Briefing Note #9

Calgary Impact Assessment Model (CIAM): Two Simulations

Corporate Economics

December 2010

THE CITY OF CALGARY
CHIEF FINANCIAL OFFICER'S DEPARTMENT

Table of Contents

Executive Summary

- The research brief presents simulation results from the Calgary Impact Assessment Model (CIAM). The simulations estimate the effects on The City's financial position from: (1) stronger economic growth and (2) introduction of a payroll tax.
- The Calgary Impact Assessment Model is a systems model that is divided into five sub-modules: population, employment, housing, non-residential space and municipal services.
- The basecase simulation was developed for the period 1990 - 2009. The basecase is used as a yardstick against which the various policy proposals are measured.
- The simulation results showed the following:
  - A stronger economic growth
    - Population levels would be higher when compared to the basecase.
    - Total operating expenditures would be higher when compared to the basecase.
    - Debt levels would be higher when compared to the basecase.
  - Payroll tax
    - Total operating expenditures would be higher when compared to the basecase.
    - Debt levels would be lower when compared to the basecase.

1. Introduction

The research brief presents simulation results from the Calgary Impact Assessment Model (CIAM)[1]. The simulations were designed to estimate the impact of changes to the economic growth rate and changes in The City's revenue sources on The City's major financial indicators.

The brief is divided into four parts. The first introduces the topic and lays out the organization of the report. The second describes the model and its structure. The third part describes the model's basecase. The final section presents the model's results.

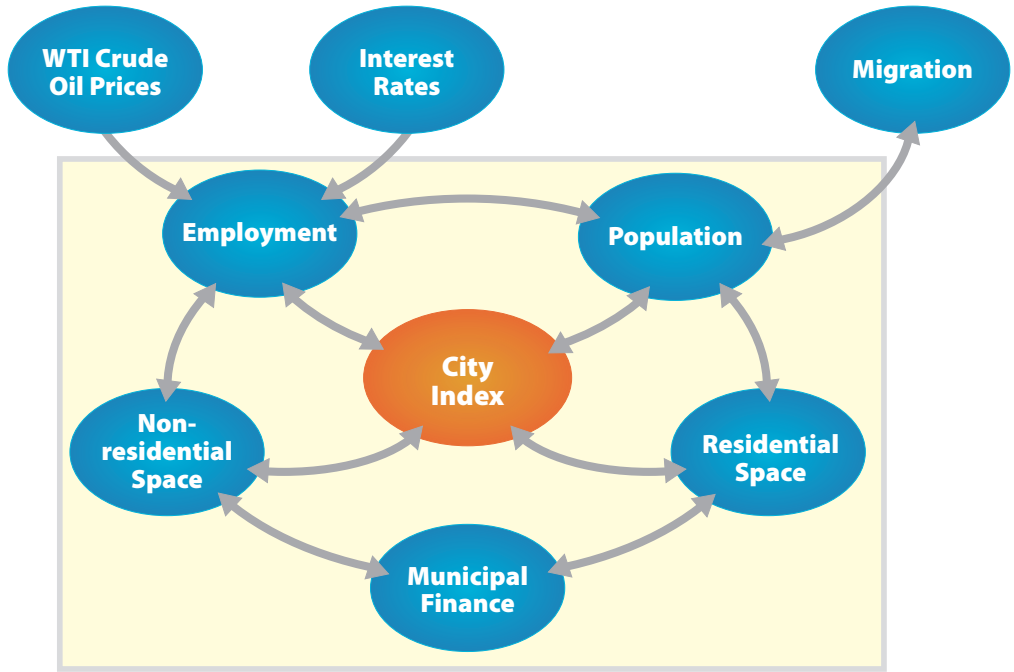
2. Model Structure

The model is made up of five key components: population, employment, housing, non-residential space (including office, industrial and commercial space) and municipal services.

1 Calgary Impact Assessment Model is the result of work that was done at The City of Edmonton and The City of Calgary. Previous versions of the model were presented at different professional/academic venues, including the System Dynamics Conference in Palermo, Italy in 2002. The current version of the model was calibrated by Corporate Economics and reviewed by Prof. Nathaniel Osgood from the University of Saskatchewan.

Overview of the Model

Chart 1
Local Economy and the External Environment

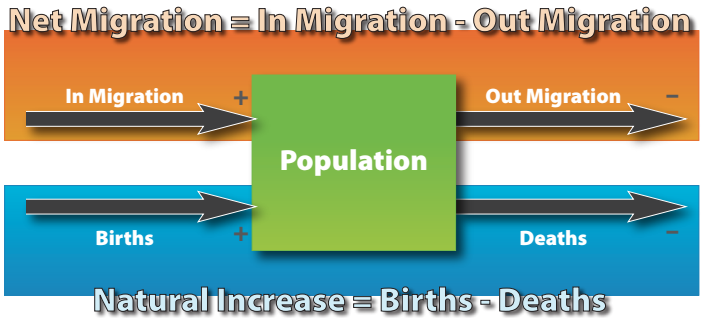


2.1. Population and Labour Market Modules

Population is the main driver of the model and is constantly changing through changes migration and ageing. It is estimated by the ***cohort survival*** methodology which allows for an accounting of population by its various age components: births, deaths and migration. Migration occurs when there is a imbalance between the demand and supply for labour. Usually the demand for labour exceeds supply during periods of increased economic activity and this results in in-migration. The contrary occurs during periods of economic slowdown. Most individuals who move into the region are generally in the younger age cohorts and many women are in the childbearing age groups. The absence of migration over an extended period of time could lead to a decline in the level of population. Consequently, positive net migration can cause the population to renew itself.

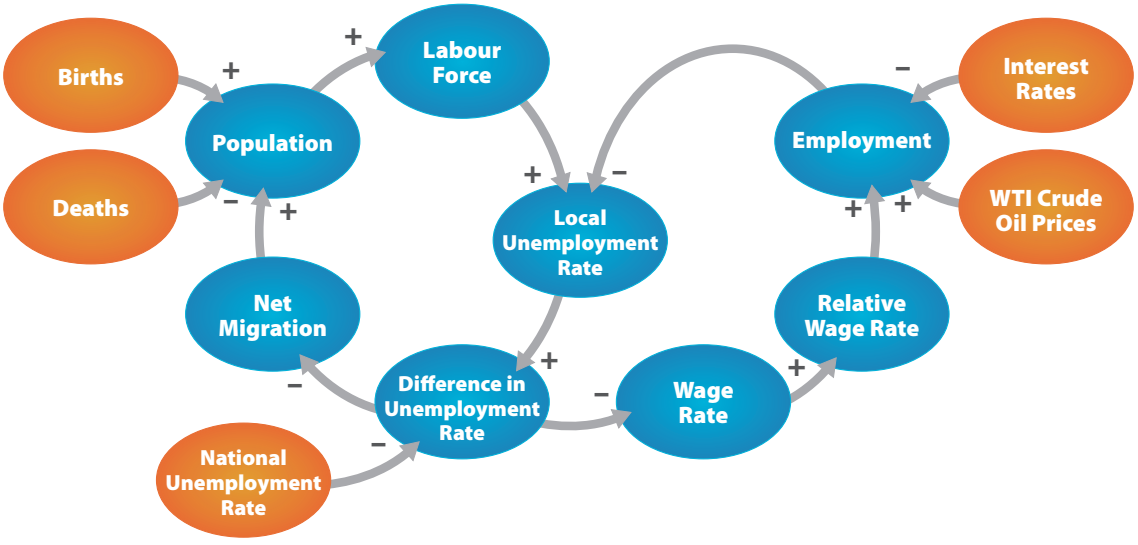
Population

Chart 2
Components of Population Growth



Labour Market

Chart 3
Drivers of the Labour Market



2.2. Real Estate Module

The real estate module is divided into residential and non-residential housing. The stock of space is increased by construction and decreased by demolition. The market price of space is an important driver of the demand for space. A change in the market price influences the qualifying income/space required per worker. A change in the vacancy rate impacts the expected construction or sellers price of space.

Real Estate

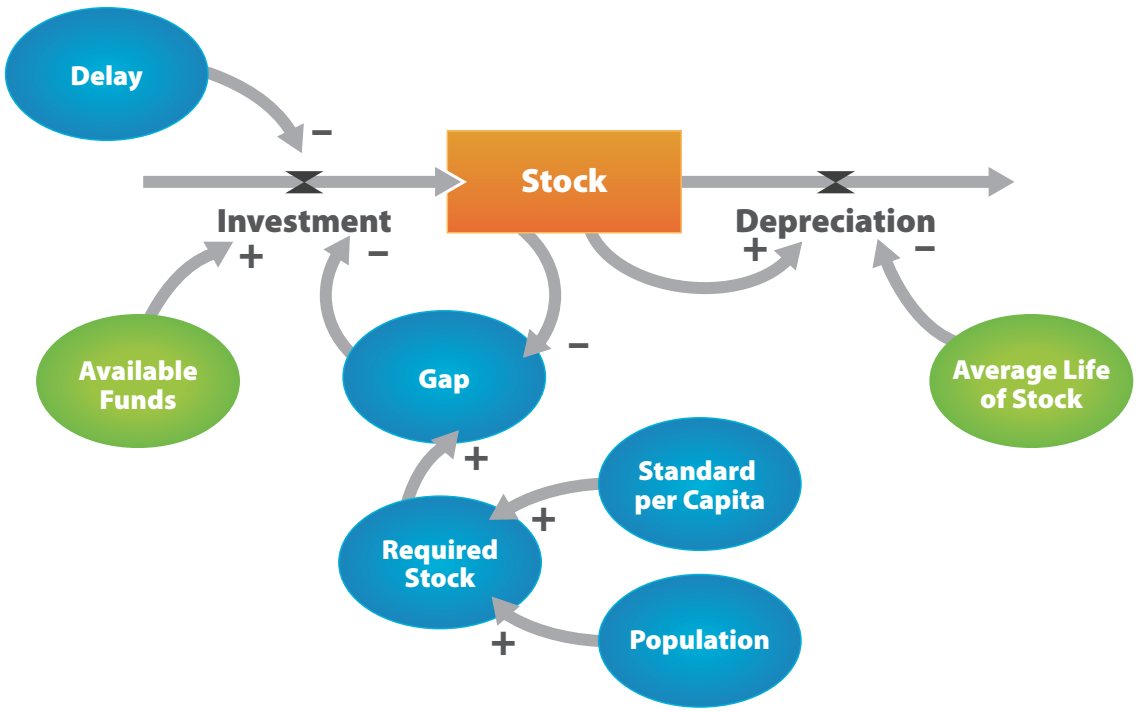
Chart 4
Drivers of the Residential Housing Market

2.3. Municipal Government Module

Municipal finance is a complex system. The municipality draws revenues from residential and non-residential assessment, government transfers and user fees. This amount is used to provide services to its citizens and to partly finance capital. Businesses and migrants are attracted by the availability of services, employment and affordable housing.

Municipal Finance

Chart 5
Components of Municipal Capital



2.4. Main Assumptions of the Model

The equations below contain the model's basic assumptions:

1. Demand for Services = f(Population, Standards)
2. Supply of Services = f(Employees, Municipal Capital)
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)

3. Basecase

The main purpose of the basecase is to provide a yardstick to rank the policy simulation. Consequently, it is possible to say whether or not the policy option would leave The City the same, worse off or better off.

3.1. Estimation of Parameters

The estimation of the model required data of adequate quantity and quality[2]. The model estimation process relied on a variety of data sources and methods. These can be group into three categories: data collection, calibration and expert validation.

3.2. Collection of Historic Data

Time series data was gathered for the period 1990 to 2009 from a variety of sources including The City of Calgary's published and unpublished records (annual reports). In cases where there were gaps in a particular time series, the gaps were filled through estimation.

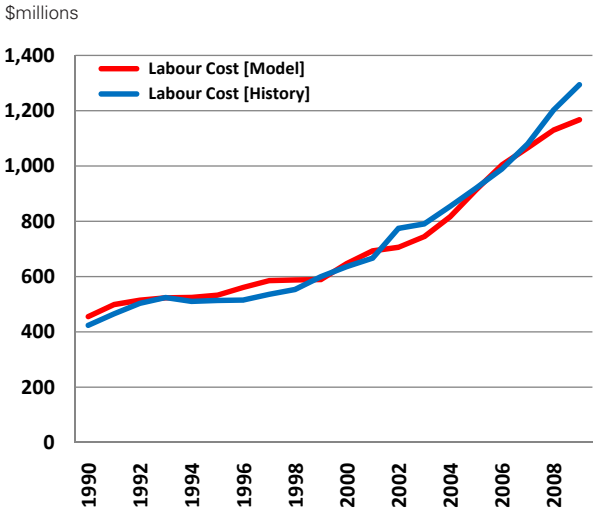
3.3. The Calibration Process

The model was estimated for the period 1990 – 2009 using Vensim's© 5.5 optimization routine. This was an iterative process which involved repeated modifications to the model's parameters. The objective was to select those parameters that allowed the model to generate results that were as close as possible to the historic data. Following each change, a new model solution was computed and the simulation error for the particular series was tabulated. This process was repeated until an acceptable error was achieved. Examples of the simulated values collected against the historic data are shown in figures 6 to 8.

2 This part of the estimation process consisted of collaborating with Prof. Osgood from the University of Saskatchewan and presenting the model and its results to selected groups of The City of Calgary's employees and asking them to express their opinions on the model's logical structure, assumptions and quantitative results. Specifically, they were asked whether or not they agreed with the model's structure, assumptions and results and if not to state the reasons for their objections. In addition, they were invited to make suggestions for model improvement.

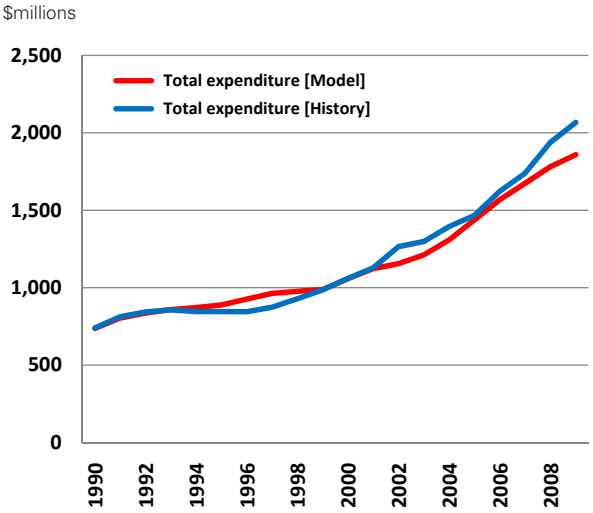
Municipal Operating Costs

Chart 6
Labour Cost



Sources: Finance & Supply, Corporate Economics

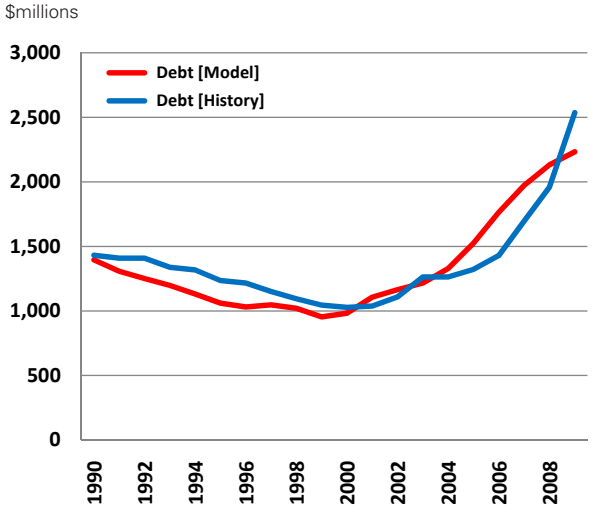
Chart 7
Total Expenditures



Sources: Finance & Supply, Corporate Economics

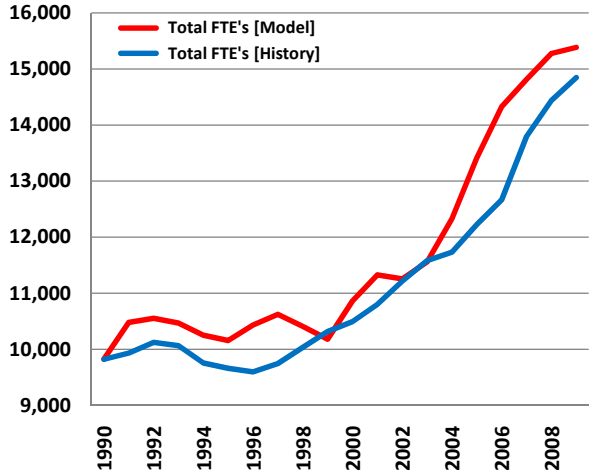
Debt and Number of Employees

Chart 8
Debt



Sources: Finance & Supply, Corporate Economics

Chart 9
Total FTEs



Sources: Finance & Supply, Corporate Economics

4. Application of the Model

The model was used to simulate the effects of the following: (1) higher oil prices and (2) the imposition of a one per cent payroll tax. The effects of these changes were measured by comparing how a given variable would change when compared against its baseline value. The baseline values were the estimated values from the 1990-2009 period. The study therefore asked the question, how history would have been different if a particular policy was in place. This approach (ex-post) is far superior to the alternative approach (ex-ante) because the analyst is able to avoid challenges about the reasonableness of various assumptions surrounding the basecase.

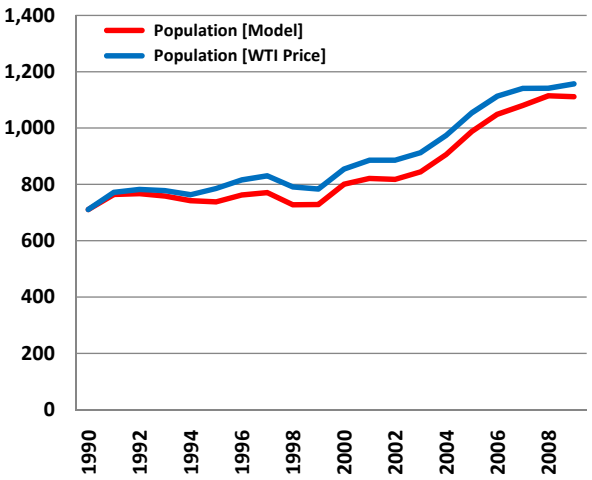
1. Higher economic growth.

- Higher economic growth was achieved over the 1990-2009 period by assuming higher oil prices.
- **Policy**. This simulation examines the financial impact on the municipality if the price of West Texas Intermediate (WTI) crude oil would have been ***20 per cent higher*** during the analysis period (1990 - 2009).
- **Assumption**. The model assumes that crude oil price would have an impact on total employment since Calgary is home to most of the energy companies operating in Alberta.
- **Results.** Higher crude oil prices would have placed additional pressure on The City's budget:
  - Total population would have grown faster relative to the basecase. An increase in crude oil prices would have increased economic activity in the province and this would demand an increase level of employment. Increased economic activity in the city would attract migrants from outside the region and this would have increased total population.
  - Total operating expenditures would have been higher than the basecase. Providing services to a higher level of population would have required increased investment in capital, causing operating expenditures to increase.
  - Total debt would have been higher relative to the basecase as The City finances capital through taxes and debt. This scenario would require an increase in borrowing to finance the increased level of capital due to an increase in population.
  - The simulation shows higher economic growth and has a more adverse effect on The City's financial position.
  - Total gap would grow faster under this scenario. The City would have been unable to close the gap as population growth would have outpaced investment in capital.

Total Population and Municipal Expenditures

Chart 10
Population

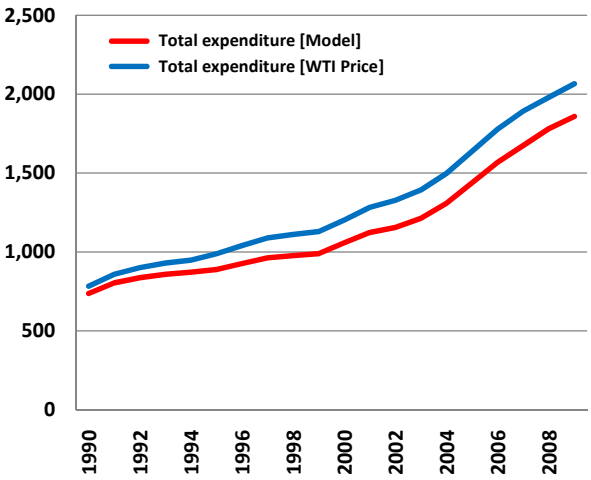
thousands of persons



Sources: Finance & Supply, Corporate Economics

Chart 11
Total Expenditures

$millions

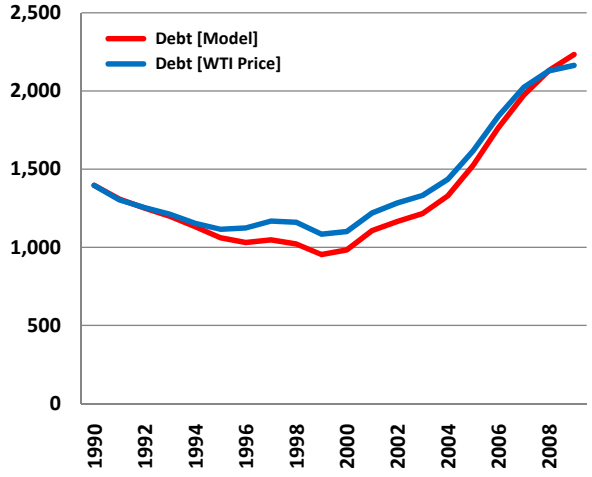


Sources: Finance & Supply, Corporate Economics

Total Debt and Gap

Chart 12
Debt

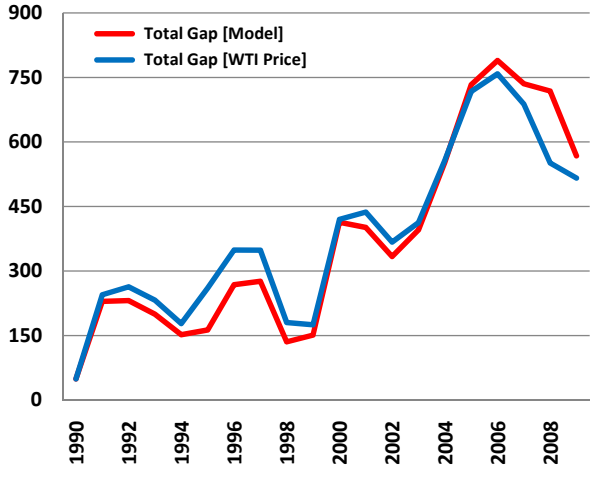
$millions



Sources: Finance & Supply, Corporate Economics

Chart 13
Total Gap

$millinos



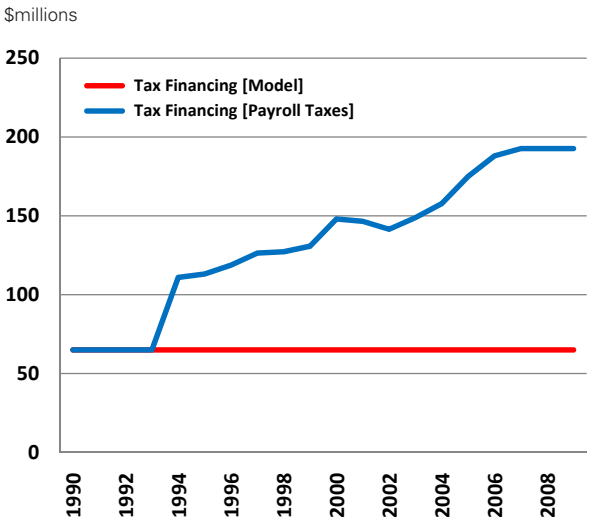
Sources: Finance & Supply, Corporate Economics

2. ***Impose a one per cent payroll tax on total wage bill.***

- The simulation in the previous section shows that The City does not benefit from economic growth. The current simulation illustrates how this could be rectified by using a growth sensitive revenue source.
- **Policy**. This scenario examines the financial impact on the municipality if The City would have received ***1 per cent*** of the total wage bill in Calgary during the analysis period (1990 - 2009). This revenue would have been distributed evenly between financing capital projects and non-tax revenues.
- **Assumption**. The model assumes that an increase in funding and revenues would increase investment in capital and reduce The City's total debt.
- **Results.** Increased level of funding and revenues would have placed less pressure on The City's budget:
  - Total tax financing would have increased significantly compared to the basecase. This would allow The City to fund major capital projects and thereby reducing the total gap.
  - Total operating expenditures would have been higher than the basecase. Providing services to a higher level of population would have required increased investment in capital, causing operating expenditures to increase.
  - Total debt would have been lower relative to the basecase as The City finances capital through an increase in funding. This scenario would require a decrease in borrowing.
  - Total gap would grow slower under this scenario. The City would have been able to close some of the gap.

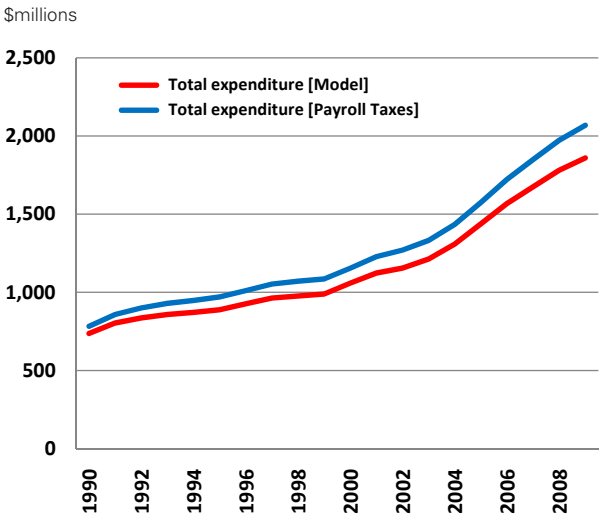
Financing of Capital and Operating Expenditures

Chart 14
Tax Financing



Sources: Finance & Supply, Corporate Economics

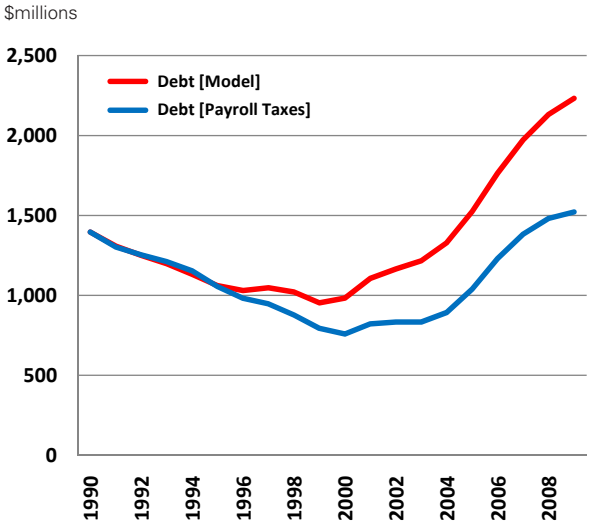
Chart 15
Total Expenditures



Sources: Finance & Supply, Corporate Economics

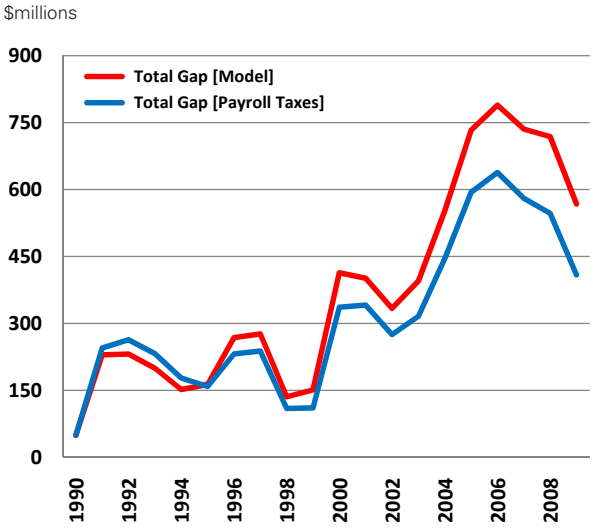
Total Debt and Gap

Chart 16
Debt



Sources: Finance & Supply, Corporate Economics

Chart 17
Total Gap



Sources: Finance & Supply, Corporate Economics

5. Conclusion

This paper provides a summary of Calgary Impact Assessment Model (CIAM) and the results of the two applications of the model. Each simulation is judged against a basecase. The first scenario assumes higher crude oil prices during the study period. The results show increased economic activity which lead to an increase in the demand for labour, consequently increasing migration and total population. But, providing services to a larger population base requires a larger infrastructure stock. The municipality's level of debt and operating expenditures would increase under this scenario, while the difference between required and actual capital would also widen since The City is restricted in its level of funding. The municipality finances capital through a combination of debt and tax revenues.

The second simulation assumes a 1 per cent payroll tax levied from the total wage bill in Calgary. This amount would be distributed evenly between financing capital projects and non-tax revenues. The simulation shows that tax financing increases during the study period, which allow the municipality to reduce its level of debt, consequently reducing the gap.

The two scenarios confirm the notion that the municipality does not fully capture the benefits of increased economic activity. Policies focusing on providing the local government with additional tax revenues place less pressure on The City's debt position and therefore reduces the gap between required and actual infrastructure.

Model documentation:

Volume 1: Report by Dr. Nathaniel Osgood, University of Saskatchewan.

Volume 2: Model description

Volume 3: Model equations

Volume 4: Model constants

Volume 5: Tables used in the model

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Calgary Impact Assessment Model (CIAM)

Who We Are

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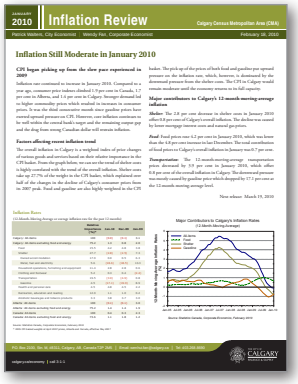
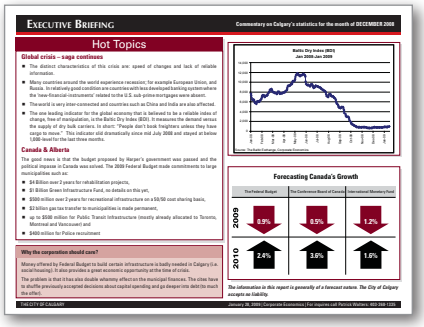


Commentary
Executive Briefing



Quarterly
Calgary's Quarterly Economic Outlook

Corporate Research Analyst: **Estella Scruggs**