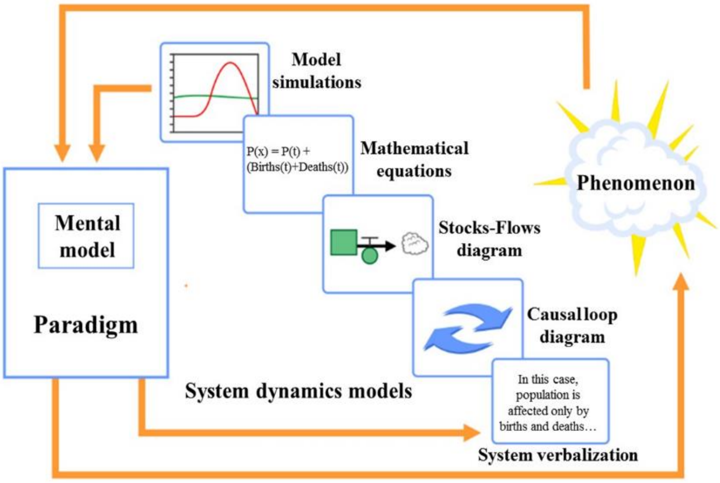

Figure 1. Methodology for building the system dynamics model. Source: adapted from Andrade (2001).

System Dynamics model

The feedback structure in Figure 2 shows a dynamic hypothesis of ITD. The "*Intuitive policy*" balancing loop depicts how traffic congestion is mitigated by building new roads. Once the road construction has finished, this policy brings immediate positive effects, such as, higher travel speeds and lower travel times. Nonetheless, new roads alleviate a symptom corresponding to a deeper problem: a high dependence of private vehicle as means of transport. The side effect of road construction appears in a medium-term time horizon caused by the "*Induce travel demand*" reinforcing loop. Higher travel speeds enhance attractiveness of car use; consequently, this benefit induces drivers to travel more kilometers. Then traffic congestion reappears equal or worse than its previous state before road construction.

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[2] More information about Evolución software in Andrade et al. (2010).

[3] For more information about SIMON research group, please visit www.simon.uis.edu.co

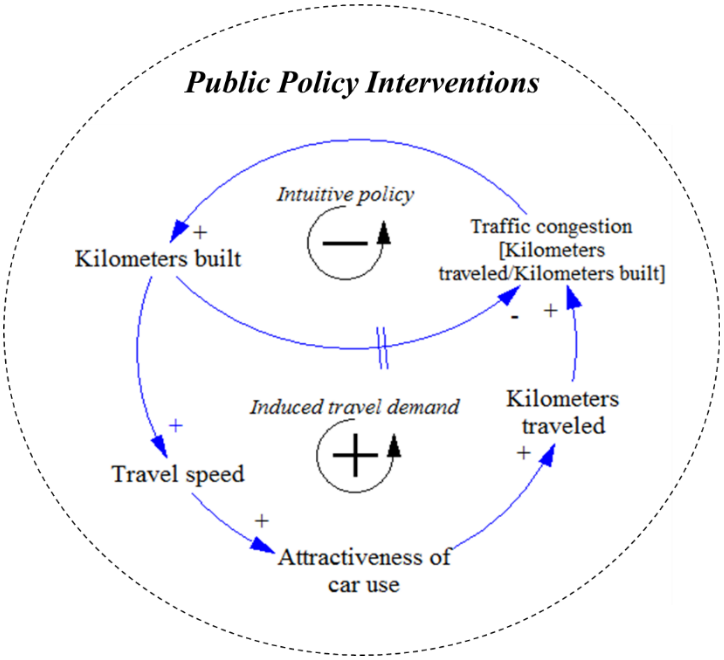

Figure 2. Feedback structure of ITD. Source: adapted from Angarita et al. (2015)

However, although the feedback mechanism in Figure 2 is a structural explanation of ITD, the structure's center is based on cars and travel speed as measure of travel performance. Within this framework the public policy interventions that can be deployed would be under the old transport planning paradigm. This means that new roads appear as the only policy that could address ITD. Therefore, we propose to move the structure's center from private vehicles to people. This allows talking about accessibility of people rather than mobility attached to cars traveling at higher speeds (Litman, 2015a). Besides, it is necessary to expand the boundaries of the model to consider alternative strategies beyond new roads that contribute to address ITD within urban contexts wherein road construction is still necessary to guarantee connectivity. Expanding the boundaries of the model we have identified two strategies to deal with ITD: discouraging car use by means of congestion pricing and high quality public transport, such as can be seen in Figure 3.

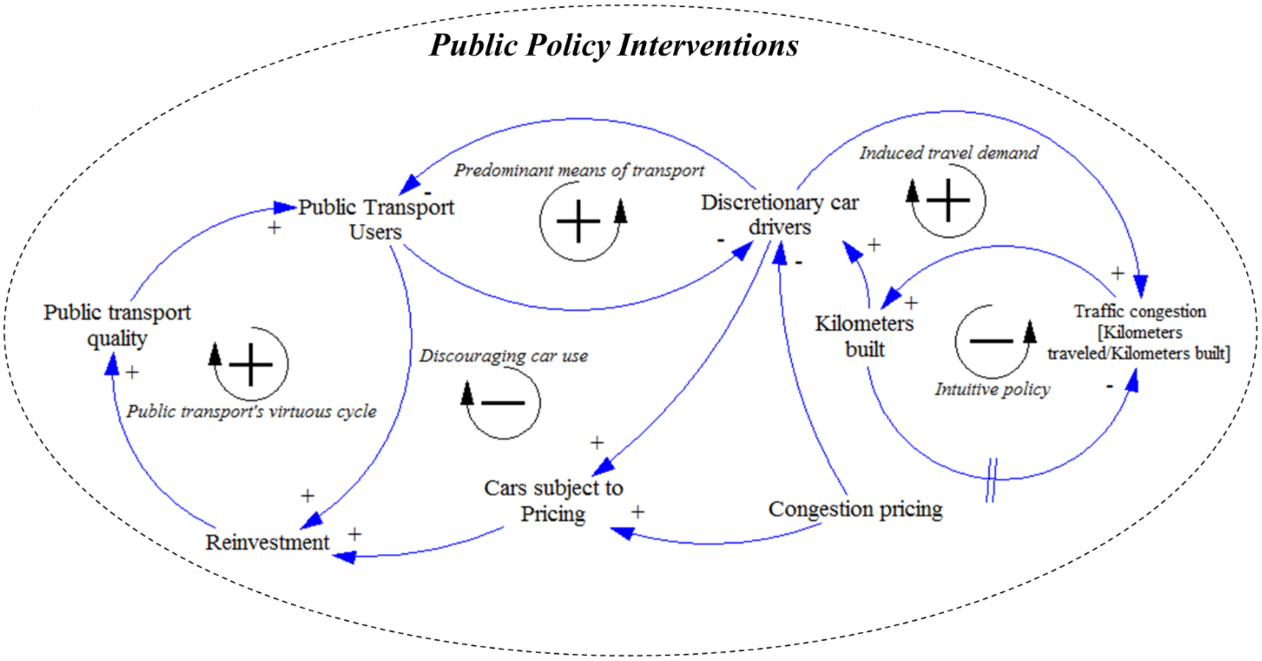

Figure 3. Feedback structure to intervene ITD. Source: authors.

The feedback structure in Figure 3 depicts a dynamic hypothesis to address ITD. The structure contains five feedback loops described below:

- *"Intuitive policy":* this balancing loop represents the intuitive decision-making process in which more roads are built to reduce traffic congestion. When road congestion increases more kilometers are built, and thus, traffic jams remain under control.
- "*Induced travel demand*": this reinforcing loop depicts how higher travel speeds induce drivers to travel more kilometers. This means that cars will tend to remain more time on roads, which causes that traffic congestion reappears equal or worse than its previous state before road construction.
- *"Predominant means of transport":* this reinforcing loop shows the movement of people from public transport to private vehicles, and vice versa. More people using public transport means that less discretionary drivers are on roads using their cars. However, lower traffic congestion induces more car use, which implies less people using public transport. This feedback loop depicts an exponential growth in the use of public transport or car that in some point reaches an equilibrium state. Such growth can be achieved by the mode that offers better conditions for traveling. In this sense, the rise of one means implies a decline for the other.

It is important to clarify that the use of private vehicle is influenced by instrumental, symbolic and affective variables (Yong Le Loo et al, 2015). Car drivers that are leveraged by both symbolic and affective variables are not willing to use other means of transport regardless traffic congestion because car represents social status for them. On the other hand, there are discretionary drivers who have to options: driving a car or using public transport. They are influenced by instrumental variables, such as travel speed, travel time, quality of service, etc. In this model we consider only discretionary drivers because they are the ones that can be attracted by high quality public transport.

- *"Discouraging car use":* this balancing loop shows how congestion pricing focused to discourage car use can contribute to reduce the number of private vehicles traveling on roads. More car use implies more private vehicles subject to congestion pricing. More cars subject to pricing means more money that can be invested in public transport to improve its quality. More public transport quality increases public transport use, and finally it decreases car use.
- *"Public transport's virtuous cycle"*: this reinforcing loop depicts how public policy can improve public transport quality ensuring efficient operation as well as high management performance of the public transport system. More public transport use generates more revenue coming from fares paid by users. More revenue poses more possibilities to reinvest and improve service quality. More public transport quality influences more users to travel in this transport mode. Finally, it is important to clarify that kind of public transport considered in this model is the bus rapid transit system.

The feedback structure in Figure 3 gives a qualitative representation that is useful for describing the influences of public transport and congestion pricing on ITD. However, decision-making processes require testing these policies. Then it is necessary to formulate the stocks-flows diagram, as the mathematical representation of the feedback structure in Figure 3, using a graphical language of accumulators and pipes that allows for computer simulation. The stocks-flows diagram can be seen in Figure 4. In addition, types, units and formulas of each variable are shown in Table 1.

The approach here is based on linking differential equations that are presented in terms of a graphical language of 'stocks' and 'flows', which keeps the model transparent and easy to understand. Stocks are depicted by rectangles suggesting a box that holds the content. Flows can be inflow to a stock or outflow from a stock. They are represented with valves that control the rate of flow into or out of the stock. Undergirding the notation of ‘stocks’ and ‘flows’ is the mathematical notation that shows how the stock is the integral of inflow minus outflow starting with an initial level of stock. As a stock with inflows and outflows is linked to other stocks and flows, the system structure is described by a set of linked linear and non-linear differential equations.

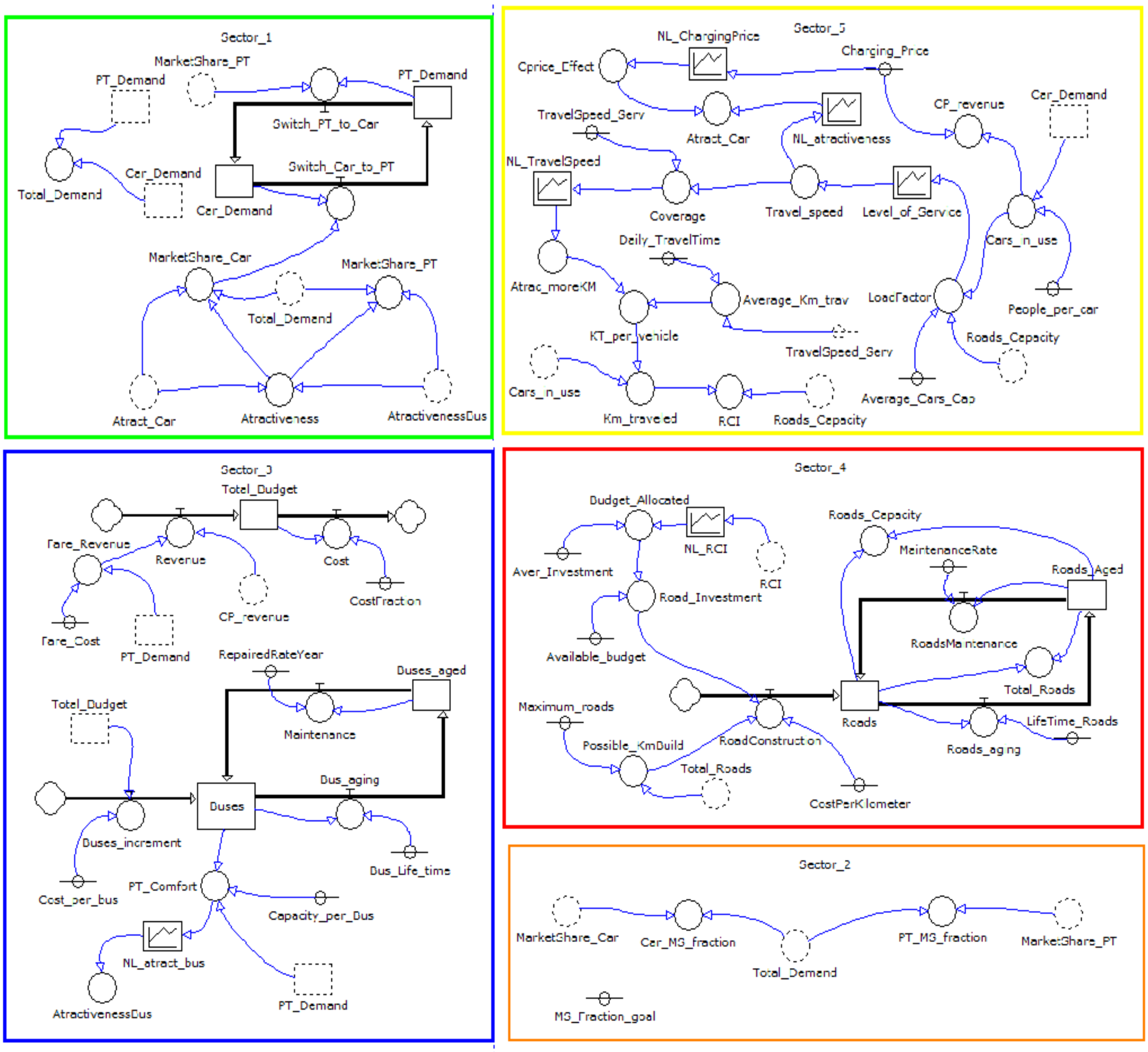

Figure 4. The stocks-flows diagram built on the basis of the feedback structure proposed in Figure 3.

Type	Variable names	Units	Formulas/Value
Levels	Buses	Buses	8000
	Buses_aged	Buses	Initial value = 1
	Car_Demand	People	Initial value = INT(40000)
	PT_Demand	People	Initial value = INT(90000)

	Roads	Kilometers	Initial value = 1319
	Roads_Aged	Kilometers	Initial value = 100
	Total_Budget	Colombian Pesos[4]	Initial value = 0
Flows	Bus_aging	Buses/year	Buses/Bus_Life_time
	Buses_increment	Buses/year	ABS(Total_Budget/Cost_per_bus)
	Cost	Colombian Pesos/year	CostFraction*Total_Budget
	Maintenance	Buses/year	Buses_aged/RepairedRateYear
	Revenue	Colombian Pesos/year	Fare_Revenue+CP_revenue
	RoadConstruction	Kilometers/year	MIN(Possible_KmBuild,(Road_Investment/CostPerKilometer))
	RoadsMaintenance	Kilometers/year	Roads_Aged/MaintenanceRate
	Roads_aging	Kilometers/year	Roads/LifeTime_Roads
	Switch_Car_to_PT	People/year	INT(IF(Car_Demand>MarketShare_Car,Car_Demand-MarketShare_Car,0))
	Switch_PT_to_Car	People/year	INT(IF(PT_Demand>MarketShare_PT,PT_Demand-MarketShare_PT,0))
Parameters	TravelSpeed_Serv	Kilometers/hour	60
	Available_budget	Colombian Pesos	50000000
	Aver_Investment	Dimensionless	1
	Average_Cars_Cap	Cars/kilometers	53
	Bus_Life_time	Years	15
	Capacity_per_Bus	People/Bus	90
	Charging_Price	Colombian Pesos	30000
	CostFraction	Dimensionless	0.4
	CostPerKilometer	US dollars	1200
	Cost_per_bus	Colombian Pesos * Bus	450000000
	Daily_TravelTime	Hour	0.53
	Fare_Cost	Colombian Pesos	2100
	LifeTime_Roads	Years	10
	MS_Fraction_goal	Dimensionless	0.5
	MaintenanceRate	Kilometers*year	1.1
	Maximum_roads	Kilometers	3000
	People_per_car	People*car	1.3
	RepairedRateYear	Buses*year	300
Auxiliary Variables	Atrac_moreKM	Dimensionless	NL_TravelSpeed
	Atract_Car	Dimensionless	NL_atractiveness-(NL_atractiveness*Cprice_Effect)
	Atractiveness	Dimensionless	Atract_Car+AtractivenessBus
	AtractivenessBus	Dimensionless	NL_atract_bus
	Average_Km_trav	Kilometers	(Daily_TravelTime*TravelSpeed_Serv)
	Budget_Allocated	Percentage fraction	NL_RCI*Aver_Investment
	CP_revenue	Colombian Pesos	Cars_in_use*Charging_Price
	Car_MS_fraction	Percentage fraction	MarketShare_Car/Total_Demand
	Cars_in_use	Cars	INT(Car_Demand/People_per_car)
	Coverage	Dimensionless	Travel_speed/TravelSpeed_Serv
	Cprice_Effect	Dimensionless	NL_ChargingPrice
	Fare_Revenue	Colombian Pesos	PT_Demand*Fare_Cost
	KT_per_vehicle	Kilometers/car	(Average_Km_trav*Atrac_moreKM)
	Km_traveled	Kilometers	(Cars_in_use*KT_per_vehicle)
	LoadFactor	Dimensionless	Cars_in_use/(Roads_Capacity*Average_Cars_Cap)
	MarketShare_Car	People	INT(Total_Demand*(Atract_Car/Atractiveness))
	MarketShare_PT	People	INT(Total_Demand*(AtractivenessBus/Atractiveness))
	PT_Comfort	Dimensionless	PT_Demand/(Buses*Capacity_per_Bus)
	PT_MS_fraction	Percentage fraction	MarketShare_PT/Total_Demand

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[4] 1 Colombian peso = 0,0003 US dollars

	Possible_KmBuild	Kilometers	IF(Maximum_roads-Total_Roads<=0,0,Maximum_roads-Total_Roads)
	RCI	Dimensionless	(Km_traveled/Roads_Capacity)/5000
	Road_Investment	Colombian Pesos	Available_budget*Budget_Allocated
	Roads_Capacity	Kiloemeters	(Roads+(0.5*Roads_Aged))
	Total_Demand	People	PT_Demand+Car_Demand
	Total_Roads	Kiloemeters	Roads_Aged+Roads
	Travel_speed	Kiloemeters/hour	Level_of_Service
Nonlinear Relationships	Level_of_Service	Dimensionless	INTSPLINE(2,0,0.1,70,70,69.78011,69.15294,65.14715,55,43.76162,36.23386,31.84257,28.7261,26.34724,24.80476,25,25,25)
	NL_ChargingPrice	Dimensionless	INTSPLINE(2,20000,5000,0.15,0.2,0.3,0.35,0.37,0.4)
	NL_RCI	Dimensionless	INTSPLINE(2,0,0.01,1,1,1,1,1,1.002176,1.026785,1.060095,1.105891,1.189226,1.282666,1.388878,1.483599,1.516424,1.51621,1.514696)
	NL_TravelSpeed	Dimensionless	INTSPLINE(2,0,0.5,0.5,0.5,0.5,0.5,0.5,0.5,0.5,0.5,0.5,0.5027745,0.5310213,0.5567682,0.6047732,0.653834,0.6986897,0.7313026,0.7639101,0.8902754,0.95,1,1.069745,1.163354,1.25,1.30633,1.326724,1.329709,1.332582,1.334443,1.331922,1.334443,1.330802)
	NL_atract_bus	Dimensionless	INTSPLINE(2,0,0.25,0,0.25,0.5,0.75,1)
	NL_atractiveness	Dimensionless	INTSPLINE(2,0,1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1277864,0.1475066,0.1595796,0.1862906,0.2019071,0.2287653,0.2463061,0.2595864,0.2816468,0.2993035,0.321371,0.3478528,0.3655072,0.3875752,0.422884,0.4493656,0.4714336,0.4846745,0.5067425,0.5199833,0.5420513,0.5552921,0.5773601,0.5861873,0.6038417,0.612669,0.6303234,0.6523914,0.6744594,0.7053546,0.7274226,0.7450771,0.7671451,0.7803859,0.7847995,0.8068675,0.8245219,0.8421763,0.8730715,0.8907261,0.9083796,0.926038,0.9480937,0.9702026,0.978908,0.9876161,0.99,1,1,1,1,1,1,1,1,1,1)

Table 1. Equations of the stocks-flows diagram.

Simulation results and Scenarios assessment

	Public Policies			
Scenarios	Road construction for traffic congestion	Road construction for connectivity	High public transport's quality	Area-based congestion pricing
Business as usual	**ON**	**ON**	**OFF**	**OFF**
Pricing reform	**OFF**	**ON**	**OFF**	**ON**
Public transport	**OFF**	**ON**	**ON**	**OFF**
Comprehensive	**OFF**	**ON**	**ON**	**ON**

Table 2. Scenarios assessment for the model built.

Having formulated both the causal loop diagram and the stocks-flows diagram, this section presents model simulations. These are the quantitative temporal evolution of the model that we proposed. Behaviors observed in the graphs below emerge from dynamic relationships between the feedback loops that are described in Figure 3. Before running simulations, we defined a scenarios assessment that can be seen in Table 2.

In Table 2 there are four scenarios and four public policies. The word “ON” represents the inclusion of a policy in a scenario, while the word “OFF” means that a policy is not included in the scenario. Besides, it is important to notice that the policy road construction to guarantee connectivity is present in all scenarios to supply high urban development of cities in some Latin American countries. Each scenario is described below:

- Business as usual: this scenario depicts the old transport planning paradigm in which road construction is a policy used with two purposes: to reduce traffic congestion as well as to guarantee connectivity. In this scenario is possible to see how new roads induce more kilometers traveled by drivers. However, to do this, it is necessary to disaggregate the scenario in two sub-scenarios: a road construction scenario to analyze how new roads induce more motorized travel demand, and a not construction scenario to depict normal travel demand growth without induced travel demand (ITD). These two scenarios are necessary because ITD cannot be evaluated simply by looking at how actual road conditions evolve; instead, motorized travel is considered to be induced if it is shown that there is more travel demand occurring when new roads are built.
- Pricing reform: in this scenario road construction is used only to guarantee connectivity, and congestion pricing is implemented to discourage car use, and thus, address ITD.
- Public transport: this scenario depicts the strengthening of public transport to attract discretionary drivers, while road construction is deployed to provide connectivity.
- Comprehensive: this scenario shows the adoption of the new transport planning paradigm. Comprehensive policies are implemented to avoid ITD while more roads are built to guarantee connectivity. These policies are high quality public transport and congestion pricing. Thus, the drivers who leave car use due to the pricing reform are attracted by public transport.

Figure 5 shows the business as usual scenario in which can be observed ITD due to new roads. More road construction improves travel speed at which cars are traveling. Higher travel speeds increase attractiveness of car use, and consequently, drivers travel more kilometers as can be seen in the road construction sub-scenario (red curve). For the case of the no road construction sub-scenario (blue curve), the increase of kilometers traveled is lower than the red curve because without new roads mobility remains congested, and there is no high travel speed that can induce cars to travel more kilometers. Finally, it is important to notice that the road construction sub-scenario reaches a state of equilibrium near 1,600,000 kilometers because the total demand of people considered in the model built is constant. This means that the number of users exchanged between car and public transport does not change over time.

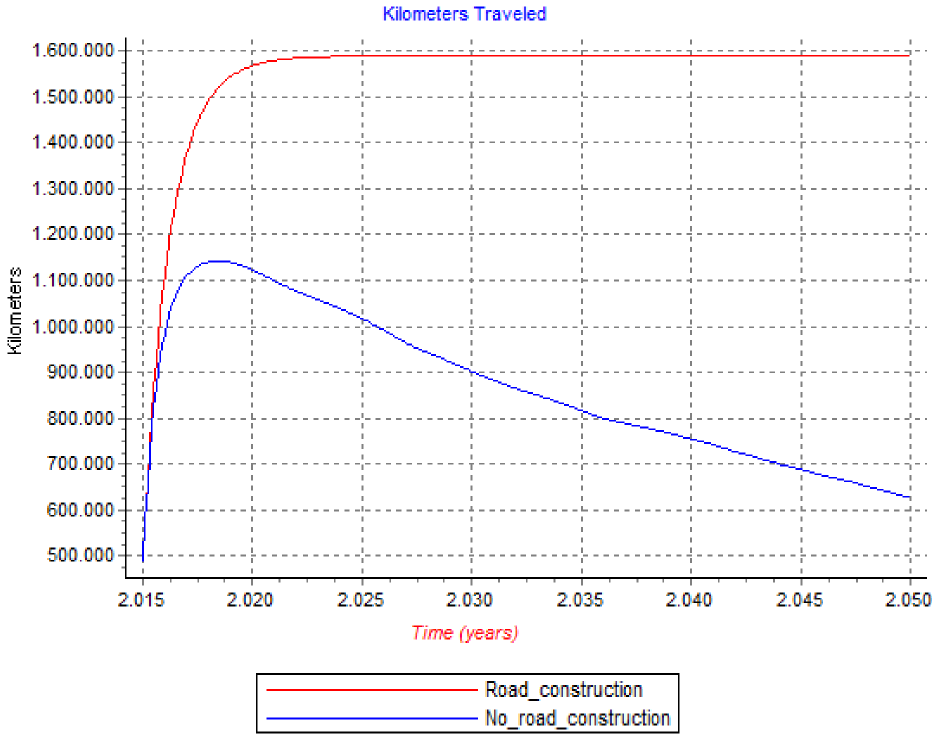

Figure 5. Induced travel demand in the business as usual scenario.

In the next step, the four scenarios are tested to evaluate their influences over kilometers traveled as can be seen in Figure 6. In the business as usual scenario, the total kilometers traveled is greater than the other three scenarios because without policies to address ITD after finishing the construction of roads for connectivity, attractiveness of car use increases and drivers travel more kilometers. In the other three scenarios, once the road construction has finished the kilometers traveled start to decrease due to the policies of high quality public transport and congestion pricing. The lowest total of kilometers traveled is reported in the scenario of comprehensive policies in which the two policies mentioned above are implemented at the same time.

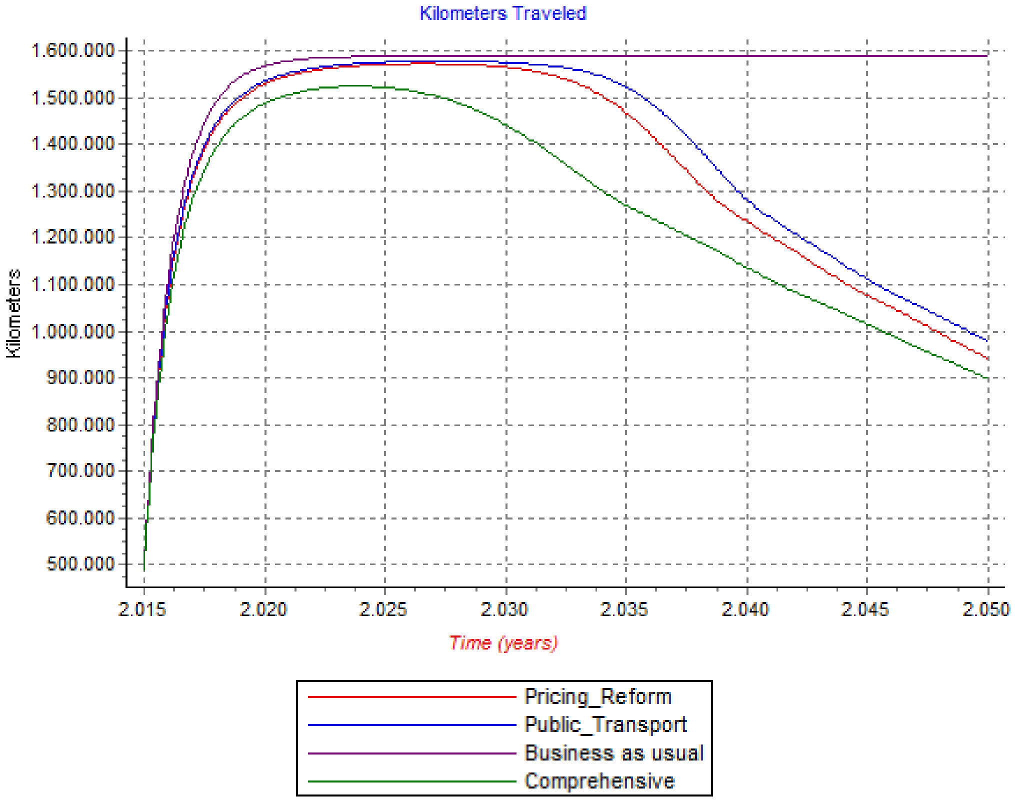

Figure 6. Kilometers traveled for the four scenarios described in Table 2.

The reduction of kilometers traveled means that car use has decreased. This can be seen through the indicated market share (IMS) of car. Figure 7 shows the IMS of car for scenarios of Table 2. More roads built without any other policy means both more available space for cars and higher travel speeds; consequently, attractiveness of car use increases and the IMS of car reaches its maximum value as can be seen in the business as usual scenario in Figure 7. Both scenarios of public transport and pricing reform decrease the IMS of car after road construction has ended. However, the lowest IMS of car is accomplished by the comprehensive scenario. This means that regardless more roads built for connectivity, the pricing reform discourages car use, and such drivers that leave private vehicle are received by public transport. Thus, it is possible to avoid the effect of ITD when roads are built as response to urban development growth.

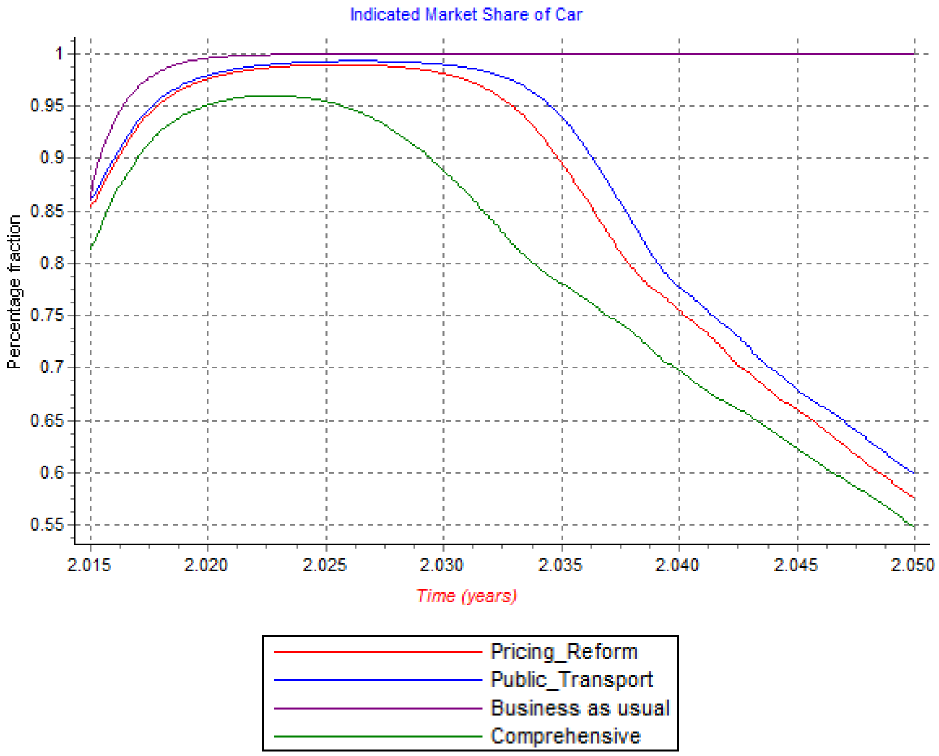

Figure 7. Indicated market share of car for scenarios in Table 2.

Summary and conclusions

The simulation results show the influence of high quality public transport and congestion pricing on addressing ITD to avoid that this phenomenon arises while road construction is undertaken to supply connectivity. We selected these policies because two reasons. First in the case of public transport (bus rapid transit system), this kind of transport system has been widely implemented in countries along Latin America (Bonicelli, 2015). Some examples are the cases of Brazil, Chile, Colombia and Venezuela. So in the challenge of dealing with ITD, it would be a feasible idea to use the alternative means of transport facilities that already exist to address this phenomenon. Second, although the congestion pricing has not been putting into practice at Latin American level, politicians and scholars are already discussing the prospects and implications of applying this policy taking as point of reference the successful cases of Stockholm and London (Rivasplata, 2013; Mahendra, 2008).

Nevertheless, although simulation results depict the effectiveness of the above-mentioned policies on addressing ITD, they are included in the model built in an ideal way. This means that current challenges that those policies are facing nowadays cannot be evaluated. In the case of bus rapid transit systems (BRT), they are facing great difficulties in some countries due to their inefficient administrative structure and its dependence upon governmental budgets. Those factors have resulted in a growing negative profit for BRT systems, and as a result, public transportation loses its demand share with respect to the growing attractiveness of car use. On the other hand, though congestion pricing seems an effective way to discourage car use; many questions have arose about its consequences on “mobility rights” of some low income travelers that would be deprived of transit in scenarios wherein public transport has low quality (Fiorello et al., 2010).

In this sense, further modelling efforts are required to represent those policies in a more realistic way. This implies to include both policies in the model using operational thinking, which means design and implement both policies structurally to know how they really would work in the context of some Latin American countries (Wheat, 2010). Then would be possible to formulate a stronger simulation tool that supports a change from the old transport planning paradigm to the new one that has been successfully implemented in developed countries.

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