A Municipal Fiscal Impact Model: Real-World Policy Modeling

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Abstract
This paper presents a summary of work that was done by the civic governments of Calgary and Edmonton that addressed the question of suburban development, infrastructure growth and rehabilitation and their financing given limited funding.

In the 1980's and 1990s, Canadian federal and provincial governments became concerned about the state of their respective finances. They responded by introducing a combination of expenditure reductions, tax increases and higher user fees. Consequently, transfer payments to municipalities were reduced.

These measures had a profound impact on the economies of the urban regions affecting the rate of renewal and obsolescence in business, residential and public infrastructures.

In this context, the Cities have had to decide how to allocate their limited financial resources between competing needs of further suburban development and growth

restricted to the already built up areas. But the Cities' financial ability to expand and to maintain their infrastructures are limited.

Keywords
Computer Model, Infrastructure, Scenario Planning, Learning Organization, System Dynamics, Municipal Fiscal Impact

1. INTRODUCTION

1.1. Purpose

The paper documents a system dynamics model of the municipal finance system for a Canadian urban municipality. The model has shown its usefulness by allowing policy analysts, municipal managers and politicians to develop a greater understanding of the workings of the municipal finance system through an explanation of how various components of the system structure interact. The model is relatively closed and is designed to display different modes of system behaviour over time. “The behaviour of a system arises from its structure. That structure consists of the feedback loops, stocks and flows, and nonlinearities created by the interaction of the physical and institutional structure of the agents acting within it” (Sterman, 2000). For example, growth and decline in, say, population or stock of municipal infrastructure would be generated by positive feedback loops; equilibrium created by negative feedback loops; and oscillations produced by negative feedback loops with time delays.

The model is made up of five key components: population, employment, housing, business structures and municipal services. Land is not modelled, as it is not a constraint in the municipalities studied. Each of the five sectors is described in the paper.

The model is an impact analysis tool since, its main purpose is to evaluate alternative scenarios. This is done by using the shock-minus-control technique, where the baseline scenario (control) is compared against a policy alternative (shock). The difference between the shock and the control scenarios is considered the net effect of policy. The shock-minus-control methodology assumes that all unknowns are the same between scenarios, whereas the quantifiable variables are viewed in relative terms.

1.2. Paper Organization

The report that follows is divided into 6 sections. Section 1 describes the report’s purpose and outlines its structure. Section 2 discusses the issues that the model was designed to address. Section 3 provides a brief overview of the literature on fiscal impact analysis methodologies. The review is intended to assist in developing an analytical framework to address the issues that were identified in section 2. The proposed model is described in section 4. Section 5 presents examples of policy simulations using the model. The final section is devoted to stating the reports conclusions and recommendations.

2. ISSUES

2.1. Background

In the 1980's, Canadian federal and provincial governments became concerned about the state of their respective finances as poor economic performance caused revenue growth to lag expenditure growth and consequently, annual operating deficits accumulated into escalating public debt. The federal government responded by introducing a combination of expenditure reductions, tax increases and higher user fees. For example, it cut transfer payments to the provinces in a number of areas including healthcare and social welfare. The provinces, in order to balance their budgets, followed a similar path to the federal government with reductions in program expenditures and transfer payments to municipalities (City of Edmonton, 1980; 2000). For example, in 1999 the City of Calgary received $129.74 per capita in operating and capital grants, well below the $210.68 received in 1990. If the province had maintained provincial grants at the 1990 level, adjusted for inflation, Calgary would have received $266.94 per capita in 2000 about $80 higher than the $184.72 actually received. Because of the significant growth in population over the last 10 years, these grants would have totalled $229,767,670 instead of the $159,000,000 that was actually provided. To address this revenue shortfall, municipalities responded by raising property taxes and user fees.

The 1990's experienced a reversal of the conditions that existed in the 1980's. The Canadian economy recorded a period of relatively rapid growth as the booming U.S. economy created an ever-expanding market for Canadian exports. This increased economic activity was located in large urban centres with most economic indicators showing that, on average, these regions grew above the national average. This growth acted as a magnet from outside the regions as migrants responded to attractive labour market conditions. During this era, federal and provincial governments' revenues grew faster than their respective expenditures and consequently, they enjoyed annual surpluses. However, despite improved fiscal balances, transfer payments to municipalities were never fully restored to pre-1980's levels. Large urban municipalities experienced increased fiscal stress during this period as municipal revenues expanded at a much slower pace than either federal or provincial revenues. At the same time these areas had to take care of the growing ranks of homeless individuals, provide new physical infrastructure to accommodate growth and upgrade the stock of existing infrastructure.

It is in response to the challenges outlined that the work presented in this paper was conducted.

2.2. Change

A municipality, at a given time, is comprised of its population and a number of physical assets. The physical assets, that give shape to the urban form, represents an accumulation of current and past investment decisions (Bruce and Carruthers, 1994). The quantity and quality of its stock of assets influence the behaviour of the economy over time. Growth occurs when investment or additions to the stock of assets exceeds depreciation or reduction, of this stock. In equilibrium, investment equals depreciation while declines in the stock of assets occur when, depreciation exceeds investment. This analysis applies to all assets, and the human population in an urban area. For example, population grows if the total of in-migration and births exceeds the total of deaths and out-migration. Population decline occurs when out-migration and deaths exceed the total of births and in-migration.

The economy and its various components are always in a state of flux. A key driver of this flux is the ageing process where individuals and assets become older over time moving through a well-defined process – the life cycle. Individuals are born; they become children, followed by adulthood and middle age and then become old. The cycle ends with death. The same applies to an asset. The asset is created by investment, and decays with time (prolonged by rehabilitation and technological innovation). Eventually, the asset is scrapped at the end of its economic life.

Change is ever present, even in states of equilibrium. In the case of the human population, the composition of the population would vary although the level or stock of the population is constant. The population composition is constantly changing through changes in-migration and ageing. Assuming other variables are constant, population ages with time. Individuals who are x years old today would be x+1 years old a year from now. Net-migration can occur when there is an imbalance between demand and supply in the labour market. For example, if labour supply is greater than demand, out-migration would occur. In-migration occurs when labour demand is greater than labour supply. The individuals who migrate are generally the young. Positive net-migration over an extended period of time generally results in an increase in the labour force source population and in the numbers of women of childbearing age. Consequently, positive net-migration can cause the population to renew itself.

A municipality should therefore track the level and composition of it assets in order to provide appropriate levels of service to its citizens. For example, the size and age of the stock of assets determine operating and maintenance costs. Also, the same applies to the delivery of human services where, the demand for municipal services is directly related to the number of individuals in the service area.

The scenario of **growth** plus **change** requires that a municipality manage its resources for maximum return, now and in the future.

2.3. Infrastructure

A municipality's infrastructure requirements are determined by the need to accommodate population and employment growth, maintaining and upgrading existing infrastructure. A city’s infrastructure is comprised of assets such as parks, bridges, buildings, roads, sewers and equipment (vehicles, machinery, etc). These assets are important because they assist the city in delivering goods and services to its inhabitants. In addition, these assets determine the quality of life in the community. For example, individuals and businesses migrate to an area because of the public and private goods and amenities that can be obtained in that area. As the population of the area grows through migration and natural increase, the area would become less attractive relative to other areas as the amount of available public goods and services per capita decreases. In order to maintain the area’s relative attractiveness, the city must increase the stock of its infrastructure through investment (Myers, 19915). For example, citizen surveys for the City of Calgary state that the City attracts businesses and individuals because of its high quality of life. This quality of life is not sustainable over the long term if significant investments are not made to update old and build new infrastructure. As more individuals and businesses are attracted to the region, increased pressures are placed on roads, parks, air, water and other environmental resources.

3. IMPACT ASSESSMENT MODELS

This section gives an overview of a selected number of impact assessment models and is not intended to serve as a manual or survey of the literature (Burchell et al., 1992; Burchell, 1990; Tischler, 1988, Ontario Municipal Affairs,1985). Instead, the intent is to provide an appropriate background for developing a research methodology to estimate the costs and revenues of alternative growth scenarios. Each model will be assessed on how it addresses the issues that were outlined in the previous section.

3.1. Fiscal Impact Assessment Models

Fiscal impact analysis is usually performed to assist municipalities to allocate their resources. It is defined as a mathematical simulation of a municipality's budgeting process where revenues and costs are estimated in response to population change (Gale, 1973). These estimates are derived by using either mental or formal[1] models of the municipal finance system[2]. The analysis is usually done by using the shock-minus-control method. A critical assumption that underpins this approach is that, the organization would continue to function with or without the proposed policy change. For example, fire prevention services would be delivered whether or not a new facility is built and or new equipment is purchased. The policy question then becomes what would be the net change that would result from implementing the new policy. Failure to perform a comparative analysis would convey the impression that the status quo is a cost free option. Specifically, the municipality cannot avoid fire prevention costs by refusing to invest in new facilities.

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[1] The formal model has the following potential strengths over the mental model (D.H. Meadows,1980):

1. "it is precise and rigorous instead of ambiguous and unquantified,
2. it is explicit and can be examined by critics for consistency or error,
3. it can contain much more information than any single mental model,
4. it can proceed from assumptions to conclusions in a logical, error-free manner,
5. it can easily be altered to represent different assumptions or alternative polices."

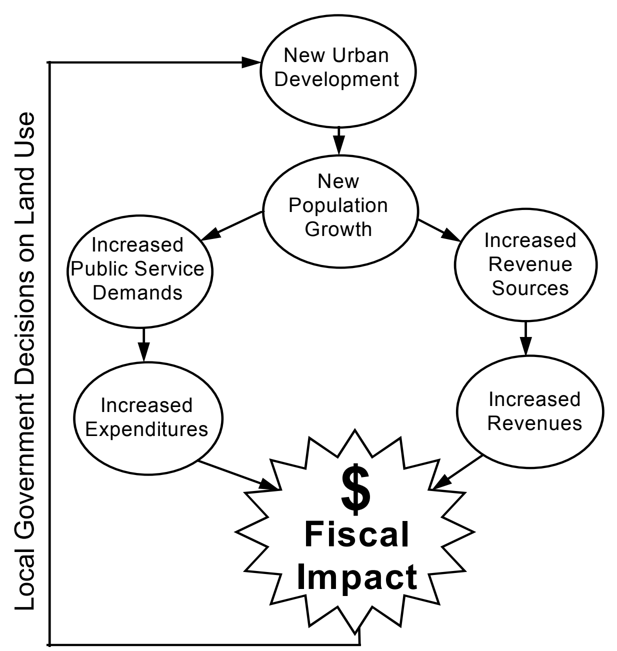
The formal models provide an explicit representation of the "real world" phenomenon that is being modelled since, they set out very clearly the assumptions that are employed in the forecasts (Hunt, 1993). This allows assumptions to be uncovered and questioned as part of policy debate. The model permits the user to conduct "what if" analyses by using a set of consistent assumptions. The benefit of using a model to conduct controlled experiments is that society could avoid or minimize the costs of policy errors. In addition, it serves as a learning experience for all stakeholders. "Modelling is not just getting the final numbers. The model also forms a rallying point around which discussion occurs. It provides the common basis for such discussion. It provokes discussion about possible futures - getting the debate going with a common currency" (Hunt, 1993).

[2] Models can be generally classified into two categories: formal and intuitive. Formal models are those that abstract from the real situation or system using symbols or physical forms. This type of model includes iconic (physical models of buildings), analog (circuit models of neurons) and symbolic models (mathematical, literal, logic). Intuitive (or less formal) mental models tend to be "gray" box models whereby not all of the relationships and dynamics of the variables involved are formally known or explained.

Change

The standard fiscal impact methodology, as represented by the work of Gale (1973) and Burchell et al. (1978), state that population growth creates an increase in demand for municipal services. At the same time the municipality's assessment base is increased as more residential and non-residential space is built to serve a larger population. However, this methodology does not show how the municipality changes over time. The reason for this is that the early fiscal impact models merely addressed the end state. They were concerned with how a community would appear after the land use proposal was fully developed. They were not interested in the path to the end state.

Figure 1
The Municipal Impact Evaluation System:



Source: Gale, Dennis. The Municipal Impact Evaluation System, Planning Advisory Service Washington D.C., September 1973

The question of the time adjustment was left to the work of later modellers. The City of Calgary (Mercer, 2000), The City of Edmonton (1980) and Tischler (1988) provide examples of how a municipality adjusts to change over time. Change is represented as exogenous in these models. Consequently, these models do not offer an explanation as to how change occurs. For example, they do not represent the effects of time on the age composition of the municipality's population or assets. Even if they do, they tend to be inconsistencies between variables. In the City of Calgary's model (Mercer, 2000), capital costs do not accumulate over time and consequently, the operating budget is not affected by the level of capital because of this.

Ford (1976), Rink and Ford (1978), Monts (1978), Rushdy (1985), and Rink (1982) addressed the issue of time and changes to investment and demand decisions[3]. These models were built around the system dynamics methodology (Forrester, 1961 and 1968) which argues that a model's behaviour is determined by its' structure[4] (Sterman, 2000). Adjustments in these models are never instantaneous because of material and information delays. In some cases, external shocks cause shortages to develop in different sectors of the model. These gaps are met through capital investment or population migration and eventually the system moves to its target or equilibrium level. In other cases, these models show that growth in an urban area could become path dependent (Atkinson and Oleson, 1996). Growth would generate further growth and there would no tendency for the economy to return to its original state (Arthur, 1994).

Population

The BOOM models are short term in nature and as a result, they do not focus on the population regeneration process. Population growth results from migration, which is treated as the balancing factor between labour demand and supply. Specifically, the models ignore the effects of natural increase on the age distribution of the population. For example, the model is unable to assess the impact of ageing on the demand for various city services and the ability of the City to deliver these services.

Infrastructure

The demand for new infrastructure is generally determined within the fiscal impact model (Gale, 1973). Population growth and service standards determine the demand for infrastructure (Mercer, 2000). However, most fiscal impact models do not model the existing stock of infrastructure. For example, the City of Calgary uses a partial approach where the need for infrastructure is matched against existing capital. The difference between these two measures is referred as the funding gap. The modelling of funding gaps recognize that all needs cannot be met, since resources are limited. However, the Calgary model does not provide a complete explanation of how the municipality could finance these gaps. The BOOM models provide such an explanation. Capital is financed through higher property taxes or non-tax revenues or debt or some combination of all three. The municipality's ability to issue new debt is limited by its bonding capacity which is a function of the its total assessment base.

Most fiscal impact models do not model the stock of capital. This is a significant omission in a long-term study since capital depreciates with time and must be maintained or upgraded to maintain its productivity. The modelled municipal operating expenditure should reflect this. In addition, the fiscal impact model must recognize the effects of ageing on the city's infrastructure. The city, at any time, must decide on how to allocate its limited resources between new and replacement investment. The failure to model the

[3] The BOOM models were developed in the late 1970s to early 1980s to assist communities adjusting to boom town conditions that resulted from escalating resource prices (Ford, 1976). Each model was developed to address a particular issue; for example, BOOM-H (Rink & Ford, 1978) discussed housing, BOOM-R (Rink, 1982) investigated regional development, and BOOM-P (Monts, 1978) examined municipal services.

[4] See Rushdy et al. 1968, Rink 1982, and Jozsa et. al. 1981 for applications to Alberta

stock of capital and link that to the operating budget makes the Calgary model incomplete.

Infrastructure plays a dual role in the local economy. It allows the municipality to produce and deliver goods and services and it affects its citizen's quality of life (Myers, 1991,1988, 1987). The first role is recognized by all of the fiscal impact models that have been examined. While many models omit the second role (Burchell, 1990), The City of Calgary's model recognizes the influence of municipal investment decisions on the quality of life.

Quality of Life

The full development of the links between investment and the quality of life and the quality of life and business and private behaviours are represented in various closed models (Forrester 1969; Alfeld and Graham, 1974; Myers, 1991,1988,1987). Myers argues that the quality of life is positively influenced by job availability, urban amenities, environmental quality and infrastructure services. The quality of life attracts migrants and also has a negative influence on the wage rate. This implies that the better the quality of life, the less a financial incentive that is required to compensate workers to come or stay in the area. At the same time, the quality of life is reduced by urban growth since growth leads to increase usage and ageing of existing facilities. The quality of life is treated in most closed models as dynamic (Alfeld and Meadows, 1974; Alfeld and Graham, 1974). It never stays the same. Migrants are attracted to an area with a relatively better quality of life and this continues until the differential between the area and its neighbours is eliminated.

Open/Closed Loop Models

Open looped models dominate the fiscal impact literature; where model behaviour is determined by the behaviour of the exogenous variables. For example the Calgary model (Mercer, 2000) is driven by the five-year operating and capital budget forecasts, the population projections and assumptions on inflation rates. This is a reasonable assumption for the very short term where most decisions for the immediate future are already made. In a long term study that may span two or more decades, using an open model becomes rather questionable. Current investment and policy decisions tend to have a delayed effect in an urban area. For example, a decision to increase the level of capital investment today would result in higher maintenance and replacement cost several years into the future. Also, an urban area is comprised of several interacting parts. For example, the decision by the municipality to spend more on roads would have a number of short and long-term effects. In order to adequately assess the effects of such a decision on the local economy and municipality, the simulation model should try to represent as closely as possible the links in the economy (Maciarello, 1975).

The major strength of the BOOM models is that they were built for policy analysis as opposed to forecasting. The model builders placed much emphasis on creating a greater understanding of the urban system. As a result, the models explicitly describe the linkages among the various sectors[5]. For example, an increase in the population will increase the demand for housing and this is reflected in the housing market through an increase in excess demand, which is translated into higher prices in the short run. Over a period of time, developers respond to higher prices and increased profits by producing more houses. As the stock and price level of house increases, the level of property tax assessment in the municipality increases.

4. THE MODEL

This section discusses the structure of the model developed in this study and develops a set of basic assumptions for linking the various components of the model (Walters and Jamal, 1996; 1999).

4.1. Overview

The local economy within a municipality is represented in figure 2 as a system consisting of a number of interacting parts of which the municipal finance system is a component (Alfeld and Meadows, 1974; Alfeld and Graham, 1974; Josza et al., 1981). The components of the model are linked through material and information flows. The diagram shows that causation is two ways: cause to effect to cause. These influences do not occur simultaneously and are separated in time.

The municipality draws on its assessment base to finance the payment for the services it provides and attracts businesses and population by the availability of services, jobs and housing. The region's economy is a very complex system, where the cause and effect of policy decisions are separated in time and space. For example, a policy that is designed to lower the unemployment rate through job creation may be successful in the short run.

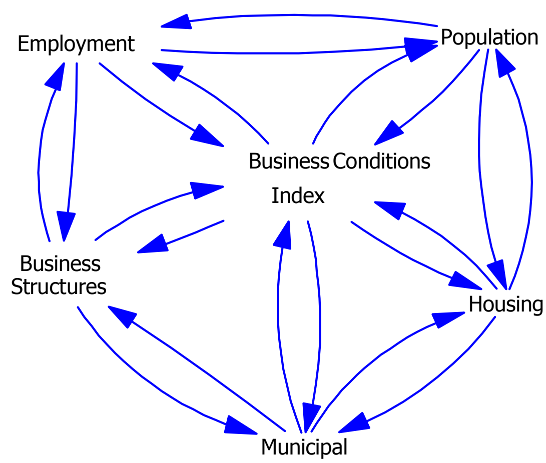


Figure 2: The City

However, in the long run, a lower unemployment rate will attract job seekers to the region and as a consequence, the unemployment rate may increase towards its initial

[5] A typical model is divided into a number of sectors. These sectors are linked through the flows of information and or material. For example, an increase in basic employment creates an imbalance between population and jobs and this results in in-migration. As population increases, the demand for public services and public goods also increases. If the available infrastructure is less than the required infrastructure to produce these goods and services, a shortage arises and this creates a need for constructing public facilities.

value. The policy would have little impact on permanently lowering the unemployment rate as the labour force grows at the same rate as employment. Also, a decision to cut back on capital maintenance costs may appear to offer cost savings in the short run. However, in the long run, The municipality may face higher maintenance and upgrade costs in order to improve the capital's productivity.

At any given time in an economy, both positive and negative feedback systems may be present. A simulation model is therefore an attempt to capture the inter-play of the positive and negative feedback behaviours over time. The ability of an economy to correct itself is generally referred to as negative feedback (Forrester, 1961). In some cases, policies or accidents of history may determine a region's economic path. In this situation, the self-correcting forces are unable to cause the economy to converge to a particular path (Arthur, 1994; Atkinson and Oleson, 1996). Once the economy has embarked on that path, change becomes self-reinforcing[6]. "Self-reinforcing feedback systems become evolutionary models because, if allowed to continue without some offsetting or opposing feedback, they cause the underlying structure to change rather than re-establishing a new equilibrium within an unchanged structure as self-correcting systems do" (Atkinson and Oleson, 1996). This type of behaviour is labelled as positive feedback.

For example, when an area is perceived to be more attractive than its surrounding environment, its population will increase as many people settle there in preference to other areas (Alfeld and Meadows, 1974). As labour markets conditions change, individuals do not respond immediately to available job opportunities since there are information delays. In addition, in the housing market, the decision to construct new housing does not result in the immediate completion of the proposed units since the housing market experiences planning and construction delays. Thus, time lags need to be explicit in this model.

4.2. Population and Employment Model

Population is estimated in the model by the cohort survival methodology. It allows for an accounting of population by its various age components. In a long-term study, this is a basic requirement. A city's population provides the local economy with its labour on the supply side and acts as consumers on the demand side. Over the policy analysis horizon, the model shows how population renews itself through the process of net-migration and natural increase.

[6] The U.S. Congress, Office of Technology Assessment offers the following explanation for urban sprawl, "…[W]hen all or part of a metropolitan area undergoes economic dislocation leading to out migration, many houses, factories, and offices and land remain vacant or underused, public infrastructure is underused. With urban decline, local spending on social services usually increases and, because of a smaller tax base, tax rates often increase, leading to fiscal difficulties that are today evident in many central city and inner suburban governments. A reduced tax base in the medium term means that less is spent on city services, including infrastructure, transportation, police protection, and education. This can in turn lead to increases in congestion, crime and other negative externalities, while reducing educational levels and some of the benefits to firms of agglomeration economies. As a result, further rounds of outmigration occur, threatening to create a downward cycle…"

The population and employment model is based on the following assumptions:

- births and in-migration increase the initial population.
- deaths and out-migration reduce the population level.

The employment section of the model is based on the export base theory. It states that total employment in an urban area is aggregated into basic and non-basic activity. The basic sector provides urban area with its reason to exist. It exists because it exports goods and services to other areas as it enjoys a comparative advantage over these areas. The advantage is influenced by its relative abundance of factors of production, and a relative attractive taxation system (Myers, 1991). As a result, basic employment is negatively related to the cost of doing business. The non-basic activity on the other hand is further disaggregated into population and employment serving activities. The non-basic sector plays a supporting role to the basic sector. It supplies output to the basic sector and to city's population. Consequently, the model assumes activities to be positively correlated with the level of total population. In addition, employment in the business-serving sector is expected to be positively correlated with the level of total employment in the basic sector. For example, if all of the businesses in the non-basic sector are destroyed, other businesses would arise to take their place. Thus, non-basic employment is positively related to basic employment.

The structure of the population/employment model is sketched in figure 4 (Hamilton et al., 1963). For example, a decline in the local unemployment rate relative to the national unemployment rate will attract individuals to a city because of increased chances of finding employment. Assuming all things are constant, the decline in local unemployment rate relative to the national level will increase total population through net migration. An increase in total population will therefore increase the labour force,

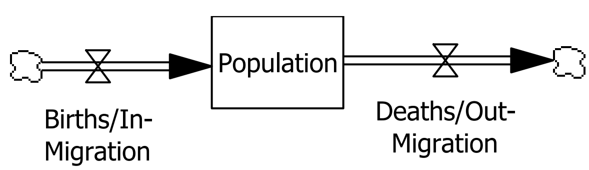


Figure 3: Population Renewal

causing the local unemployment rate to increase.

A relatively low unemployment rate causes an increase in the target relative wage. As a result the area cost competitiveness decreases and affects the growth rate of export based employment, which decreases the level of total employment. As employment decreases, the unemployment rate increases which causes the target relative wage rate to decrease.

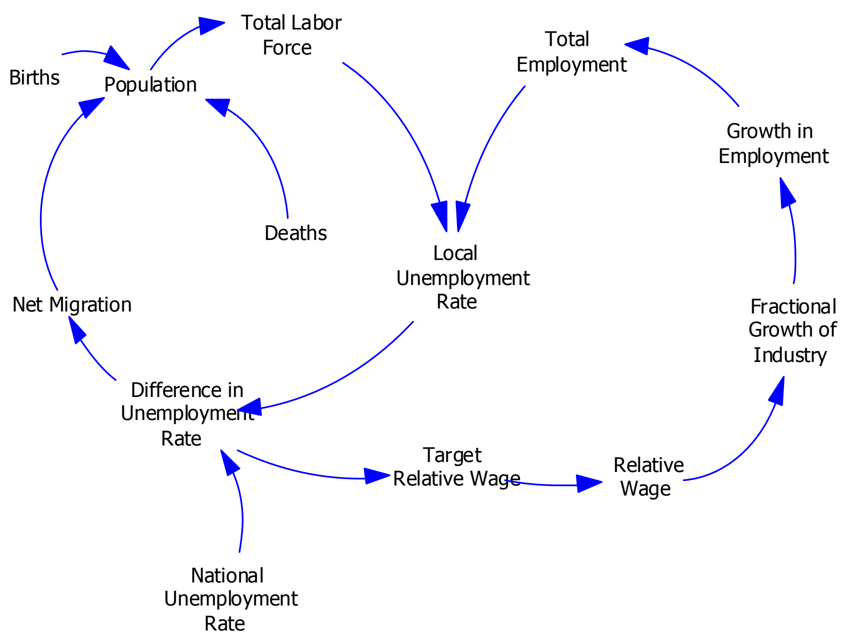


Figure 4: Population/Employment Model

4.3. Business Structures Model

Business structures refer to business space that is used to accommodate business activity. Employees are housed in business structures (Mass, 1978). The stock of business structures is increased by construction and is reduced by demolition. The stock of infrastructure ages over time with investment a major component in maintaining the quality of that infrastructure.

Structures tend to go through a life cycle that is similar to that of people. Buildings are constructed, age, and eventually they are demolished, as they become obsolete. This process is depicted by the figure 5, which shows that the stock of buildings will remain constant if the rate of demolition equals the rate of construction. If construction exceeds demolition, the building stock will increase and, the opposite will occur if the demolition outstrips construction. The main purposes of the business structures sub-model are to estimate an average price and the total amount of space that is occupied. This information is used to determine the total value of tax assessable space in the non-residential market.

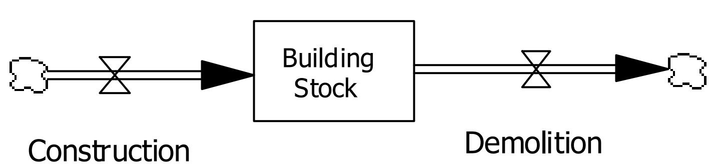


Figure 5: Building Structures

The market for business structures is represented by two feedback loops: demand and supply (figure 6). These loops are linked by the business structures vacancy rate and the business structures market price. An increase in the vacancy rate exerts downward pressure on the market price for business structures. On the supply side, this causes developers to adjust their future price – business structures expected price - expectations downwards. Because of lower than forecasted profit margins developers will scale back the amount of new business structures construction. As a result, the amount of new space that will be added to the stock of business structures will be reduced. On the demand side, a reduction in the price will increase the amount of space required per employee and thus, the total space that is occupied will be increased. This will result in a lowering of the vacancy rate.

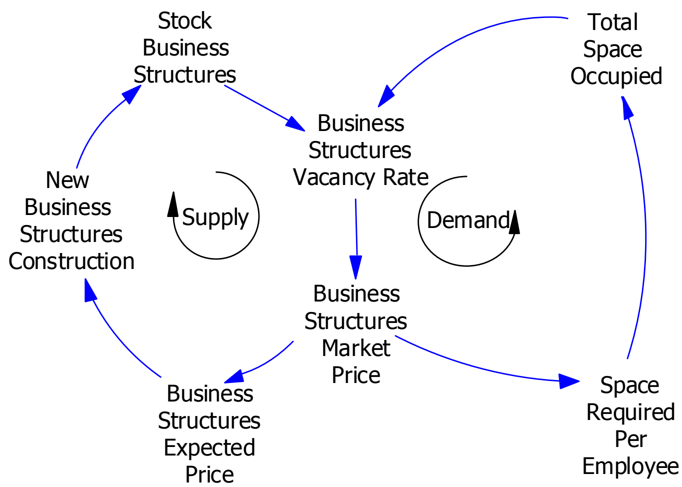


Figure 6: Business Structure Market

4.4. Housing Model

The housing market, like any other market at its most aggregate level, is represented by two feedback loops[7] (figure 7). On the demand side, assuming all things are equal, an increase in the total number of families will result in an increase in demand for housing which causes the vacancy rate to decline. At a lower vacancy rate upward pressure is exerted on the market price for housing. The higher housing price will cause the average mortgage payments to increase thus resulting in a higher qualifying income for new home purchasers. As the qualifying income increases, the fraction of families that are qualified declines and as result, the demand for housing will fall. On the supply side, an increase in the housing stock increases the vacancy rate, which depresses the market price for housing. As a result, the seller's forecast of the price/cost ratio is lowered. The decrease in the seller's forecasted profit margin results in a reduction in the number of housing units started.

[7] This section draws on the work of Rink and Ford (1978).

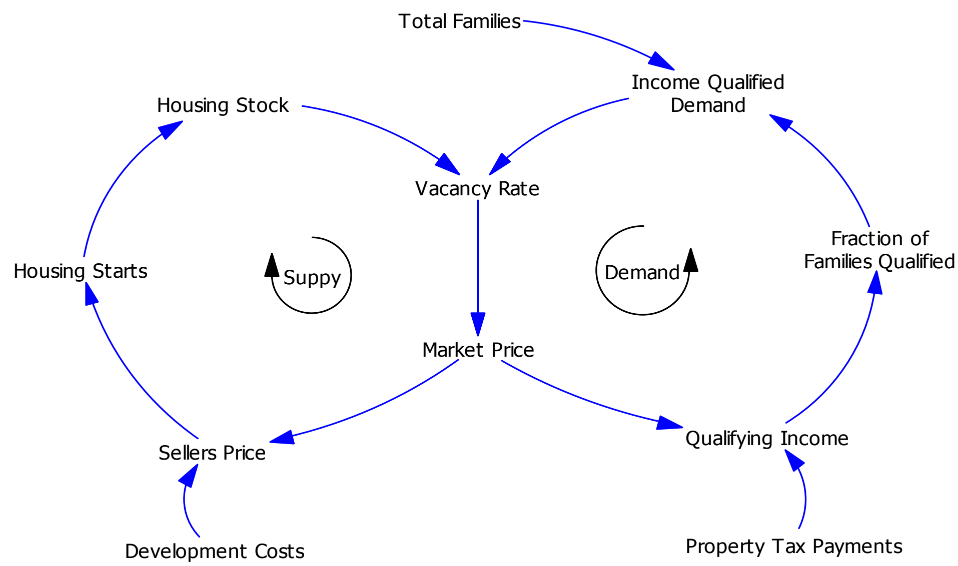


Figure 7: Housing Market

4.5. Business Condition Index

The business condition index is a composite measure of the region's relative attractiveness for businesses and people. The index is comprised of employment/population ratio, the housing/population ratio and the per capita value of municipal services. The higher the employment/population ratio, the more attractive the region becomes to migrants. Similarly, the higher the housing/population ratio, the more attractive the area becomes to migrants. Finally, the greater the availability of municipal services, the more attractive the area becomes to businesses and individuals. An increase in the local business conditions index relative to the provincial average would attract migrants and businesses to the local area.

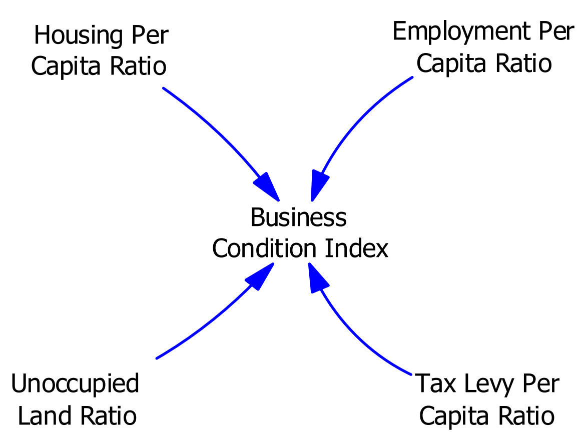


Figure 8: Business Conditions Index

4.6. Municipal Finance Model

The following ten generic equations presented in table 1 summarizes the municipal finance model.

Table 1

Municipal Finance Generic Equations
1. Demand for Services = f(Population, Standards)
2. Supply of Services = f(Population, Municipal Revenues)
3. Infrastructure Gap = Demand for Services - Supply of Services
4. Cost of Infrastructure Gap = Infrastructure Gap * Unit Cost
5. Municipal Capital = Integ (Municipal Investment - Municipal Capital Depreciation, Initial Capital Stock)
6. Municipal Investment = Min. (Cost of Infrastructure Gap, Funds Available for Capital)
7. Municipal Employees = f(Supply of Service, Municipal Capital)
8. Municipal Operating Cost = Labour Cost + Non-Labour Cost
9. Labour Cost = Municipal Employees * Average Labour Cost
10. Non-Labour Cost = f(Municipal Capital)

The demand for municipal services is directly related to the level of the City's population and the level of service. The greater the level of population and service level, the greater the need for municipal services.

The supply of municipal services is modelled as a function of population and municipal revenues. The greater the level of population the higher government income will be. The cost of services demanded by the higher level of population will therefore increase the City's debt.

An infrastructure gap is thought to exist when demand for services exceeds the supply. Also, the infrastructure gap could increase if demand for services grows faster than the supply of services. The cost of the infrastructure gap is estimated as the product of the infrastructure gap and the unit cost of capital.

At a given time, the municipal capital stock is increased by investment and reduced by depreciation. The level of municipal capital and the average life of capital influence depreciation. Municipal investment decisions are influenced by the gap between service needs and the supply of services, assuming that financial resources are available.

The first six equations in table 1 describe the capital budgeting process. The model uses the stock adjustment methodology to capture this process. It states that investments occur when needs exceed supply, assuming funds are available.

Municipal operating cost is defined as the sum of labour and non-labour costs. Labour costs are expressed as the product of the level of municipal employment and the average labour cost. Non- labour cost is expressed as a function of the level of municipal capital. The higher the level of municipal capital, the greater the amount of non-labour cost.

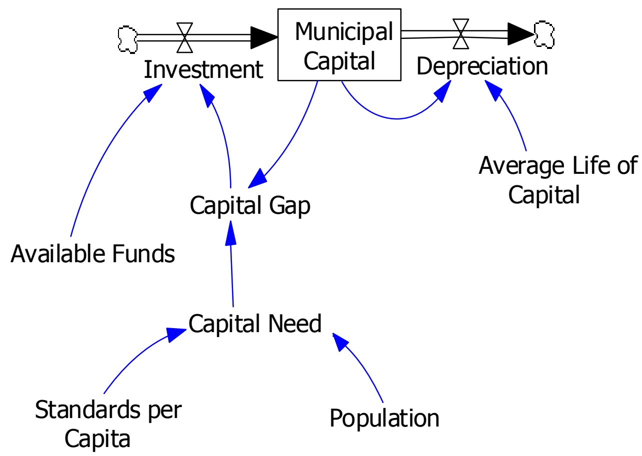


Figure 9: Municipal Finance System

5. APPLICATION OF THE MODEL

This section provides two examples of the application of the model outlined in section 4. The model was coded and run using Vensim 4.

5.1. Debt Repayment

This simulation examines the financial impact on a hypothetical municipality of allocating the proceeds from the sale of a City owned asset towards the payment of its debt. These impacts were estimated by comparing the shock and control values of a selected number of key policy variables over a 20-year horizon.

Policy Choices

- The city allocates $500 million towards the "paydown" of its municipal debt. This occurs in year 2002[8].

Key Assumptions

- A discount rate of 6.0% is used to calculate present value.
- Cost savings would not create room for additional municipal expenditures. Instead, the savings is passed on to the taxpayers as reduced tax payments.
- The difference between (control and shock) scenarios is primarily due to changes in the key policy variables.

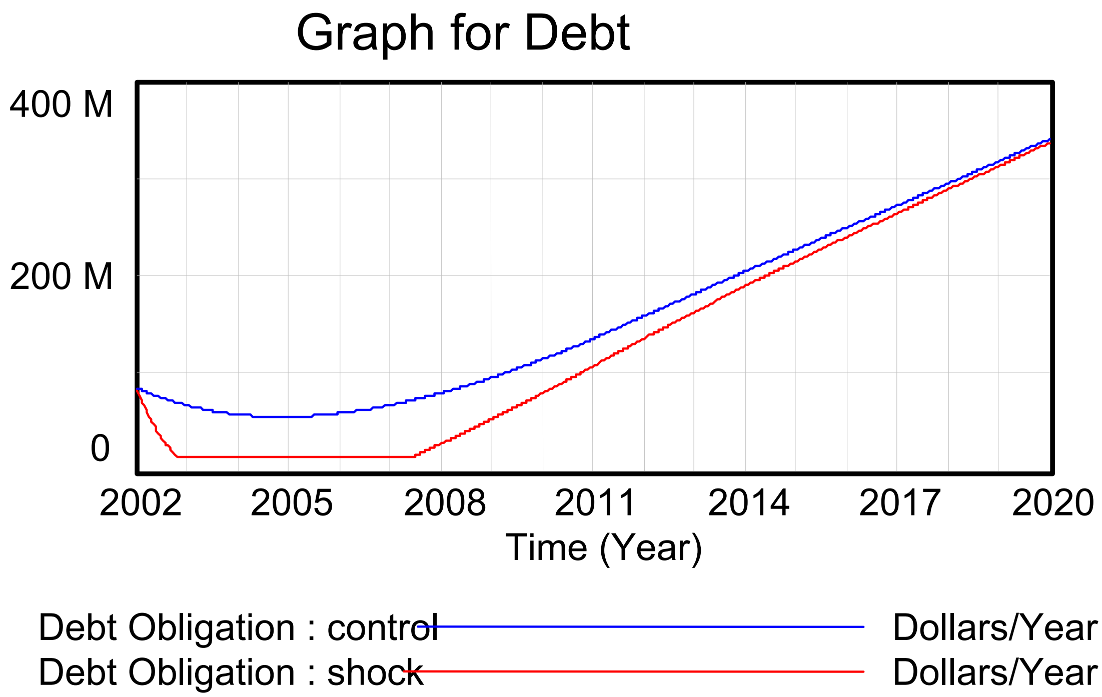
Results

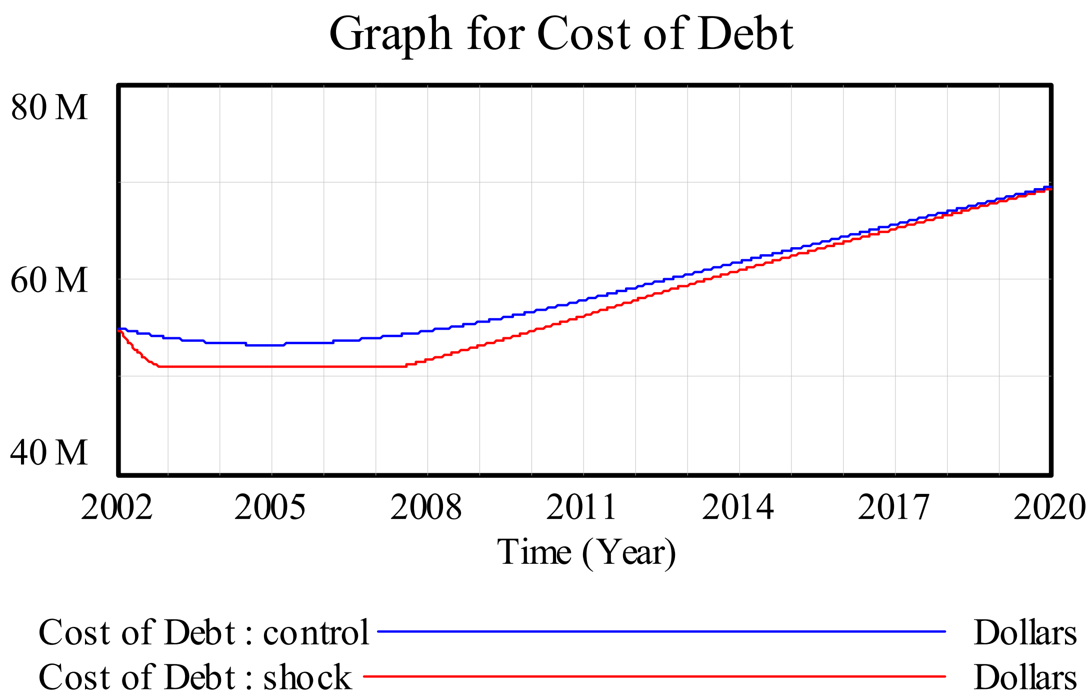
Payment of the city's debt results in a reduction of the amount of money that the city sets aside each year to meet the payments on the principal (debt repayment) and interest (cost

[8] The City would purchase various financial instruments to defray the cost of any penalties arising from the early repayment of the debt. The assumption here is that the gains from the financial instrument would roughly match the financial penalty.

of debt). These benefits accrue to the taxpayers over a number of years. During this period, the municipality experiences increased growth as its economic and demographic bases increase. Consequently, the municipality is required to provide services to accommodate the increased population and to service existing facilities. The city's debt obligation declines by about 77% below the base case from about 2004 to 2006. As the simulation moves forward, the difference between the shock and control scenarios becomes less. The city's population base grows over time and consequently, the requirements for new capital increase accordingly.

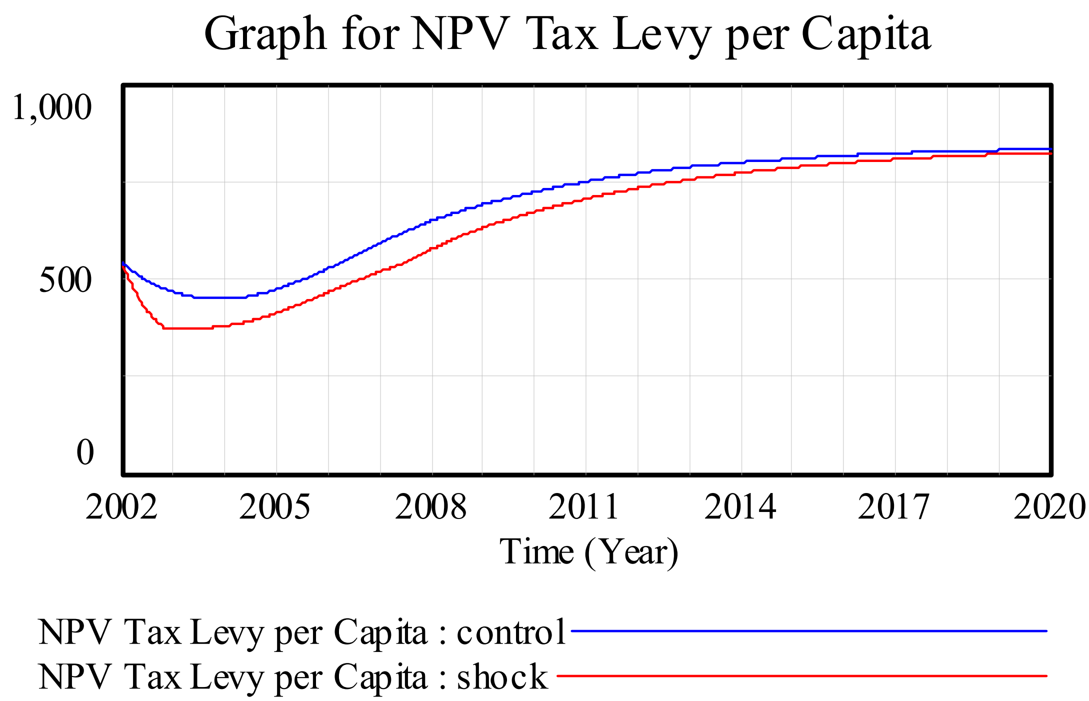
The major savings on the debt servicing costs is experienced between 2004 and 2008. The City saves about 5% annually on debt servicing in this period. The savings decline over time as the requirement for capital grows under both scenarios.





The tax levy refers to the amount of expenditures less non-property tax revenues; the amount of municipal revenues that has to be raised from taxation on property. The tax levy per capita measures the tax burden that an average individual bears. The tax levy is expected to decline in the shock scenario relative to the baseline base-case since the city has a relatively lower debt obligation, in the short run. The tax savings are greatest in the 2004 to the 2010 period. In this period, the savings range from a high of 16% in 2004 to 7% in 2010. Past 2010, the savings are reduced.

The key conclusion drawn from the modeling of the debt paydown is that the city would reap a significant benefit in the short run since, the debt obligation would be relatively lower. However, in the long run, the difference between the base-case and the shock scenario is relatively insignificant. Under both scenarios in the long run, higher population levels would create an increased demand for municipal infrastructure. Consequently, the demand for debt financing would increase in both scenarios.



5.2. Construction Finance
The purpose of the analysis is to estimate the financial impact of two polar methods for financing construction within a city

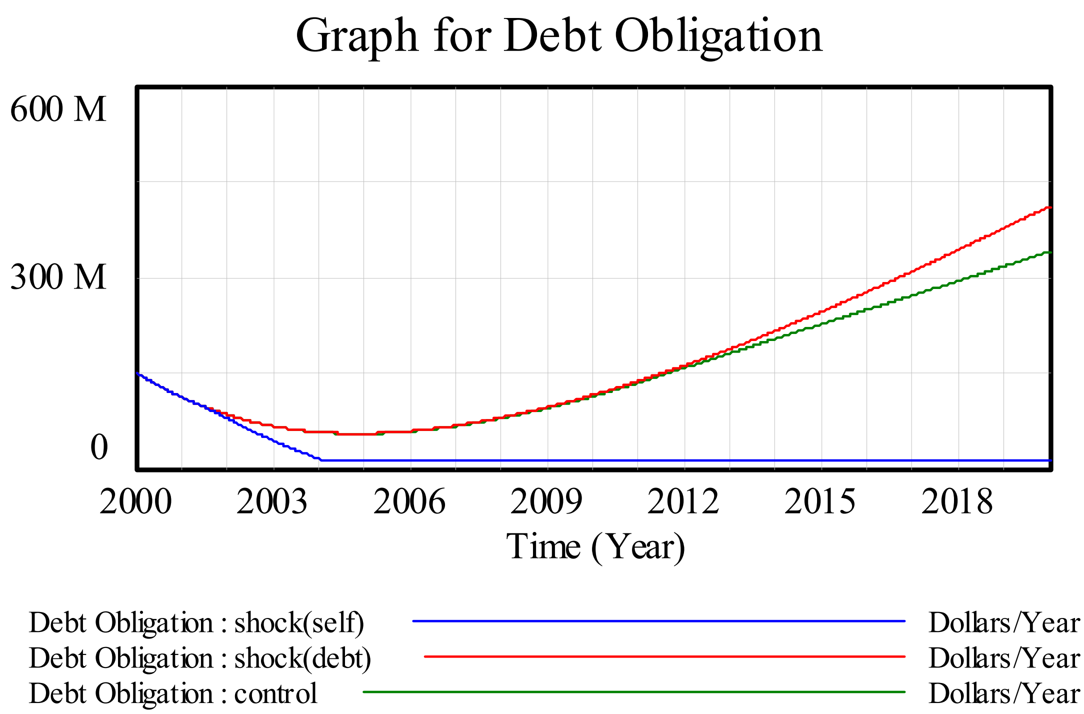
Policy Choices
The study assumes that the city could use one of these options to finance construction:
- The city finances 100% of the cost of the required construction projects through taxation (shock: self or *self-financing*) or;
- The city finances 100% of the cost of the required construction projects through debt (shock: debt or *debt financing*) or;
- The city finances 40% of the cost of the required construction projects through taxation and the remainder by debt (control).

Key Assumptions
- A discount rate of 6.0% is used to calculate present value.
- The difference between the scenarios is primarily due to changes in the key policy variables.

Results
In the self-financing option, the city's debt obligation declines significantly below the base-case as soon as the policy is implemented and remains there throughout the simulation. Whereas in the debt financing option, the city's debt obligation grows above the baseline estimate and diverges significantly towards the end of the time horizon. The divergence occurs as higher population levels create a growing demand for infrastructure. This requires the issuance of debt to finance capital purchases. The debt-financing

alternative increases the city's debt position throughout the simulation. New debt is obtained in the debt-financing scenario only when the assessment base expands.

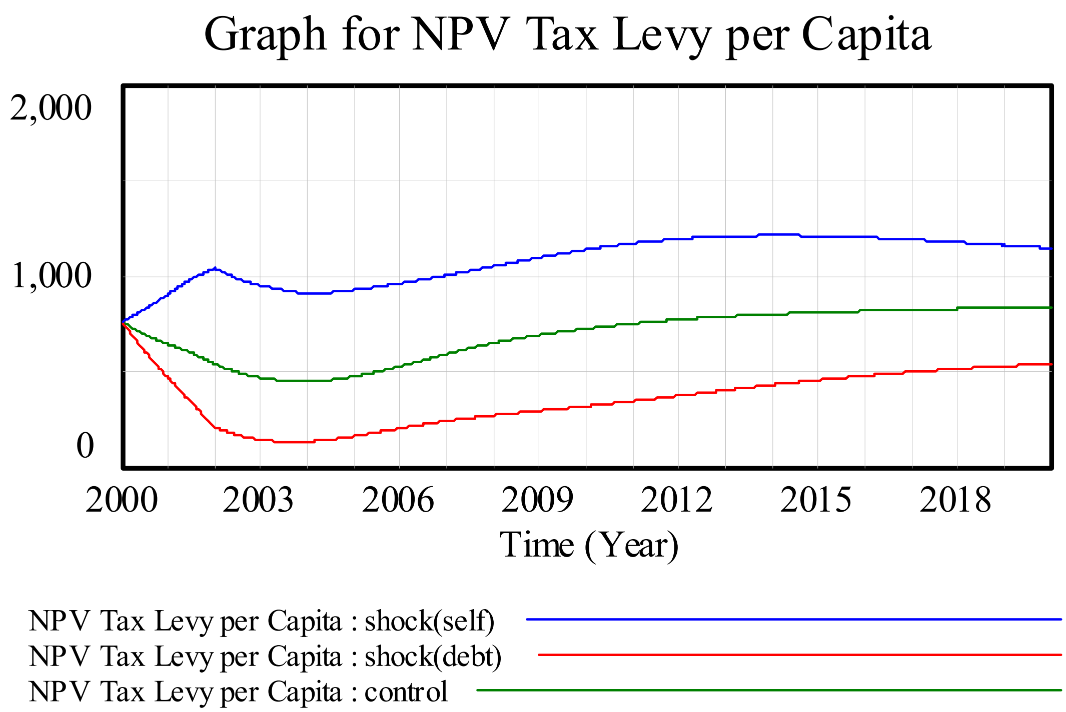
Population is expected to grow below the baseline in the self-financing option. Higher taxation requirements cause the business base to grow at a slower level. Consequently, the labour market looses its attractiveness for would-be migrants. The level of migration falls relative to the base and so does the level of population.



The increase in taxes is the greatest under the self-financing scenario. While, the tax levy per capita decreases below the control scenario under the debt-financing option. This stems from the fact that providing for infrastructure is distributed over many years rather than a single year as in the case of self-financing.

The higher tax burden, compared to the control option, resulting from self-financing, results in lower population and employment levels when compared to the base scenario. A lower employment level reduces the demand for space. Whereas, a lower mill rate, resulting from debt financing, results in an increase of population and employment. The lower mill rate induces business creation activities in the region, resulting in an increase in the demand for business space. The increase in taxes under the self-financing option, compared to the control scenario, would increase the production costs of local businesses. The increased production costs would place businesses in a less competitive position, making it difficult for them to export their services beyond the region.

The self-financing option has its major impact on the city and its economy throughout the simulation. Population decline decreases the demand for municipal infrastructure and as a result, decreases the requirements for new capital. The ability to finance construction through debt creation is directly linked to the city's economic development potential. A higher rate of growth increases the city's debt limit and thus its ability to raise new debt.



5.3. Summary

The paper provides summary results from two simulations that served to illustrate the usefulness of the model. Each simulation is judged against a base-case. The first reports on a debt paydown policy. The municipality benefits in the short run as its debt obligation falls. Over the long run, there is no significant difference between this simulation and the baseline. The municipality is required to service a larger population base and consequently, it requires a larger infrastructure stock. This infrastructure stock is financed by a mixture of increased debt and higher taxes. The second simulation compares debt financing against pay-as-you-go. The simulation shows that debt financing has an advantage over pay-as-you-go since, the tax rate is significantly lower than the alternative. This occurs because capital is financed over the life of the asset rather than in the current year.

6. IMPLICATIONS FOR MANAGING CHANGE

The paper describes a systems dynamics model that was used in two Canadian cities to examine various municipal finance policies. The model is comprised of five sub-models and these are linked by the flows of material and information. The population sector plays a key role in the model, since it provides the economy with its labour supply and also, it creates the demand for municipal services. Over the long run, the population sets the maximum growth rates for the economy and for the demand for municipal services. Also, the model shows the close links between the municipality and its economy. The municipality provides services to the population and business sectors and draws its financial resources from them to finance its operations.

6.1. Working with Decisions Makers

The purpose of modeling this complex environment is to help develop insight for a range of stakeholders and provide them with a framework for better decision making. We found that decision-makers needed to feel comfortable with the overall structure of the model and process by which it was used, especially as compared with previous approaches to decision making. The level of risk of arriving at wrong conclusions and thereby possibly making wrong decisions, was also a concern. Much has been written about client/management involvement in model building and analysis (e.g. Richardson 1996, Sterman, 2000).

Much of the change management process involved the unfreezing and freezing of decision-maker mental models and building of confidence in the systems thinking approach and results of the models built. A map of the resistance to change (or adoption of modeling process) is a useful tool to identify the needs of the various stakeholders involved in complex decision making environments and the necessary transition strategies.

Most of the modeling work reported in this paper was focused on the qualitative comparison of alternate policy scenarios. Thus, the risk of significant error in making wrong decisions was not a major concern, though identifying the strengths and weaknesses of models used provided useful insight into such risks. Monte Carlo analysis would provide future insight.

6.2. Modeling Issues

As a result of using the model for analysis of the various (two reported and others) various improvements in the model are contemplated. These include improvements in accuracy, simplicity and flexibility and thus usability. The speed of running simulations is not considered a crucial issue. These are:

- ongoing efforts for model validation (e.g. face, trace, historical, multi-stage, and internal);
- development of Monte Carlo models with estimates of uncertainty in various key variables and inputs;
- development of a gaming interface to allow users to run their own scenarios through improved user interfaces and data input;
- development of infrastructure deterioration models to better account for the timing and level of rehabilitation of existing assets.

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