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Alberta Infrastructure & Transportation

Economic Benefits for Development of High Speed Rail Service in the Calgary-Edmonton Corridor

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Prepared by

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This report was prepared by Transportation Economics & Management Systems, Inc. (TEMS) for the Government of Alberta. The report's contents do not necessarily constitute the official policy and position of the Government of Alberta.

Executive Summary

The Alberta High Speed Rail (HSR) Economic Analysis consists of two independent assessments.

1. An analysis of demand side user benefits as defined by Transport Canada economic evaluation.

2. A supply side analysis of economic benefits designed to identify the community benefits in terms of long-term jobs, income and property value increases. This analysis uses the TEMS Economic Rent analysis.

The key results of the analysis are –

User Benefits: The Alberta HSR project generates $4.6 to $33.4 billion economic benefit depending on technology.

Rail Technology	Speed (Miles per hour)	User Benefits (Billions of 2006$)
Talgo	125	4.6
Jet Acela	150	8.5
TGV	200	19.5
Maglev	300	33.4

User benefits are obtained from different sources as follows -

Type of Benefit	Benefit (%)
Consumer Surplus	10-25 percent
System Revenues	45-55 percent
Resource Savings	25-40 percent
Emission Savings	1-3 percent

Community Benefits: Alberta HSR generates the following benefits by technology –

Type of Benefit	Talgo (125 mph)	Jet Acela (150 mph)	TGV (200 mph)	Maglev (300 mph)
Employment (# productivity jobs)	3,400	4,913	6,407	7,162
Income (2006$)	$230 mill	$331 mill	$436 mill	$487 mill
Provincial Income Tax (2006$)	$12 mill	$17 mill	$22 mill	$24 mill
Federal Income Tax (2006$)	$18 mill	$26 mill	$34 mill	$38 mill
Property Value (2006$)	$732 mill	$1,071 mill	$1,381 mill	$1,546 mill
Property Tax (2006$)	$ 3 mill	$ 5 mill	$6 mill	$7 mill
Average Household Income (2006$)	$194	$278	$365	$408
Average Dwelling Value (2006$)	$403	$578	$759	$849

Depending on technology implementation of Alberta HSR system will result in the following economic impacts on the province of Alberta –

- **Employment:** Between 3,400 and 7,162 permanent new jobs (136 to 286 thousand person years of employment over the life of the project);

- **Household Income:** $230 to 490 million dollars of extra household income per year ($194 to 408 for every household or $5.6 to 11.7 billion over the life of the project);

- **Development Potential**: $732 to 1,546 million dollars of increased development potential, mainly around the 5 station cities served by the Alberta HSR system;

- **Residential Property Value**: $403 to 849 of residential property value for every dwelling unit;

- **Provincial Tax:** Provincial income and property tax benefits in the range of $15 to 31 million per year (its is equivalent to $0.4 to 0.8 billion over the life of the project);

- **Total Tax:** Provincial and federal tax benefits in the range of at least $33 to 69 million per year or $0.8 to 1.7 billion over the life of the project.

In terms of the distribution of benefits, the economic regions of the province of Alberta will benefit as follows –

Economic Region	Benefit (%)
Calgary	40-45 percent
Edmonton	30-35 percent
Red Deer	20-25 percent
Camrose-Drumheller	2-5 percent
Banff – Jasper – Rocky Mountain House	1-2 percent
Athabasca – Grande Prairie, Mountain River	1-2 percent

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Introduction

The development of the Alberta High Speed Rail (Alberta HSR) system calls for a substantial investment by both the public and private sectors. While it is unclear exactly what the size of the investment will be it is clear that a project of this size needs to be fully evaluated in both financial and economic terms. As a result, Alberta Infrastructure and Transportation (AIT) needs to assess the economic impact of the project on the Alberta economy. Typically, federal and provincial governments have required a demand-side analysis of the economic benefits of a project which may be characterized as traveller or user benefits that measure time, cost and resource savings associated with making trips in the corridor. However, of real interest to policy makers and individuals who live in a corridor are also the supply side benefits of a project which may be characterized as community benefits or productivity benefits such as increased jobs, income and wealth that result from building the project.

The purpose of this Economic Benefits Study, therefore, is to measure both the demand and supply benefits generated by the development of the Alberta HSR system to AIT. To do this, two related techniques have been used by TEMS, Inc., in evaluating the Economic Benefits for the Study. These are as follow:

- Consumer Surplus Analysis of demand side user benefits
- Economic Rent Analysis of supply side community economic benefits

These two techniques play a significant role in the modern theory of transportation economics [1]. Consumer Surplus measures benefits from the demand side. Economic Rent measures benefits from the supply side.

The first, the Consumer Surplus technique is well established in the economic literature providing a measure of the benefits to users of the transport system [2], [3]. The underlying methodology has been developed into a well-established set of criteria that can be used in evaluating projects [4]. Essentially the Consumer Surplus estimates the time and cost savings an individual receives from a transportation investment.

The second, the Economic Rent Analysis is equally well established in the economic literature [3], [5] as the “mirror image” of consumer surplus but is a less well-used methodology. This is because it is more difficult to measure economic rent than to measure consumer surplus. The work on specific measurement techniques for economic rent has only been conducted in the last ten years. This reflects the growth of computer power and the ability of modern computers to handle the large number of calculations associated with conducting an Economic Rent Analysis.

As documented in the literature [6] through [7] the initial work on economic rent grew out of urban economics and in particular the measurement of property prices and commuting activity. This work was later supplemented by the development of transportation analysis techniques that greatly enriched the economic rent measurement process. This included transportation access measurement (by measuring transportation utility) and traffic movement databases (showing market interaction) that are so critical to economic rent [8]. The final formulation of economic rent techniques required the inclusion of the Economic Theory of Location and, specifically, Central Place Theory [9], [10] to provide a structure of "markets" to which the general economic rent proposition could be applied. This then provided an effective application method. Essentially the economic rent measures the improvement in income, employment and property value that individuals receive as a result of a transport investment which allows the market to work more efficiently and to raise individuals' productivity.

The following report describes the techniques as applied to the Alberta HSR in more detail, identifying the methodology, the measurement techniques, databases, and the results for each technique. The report includes the following:

Chapter 1: Introduction

Chapter 2: Economic Analysis Framework – This includes a brief assessment of the overall Economic Framework and the relationship between Consumer Surplus and Economic Rent.

> 2.1: Character of the Overall Economy
>
> 2.2: Demand Side: Consumer Surplus Methodology
>
> 2.3: Supply Side: Economic Rent Methodology – These two chapters cover theoretical and technical issues of the two developed techniques – Consumer Surplus (evaluating the demand side of the Study) and Economic Rent (evaluating the supply side).

Chapter 3: The Economic Evaluation Databases – This describes the process of developing socioeconomic and transportation databases, as well as different techniques necessary to perform both parts of Economic Benefits Study.

Chapter 4: Consumer Surplus Analysis and Results

Chapter 5: Economic Rent Analysis and Results – The results of the Alberta HSR system evaluation by the two developed techniques are presented.

Chapter 6: Station Development Impacts – Issues regarding economic evaluation results for Alberta HSR stations (including their development potential) are discussed here.

Chapter 7: Conclusion – This chapter accesses the overall benefits to Alberta of building the Alberta HSR system.

2

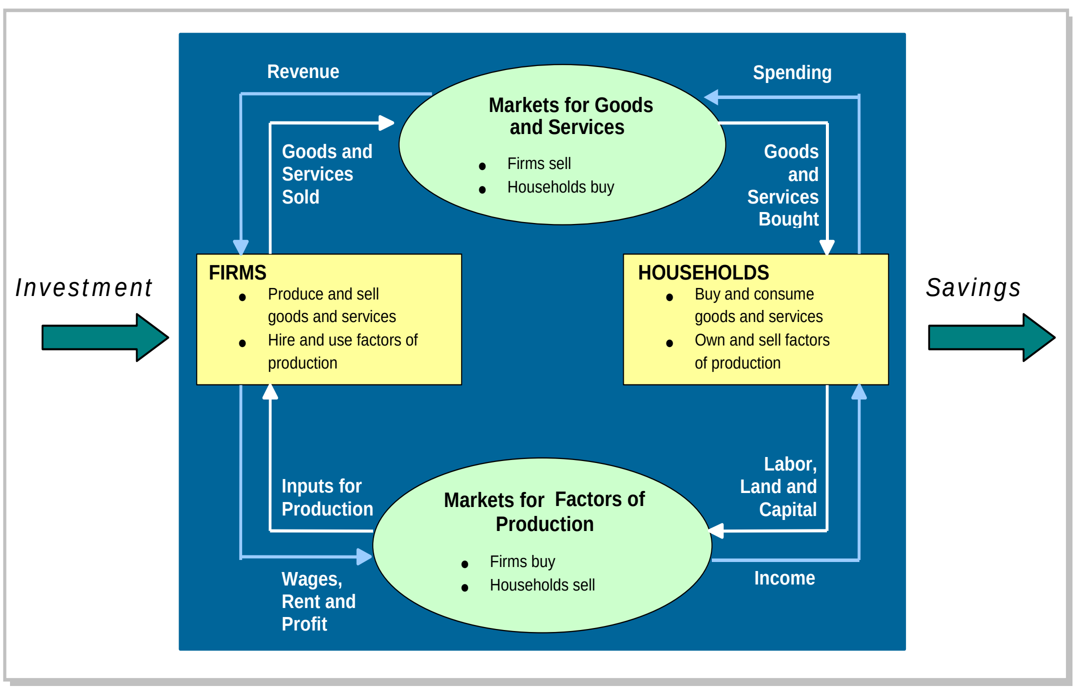
Economic Analysis Framework

In order to estimate the economic impact of the Alberta High Speed Rail (Alberta HSR), it is important to understand the character of the different economic benefits to be quantified. These benefits arise from developing and operating the system and have a substantial impact on the productivity of the provincial and local economy.

2.1 The Character of the Overall Economy

A model of the economy [11] shows that an economy is circular in character, with two equal sides (see Exhibit 2.1). On one side of the economy is the consumer side – the market for goods and services – in which consumers buy goods and services by spending the income earned by working for a commercial enterprise. For example, a transportation investment improves individuals travel times and costs and, therefore, increases consumer surplus. An analysis of the impact of a transportation investment in the market for goods and services quantifies the level of consumer surplus generated by a project, by showing how much money individuals save because a given project (i.e., a transportation improvement) reduces their cost of travel, or makes their travel more efficient.

Exhibit 2.1: Simple Model of the Economy

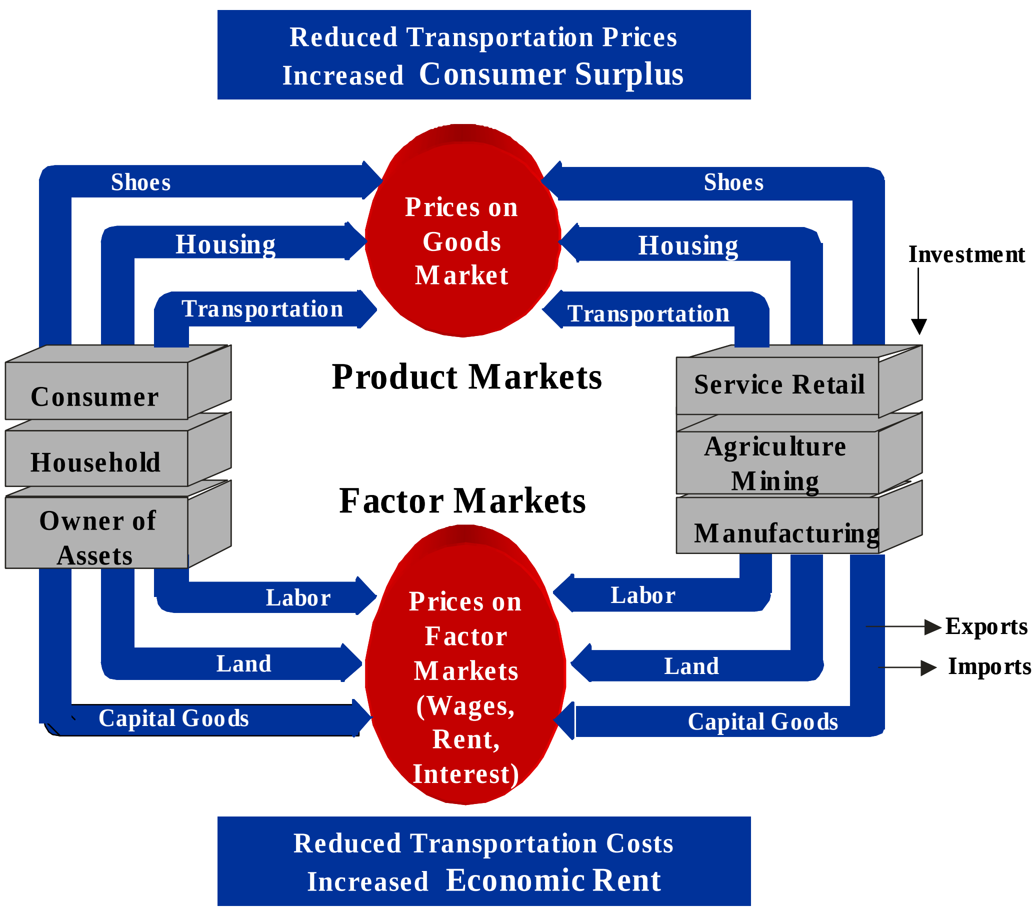


The notion that a transportation project can be worthwhile if travel is made more cost effective is based on the idea that not only the cost, but also the time of a trip, has value. This maxim is agreed to by most transportation companies and by business travellers as well as by both academia and important transportation authorities such as Transport Canada [4]. Additionally, academic and empirical research has shown that this concept holds true for commuters and recreational travellers as well [12]. Considerable research has been carried out to both identify the theoretical justification for value of travel time and to quantify its value.

On the other side of the economy is the market for factors of production. Most importantly, it is the market for land, labor and capital, which individuals provide to firms in exchange for wages, rent and profit. From the perspective of policy makers and the local community, this side of the economy is very interesting as it shows how investment in a new transportation infrastructure changes the efficiency of the economy and how the investment increases transportation efficiency, creates new jobs, opportunities, and, therefore, increases income and wealth and expands the tax base.

One of the most important aspects of the circular economy model is that it shows that any project has two impacts, one in the consumer market – the benefits to travellers; the second, in the factor of supply side of the economy – the benefit to the community in terms of improved welfare such as increases in jobs, income and wealth (see Exhibit 2.2).

Exhibit 2.2: Relation between Consumer Surplus and Economic Rent in the Economy



For the economy to reach equilibrium, both sets of benefits must be realized. As such, the benefits of a project are realized twice, once on the demand side and once on the supply side. As a result, there are two ways to measure the productivity benefits of a transportation project and, theoretically, both measurements must equal each other [13]. This is a very useful property since in specific analysis one can be used to check the other, at least at the aggregate level. This is very helpful and provides a check on the reasonableness of the estimates of project benefits.

However, in assessing the benefits of a transportation project, it is important not to double-count the benefits by adding supply side and demand side benefits together. It must be recognized that these two sets of benefits are simply different ways of viewing the same benefit. The two markets are both reflections of and measure the same thing. For example, if both sets of benefits equal $50 million, the total benefit is only $50 million, but expressed in two different ways: travellers get $50 million of travel benefits and the community gets $50 million in jobs, income, increased profits and an expanded tax base.

Therefore, if a given transportation project is implemented, equivalent productivity benefits will be seen in both the consumer market for goods and services (as the economy benefits from lower travel times and costs), as well as in the supply side factor markets. In the supply side market, improved travel efficiency is reflected in more jobs, income and profit. For a given transportation investment, therefore, the same benefit occurs on both sides of the economy. In the consumer markets, users enjoy lower travel costs and faster travel times. On the supply side of the economy, the factor markets take advantage of the greater efficiency in transportation. As a result, both sides of the economy move to a new level of productivity in which both sides of the economy are balanced in equilibrium.

To measure the benefit of a project, a demand-side analysis is required to measure the consumer surplus, i.e., the value of time savings to travellers, as well as resource savings like reduced energy, accidents and emissions. However, this improved efficiency will generate supply-side spending and productivity benefits that have a very real impact on the performance of the local economy. The method that develops estimates of productivity jobs and wealth creation is an Economic Rent Analysis. It measures how the performance of a new transportation facility raises the efficiency of the economy. This efficiency improvement creates jobs and income, and raises local property values to reflect the improved desirability of living or working in the area.

Two effective techniques have been developed for measuring both the demand (Consumer Surplus) and the supply (Economic Rent) side of the Alberta HSR system. In each case the fundamental economic rational for the technique is discussed and its underlying theory will be evaluated.

Specific methods for applying these two economic theories will be identified and appropriate measurement techniques will be developed. In particular, the issue of measuring the quality of the transportation system will be addressed.

2.2 Demand Side: Consumer Surplus Methodology

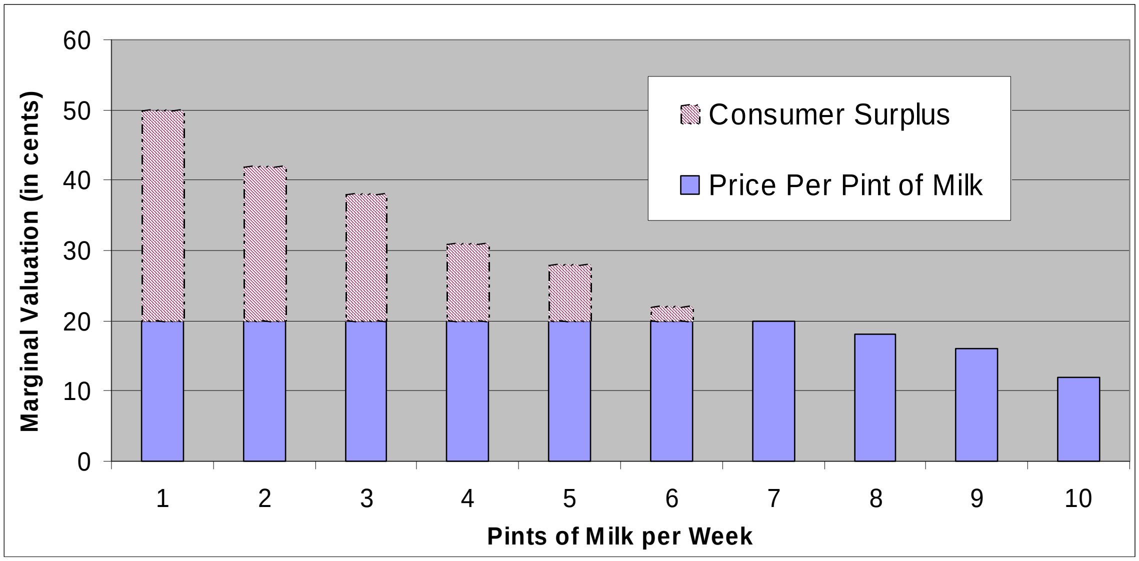
For the purposes of the Alberta High Speed Rail Economic Benefits Study the Benefit-Cost Analysis methodology developed by Transport Canada has been adopted [4].

In normative or allocative economics, the worth or value of a thing to a person is determined simply by what a person is willing to pay. If a person is willing to pay $100 for a gallon of cider, it may be inferred that it is (in his own estimation) worth to him no less than $100. If the gallon is priced at $5, the purchase of one gallon of it provides him with a benefit or consumer’s surplus of $95 (i.e., $100 less $5). The consumer’s (consumers’ or consumer) surplus is one of the most crucial concepts in the measurement of social benefits in any social benefit calculation and typically accounts for 40 to 60 percent of the benefits. It is clear that for all except marginal changes in the amount of a good, the market price prevailing in a perfectly competitive setting is an inadequate index of the value of the good to an individual. Using partial analysis, therefore, the economist engaged in a benefit calculation has to go beyond a simple price, times quantity measure of the benefits arising from the products or services of a project. Instead, ceteris paribus (all things being equal), the economist makes use of the area under the entire demand curve. Even in common sense terms, when an investment project is designed to save some part of the costs incurred in making use of existing facilities, the consumers’ surplus concept is implicit in the cost-saving calculation. Indeed, the magnitude of this cost saving is itself no more than a part, the major part it is true, of the horizontal segment of consumers’ surplus that is measured by the fall in the price of the service. In addition, as a result of a reduced price, new purchasers will enter the market. Since they are willing to pay a price higher than that proposed, they would also receive a benefit.

Given that the market demand curve is the required analysis framework, it is important to understand what goes into its profile. This will include the nature of the population for given size, tastes, the price of all other goods and productive services, and the distribution of society’s assets among its members. A change in any of these things can change the shape of the demand curve in question. Any resulting change in the measure of consumers’ surplus will then require careful interpretation. It should be noted that the interpretation of consumers’ surplus demands a reversal of the causal direction usually implied in the interpretation of the demand curve. Instead of analysis considering the maximum amount consumers are willing to buy at a given price, the analysis considering the maximum price the consumers are willing to pay for the last unit of that good.

Alfred Marshall [14] provided a simple, yet workable, definition of consumer surplus: the maximum sum of money a consumer would be willing to pay for a given amount of the good, less the amount he actually pays. We may extend the idea by thinking about asking a consumer the maximum sum per week he would be willing to pay for a good, say, one pint of milk, the maximum sum he will then pay for a second, the maximum for a third, and so on. These sums, which we can speak of as ‘marginal evaluations,’ are plotted as the heights of successive columns in Exhibit 2.3. If a price per pint of milk is fixed at, say twenty cents, he continues to buy additional pints of milk until his marginal valuation is equal to that price. Exhibit 2.3 illustrates a case in which the person buys seven pints of milk at twenty cents, so spending $1.40 per week on milk. The area contained in the shaded parts of the columns above the price line is a sum of money equal to the person’s consumer surplus.

Exhibit 2.3: The Value Obtained by Individual Buying Milk

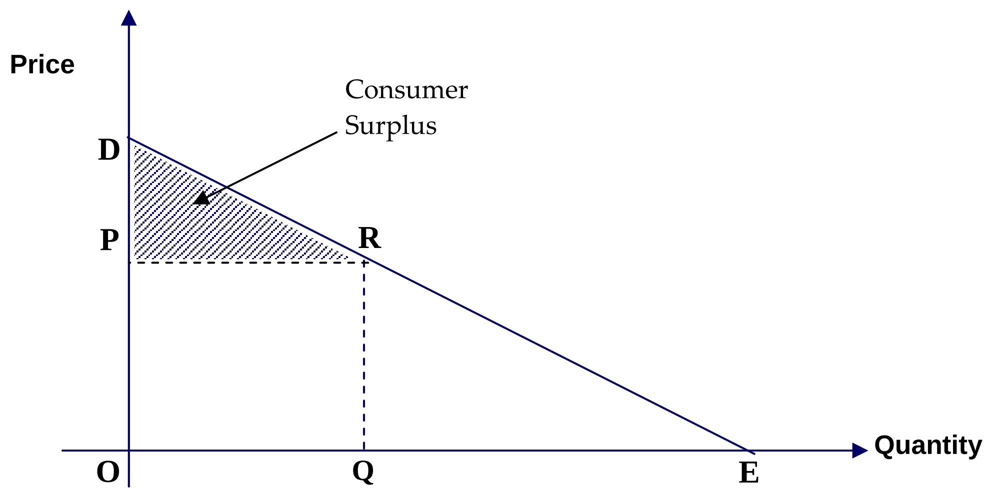


Once perfect divisibility is assumed, the stepped outline of the columns gives way to a smooth demand curve. From a point on the vertical, or price axis, the horizontal distance to the curve measures the maximum amount of the good he will buy at that price. The market demand curve, being a horizontal summation of all the individual demand curves, can be regarded as the marginal valuation curve for society. For example, the height QR in Exhibit 2.4, corresponding to output OQ, gives the maximum value some person in society is willing to pay for the Q^{th} unit of the good — which, for that person, may be the first, second or n^{th} unit of the good bought. But to each of the total number of units purchased, which total is measured as a distance along the quantity axis, there corresponds some individual's maximum valuation. The whole area under the demand curve, therefore, corresponds to society's maximum valuation for the quantity in question. If say, OQ is bought, the maximum worth of OQ units to society is given by the trapezoid area ODRQ. Now the quantity OQ is bought by the market at price OP. Total expenditure by the buyers is, therefore, represented by the area OPRQ. Subtracting from the maximum worth of buyers what they have to pay leaves us with a total consumers' surplus equal to triangle DRP.

If an entirely new good X is introduced into the economy, and is made available free of charge, the area under the resulting demand curve, ODE (given that prices of all other goods are unaffected) is a good enough measure of the gain to the community in its capacity as consumer. This is the methodology that is typically used for justifying transportation investments, based on the user's value of time savings. Again, however, if the project is a rail project and a price OP is charged for the use of the system, the amount OQ will be bought, leaving the triangular area PDR in Exhibit 2.4 as the consumers' surplus. This is the estimated consumers' surplus that needs to be entered as benefits in all benefit-cost calculations.

It is worth noting that because many transport projects often do not charge a price to users, e.g., new highways, bridges, tunnels, while other projects do charge users for services offered, e.g., railroad, airline, bus revenues are included within the benefits of a Benefit-Cost analysis. This is to assure modal equity and treat all modes equally in the project evaluation process.

Exhibit 2.4: Consumer Surplus of a Good or Service



Any investment having the object of reducing the cost of a product or service is deemed to confer a benefit on the community, often referred to as a cost difference or cost saving. The benefit of a new motorway, or flyover, is estimated by reference to the expected savings of time, and of the cost of fuel and other resources, by all motorists who will make use of the new road or flyover.

It has become the convention in transport economics to argue that time has value and, as such, economists have measured the value of time. In transportation economics benefit-cost analysis, it is agreed that both time and money have a cost and that they should be incorporated into a single metric called "generalized cost."

Generalized cost is defined as:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} \qquad (1)$$

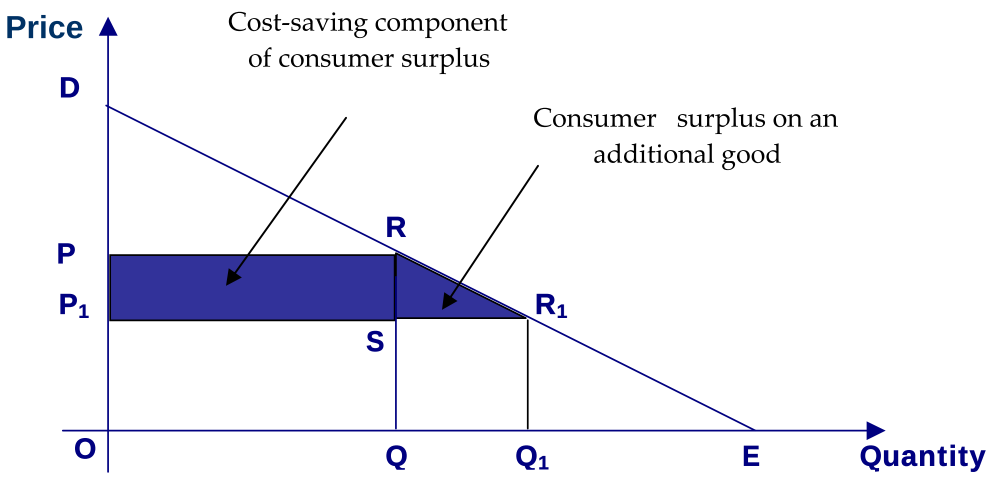
Where:

TT_{ijm} = Travel Time between zones i and j for mode m;
TC_{ijmp} = Travel Cost between zones i and j for mode m and trip purpose p;
VOT_{mp} = Value of Time for mode m and trip purpose p.

In transport economics benefit-cost studies, the price of travel is redefined to include both the time and cost of travel, as specified in the generalized cost metric.

As already indicated, however, the concept of cost-saving is derived directly from the concept of consumers' surplus, as can be shown by reference to Exhibit 2.5. Thus, prior to the introduction of a new transport system, the consumers' surplus, as measured by time and money savings from using this particular facility, is the triangle PDR. If the facility halves the cost of the journey (in terms of both time and money) from OQ to OQ_1, the consumers' surplus increases from PDR to P_1DR_1, an increase equal to the shaded strip PP_1R_1R.

Exhibit 2.5: Consumer Surplus as a Result of Reduced Price



This increase of consumers' surplus can be split into two parts. The first part is the cost-saving component, the rectangle PP_1SR, which is calculated as the saving per journey, PP_1, multiplied by the original number of journeys made, OQ. The other component, represented by the triangle SRR_1, is the consumers' surplus made on the additional journeys undertaken, QQ_1, either by the same motorists or by additional motorists. The cost saving item that enters a benefit-cost calculation is, as indicated, no more a portion of the increment of consumers' surplus from a fall in the cost of the good. Since it takes no account of the additional goods that will be bought in response to the fall in cost, the cost-saving rectangle alone can be accepted as a minimum estimate of the benefit.

The extent of the collective improvement from the introduction of a transport facility is, then, expressed in terms of a sum of money (in terms of cost and time) that is measured by a triangle of consumers' surplus, such as PDR in Exhibit 2.5. Its interpretation is simply the maximum amount of money the group, as a whole, would offer in order to be able to buy OQ of this new good at price P. The extent of the collective improvement from a reduction in its price, however, is expressed as an increment of consumers' surplus, as for example, the strip PP_1R_1R in Exhibit 2.5. The strip can be interpreted as the maximum amount of money the group as a whole would offer in order to have the price reduced from OP to OP_1.

Thus:

$$\text{Consumer Surplus} = \text{Area (Rectangle } PRP_1S) + \text{Area (Triangle } RSR_1) \quad (2)$$

$$\text{Consumer Surplus} = PR * PP_1 + \tfrac{1}{2} * RS * SR_1 \quad (3)$$

2.3 Supply Side: Economic Rent Methodology

The concept of Economic Rent is derived from basic Ricardian economic theory and provides a means of explaining the increased value of economic resources (land, labour and capital) and their change in value in different circumstances or market conditions. Accessibility is a key spatial variable that affects the likely uses of economic resources and, therefore, their value. Changes in accessibility result in changes in the economic rent that economic resources can command and, therefore, the value and character of the economic activities that take place at any location. As a result, for important economic welfare criteria (such as employment, household income, and property values), an evaluation can be made of the likely change in economic rent that will be associated with an improvement in accessibility generated by a given transportation investment.

Economic rent may be defined as the difference between what the factors, or productive services, of a resource-owner earn in their current occupation and the minimum sum he is willing to accept to stay there. It is then a measure of the resource-owner's gain from having the opportunity of placing his factors in the chosen occupation at the existing factor price, given the prices his factors would earn in all other occupations. It is the proper counterpart of consumers' surplus when this is regarded as the consumers' gain from having the opportunity of buying a particular good at the existing price, where all other prices are given. And like a change in the consumers' surplus, it is a measure of the change of his welfare when the relevant prices in the market are altered. Whereas the increase of consumers' surplus is a measure of his welfare gain for a fall in one or more product prices, the increase in that person's economic rent is a measure of his welfare gain from an increase in the price or the volume of the sale of his factors, i.e. increased sales should generate increased profit.

Conventionally, a person's price-demand curve is drawn as sloping downward to the right, his price-supply curve as sloping upward to the right. If income effects are zero, the individual's demand curve must slope downward: it can slope upward—the characteristic of a so-called "Giffen good"—only if the income effect is negative, and largely relative to the substitution effect. Similar remarks apply to the individual's supply curve. If the income-effect or rather, the 'welfare effect'[1] is zero, the individual supply curve must slope upward: it can slope downward, or become 'backward-bending,' only if the welfare effect is positive and largely relative to the substitution effect[2].

Typically, the level of economic rent can be calculated as follows:

$$\text{Economic Rent (ER)} = f\,(P_t, I_t, E_t, C_t, T_t) \qquad (4)$$

[1] Assuming his money income constant, a fall in the price of a good, which makes a person better off, can be regarded as an increase in his real income. There is some rise in his money income that (given all other prices constant) will be accepted by him as equivalent to a fall in the price of that good. Here, no difficulty arises in identifying the increase in his welfare with the income effect so measured. In the case of his supplying a service to the market, however, the person's money income cannot be assumed constant, since, obviously, it varies with the amount of the service he elects to supply at the price offered. What is more, a rise or fall in the resulting money income does not necessarily correspond with a rise or fall in his welfare. A rise in the wage rate, for instance, may result in workers choosing to reduce hours while maintaining the same income, notwithstanding which his welfare has increased: for his income is the same while he enjoys additional leisure. A positive welfare effect, that is, can be associated with no change in his money income or even with a reduction in his money income. For this reason, it is more sensible to talk of the 'welfare effect' resulting from a change in the supply price.

[2] An increase of welfare has a normal or positive welfare effect if the person offers less at any given price—if that is, he keeps more of the good he is offering for himself. A worker who came into an inheritance would supply less labor. Hence if the price of a good a person supplies is raised, the substitution effect induces him to supply more while a positive welfare effect causes him to supply less. As distinct then from the income effect on the demand side, the welfare effect on the supply side, if it is positive, works against the substitution effect.

Where:

P_t is a measure of Population structure of an area in year t;

I_t is a measure of Industrial structure of an area in year t;

E_t is a measure of Education level of an area in year t;

C_t is a measure of Cultural characteristics of an area in year t;

T_t is a measure of Transportation efficiency of an area in year t.

Any analyzed region (area) has its own 'Economic Rent Profile'. Economic rent profile shows the spacial distribution of the economy in terms of key factors such as income, property value and wealth. Characteristics listed above might have a significant impact on economic rent profile.

Population Structure: The population structure can affect the economic potential of an area positively or negatively. For example, an aging population could have a negative effect on the economy as the number of workers in the work force may fall. This can reduce productivity and, as a result, reduce the economic rent profile. Alberta might experience this problem in the future if the tendency of population aging continues: in the last 40 years the number of seniors in the province increased by 162 percent, while the total population increased by 85 percent. At the same time, it is too early to worry about real aging of Albertans: in 2005 province of Alberta still had the lowest percentage of seniors in the country – 10.5 percent, while the comparable figure for Canada was 13 percent[3]. Typically, the more productive the adult population of an area is, the higher the economic rent profile.

Industrial Structure: The nature of the industrial structure and resource base defines the potential economic rent profile of an area, e.g., manufacturing, commercial, agricultural, residential, and service industry. The higher the value added by industry, the higher the area's economic rent profile. For example, the "new economy" jobs in biotech, computers and finance all have very high incomes and economic rent profiles associated with them. The City of Toronto in the 1970s and 1980s was saved from a major loss of economic rent associated with the failing metal manufacturing industry and its associated jobs by a massive infusion of financial sector jobs [16].

Education Level: Educational levels can have a dramatic impact on economic rent potential of an area. Typically, a higher education level (especially Ph.D.'s or other high degrees) will increase the wealth generated by the population. The Baltimore-Washington region, for example, boasts one of the highest concentrations of Ph.D.'s in the US, which supports the growth of high tech industry in the region[4]. Provinces of Ontario and Alberta, for example, have the highest share of people with Master or Doctorate Degree in Canada[5].

[3] Statistics Canada, Annual Demographic Statistics 2005; Alberta Seniors and Community Supports. http://www.seniors.gov.ab.ca/policy_planning/factsheet_seniors/aging_population/increase/index.asp

[4] According to the data assembled by the Metropolitan Washington Council of Governments (source: US Census Bureau), 20.6 percent of individuals over the age of 25 residing in the Baltimore-Washington region have a graduate or professional degree. This is well above the national average of 8.9 percent.

[5] Statistics Canada. 2001 Census of Population. http://www40.statcan.ca/l01/cst01/educ41c.htm

Cultural Characteristics: Differences in cultural, ethnic and other social characteristics of an area can impact its economic potential. For example, cultural belief systems can impact the ability of a population to work at certain jobs or in a certain way and, therefore, the level of economic rent that can be attained. A survey by the United Nations of the economic growth potential of Arab countries found that the low level of freedom, limited Internet use and the absence of women in the workforce have had a marked negative impact on economic productivity [17].

Transportation Efficiency: Transportation efficiency can greatly affect the economic potential of an area. The more effective a transportation system in moving people and goods, the greater its ability to generate wealth if the economy is responsive to the opportunity presented. Since the quality of a transportation system is a management variable and can be changed in the short term, investment in the transportation system can generate economic development if the investment is made in a growing and vibrant economy. The level of response that the economy will have to a transportation investment is measured by the economic rent profile.

Where it is important to recognize that education, population, industry, structure, and culture can change over time changing the economic rent profile, these are not factors that typically change rapidly. Only if an area experiences a significant dislocation or migration associated with rapid and dramatic population and industrial base shifts will it experience a radical change in its economic rent profile. For example, the influx of Hong Kong residents to Vancouver, Canada, in the 1980s dramatically changed the economic rent profile of several areas of the city’s downtown. The effect was largely due to the wealth and “entrepreneurial” capability of this new population. In the United States one of the issues for the Midwest is the fact that while it has some of the country’s leading academic institutes, it is still losing much of this talent because it is not developing the New Economy businesses at a sufficient rate.

In the absence of a major dislocation, we can assume that the economic rent factors I_t, E_t, P_t, and C_t will remain largely unchanged. However, transportation efficiency can change significantly in the “short term.” Major transportation infrastructure projects can dramatically change the accessibility of markets and the opportunity for economic growth. This can apply to the measurement of goods in a manufacturing-dominated economy or to the movement of people in a service industry-dominated economy. The economic rent generated by transportation improvements (T_t) has driven the desire to move people more quickly and cost-effectively over time. As a result, our Economic Rent model reduces to:

$$ER = f(T_t) \qquad (5)$$

By using socioeconomic variables (SE_i) as a proxy for economic welfare and generalized cost (GC_i) as a specific metric for transportation efficiency[6] measured in terms of time and cost the economic rent equation can be rewritten as:

$$SEi = \beta_o GC_i^{\beta_1} \qquad (6)$$

[6] In certain cases it is important to use travel utility as a metric for transportation efficiency included into Economic Rent model (see chapter 3).

Where:

SE_i – Economic rent factors – i.e. socioeconomic measures such as employment, income, property value of zone i;

GC_i - Weighted generalized cost of travel by all modes and for all purposes from (to) zone i to (from) other zones in the study area;

β_0 and β_1 - Calibration parameters.

The resulting curve generated by this function is the economic rent profile for transportation accessibility. For public modes (rail, bus, air) and private modes (auto), the generalized cost of travel includes all aspects of travel time (access/egress time and in-vehicle time), travel cost (fares, tolls, parking charges), and service frequency.

The generalized cost of travel is typically defined in travel time rather than dollars. Costs are converted to time by applying appropriate conversion factors. The generalized cost of travel between zones i and j for mode m and purpose p is calculated as follows[7]:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH}{VOT_{mp} * F_{ijm}} \qquad (7)$$

Where:

TT_{ijm} = Travel time between zones i and j for mode m (in-vehicle time + waiting time + delay time + connect time + access/egress time + interchange penalty), with waiting, delay, connect and access/egress time multiplied by two to account for additional disutility felt by travellers for these activities[8];

TC_{ijmp} = Travel cost between zones i and j for mode m and purpose p (fare + access/egress cost for public modes, operating cost for auto);

VOT_{mp} = Value of Time for mode m and purpose p;
VOF_{mp} = Value of Frequency for mode m and purpose p;

F_{jjm} = Frequency in departures per week between zones i and j for mode m;

OH = Operating Hours per week.

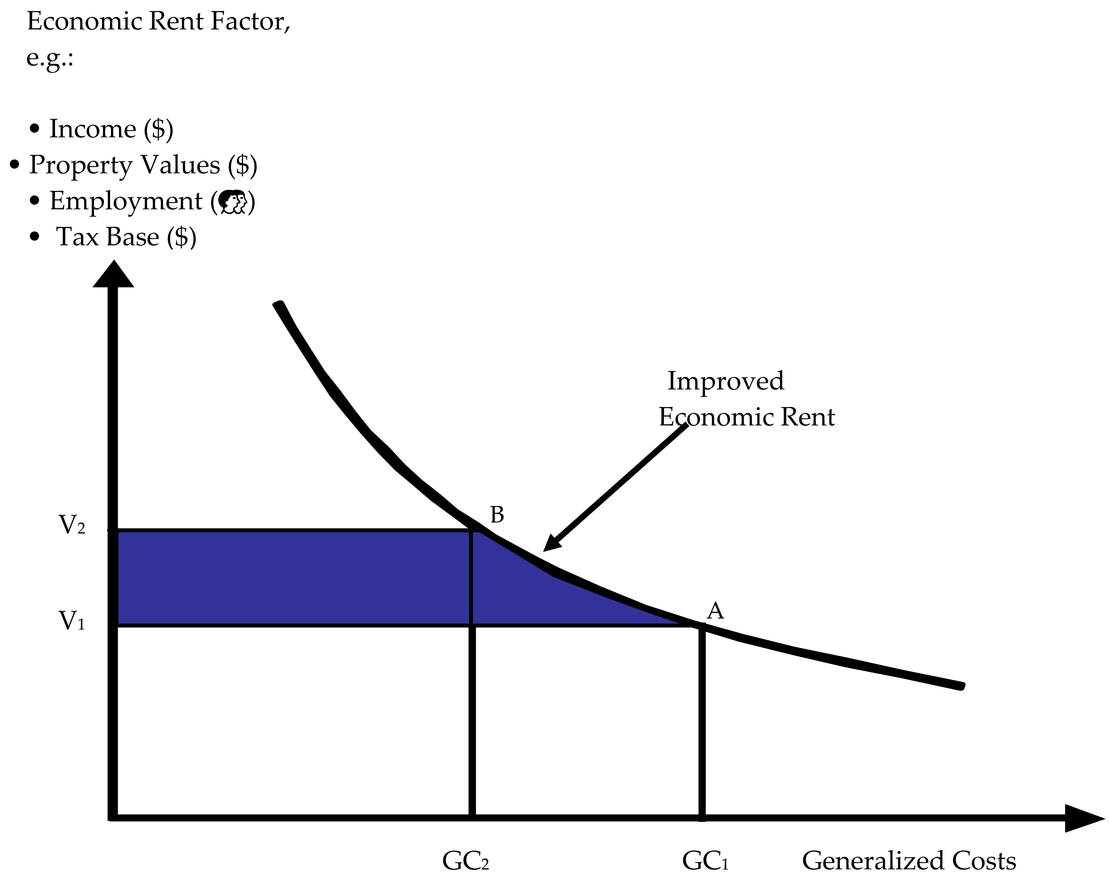
The Economic Rent theory builds from the findings in Urban Economics, and Economics of Location that support the Central Place Theory [9], [10]. Central Place Theory argues that in normal circumstances places that are closer to the "center" have a higher value or economic rent. This can be expressed in

[7] In comparison with formula (1) formula (7) includes not only value of time, but also value of frequency. For certain regions generalized cost might also include value of reliability and/or value of seasonality.

[8] Issues of travel time calculation, including the weighting factor for travel time is broadly discussed in the literature. See, for example: [18], [19]:

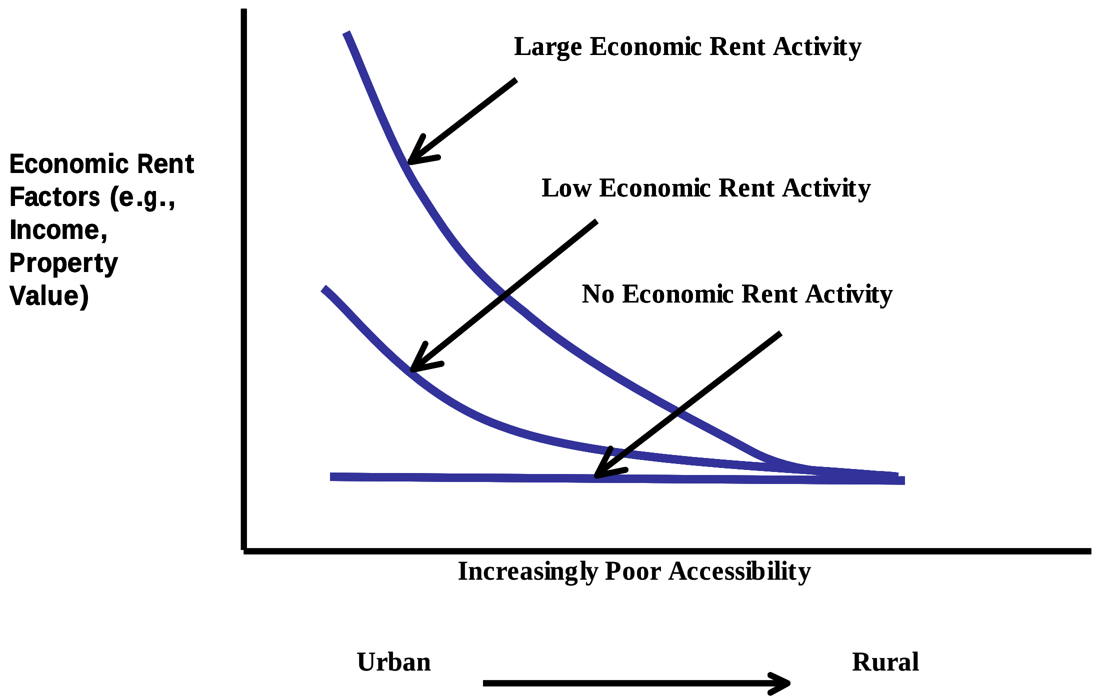
economic terms, particularly jobs, income, and property value. There is a relationship between economic rent factors (as represented by employment, income, and property value) and impedance to travel to market centers (as measured by generalized cost). As a result, lower generalized costs associated with a transport system improvement lead to greater transportation efficiencies, and increased accessibility. This, in turn, results in lower business costs/higher productivity and, consequently, in an increase in economic rent. This is represented by moving from point B to point A in Exhibit 2.6.

Exhibit 2.6: Economic Rent Illustration



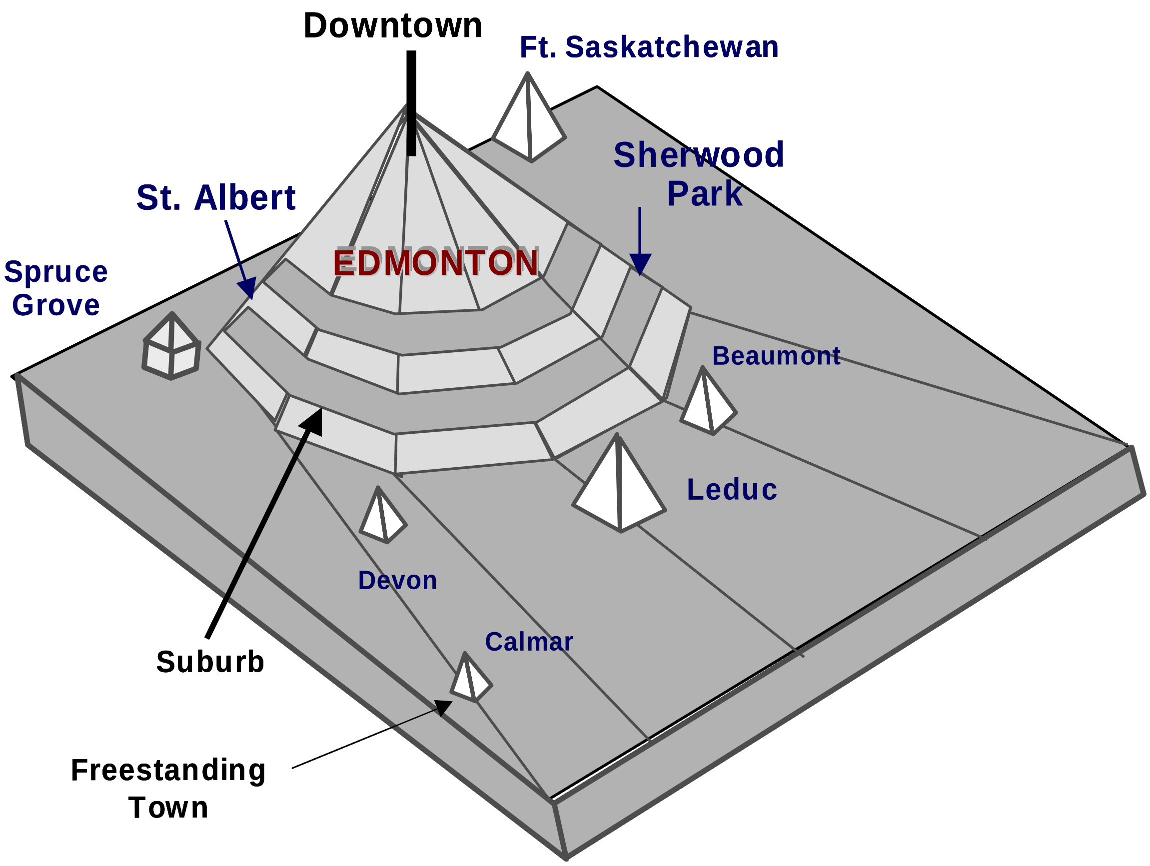
It should be noted that the shape of the economic rent curve reflects the responsiveness of the economy to an improvement in accessibility. Large cities typically have very steep curves, which indicate more significant economic impacts due to a transportation improvement; smaller communities have less steep curves, and rural areas have very flat curves that indicate lower economic responsiveness (see Exhibit 2.7).

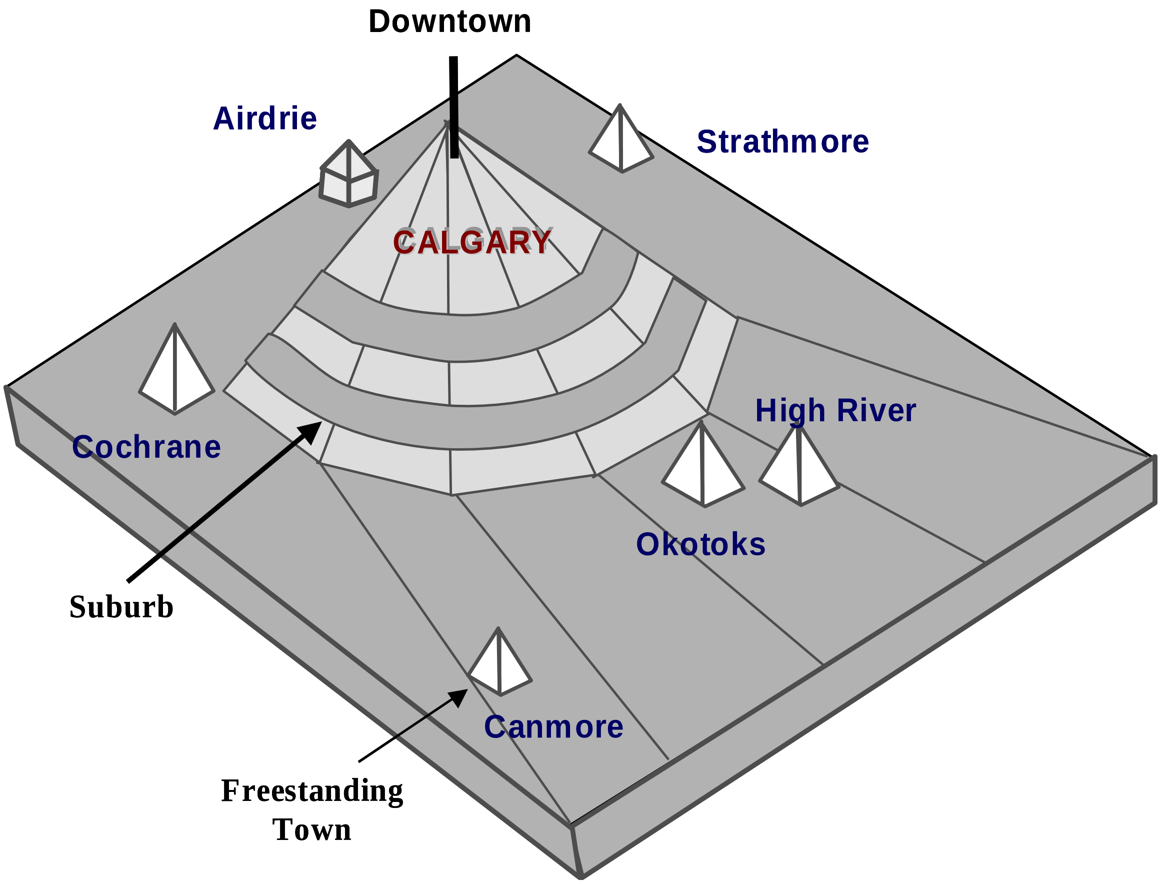
Exhibit 2.7: Types of Economic Rent Curve

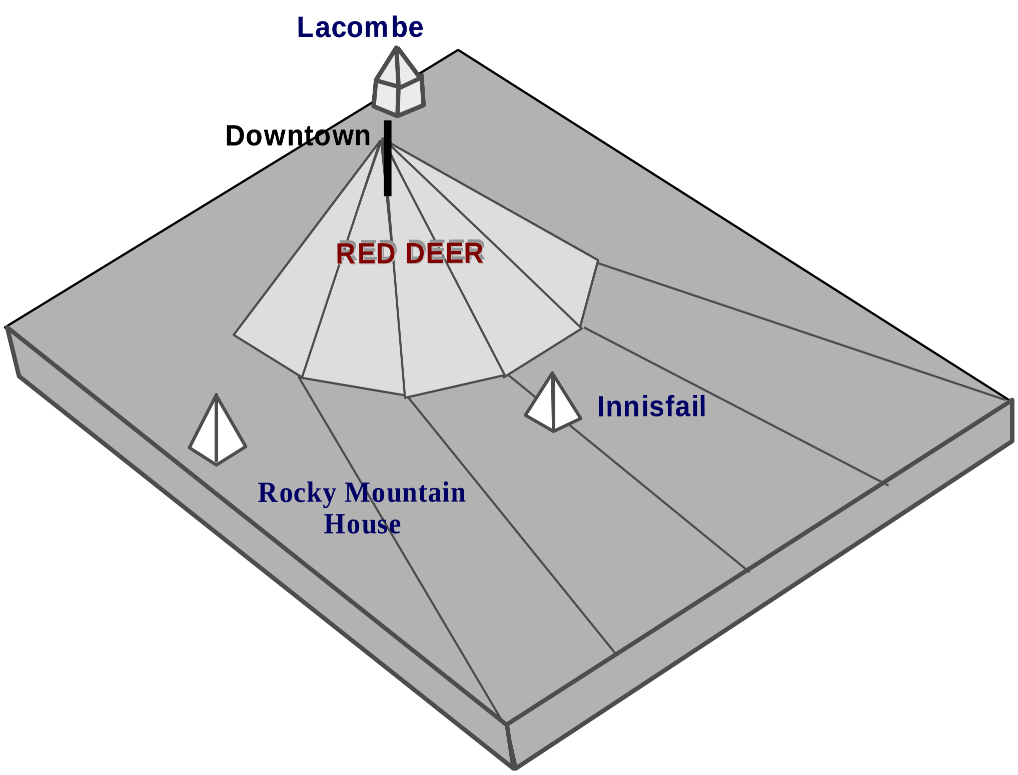


Given that the economic rent profiles exist in all directions from a given market center it is inevitable that the rent profiles will link into 'rent tents,' and that the rent tents will merge across the study area into a 'rent surface' which measures the economic rent for the whole study area - province of Alberta. As the economy grows so the rent tents become higher and the economic rent profiles steeper, see Exhibit 2.8.

Exhibit 2.8: Interaction of Economic Rent Profiles Creates Economic Rent Tents (Edmonton, Calgary and Red Deer Area Economic Rent Tents - Schematic)




Downtown
Airdrie
Strathmore
CALGARY
Cochrane
High River
Okotoks
Suburb
Canmore
Freestanding Town


Lacombe
Downtown
RED DEER
Innisfail
Rocky Mountain House

3

The Economic Evaluation Databases

3.1 Introduction

The purpose of the Alberta HSR Economic Benefits Study is to explore the full range of economic impacts that will result from the development of the Alberta HSR system. As previously described, two major tools are being developed to facilitate this process[9]. These are as follow:

- Consumer Surplus Analysis of User Benefit
- Economic Rent Analysis of Producer Benefits

To meet this need a series of databases calculation processes were developed for the study. (See exhibits 3.1 through 3.3.) The following section outlines the development and calibration process adopted by the study.

3.2 Economic Benefits Study Process

Both Consumer Surplus and Economic Rent analyses are highly integrated. They use overlapping databases that reflect both supply and demand sides of the Alberta High Speed Rail (Alberta HSR) system. The modeling and calibration process for both the Consumer Surplus and Economic Rent assessments are shown in Exhibit 3.1. This overall process has four main stages as follows:

- ***Stage 1:*** Four-mode transportation network, origin-destination and socioeconomic databases were developed in order to provide input to the evaluation tools, so that they can meet the assessment requirements. Those databases are related to a comprehensive zone system that defines specific geographic areas. (See exhibits 3.4 through 3.7.)

- ***Stage 2***: A transportation demand analysis applies the calibrated demand functions in the COMPASS™ travel demand model to provide traffic volumes and the cost of travel (generalized cost) that are used in both Consumer Surplus and Economic Rent analysis.

- ***Stage 3:*** Economic Rent modeling and supply curve calibration is developed using the RENTS™ model.

[9] In addition to the use of these major assessment tools, further analysis was completed to assess the impact of increased government receipts from increased taxes.

- ***Stage 4:*** Detailed Consumer Surplus and Economic Rent analysis with user benefits and producer benefits results is generated.

Economic Rent modeling and calibration process has its own specific features, as illustrated in Exhibit 3.2.

3.3 Developing the Databases

This process is illustrated in Exhibit 3.3. A very important factor here is the availability of information used to develop and evaluate the Alberta HSR system. These databases include the following:

- ***Operating Plan:*** This plan specifies the character of Alberta train operations, including labour, equipment, cash flows and secondary activities such as parcel system, onboard services, equipment maintenance, track maintenance, and administrative and sales services.

- ***Travel Data:*** This demand database specifies the origin destination of travel by four modes: air, auto, intercity bus (Greyhound and Red Arrow), and intercity rail, and by two purposes, business and community.

- ***Network Data:*** This supply side data specifies the cost and time of travel (generalized cost) by each mode and purpose for the total Alberta study area - province of Alberta – 158 internal and external zones in the system (see exhibits 3.4 through 3.7).

- ***Socioeconomic Data:*** This database specifies the base and forecast year levels of population, employment and income for each travel zone. This provides an understanding of the change in the economy of Alberta over the next forty-five years.

In access to the data developed specifically for the Alberta HSR system Consumer Surplus Analysis, additional Economic Rent datasets include the following:

- ***Property Data:*** specifying the commercial and residential value of individual properties, as well as the number of different types of property (i.e. – dwelling units) in each zone.

- ***Tax Data:*** specifying the level of taxation in each zone.

- ***Station Data Base:*** collecting socioeconomic base year data for cities/towns that serve as station sites.

Database development process illustrated in Exhibit 3.3 provides the geographic framework of transportation network and socioeconomic and transportation data that are to be obtained from various sources.

3.4 Socioeconomic Database

This database is prepared using multiple official sources. Statistical base and historical data on population, employment, average household income, number of households, number of dwelling units was obtained from the 1991, 1996, 2001 and 2006 Census of Canada (Statistics Canada).[10] Data for zones in the City of Edmonton (which correspond to the inner city traffic districts[11]) was obtained from the City of Edmonton demographic database.[12] Population and employment data for zones in the City of Calgary was obtained using City of Calgary database and Calgary Regional Transportation model[13]. Property value data (differentiated by property type) was obtained from Alberta Municipal Affairs Assessment Report[14]. Tax data was collected using multiple official sources[15].

Projections on population, employment and average household income were developed using official projections at the national, provincial and local levels. These projections were analyzed and processed using the Demographic Projections Model developed by TEMS. During the model calibration process, data on population, employment and income for the base and forecast years was adjusted to the zone system of the study area.

In TEMS' Demographic Projections Model forecasts made for the province and divisions were integrated with the forecasts made for the cities (subdivisions) and even smaller areas. For example, population and employment projections for study zones in the City of Edmonton and Edmonton CMA were prepared using the long-term forecasts for the corresponding traffic districts and traffic zones[16]. For the City of Calgary and Calgary region, population and employment projections for the study zones were made using the long-term population forecasts for transportation zones developed by the City of Calgary and reflected in the Calgary Regional Transportation Model and Calgary and Region Socioeconomic Outlook[17].

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[10] Census of Canada, Statistics Canada: http://www12.statcan.ca/english/census01/home/index.cfm ; Alberta First: http://www.albertafirst.com/profiles/community/

[11] The map of Edmonton traffic districts is available on the City of Edmonton website: http://www.edmonton.ca/infraplan/demographic/Sector%20Profiles/TD/tdmap.pdf . In the zoning system developed by TEMS for the study area zones # 1-31 correspond to the City of Edmonton traffic districts.

[12] Edmonton Alberta's Capital City. Demographic. City Sector Profiles. http://www.edmonton.ca/infraplan/demographic/Sector%20Profiles/TD/TD%20by%20Topic.pdf

[13] Calgary Regional Transportation Model . Standard Forecast Series 2005-2035 Horizon. Transportation Zones (Region). Transportation Zones (City). The City of Calgary Transportation. 2007. http://www.calgary.ca/transportation/forecasting

[14] 2007 Equalized Assessment Report. Assessment Services. Alberta Municipal Affairs & Housing: http://www.aema.gov.ab.ca/as_reports_papers.htm

[15] See: Canada Revenue Agency: http://www.cra-arc.gc.ca/tax/individuals/faq/taxrates-e.html and Alberta Municipal Affairs & Housing: http://www.municipalaffairs.gov.ab.ca/.

[16] Population & Employment Forecasts 2006-2041. Capital Region. Prepared by Applications Management Consulting Ltd. August 2007; Greater Edmonton Economic Outlook 2007. Prepared by Edmonton Economic Development Corporation. June 2007; Edmonton Socio-Economic Outlook 2007-2012. Prepared by the City Forecast Committee. May 2007.

[17] Calgary Regional Transportation Model . Standard Forecast Series 2005-2035 Horizon. Transportation Zones (Region). Transportation Zones (City). The City of Calgary. Transportation. 2007. http://www.calgary.ca/transportation/forecasting; Socio-Economic Outlook 2006-2016. Calgary and Region. October 2006. The City of Calgary.

Long-term and medium-term population projections available for the major cities or subdivisions in the province of Alberta (such as Strathcona County, Red Deer, Lethbridge, Medicine Hat and Grande Prairie)[18] were also used. Use of historical (1991-2006) trends for each subdivision together with all available official population projections (including projections at the national level through 2056)[19] resulted in developing population projections by study zone for the three scenarios and the 45-year forecasting period.

Using long-term population projections by age group (low, moderate and high) for census divisions in the province of Alberta from Alberta Finance, employment projections for economic regions from Alberta Human Resources & Employment[20] and historical trends on employment rate for each census division from Statistics Canada, TEMS developed employment projections. Historical growth rates in each subdivision were used to develop the final projections for employment by zone.

Long-term projections on average household income were made using historical trends for each sub-division and projections from Canadian Demographics[21].

[18] Strathcona County Population Forecast Based on Census Date & Occupied Dwellings Units. Economic Development and Tourism. See: www.strathconacounty.com;
City of Red Deer Population Projections 2007-2031. Final Report August 25, 2006. The City of Red Deer. Parkland Community Planning Services. Prepared by Schollie Research & Consulting. http://www.city.red-deer.ab.ca;
Population projections for the city of Lethbridge, 2001 to 2031. Urban Futures Incorporated. Prepared for the City of Lethbridge. November 2001. See: http://www.lethbridge.ca;
State of the City 2007. Medicine Hat The Gas City. http://www.city.medicine-hat.ab.ca
City of Grande Prairie Economic Development. Economic Profile. http://www.cityofgp.com

[19] Population Projections for Canada, Provinces and Territories 2005-2031. Statistics Canada. Catalogue # 91-520-XIE http://www.statcan.ca/english/freepub/91-520-XIE/0010591-520-XIE.pdf; Alberta Infrastructure and Transportation.

[20] Alberta Regional Occupation Outlook :2006-2011. September 2006; Alberta Occupational Supply and Demand Outlook: 2006-2016. November 2006. Alberta Human Resources and Employment; http://employment.alberta.ca

[21] Canadian Demographics. Data Mapping Wizard. MS MapPoint 2004.

Exhibit 3.1: Economic Impact Study - Modeling and Calibration Process

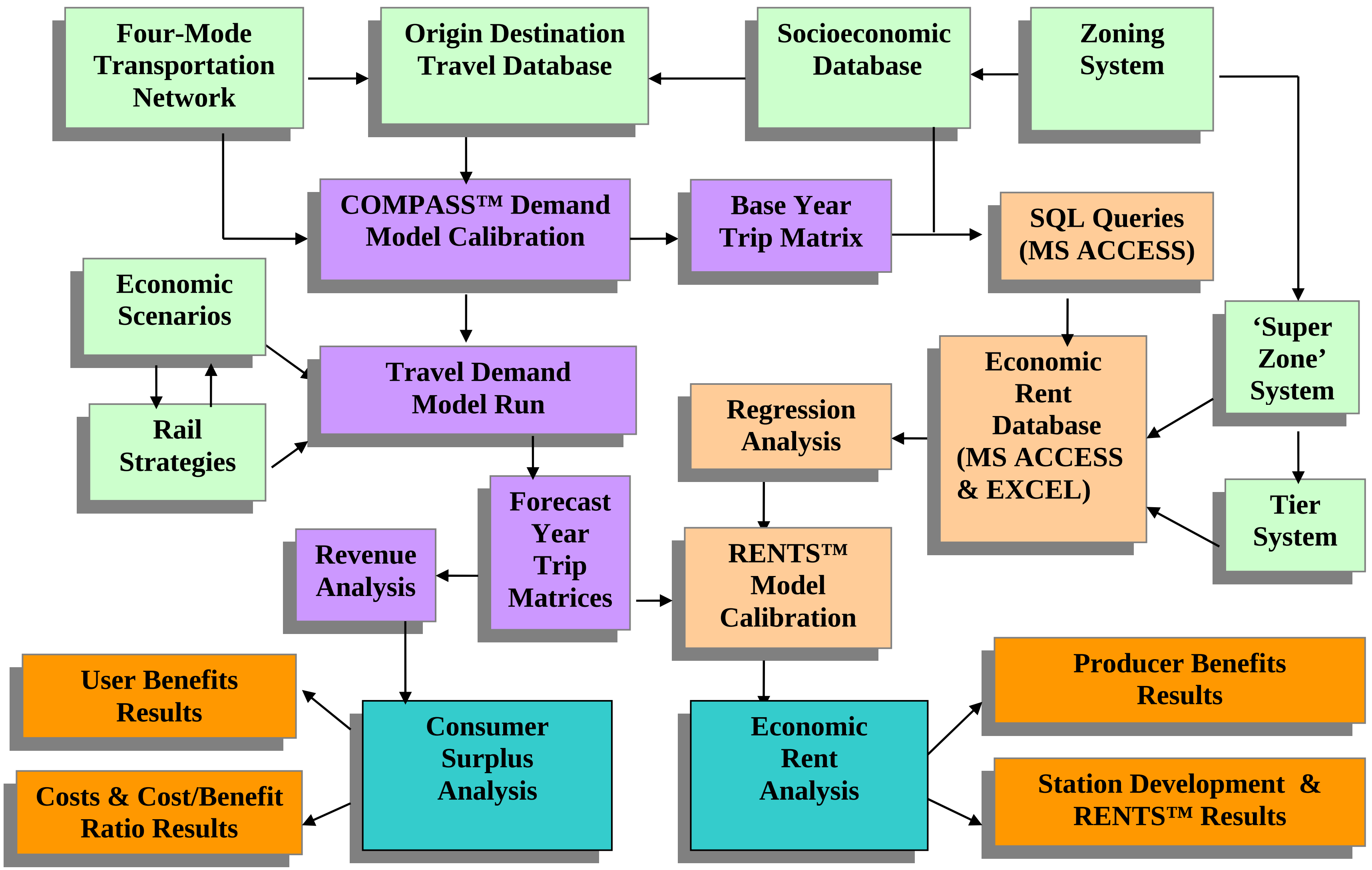


Exhibit 3.2: Economic Rent Study – Modeling and Calibration Process

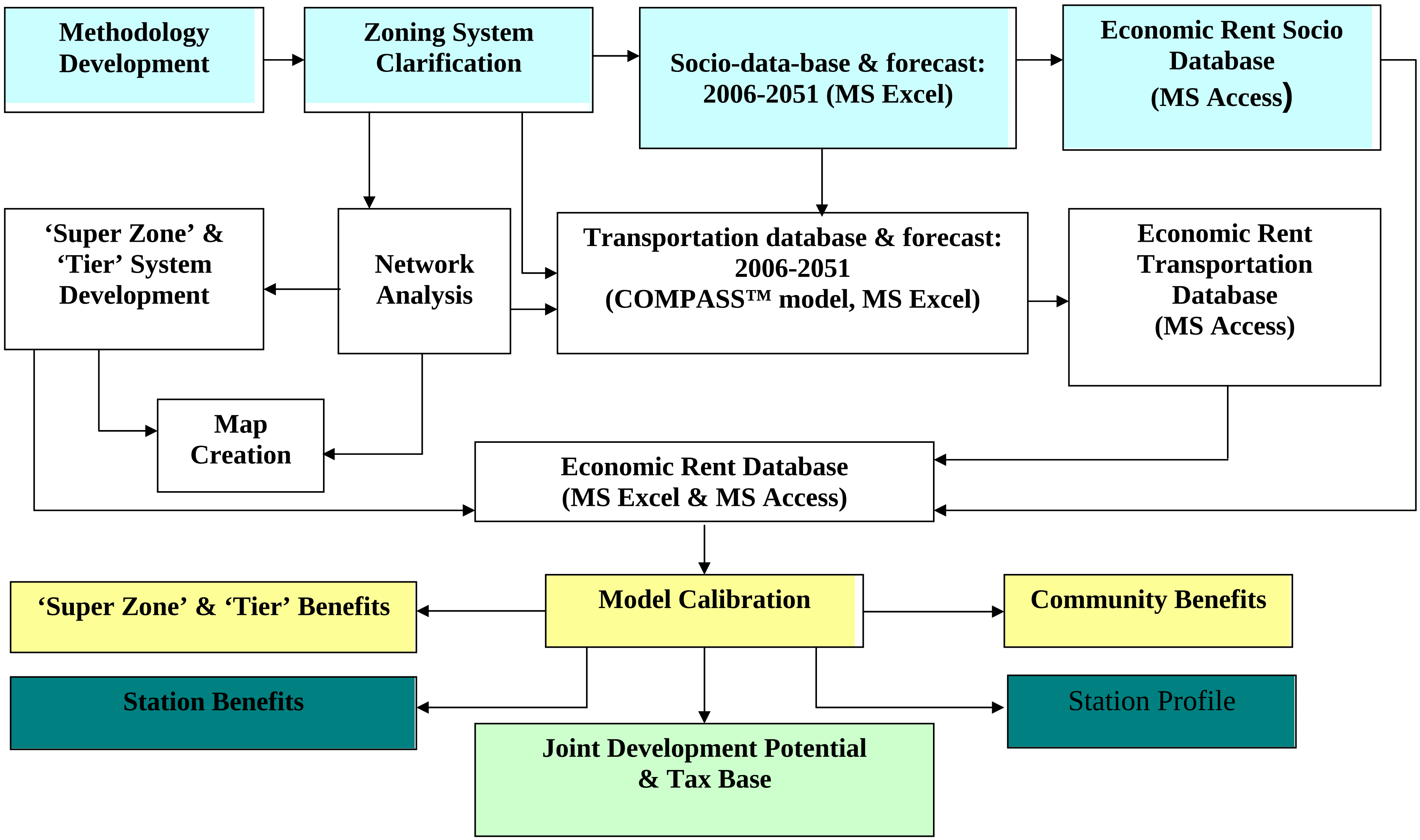


Exhibit 3.3: Economic Impact Study – Database Development

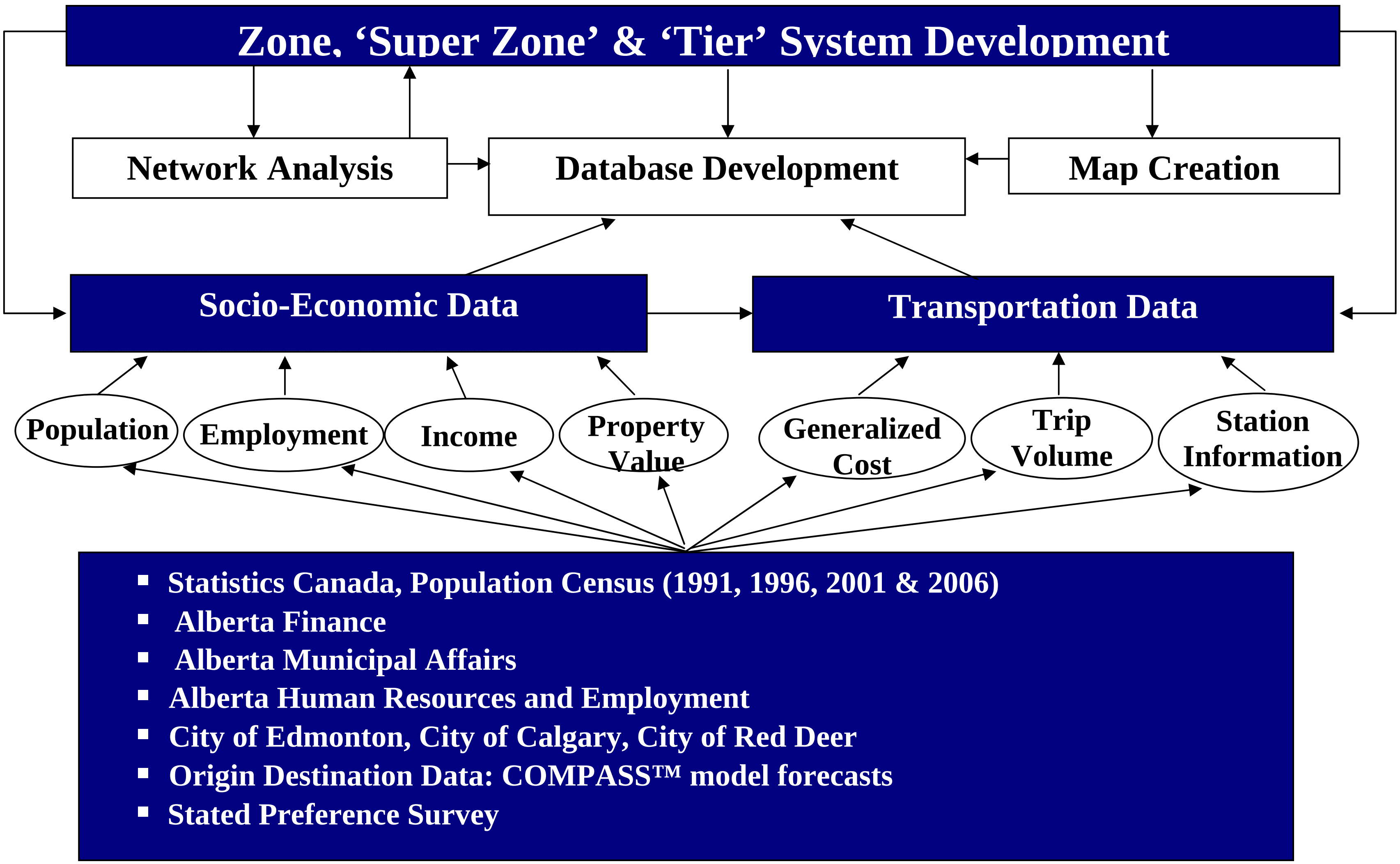


Exhibit 3.4: Alberta HSR Study Area Zoning System

Exhibit 3.5: Edmonton to Calgary Corridor

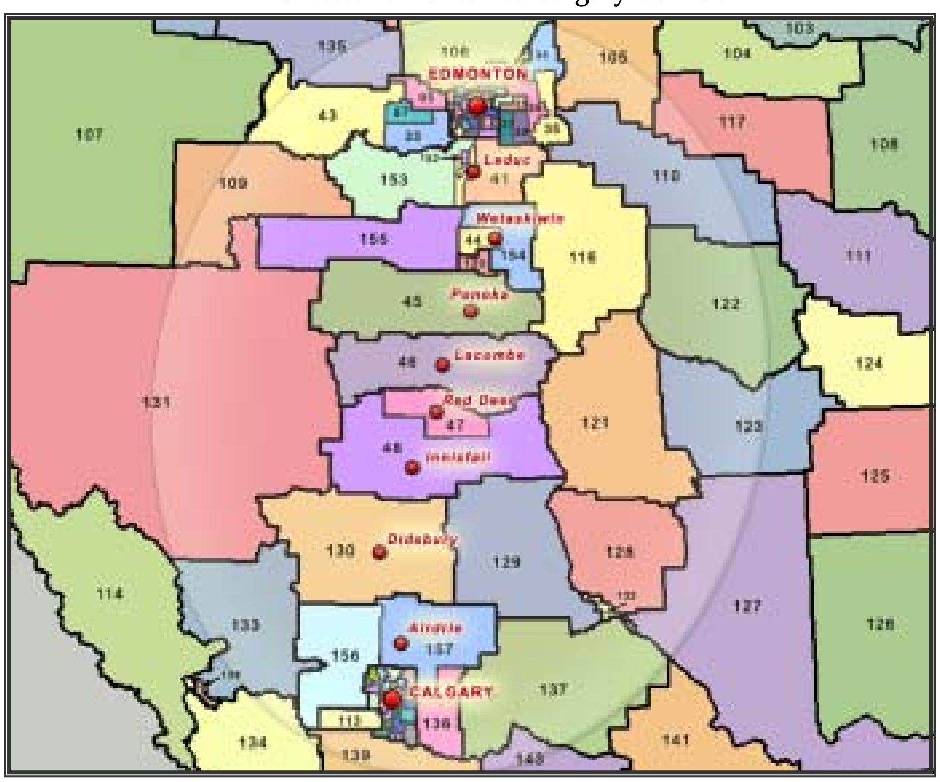


Exhibit 3.6: Alberta HSR Study Area Zoning System: The City of Edmonton and Edmonton Region

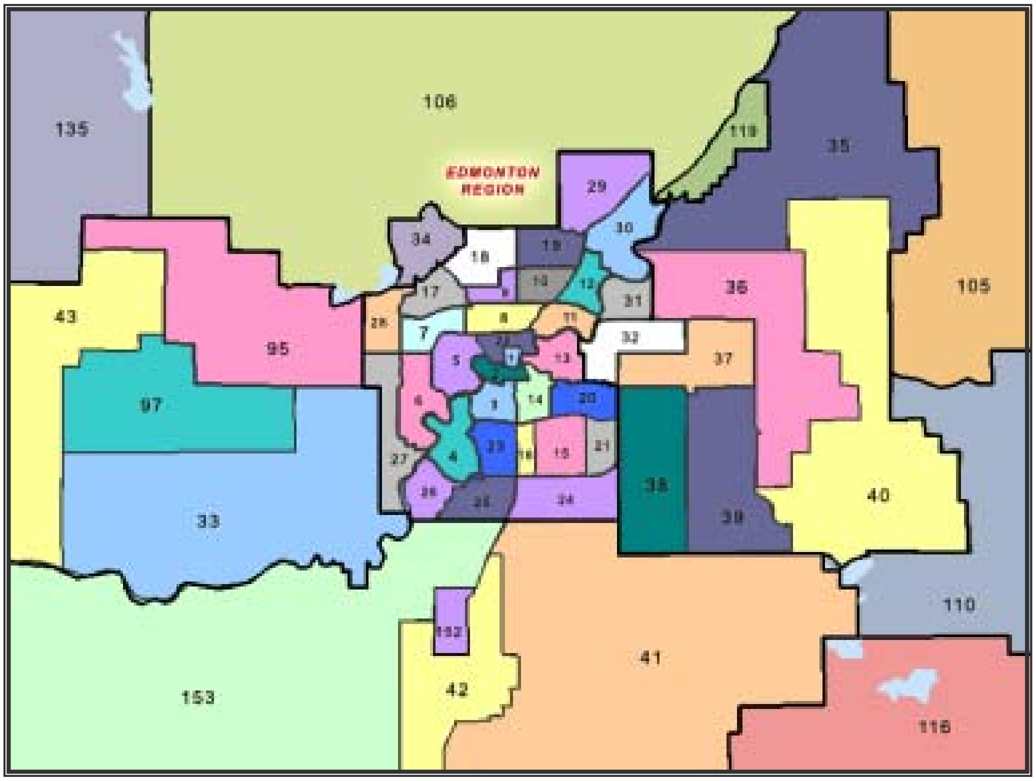
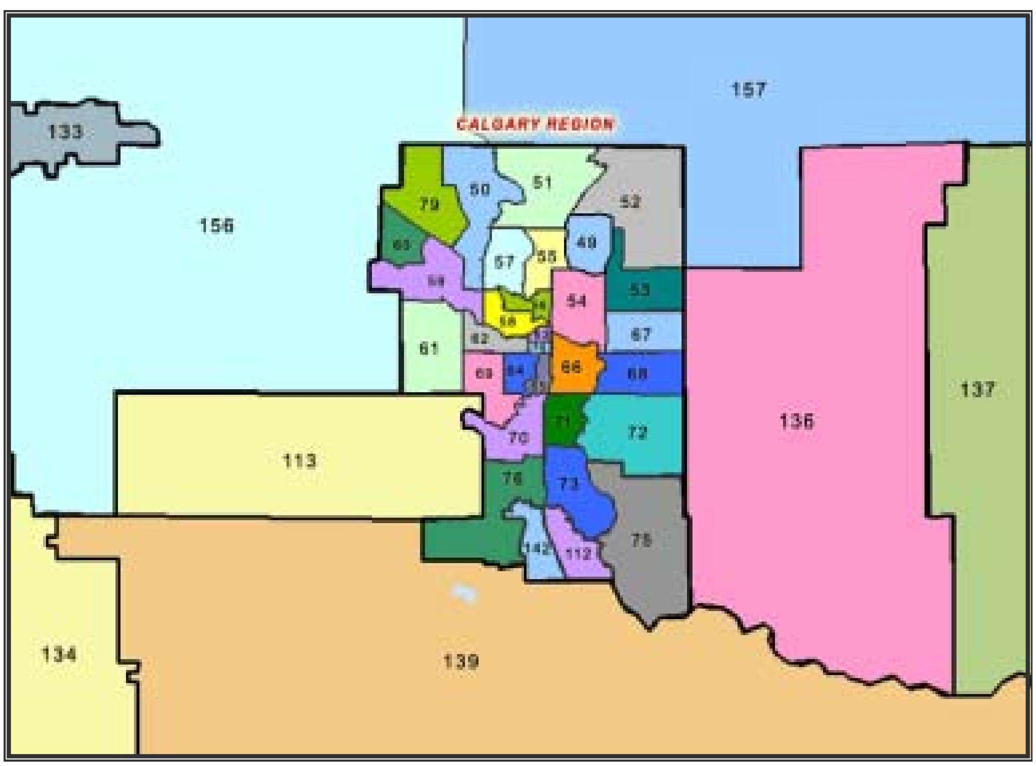


Exhibit 3.7: Alberta HSR Study Area Zoning System: The City of Calgary and Calgary Region



3.5 Travel Demand Database

This database is prepared using the framework of the COMPASS™ demand model. It includes the analysis of origin destination data by two purposes in relation to different transportation networks, stated preference data and socioeconomic data.

The main strength of the COMPASS™ Model System is in its capability to provide comparative evaluations of alternative socioeconomic scenarios and network strategies (transport systems and costs). Travel forecasts are made for 40- to 50-year-period for different transportation modes (i.e., car, air, bus and rail) and different trip purposes (business and non-business). Trip volume forecasts (T_{ijp}) - the total number of trip origin and destination for each zone pair, - are made in COMPASS™ using base and projected socioeconomic data (SE_{ijp}) on population, employment and average household income for each zone. As shown in Equation (8) the total number of trips between any two zones for all modes of travel (T_{ijp}) segmented by trip purpose is also a function of the total travel utility of the transportation system between these two zones.

As a result, the model considers not just socioeconomic growth, but also the quality of service offered by all modes between all zones. Increasing travel costs and lower economic growth mean reductions in relative trip making, while falling travel cost and higher economic growth increases the growth of trips between zones. In this respect the COMPASS™ model behaves like a typical demand model, but differs from the typical 'four step' model, which has a fixed origin-destination matrix and is insensitive in terms of total demand to rising or falling travel costs.

(The coefficients β_{0p}, β_{1p}, β_{2p} for each purpose p are to be estimated in the frame of the regression analysis.)

$$T_{ijp} = e^{\beta_{0p}}(SE_{ijp})^{\beta_{1p}} e^{\beta_{2p} U_{ijp}} \qquad (8)$$

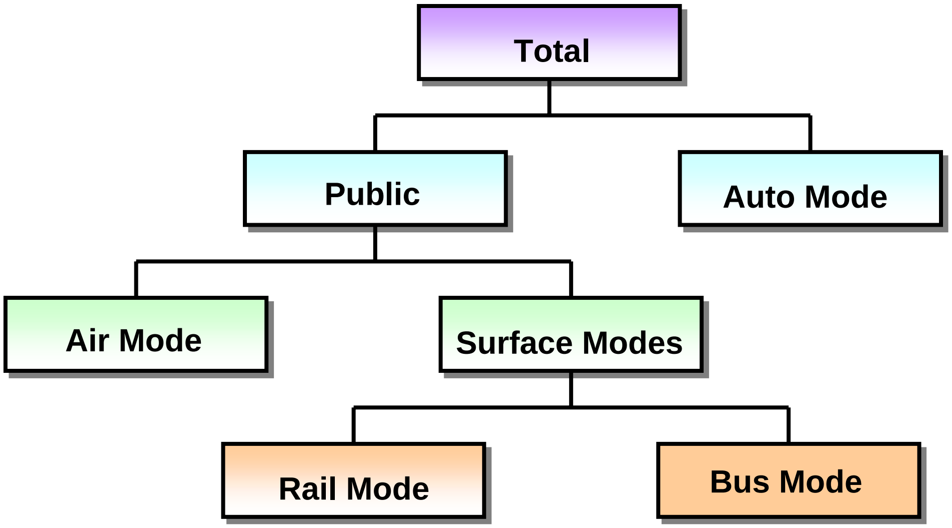
Travel utility (U_{ijp}) is generated as a function of the weighted sum of the generalized cost, see (9), and provides a measure of the quality of the transportation system in terms of time, cost, reliability and level of service provided by all modes for a given trip purpose. Generalized cost is a specific metric for transportation efficiency defined in terms of time (see equations 1 and 7 in chapter 2). Base generalized cost corresponds to the existing network, while projected generalized cost corresponds to the network after Alberta HSR project implementation.

$$U_{ijp} = f(GC_{ijp}) \qquad (9)$$

Data on average (weighted) generalized cost (i.e., travel utility) and average weighted volume of trips is required by Economic Rent model and is calculated later in the frame of this model applying database and statistical analysis programming tools.

Travel utility used in the total demand model is a logical and intuitively sound method of assigning a value to the travel opportunities provided by the regional transportation system. The travel utility function is different for different types of modes. Total utility of the regional transportation system is an aggregate function. It is generated by a level-by-level combination of travel utilities calculated for each different type of mode. Relative modal shares of each travel mode included in the total utility function are derived by comparing the relative levels of service offered by each of the travel modes. The Modal Split structure for Alberta HSR transportation is presented in Exhibit 3.8.

Exhibit 3.8: Total Demand and Model Split Structure



3.6 Super Zone and Tier System

The development of a 'super zone' and urban 'tier structure' is a critical input for measuring the economic rent 'profiles' and 'tents' that exist today in the study area. The economic rent profile and tents provide an understanding of the local economy and the interdependence of cities, towns and urban areas along the rail corridors of the study area. Within any settlement pattern the largest markets will tend to dominate hinterlands that will include other cities. Using Christalla [9] Location Theory it is likely that different urban areas will belong to a hierarchy of settlements within a market area of a dominant city. In Alberta, for example, Edmonton's market area, hinterland includes Wetaskiwin and Camrose. As a result, to develop the relevant economic rent 'profiles' or 'tent' it is necessary to divide the study area into super zones that describe the economic rent tent of the dominant city and its supporting urban areas.

By evaluating the role of each city and its connectivity to the rail station, Alberta HSR study area was partitioned into three super zone regions (or market areas), as shown in Exhibit 3.9. Since the Alberta HSR system does not have a hub (see Exhibit 3.10) both Calgary and Edmonton were selected as the major cities in the super zone system. The Red Deer market area also formed its own super zone. Each 'super zone center' is an urbanized area (large city). The population density in each principal city (center of the super zone) is much higher than the average density in this super zone (see Exhibit 3.11).

In addition, each super zone is to be broken down into a hierarchy of cities that reflect their relative interaction with each other and with the principal city of the super zone. Each zone is categorized within the tier system based on its socioeconomic characteristics and its connectivity in the transportation network. The Alberta HSR regional system is shown in Exhibit 3.12. The hierarchy contains four levels (tiers). Regional systems were developed for the Alberta HSR study in accordance with Economics of Location and Central Place Theory [9], [10]. The classification of cities in a hierarchy system was made using population and population density as criteria.

Economic Rent analysis is performed separately for each transportation zone in the frame of each super zone and for each level. Hierarchy structures of the cities in the super zone plays an especially important role in the final stage of Economic Rent analysis – in the process of distributing benefits between stations.

Exhibit 3.9: Alberta HSR 'Super Zone' System

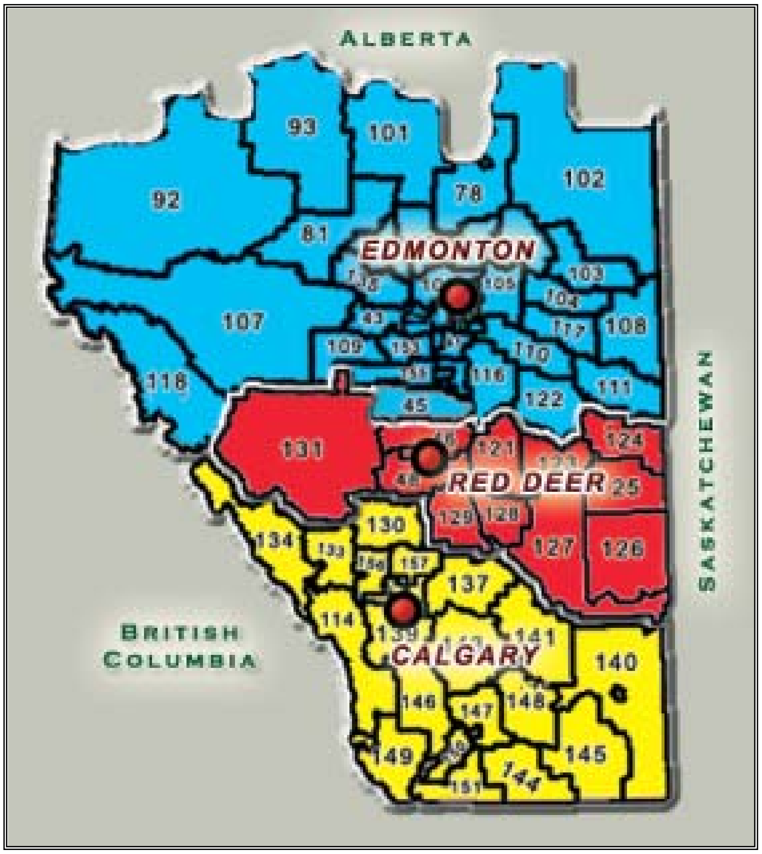


Exhibit 3.10: Alberta High Speed Rail - Preliminary Plan

Exhibit 3.11: Population Density, 2006. Super Zone Center vs. Average in Super Zone

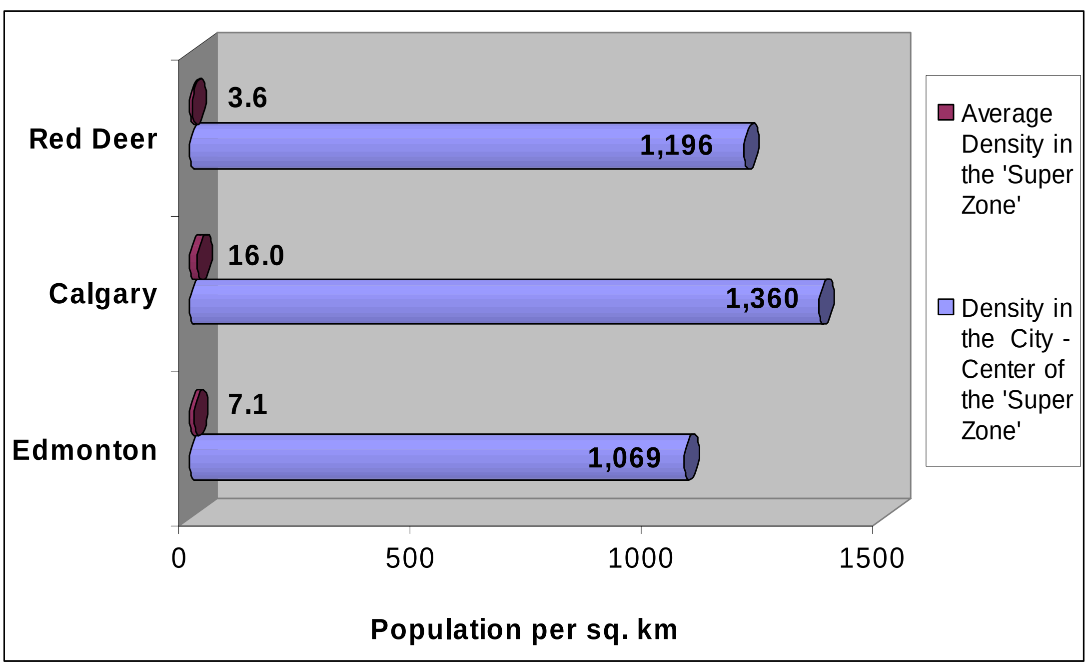
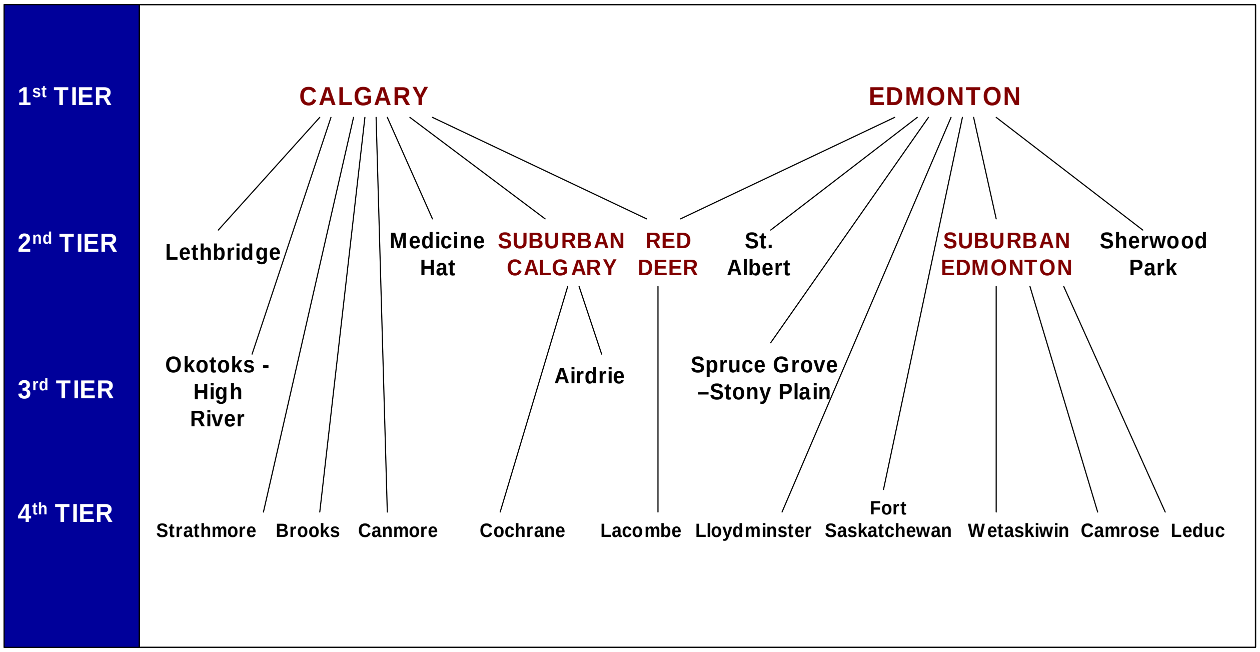


Exhibit 3.12: Alberta HSR Hierarchy of Urban Settlements



3.7 Conclusion

It was found that the socioeconomic and transportation databases developed provided a solid basis for the evaluation of Economic Rent and Consumer Surplus. The use of these two techniques will allow an evaluation of both demand side and supply sides of the economic benefits of the project.

4

Consumer Surplus Analysis and Results

4.1 Introduction

In the Alberta High Speed Rail (HSR) Economic Benefits Study benefits were quantified in terms of passenger rail system user benefits and other-modes user benefits. The expected user benefits will be derived from several sources. These include the following:

- ***Alberta HSR User Benefits:*** The reduction in travel times that users of the Alberta HSR System receive;

- ***Benefits to Users of Other Modes:*** The reduction in travel times and costs that users of other modes receive as a result of lower congestion levels. Here we have savings in other mode costs and reductions (savings) in emissions as a result of travellers being diverted from air, bus and auto to the Alberta HSR.

4.2 Alberta HSR User Benefits: Consumer Surplus and System Revenues

The analysis of Alberta HSR user benefits (Consumer Surplus analysis) is based on a measurement of the improvements in generalized cost of travel, which includes both time and money provided by a transport investment. Time is converted into equivalent monetary values by the use of values of time (VOTs). VOTs are derived from stated preference surveys used in the TEMS COMPASS™ Multimodal Demand Model for development of the ridership and revenue forecasts (see chapter 2). These VOTs are consistent with previous academic and empirical research.

The Alberta HSR user benefits are measured as the sum of both system revenues and consumer surplus. Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone.

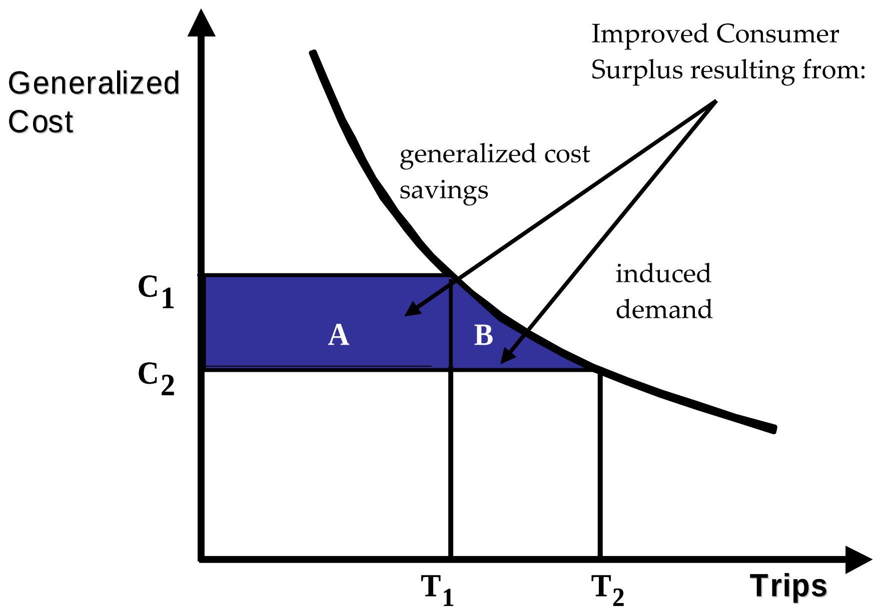
Revenues are included in the measure of user benefits in Consumer Surplus analysis as a proxy measure for the consumer surplus foregone. The benefits apply to existing rail travellers, as well as new travellers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system. Only passenger revenues are included in the study, no revenues generated by freight or commercial transport is included.

The COMPASS™ Demand Model estimates consumer surplus by calculating the increase in regional mobility and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term 'generalized cost' refers to the combination of time and fares paid by users to make a trip (see chapter 2, formula (1)). A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which, in turn, leads to an increase in consumer surplus.

It should be noted that passenger rail fares used in this analysis are those used for development of the Alberta HSR financial projections and operating ratios. As a rule, these fares are slightly lower than the average optimal fares derived from the revenue-maximization analysis that was performed for each high-speed rail alternative for the Alberta corridor. Charging slightly less than the revenue-maximizing fare greatly increases the ridership and consumer surplus associated with the system without reducing the revenues by very much.

Exhibit 4.1 presents a typical demand curve in which Area A represents the improvement in consumer surplus resulting from generalized cost savings for existing rail users, while Area B represents the consumer surplus resulting from induced traffic and trips diverted to rail.

Exhibit 4.1: Consumer Surplus Concept



The formula for consumer surplus is as follows:

$$\text{Consumer Surplus} = \text{Area A} + \text{Area B} = (C_1 - C_2)^*T_1 + \text{Area B} \qquad (10)$$

Where: Area B approximately equals $(C_1 - C_2)^*(T_2 - T_1)/2$

And where:

C_1 = Generalized cost users incur before the implementation of the system;
C_2 = Generalized cost users incur after the implementation of the system;
T_1 = Number of trips before operation of the system;
T_2 = Number of trips during operation of the system.

4.3 Other Mode Benefits: Resource Savings

In addition to rail-user benefits, travellers by auto or air will also benefit from the Alberta HSR, as the system will contribute to highway congestion relief and reduced travel times for users of these other modes.

- ***Airport Congestion:*** Using projections from the COMPASS™ Model, benefits to air travellers resulting from reduced air congestion are to be identified by estimating the number of passenger air trips diverted to rail.

- ***Highway Congestion:*** There will be reduced congestion and delays on highways due to auto travellers diverting to the Alberta HSR.

- ***Air-Carrier Operating Costs:*** Benefits to air carriers in terms of operating costs savings resulting from reduced congestion at airports are calculated in much the same way as the time savings benefits to air travellers

4.4 Other Mode Benefits: Emissions

The implementation of a new high-occupancy mode of transport like rail has the effect of lessening emissions because of diversion. The diversion of travellers to rail from the auto, air and bus modes generates emissions savings. For the Alberta HSR, we have used the assumption that the emissions savings are proportional to the number of diverted vehicle miles. (We used separate factors for air, bus and auto vehicle miles.) The estimation of emissions benefit is then multiplied by the number of vehicle miles saved by implementation of the Alberta HSR, yielding an estimate of total emission benefit[22].

4.5 Measures of Economic Benefit

In order to give a long-term measure of the project revenues, the Net Present Value (NPV) method was used to rank the proposed technological options. This method of evaluating an infrastructure project allows for the consideration of the time value for money by estimating the Present Value (PV) in "today's dollars" of the future cash flow of the project, i.e., discounted cash flows. The discounted values for revenues were computed using the discounting formula.

Present value is defined as:[23]

$$PV = \sum C_t / (l + r)^t \qquad (11)$$

and where:

[22] M.Q. Wang, D.J. Santini and S.A. Warinner (1994), Methods of Valuing Air Pollution and Estimated Monetary Values of Air Pollutants in Various U.S. Regions, Argonne National Lab. Also see M.Q. Wang, D.J. Santini and S.A. Warinner (1995), "Monetary Values of Air Pollutants in Various U.S. Regions," Transportation Research Record 1475, Transportation Research Board (www.trb.org), pp. 33-41

[23] See [15] for details.

PV = Present value of all future cash flows;
C_t = Cash flow for period *t;*
r = Opportunity cost of money;
t = Time.

Discount Analysis: For the purposes of the Alberta HSR Economic Benefits Study a 40-year life was defined for the project. As a result, all cash flows were estimated in present value terms by applying a discount rate to the 40-year cash flow.

Discount Rates: A Benefit-Cost analysis requires that a discount rate is selected in order to identify the real cost of money for a project. TEMS, Inc., recommends using a three-percent social discount rate that reflects the cost of long-term government bonds. Government of Canada also assumes the possibility of using a three-percent rate in benefit-cost analysis[24]. This rate reflects the real cost of money for a project like the Alberta HSR and, as such, shows the real value of the project. However, since Transport Canada also suggests using eight percent real discount rate[25] we performed benefit analysis using both discount rates.

4.6 User Benefit Results

The discounted values for revenues were computed using data on cash flow in a 40-year period (2011-2051) and applying both three percent and eight percent discount rates. Exhibit 4.2 shows yearly revenues, the present value of the revenues and the net present value for the four technology options considered. (Discount rate was set to three percent here.) Detailed forecasts were produced on a five-year interval; hence, all intermediate points have been produced by interpolation.

Exhibit 4.2: Present Value Revenue Stream (by year 2011-2051) and Net Present Value for Four Technologies (with a discount rate of three percent, in millions of 2006$)

Year	Talgo (125 mph)		Jet Acela (150 mph)		TGV (200 mph)		Maglev (300 mph)	
	per year	PV	per year	PV	per year	PV	per year	PV
2011	55.127	55.127	118.872	118.872	236.879	236.879	438.833	438.833
2012	57.139	55.474	122.656	119.084	246.011	238.846	455.754	442.480
2013	59.150	55.755	126.441	119.182	255.144	240.498	472.676	445.542
2014	61.162	55.972	130.225	119.174	264.276	241.850	489.597	448.051
2015	63.174	56.129	134.009	119.065	273.409	242.920	506.518	450.035
2016	65.186	56.230	137.794	118.862	282.541	243.722	523.440	451.524
2017	67.197	56.277	141.578	118.569	291.673	244.272	540.361	452.544
2018	69.209	56.273	145.362	118.193	300.806	244.583	557.282	453.121
2019	71.221	56.222	149.146	117.738	309.938	244.668	574.203	453.281
2020	73.232	56.126	152.931	117.209	319.071	244.541	591.125	453.048
2021	75.244	55.989	156.715	116.611	328.203	244.214	608.046	452.443
2022	77.178	55.755	160.382	115.864	336.935	243.409	624.170	450.914

[24] See: Canadian Cost-Benefit Analysis Guide: Regulatory Proposals. 4.7 Discount Rates. http://www.regulation.gc.ca/ .

[25] Ibid.

2023	79.111	55.487	164.049	115.061	345.668	242.444	640.294	449.089
2024	81.045	55.188	167.717	114.207	354.400	241.329	656.417	446.988
2025	82.978	54.858	171.384	113.305	363.132	240.073	672.541	444.629
2026	84.912	54.502	175.051	112.359	371.865	238.686	688.665	442.028
2027	86.846	54.119	178.718	111.371	380.597	237.175	704.789	439.201
2028	88.779	53.713	182.385	110.346	389.329	235.551	720.913	436.164
2029	90.713	53.284	186.053	109.286	398.061	233.819	737.036	432.931
2030	92.646	52.835	189.720	108.195	406.794	231.989	753.160	429.517
2031	94.580	52.367	193.387	107.074	415.526	230.067	769.284	425.934
2032	96.613	51.934	197.092	105.947	424.725	228.310	786.198	422.620
2033	98.645	51.482	200.797	104.794	433.923	226.461	803.111	419.138
2034	100.678	51.012	204.502	103.619	443.122	224.526	820.025	415.500
2035	102.710	50.527	208.207	102.424	452.320	222.512	836.938	411.718
2036	104.743	50.026	211.912	101.210	461.519	220.424	853.852	407.804
2037	106.775	49.511	215.617	99.980	470.718	218.269	870.765	403.769
2038	108.808	48.984	219.322	98.736	479.916	216.053	887.679	399.623
2039	110.840	48.446	223.027	97.480	489.115	213.781	904.592	395.376
2040	112.873	47.897	226.732	96.213	498.313	211.457	921.506	391.038
2041	114.905	47.339	230.437	94.937	507.512	209.088	938.419	386.616
2042	117.122	46.847	234.295	93.715	517.759	207.097	957.366	382.934
2043	119.339	46.344	238.153	92.484	528.007	205.045	976.313	379.139
2044	121.556	45.830	242.012	91.245	538.254	202.936	995.260	375.239
2045	123.773	45.306	245.870	89.999	548.502	200.776	1,014.207	371.245
2046	125.990	44.775	249.728	88.749	558.749	198.570	1,033.155	367.166
2047	128.206	44.235	253.586	87.495	568.996	196.322	1,052.102	363.009
2048	130.423	43.690	257.444	86.239	579.244	194.037	1,071.049	358.783
2049	132.640	43.138	261.303	84.982	589.491	191.718	1,089.996	354.495
2050	134.857	42.582	265.161	83.725	599.739	189.370	1,108.943	350.153
2051	137.074	42.021	269.019	82.470	609.986	186.995	1,127.890	345.762
NPV		**2,099.606**		**4,306.071**		**9,205.283**		**17,039.423**

The results show that the revenue estimates increase significantly with speed. For Talgo (125 mph) the revenue is nearly $2.1 billion, for Jet Acela (150 mph) it is $4.3 billion, for TGV (200 mph) it is $9.2 billion and for Maglev (300 mph) it is $17 billion.

Exhibit 4.3: Present Value Consumer Surplus (by year 2011-2051) and Net Present Value for Four Technologies (with a discount rate of three percent, in millions of 2006$)

Year	Talgo (125 mph)		Jet Acela (150 mph)		TGV (200 mph)		Maglev (300 mph)	
	per year	PV	per year	PV	per year	PV	per year	PV
2011	13.134	13.134	25.98	25.980	113.568	113.568	207.867	207.867
2012	13.629	13.232	26.825	26.044	113.568	110.260	216.067	209.774
2013	14.124	13.313	27.671	26.082	113.568	107.049	224.267	211.393
2014	14.619	13.378	28.516	26.096	113.568	103.931	232.466	212.740
2015	15.114	13.429	29.362	26.087	113.568	100.904	240.666	213.829
2016	15.609	13.464	30.207	26.057	113.568	97.965	248.866	214.674
2017	16.078	13.465	31.011	25.971	122.247	102.380	256.632	214.925
2018	16.547	13.455	31.815	25.869	130.926	106.454	264.397	214.979
2019	17.017	13.433	32.619	25.750	139.604	110.205	272.163	214.848
2020	17.486	13.401	33.423	25.616	148.283	113.647	279.928	214.542
2021	17.955	13.360	34.227	25.468	156.962	116.794	287.694	214.071
2022	18.421	13.308	35.031	25.307	161.139	116.410	295.374	213.384
2023	18.887	13.247	35.835	25.134	165.316	115.950	303.054	212.556
2024	19.353	13.178	36.640	24.950	169.494	115.417	310.734	211.595
2025	19.819	13.103	37.444	24.755	173.671	114.817	318.414	210.509
2026	20.285	13.020	38.248	24.550	177.848	114.154	326.094	209.307
2027	20.747	12.929	39.067	24.345	182.047	113.446	333.838	208.037
2028	21.208	12.831	39.886	24.132	186.246	112.682	341.582	206.663
2029	21.670	12.729	40.705	23.910	190.444	111.866	349.327	205.193
2030	22.131	12.621	41.524	23.681	194.643	111.002	357.071	203.632
2031	22.593	12.509	42.343	23.444	198.842	110.094	364.815	201.989
2032	23.106	12.421	43.238	23.243	203.537	109.411	373.411	200.727
2033	23.619	12.326	44.133	23.033	208.233	108.675	382.007	199.367
2034	24.131	12.227	45.028	22.815	212.928	107.889	390.604	197.916
2035	24.644	12.123	45.923	22.591	217.624	107.056	399.200	196.380
2036	25.157	12.015	46.818	22.361	222.319	106.181	407.796	194.766
2037	25.620	11.880	47.546	22.047	226.388	104.975	415.223	192.537
2038	26.083	11.742	48.275	21.733	230.457	103.749	422.649	190.272
2039	26.545	11.602	49.003	21.418	234.526	102.506	430.076	187.976
2040	27.008	11.461	49.732	21.103	238.595	101.247	437.502	185.653
2041	27.471	11.318	50.46	20.789	242.664	99.974	444.929	183.305
2042	28.029	11.211	51.327	20.530	247.780	99.109	454.344	181.732
2043	28.588	11.102	52.195	20.269	252.896	98.209	463.759	180.095
2044	29.146	10.989	53.062	20.006	258.012	97.277	473.175	178.399
2045	29.705	10.873	53.930	19.741	263.128	96.317	482.590	176.650
2046	30.263	10.755	54.797	19.474	268.244	95.329	492.005	174.850

2047	30.770	10.617	55.595	19.182	272.801	94.125	500.392	172.651
2048	31.276	10.477	56.392	18.890	277.358	92.910	508.779	170.432
2049	31.783	10.337	57.190	18.600	281.914	91.686	517.165	168.196
2050	32.289	10.195	57.987	18.310	286.471	90.454	525.552	165.945
2051	32.796	10.054	58.785	18.021	291.028	89.217	533.939	163.683
NPV		**502.265**		**943.383**		**4,315.291**		**8,088.037**

It can be seen in Exhibit 4.4 that the consumer surplus increases with speed, although not as dramatically, as with revenues (see Exhibit 4.5). The consumer surplus increases from $0.5 billions for Talgo (125 mph) to $0.9 billions for Jet Acela (150 mph), to $4 billions for TGV (200 mph) and $8 billions for Maglev (300 mph).

Exhibit 4.4: Present Value Emission Savings (by year 2011-2051) and Net Present Value for Four Technologies (with a discount rate of three percent, in millions of 2006$)

Year	Talgo (125 mph)		Jet Acela (150 mph)		TGV (200 mph)		Maglev (300 mph)	
	per year	PV	per year	PV	per year	PV	per year	PV
2011	3.106	3.106	4.898	4.898	8.339	8.339	11.436	11.436
2012	3.188	3.095	5.028	4.882	8.629	8.378	11.844	11.499
2013	3.271	3.083	5.158	4.862	8.919	8.407	12.252	11.549
2014	3.353	3.068	5.289	4.840	9.209	8.428	12.660	11.586
2015	3.435	3.052	5.419	4.815	9.499	8.440	13.068	11.611
2016	3.517	3.034	5.550	4.787	9.789	8.444	13.476	11.625
2017	3.600	3.015	5.680	4.757	10.079	8.441	13.884	11.628
2018	3.682	2.994	5.811	4.724	10.369	8.431	14.292	11.621
2019	3.764	2.972	5.941	4.690	10.659	8.414	14.700	11.604
2020	3.847	2.948	6.071	4.653	10.949	8.392	15.108	11.579
2021	3.929	2.924	6.202	4.615	11.239	8.363	15.516	11.545
2022	4.008	2.895	6.328	4.572	11.515	8.319	15.903	11.489
2023	4.086	2.866	6.455	4.527	11.791	8.270	16.290	11.425
2024	4.165	2.836	6.581	4.482	12.067	8.217	16.677	11.356
2025	4.244	2.806	6.708	4.435	12.343	8.160	17.064	11.281
2026	4.323	2.775	6.834	4.387	12.620	8.100	17.451	11.201
2027	4.402	2.743	6.961	4.338	12.896	8.036	17.838	11.116
2028	4.480	2.711	7.087	4.288	13.172	7.969	18.225	11.026
2029	4.559	2.678	7.214	4.237	13.448	7.899	18.612	10.933
2030	4.638	2.645	7.340	4.186	13.724	7.827	18.999	10.835
2031	4.717	2.611	7.467	4.134	14.000	7.751	19.386	10.734
2032	4.799	2.580	7.594	4.082	14.291	7.682	19.792	10.639
2033	4.882	2.548	7.722	4.030	14.582	7.610	20.197	10.541
2034	4.964	2.515	7.849	3.977	14.874	7.536	20.603	10.439
2035	5.046	2.482	7.977	3.924	15.165	7.460	21.008	10.335

2036	5.129	2.450	8.105	3.871	15.456	7.382	21.414	10.227
2037	5.211	2.416	8.232	3.817	15.747	7.302	21.819	10.117
2038	5.294	2.383	8.360	3.763	16.039	7.220	22.225	10.005
2039	5.376	2.350	8.487	3.710	16.330	7.137	22.630	9.891
2040	5.459	2.316	8.615	3.656	16.621	7.053	23.036	9.775
2041	5.541	2.283	8.742	3.602	16.912	6.968	23.441	9.657
2042	5.633	2.253	8.876	3.550	17.239	6.895	23.899	9.559
2043	5.724	2.223	9.010	3.499	17.566	6.822	24.356	9.458
2044	5.816	2.193	9.143	3.447	17.893	6.746	24.814	9.355
2045	5.907	2.162	9.277	3.396	18.220	6.669	25.271	9.250
2046	5.999	2.132	9.411	3.344	18.547	6.591	25.729	9.144
2047	6.090	2.101	9.545	3.293	18.874	6.512	26.187	9.035
2048	6.182	2.071	9.678	3.242	19.200	6.432	26.644	8.925
2049	6.273	2.040	9.812	3.191	19.527	6.351	27.102	8.814
2050	6.365	2.010	9.946	3.140	19.854	6.269	27.559	8.702
2051	6.457	1.979	10.080	3.090	20.181	6.187	28.017	8.589
NPV		**106.344**		**167.733**		**311.851**		**431.137**

The emissions savings increase from $106 millions for Talgo (125 mph) to $168 millions for Jet Acela (150 mph), to $312 millions for TGV (200 mph) and $431 millions for Maglev (300 mph).

Exhibit 4.5: Present Value Resource Savings (by year 2011-2051) and Net Present Value for Four Technologies (with a discount rate of three percent, in millions of 2006$)

Year	Talgo (125 mph)		Jet Acela (150 mph)		TGV (200 mph)		Maglev (300 mph)	
	per year	PV	per year	PV	per year	PV	per year	PV
2011	56.126	56.126	88.215	88.215	150.684	150.684	206.775	206.775
2012	57.617	55.938	90.561	87.924	155.324	150.800	212.733	206.537
2013	59.107	55.714	92.908	87.575	160.563	151.346	220.280	207.635
2014	60.598	55.456	95.255	87.172	165.801	151.732	227.826	208.493
2015	62.088	55.165	97.602	86.718	171.040	151.967	235.373	209.126
2016	63.579	54.844	99.949	86.217	176.279	152.060	242.919	209.544
2017	65.031	54.463	102.350	85.717	181.518	152.018	250.465	209.761
2018	66.483	54.057	104.752	85.173	186.757	151.850	258.012	209.787
2019	67.936	53.629	107.153	84.588	191.995	151.563	265.558	209.634
2020	69.388	53.180	109.555	83.964	197.234	151.164	273.105	209.312
2021	70.840	52.712	111.956	83.306	202.473	150.659	280.651	208.831
2022	72.261	52.203	114.207	82.506	207.486	149.892	287.606	207.773
2023	73.681	51.679	116.459	81.682	212.499	149.043	294.561	206.599
2024	75.102	51.141	118.710	80.836	217.513	148.115	301.515	205.317
2025	76.522	50.590	120.962	79.970	222.526	147.116	308.470	203.935
2026	77.943	50.029	123.213	79.086	227.539	146.049	315.425	202.459

2027	79.420	49.492	125.583	78.259	232.516	144.896	322.159	200.759
2028	80.897	48.944	127.953	77.414	237.493	143.687	328.893	198.985
2029	82.374	48.386	130.324	76.551	242.471	142.426	335.626	197.145
2030	83.851	47.819	132.694	75.673	247.448	141.116	342.360	195.243
2031	85.328	47.244	135.064	74.782	252.425	139.762	349.094	193.285
2032	86.797	46.658	137.269	73.789	257.763	138.561	356.568	191.673
2033	88.267	46.066	139.474	72.790	263.102	137.311	364.042	189.991
2034	89.736	45.469	141.679	71.788	268.440	136.016	371.515	188.244
2035	91.206	44.867	143.884	70.781	273.779	134.681	378.989	186.438
2036	92.675	44.262	146.089	69.773	279.117	133.308	386.463	184.577
2037	94.181	43.671	148.471	68.845	284.294	131.826	393.894	182.646
2038	95.687	43.077	150.854	67.913	289.471	130.317	401.324	180.672
2039	97.193	42.481	153.236	66.976	294.649	128.784	408.755	178.657
2040	98.699	41.883	155.619	66.036	299.826	127.230	416.185	176.607
2041	100.205	41.283	158.001	65.094	305.003	125.657	423.616	174.524
2042	101.802	40.720	160.292	64.115	310.900	124.356	431.899	172.754
2043	103.399	40.154	162.583	63.137	316.797	123.024	440.182	170.939
2044	104.997	39.586	164.875	62.162	322.695	121.664	448.465	169.083
2045	106.594	39.018	167.166	61.190	328.592	120.279	456.748	167.190
2046	108.191	38.449	169.457	60.222	334.489	118.872	465.031	165.264
2047	109.894	37.917	171.963	59.333	340.637	117.531	473.043	163.215
2048	111.598	37.383	174.469	58.444	346.785	116.167	481.055	161.145
2049	113.301	36.849	176.976	57.557	352.934	114.783	489.068	159.058
2050	115.005	36.313	179.482	56.672	359.082	113.381	497.080	156.955
2051	116.708	35.778	181.988	55.790	365.230	111.964	505.092	154.839
NPV		**1,920.692**		**3,025.735**		**5,623.657**		**7,781.406**

The resource savings increase from $2 billions for Talgo (125 mph) to $3 billions for Jet Acela (150 mph), to $5.6 billions for TGV (200 mph) and 7.8 billions for Maglev (300 mph).

Overall User Benefits (Consumer Surplus analysis) results for the Alberta HSR system are presented in exhibits 4.6 through 4.11. Results are given separately for each of the four analyzed types of rail technology. For each alternative technology the benefits are both large and positive. The user benefits analysis estimates the implementation of Alberta HSR will generate between $4.6 and $33.4 billion in user benefits (depending on rail technology) in economic benefits to the province. Exhibits 4.6 through 4.10 represent Alberta HSR overall user benefits (Lifecycle net present values in billions of 2006$, 40 years at three-percent and eight-percent discount rate.) NPV of the benefits by each type of technology is schematically shown in exhibits 4.10 and 4.11. Overall user benefits include revenues, consumer surplus, resource savings and emission savings. Each portion of benefits is computed independently as shown in the exhibits 4.2 through 4.5, and their net present values are then added to obtain the overall benefits shown in exhibits 4.10 and 4.11.

Exhibit 4.6: User Benefits for Talgo (125 mph) Technology
(40 years Net Present Value, in Billions of 2006$)

Benefit Parameters	@3.0%	@8.0%
Alberta HSR User Benefits:		
Consumer Surplus	0.50	0.24
System Revenues	2.10	1.12
Total Alberta HSR User Benefits	**$2.6**	**$1.4**
Other Mode User Benefits:		
Resource Savings	1.92	1.05
Emission Savings	0.11	0.06
Total Other Mode User Benefits	**$2.0**	**$1.1**
Total Benefits	**$4.6**	**$2.5**

Exhibit 4.7: User Benefits for Jet Acela (150 mph) Technology
(40 years Net Present Value, in Billions of 2006$)

Benefit Parameters	@3.0%	@8.0%
Alberta HSR User Benefits:		
Consumer Surplus	0.94	0.45
System Revenues	4.31	2.33
Total Alberta HSR User Benefits	**$5.3**	**$2.8**
Other Mode User Benefits:		
Resource Savings	3.03	1.65
Emission Savings	0.17	0.09
Total Other Mode User Benefits	**$3.2**	**$1.7**
Total Benefits	**$8.5**	**$4.5**

Exhibit 4.8: Use Benefits for TGV (200 mph) Technology
(40 years Net Present Value, in Billions of 2006$)

Benefit Parameters	@3.0%	@8.0%
Alberta HSR User Benefits:		
Consumer Surplus	4.32	1.99
System Revenues	9.23	4.91
Total Alberta HSR User Benefits	**$13.6**	**$6.9**
Other Mode User Benefits:		
Resource Savings	5.62	3.01
Emission Savings	0.31	0.17
Total Other Mode User Benefits	**$5.9**	**$3.2**
Total Benefits	**$19.5**	**$10.1**

Exhibit 4.9: Use Benefits for Maglev (300 mph) Technology
(40 years Net Present Value, in Billions of 2006$)

Benefit Parameters	@3.0%	@8.0%
Alberta HSR User Benefits:		
Consumer Surplus	8.09	3.79
System Revenues	17.09	9.09
Total Alberta HSR User Benefits	**$25.2**	**$12.8**
Other Mode User Benefits & Resource Benefits		
Resource Savings	7.78	4.16
Emission Savings	0.43	0.23
Total Other Mode User Benefits & Resource Benefits	**$8.2**	**$4.4**
Total Benefits	**$33.4**	**$17.3**

Exhibit 4.10: Net Present Value (40 years, @3%) of User Benefits by Technology

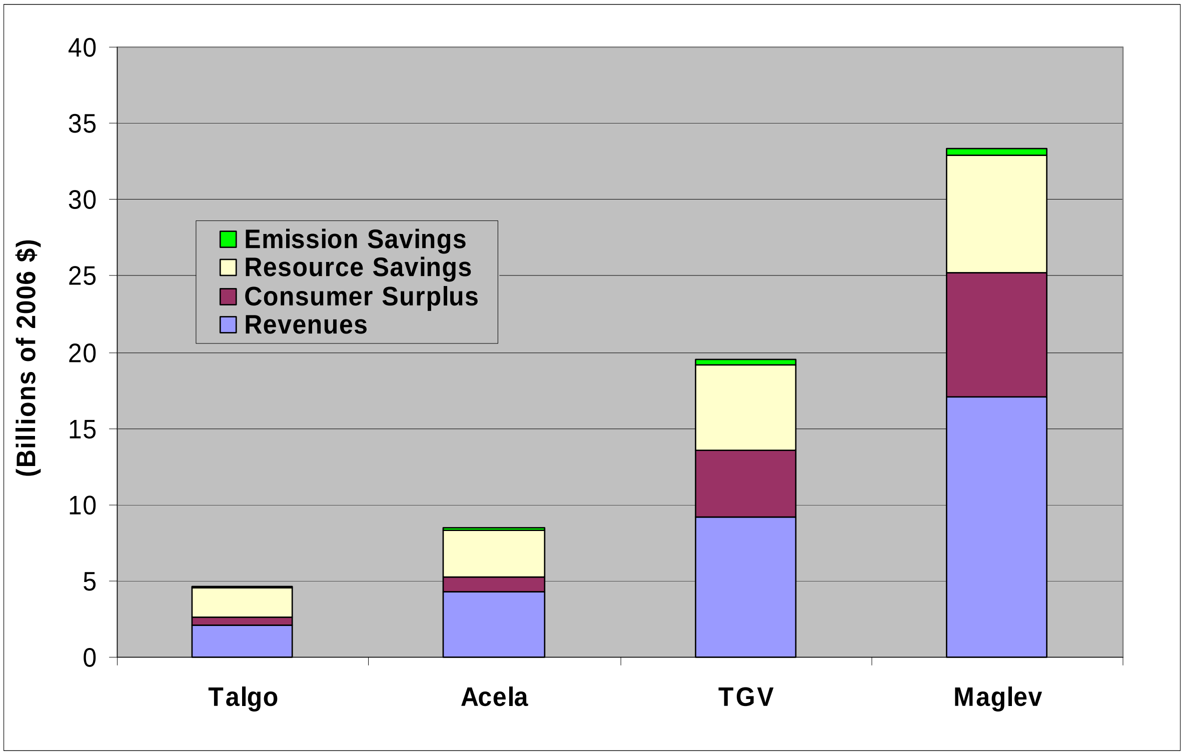
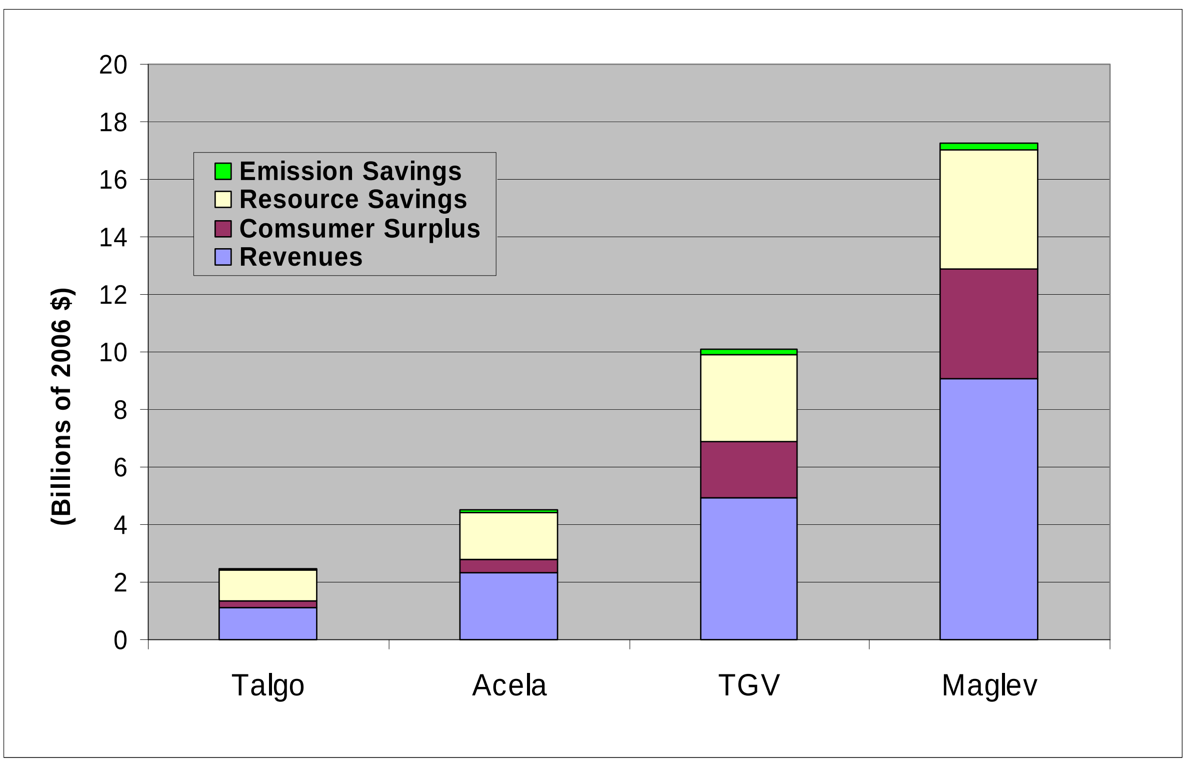


Exhibit 4.11: Net Present Value (40 years, @8%) of User Benefits by Technology



5

Economic Rent Analysis and Results

5.1 Model Calibration

In Alberta High Speed Rail (Alberta HSR) network we have four modes *m:* auto, bus (Greyhound and Red Arrow), rail and air modes and two types of trip purposes *p:* business and non-business (community). For each zone *i* of the zone system, the accessibility, measured in generalized cost is estimated as follows:

$$GC_i = \sum_p \sum_m \sum_j GC_{ij}^{mp} * T_{ij}^{mp} \quad , i=1,N \qquad (12)$$

Where:

GC_{ij}^{mp} - generalized cost of travel from zone *i* to zone *j* by mode *m* for purpose *p;*

T_{ij}^{mp} - number of trips from zone *i* to zone *j* by mode *m* for purpose *p;*

N - total number of transportation zones in the network.

The economic rent function (6) shown in Chapter 2.3 can be transformed into a linear function (linear regression model) by applying the natural logarithm[26] (ln) to both parts of the original economic rent function:

$$\ln (SE_i) = ß_o + \beta_1 \ln (GC_i) \qquad (13)$$

or simply[27]:

$$\ln (SE_i) = \beta_o + \beta_1 \ln (GC_i) \qquad (14)$$

Where:

SE_i – Economic rent factor (socioeconomic variable) of zone i;

---

[26] Natural logarithm is a logarithm to base 'e' of a given number, where 'e' is an irrational constant approximately equal 2.71828183. The natural logarithm of x is written: ln (x) or ln x. See, for example: http://www.mathwords.com/n/natural_logarithm.htm or http://www.themathpage.com/aPreCalc/logarithms.htm

[27] $\beta_o = \ln (ß_o)$

GC_i - Weighted generalized cost of travel by all modes and for all purposes from (to) zone i to (from) other zones in the zone system (GC_i is calculated using formula (12)).

β_0 and β_1 – Regression coefficients.

In the regression equation (14) ln (SE_i) is the criterion (dependent) variable, while ln (GC_i) is the predictor (independent) variable. β_0 and β_1 are the coefficients of the regression line (β_0 is the intercept and β_1 is the slope). Regression coefficients β_0 and β_1 are to be estimated in the regression model.

Application of regression analysis to the equation (14) allowed developing the Alberta High Speed Rail Economic Rent Model. In this process we established the mathematical relationship between the measure of accessibility (generalized cost of travel) and the economic rent socioeconomic variables (employment density, income density and property value density) for each transportation zone. Exhibits 5.1 through 5.3 show the observed values for natural logarithm (LN) of socio-economic variable (employment density, income density and property value density) versus natural logarithm (LN) of generalized costs of travel. The regression line reflects the relationship between socioeconomic indicators in each transportation zone included in the zone system and corresponding generalized costs, calculated using formula (12). By the tight clustering of data points around the regression line, it can be seen that in each case a very strong relationship was identified. In order to identify the strength of the relationships using not visual, but formal statistical methods we analyzed the values of the coefficient of determination (R^2) and Student's t statistics (t).

The value of the ***coefficient of determination*** (R^2) shows how much the criterion (dependent) variable is influenced by predictor variable chosen in the study [23]. In other words, the coefficient of determination measures how well the model explains the variability in the dependent variable. As a result, the coefficient of determination illustrates the strength of the relationship between the criterion and predictor variables.

Performing a 't-test' and calculating a Students' ***t statistics*** [23] for both the regression coefficients (β_0 – the intercept and β_1 - the slope) we analyze how significant regression coefficients are. Assuming a Normal distribution, a t-statistics that equals two in absolute value is generally accepted as statistically significant.

Regression statistics for each of the three socioeconomic indicators used in the model, as well as statistical measures of confidence are presented in Exhibit 5.4.

Exhibit 5.1: Employment Density as a Function of Accessibility

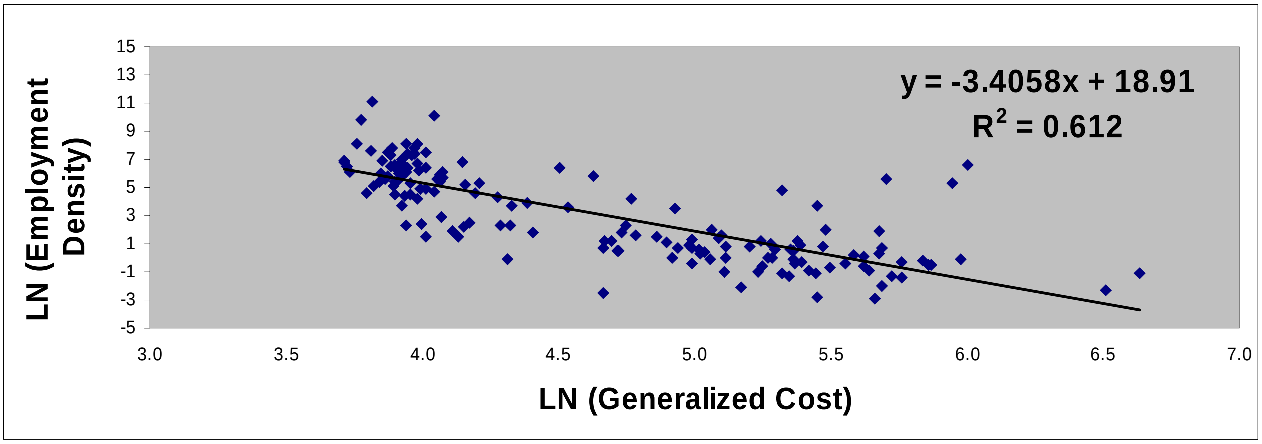


Exhibit 5.2: Income Density as a Function of Accessibility

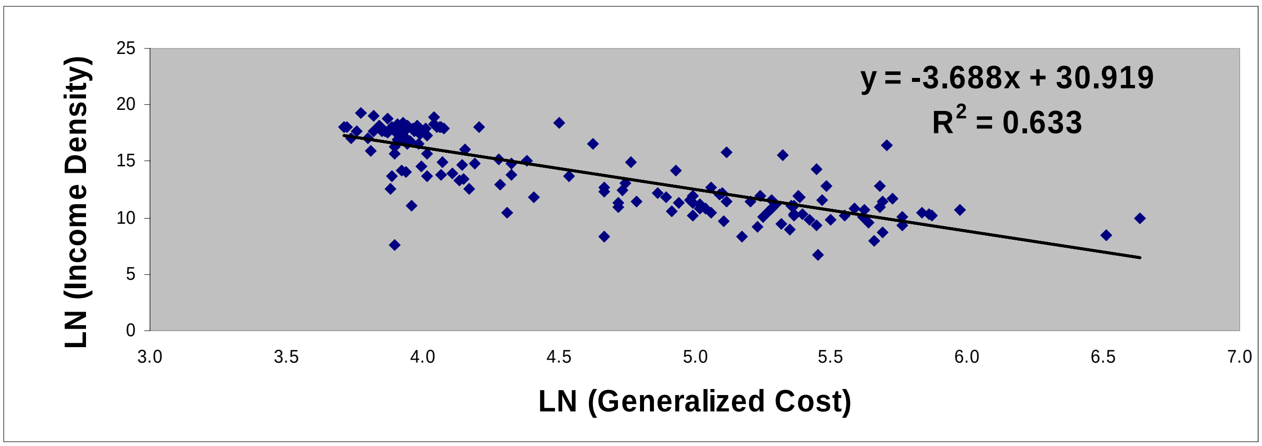


Exhibit 5.3: Property Value Density as a Function of Accessibility

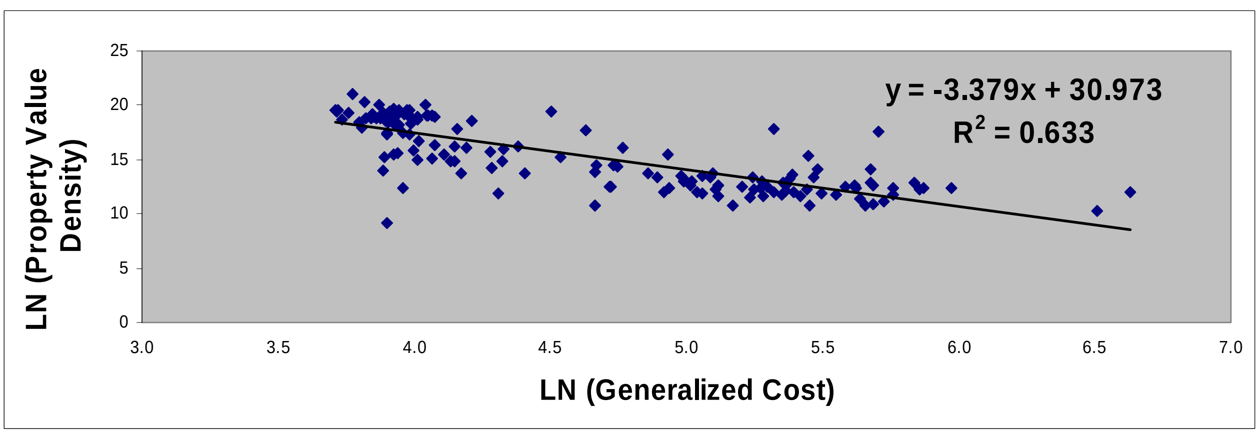


Exhibit 5.4: Economic Rent Coefficients for Employment, Income and Property Value Densities

Economic Rent Factor	Slope (β_1)	T-statistics for β_1	Intercept (β_0)	T-statistics for β_0	Coefficient of Determination (R^2)	Number of observations (N)
Employment Density	-3.41	-15.69	18.91	18.53	0.61	158
Income Density	-3.69	-16.25	30.92	29.09	0.63	155
Property Value Density	-3.38	-16.13	30.97	31.59	0.63	153

It can be seen that the calibration was successful and regression coefficients in each equation were shown to be significant. This proves that the economic rent profiles are well developed for the Alberta corridor settlement patterns. Each equation has highly significant 't' values and coefficients of determination (R^2). This reflects the strength of the relationship and, given the fact that there is a strong basis for the relationship, shows firstly that the socioeconomic variables selected provide a reasonable representation of economic rent, and, secondly, that generalized cost is an effective measure of market accessibility.

Given the performance of the models, the next step in developing the Economic Rent model is to determine the change in socioeconomic indicators as a result of accessibility improvement. In order to calculate change in economic rent factors we differentiate the economic rent function (14) with respect to generalized cost. The result of such differentiation is present in equations (15) through (17). It is easy to see that slopes β_1^E, β_1^I and β_1^{PV} in each regression equation represent economic rent elasticities. Each particular elasticity shows how much each economic rent factor changes when generalized cost of travel changes. [28]

$$\Delta EmpD_i = \frac{\partial EmpD_i}{EmpD_i} = \beta_1^E \frac{\partial GC_i}{GC_i} \qquad (15)$$

$$\Delta IncD_i = \frac{\partial IncD_i}{IncD_i} = \beta_1^I \frac{\partial GC_i}{GC_i} \qquad (16)$$

$$\Delta PvD_i = \frac{\partial PvD_i}{PvD_i} = \beta_1^{pv} \frac{\partial GC_i}{GC_i} \qquad (17)$$

Where:

GC_i - Weighted generalized cost of zone i;

$EmpD_i$, - Employment density of zone i;

$IncD_i$ - Income density of zone i;

[28] More about the role of elasticity in a measurement of economic rent profile change see: [20], [21].

PvD_i - Property value density of zone i;

$\beta_1^E\ \beta_1^I\ \beta_1^{pv}$ - Slope coefficients in regression equations.

It is seen from formulas (15) through (17) that the relative change in employment density ($\Delta EmpD_i$), household income density ($\Delta IncD_i$) and property value (ΔPvD_i) for each particular zone *i* equals the relative change in generalized cost $\frac{\partial GC_i}{GC_i}$ multiplied by regression coefficient β^E_1, β^I_1 or β^{PV}_1, respectively. The value for each slope coefficient (β_1) is obtained from the corresponding regression equation. Since area (size - S_i) of each transportation zone remains constant, absolute change in employment (∂Emp_i), household income (∂Inc_i) and property value (∂Pv_i) will be obtained from the following equations:

$$\partial Emp_i = \partial EmpD_i * S_i = \beta_1^E \frac{\partial GC_i}{GC_i} EmpD_i * S_i \qquad (18)$$

$$\partial Inc_i = \partial IncD_i * S_i = \beta_1^I \frac{\partial GC_i}{GC_i} IncD_i * S_i \qquad (19)$$

$$\partial Pv_i = \partial PvD_i * S_i = \beta_1^{Pv} \frac{\partial GC_i}{GC_i} PvD_i * S_i \qquad (20)$$

In order to calculate the impact of accessibility improvement on average household income and average residential property value we also had to determine how the improvement in accessibility influences the number of households (dwelling units) that are supported by any given area. To do this we use Economic Rent model to predict household density (dwelling density) that is supported by any given level of market access. The results of regression analysis are shown in exhibits 5.5 and 5.6 and economic rent coefficients are given in Exhibit 5.7. Again, it can be seen that good statistical relationships were derived with strong 't' values and coefficients of determination R^2.

Exhibit 5.5: Household Density as a Function of Accessibility

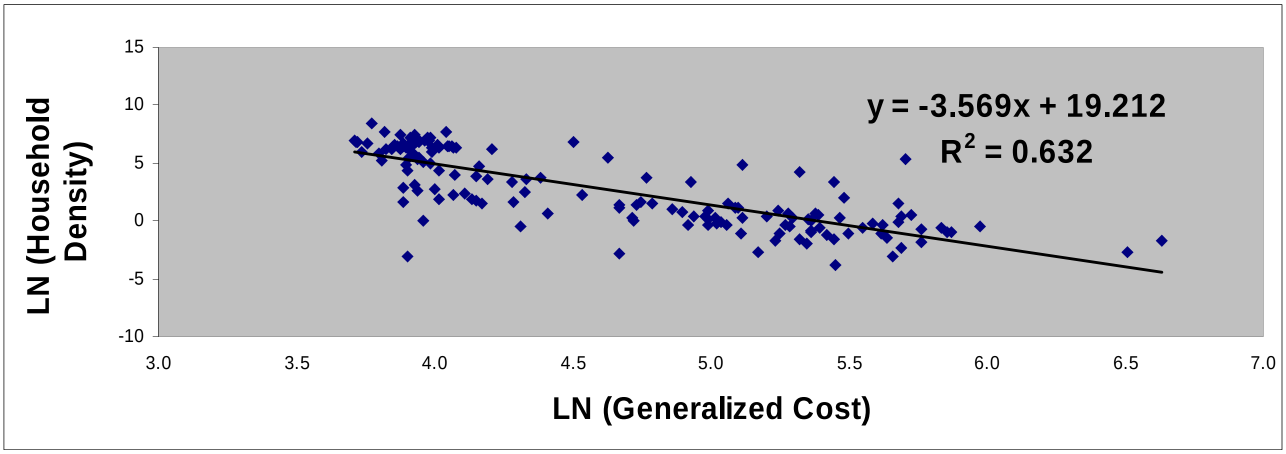


Exhibit 5.6: Dwelling Density as a Function of Accessibility

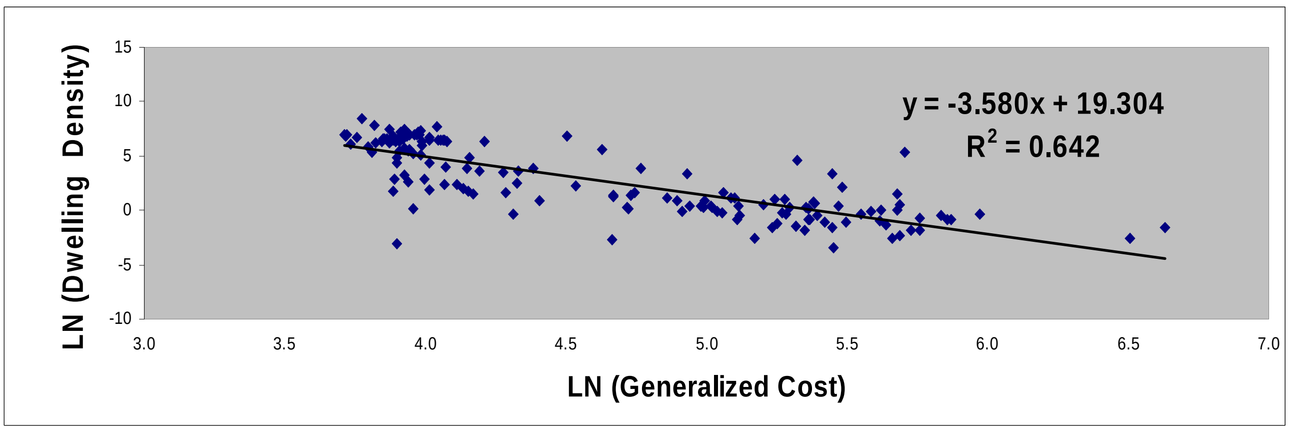


Exhibit 5.7: Economic Rent Coefficients for Household and Dwelling Density

Economic Rent Factor	Slope (β_1)	T-statistics for β_1	Intercept (β_0)	T-statistics for β_0	Coefficient of Determination (R^2)	Number of observations (N)
Household Density	-3.57	-16.22	19.21	18.64	0.63	155
Dwelling Density	-3.58	-16.47	19.30	18.98	0.64	153

Change in average household income ($\partial AvInc_i$) in zone *i* is calculated as follows:

$$\partial AvInc_i = \frac{\partial Inc_i}{(Hh_i + \partial Hh_i)}, \qquad (21)$$

where: $\partial Hh_i = \beta_1^{Hh} * \frac{\partial GC_i}{GC_i} HhD_i * S_i$

Change in average dwelling (residential property) value $(\partial AvResPv_i)$ in zone *i* was calculated as follows:

$$\partial Av\,ResP\,v_i = \frac{\partial ResPv_i}{(Dw_i + \partial Dw_i)}, \qquad (22)$$

where:

$\partial ResP\,v_i = \partial Pv_i \frac{ResPv_i}{Pv_i}$ and $\partial Dw_i = \beta_1^{Dw} * \frac{\partial GC_i}{GC_i} DwD_i * S_i$

$\partial ResP\,v_i$ - the change in residential property value in zone *i* and calculated as the share of the overall change in property value . It is assumed that in each particular zone *i* this share is equal to the share of residential property value of zone *i* in the overall property value of zone *i*.

∂Hh_i / ∂Dw_i - the change in the # of households/ dwellings in zone *i* as a result of accessibility improvement

Hh_i / Dw_i - the base number of households / dwellings in zone *i*

HhD_i / DwD_i - the base household density / dwelling density in zone *i*

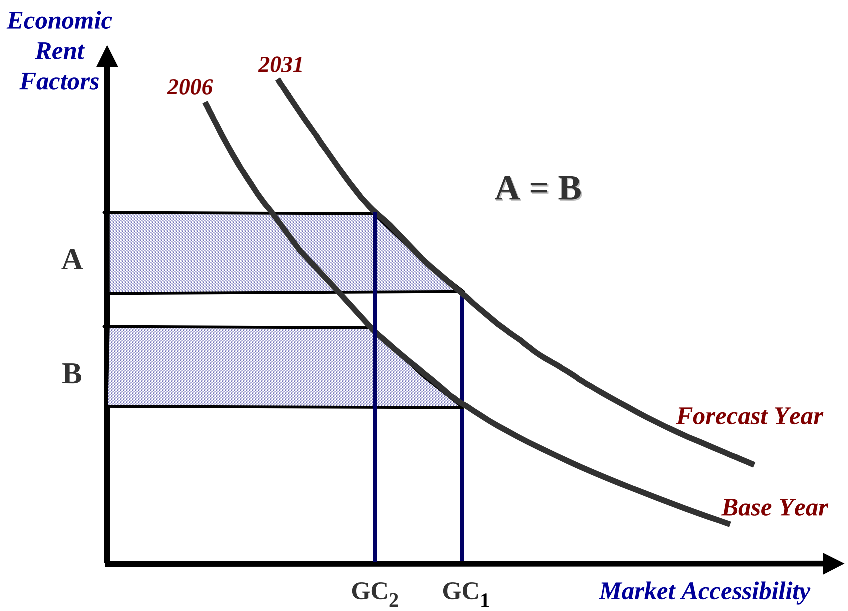
$\beta_1^{Hh} / \beta_1^{Hu}$ - the regression coefficients for household/dwelling density obtained from the table in Exhibit 5.7.

The results of the analysis show that a statistically powerful Economic Rent model can be developed that reflects the responsiveness of the economy to improved transportation access. The level of economic performance relates to the strength of the economy in the province of Alberta and diversity of its industry.

5.2 Assessment of the Impact of Economic Growth

A key assumption in the Economic Rent analysis is the impact of economic growth on the economic rent profile[29]. Economic growth will cause the economic rent profile to grow as each component that supports the economic rent profile, land, labour and capital becomes more valuable. As the economy expands, labour wages increase, so space becomes more valuable, and assets become more expensive. This increase in factor prices results in a rise in the economic rent profile. If the rise in the economic rent profile is constant as shown in Exhibit 5.8, then the increase in economic rent associated with an improvement in market accessibility (i.e. a reduction from GC_1 to GC_2) for the region is the same. As a result, in Exhibit 5.8 area A is equal to area B. This means that economic growth will not change the economic rent benefits of the project. This is the assumption made in this study.

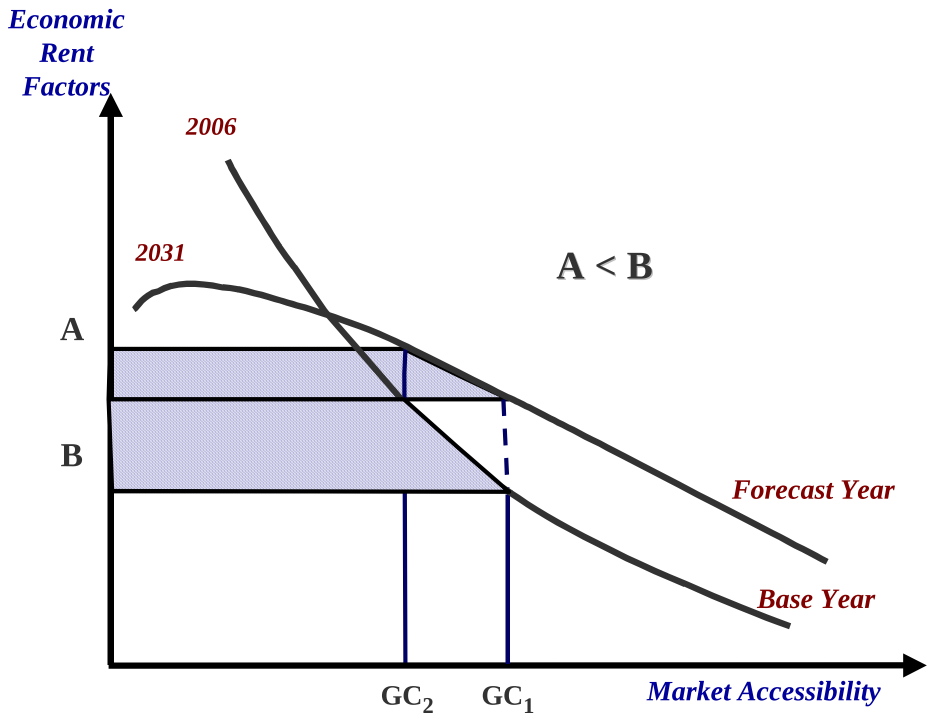
Exhibit 5.8: Impact of Economic Growth. Type 1 - Constant Profile



Under most economic conditions, however, the growth in economic rent is not the same over the region and the profile will not grow proportionally along its entire length. For example, in Exhibit 5.9 there is a decline in the forecast year economic rent profile at the market center while in the more peripheral areas (surrounding the market center) there is economic growth, i.e., growth occurs in the suburbs, but not the market center. In this environment the forecast year benefits, as measured by area A, are smaller than the base year economic benefits, measured by area B. This would suggest that using the base year economic rent profile would overstate benefits.

[29] Economic Rent profile as it was defined in Chapter 2 shows the special distribution of the economy in terms of its key factors - income, property values and wealth.

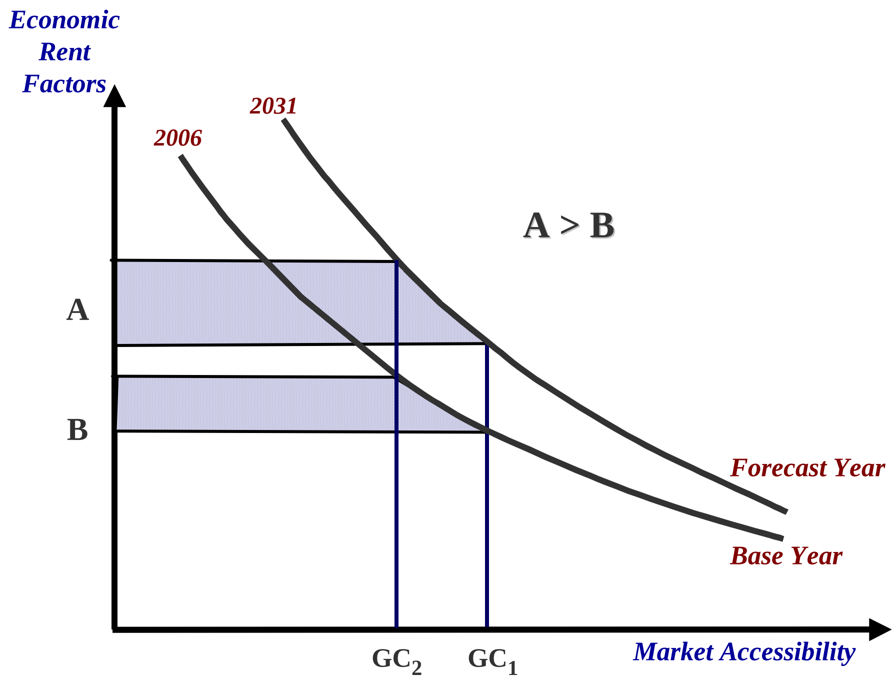
Exhibit 5.9: Impact of Economic Growth. Type 2 - Decrease in Profile



This type of growth, however, does not occur in normal markets, but rather in markets that suffer economic dislocations. For example, in the United States both Detroit and Buffalo experienced this type of growth impact when their downtown businesses failed. In Buffalo the issue was the decline of metal industries, while in Detroit it was more related to social demographic pressures. In this case a forecast of economic benefits based on a base year assessment will be an overstatement of the benefit. Certainly if any city market areas along the Calgary-Edmonton corridor suffer a major dislocation (such as experienced by Buffalo) during the life of the project, then the forecasts prepared for the Alberta HSR corridor could be overstated.

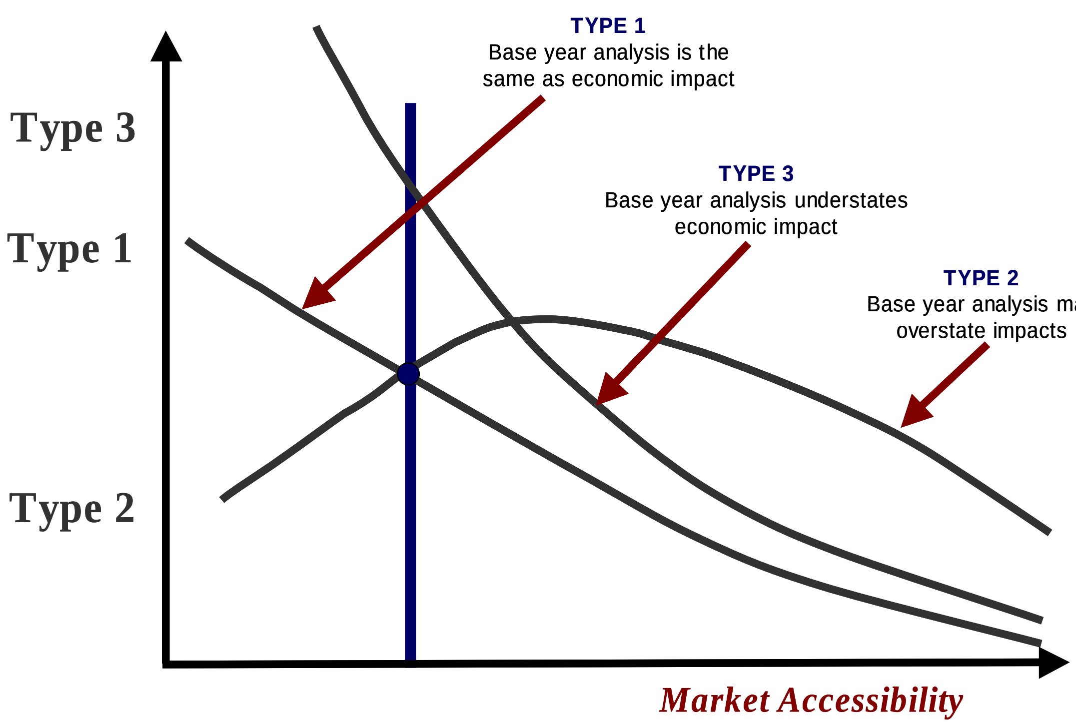
Under a normal economic growth situation in which the economy expands for a corridor, the typical impact is for growth to expand much faster at the market center than in the periphery. This reflects the fact that the market center provides the greater opportunities for growth in a normal economy and market. For example, the flood of Hong Kong Chinese into Victoria in the 1990s increased economic growth and income across the city. However, the impact was most severely fallen in the city center with the development of new high-rise buildings, restaurants and businesses within the downtown area. This increased the economic profile of the downtown area more that it did in suburban areas. In this case the measurement of economic benefit using the base year economic profile will understate the size of the benefits to be derived from the project. Area B will be smaller than area A. (See Exhibit 5.10.) Since this is the usual impact of economic growth on a market center, and as our study suggests ongoing long-term economic growth it is likely that using area B to estimate economic rent benefits understates the overall economic benefits to be derived from an Economic Rent analysis.

Exhibit 5.10: Impact of Economic Growth. Type 3 - Increase in Profile



As a result, it can be seen in Exhibit 5.11 that there are three conditions that can exist in the forecast year.

Exhibit 5.11: Types of Economic Growth



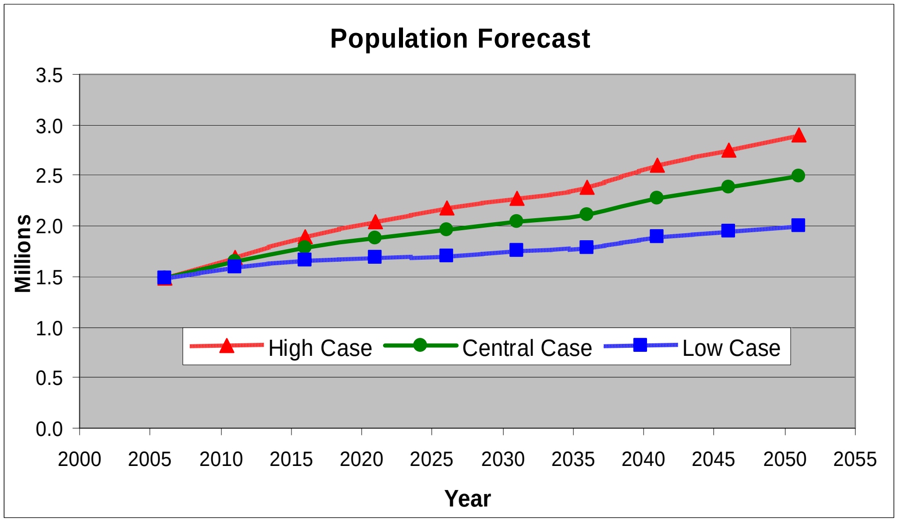
- Type 1 has constant growth. This means that base and forecast year impacts along the economic rent are the same, and the base year analysis understates the benefits.

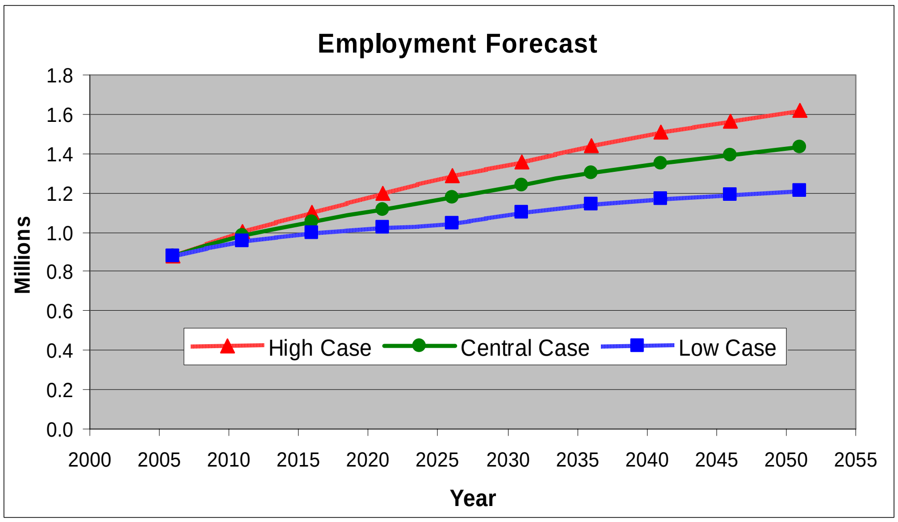
- Type 2 has negative growth at the market/city center. This typically results from a dislocation to the economy due to a loss of the economic base of the region. If this occurs the economic rent results, particularly in market centers, would be less than those that would be achieved if a base year economic rent profile is used. Using the base year economic rent profile will overstate the benefits.

- Type 3 has increased positive economic growth at the market center. As a result, the future year benefits are higher than suggested by measuring the economic rent profile in the base year.

While Type 3 is the normal situation for a city or market center, we have selected Type 1 as the basis for estimating economic benefits, which we believe is a reasonable and conservative assumption. In most towns a Type 3 environment will generate benefits greater than those estimated in this study. In one or two towns it is possible that a Type 2 conditions could prevail and lower economic benefits would be generated from the project. However, it is worth noting that such a weak performance would not be consistent with the current economic projections for Alberta economy used in the Alberta High Speed Rail Investment Grade Ridership Study, and as listed in Chapter 5 official sources. (See exhibits 5.12 through 5.14.)

Exhibit 5.12: Calgary Super Zone Socioeconomic Forecasts





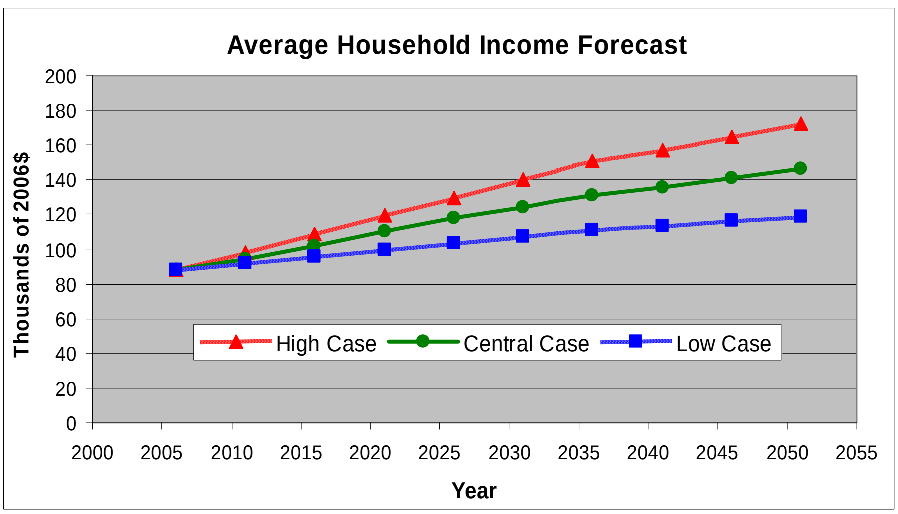
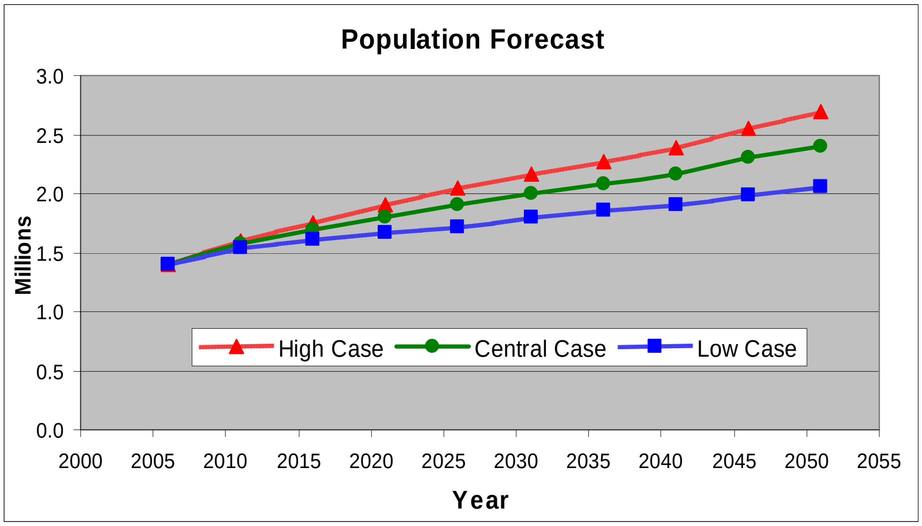
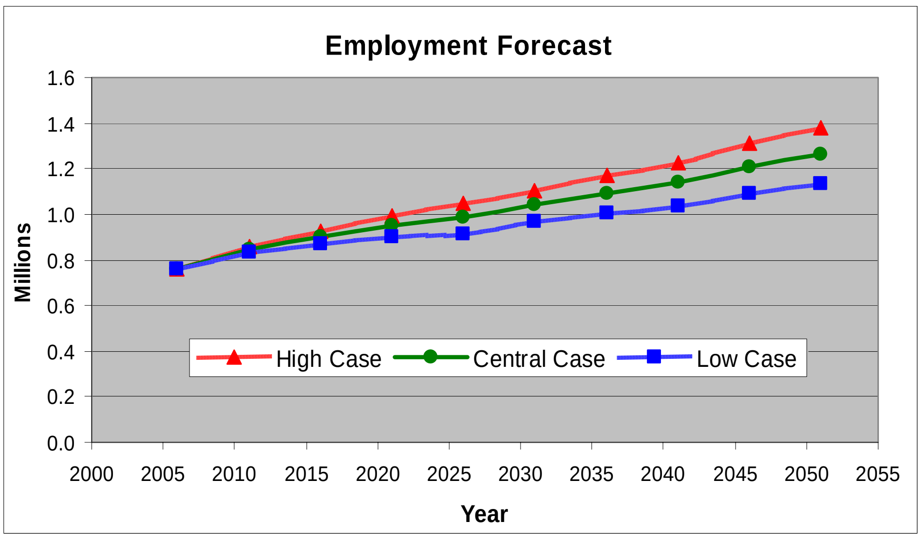


Exhibit 5.13: Edmonton Super Zone Socioeconomic Forecasts





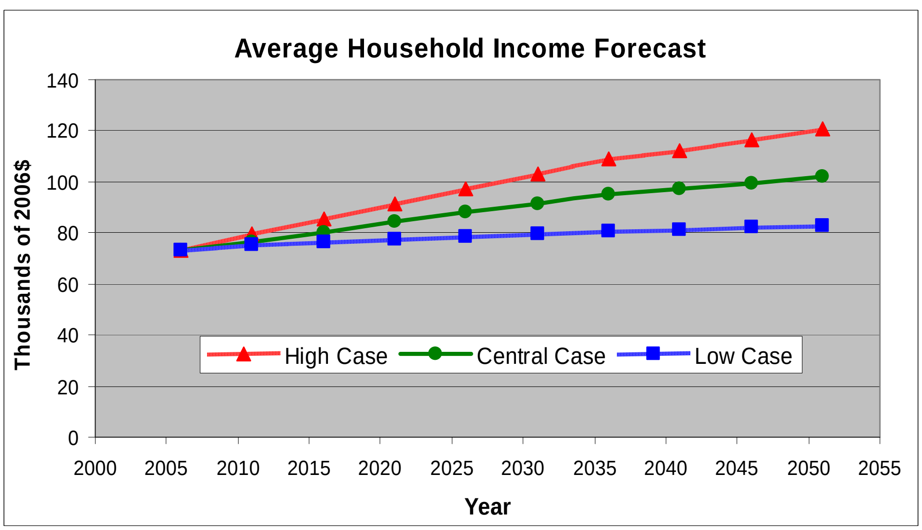
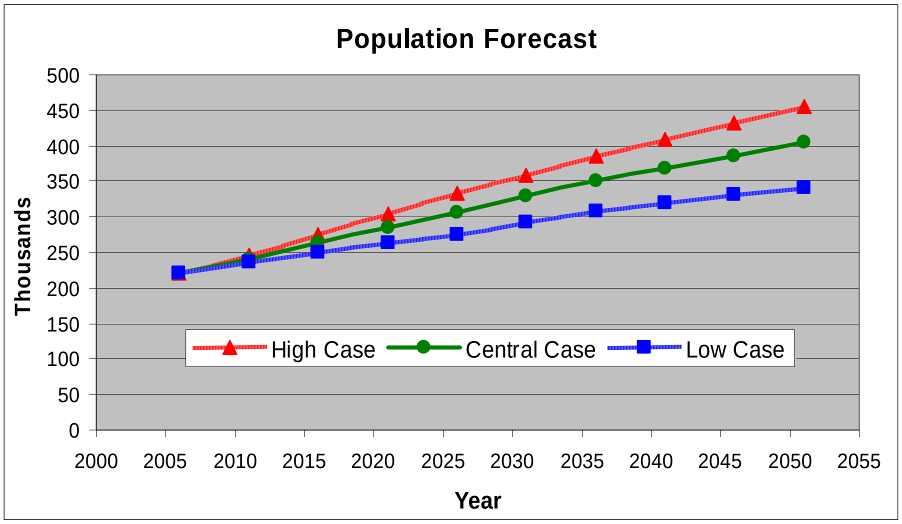
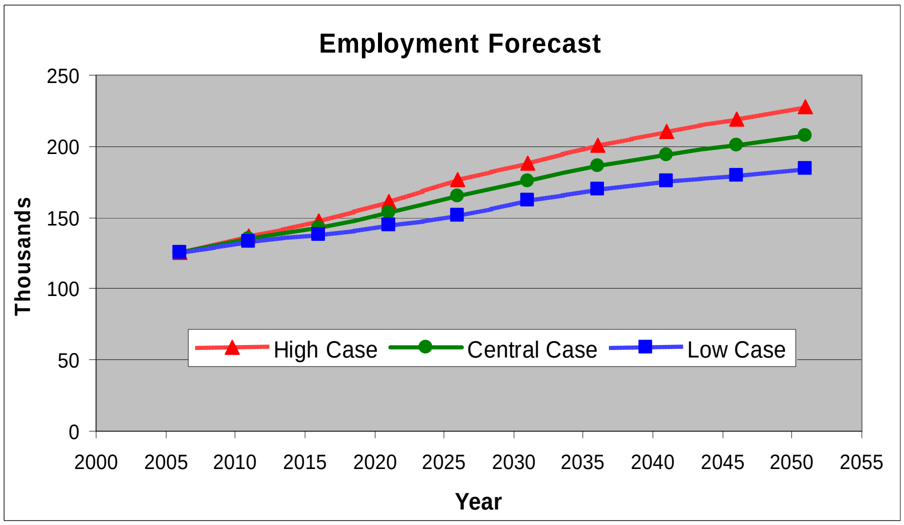
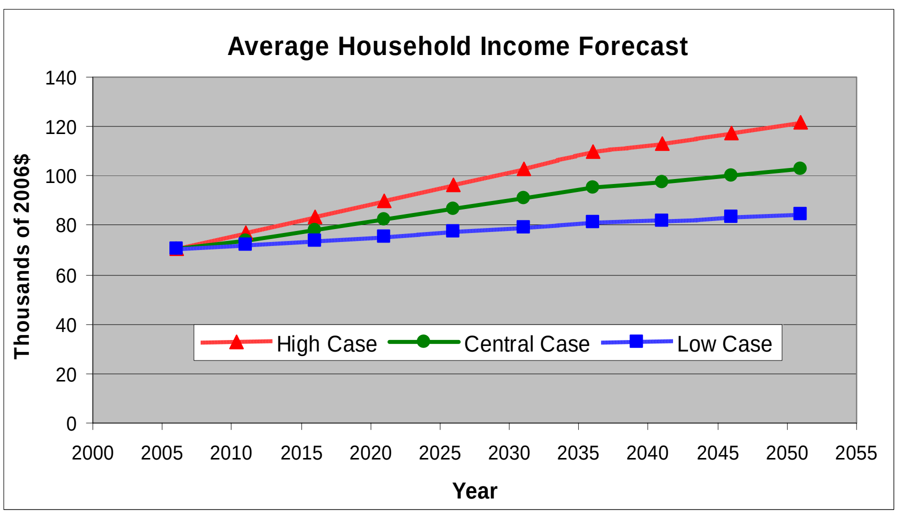


Exhibit 5.14: Red Deer Super Zone Socioeconomic Forecasts







5.3 Economic RENTS™ Results

For the Alberta three super zone region the building of the high-speed rail system will create between three and seven thousand jobs (depending on rail technology implemented); will increase development potential by at least $0.7-1.5 billion and the household income is estimated to increase by $230-490 million. It should be noted that the increase in employment, income and property value in Alberta represents a growth on the overall economy of between 0.2 and 0.5 percent on current levels. Both provincial and federal tax benefits are estimated in the range between $33 and $69 billion depending on technology used. Exhibit 5.15 represents the overall Economic Rent results by rail technology.

Exhibit 5.15: Overall Economic Rent Benefits for the Province of Alberta Derived from Implementation of the Alberta HSR System (by Rail Technology)

Economic Rent Factor	Talgo (125 mph)	Jet Acela (150 mph)	TGV (200 mph)	Maglev (300 mph)
Employment (# productivity jobs[30])	3,400	4,913	6,407	7,162
Income (2006$)	$230 mill	$331 mill	$436 mill	$487 mill
Provincial Income Tax[31] (2006$)	$12 mill	$17 mill	$22 mill	$24 mill
Federal Income Tax[32] (2006$)	$18 mill	$26 mill	$34 mill	$38 mill
Property Value (2006$)	$732 mill	$1,071 mill	$1,381 mill	$1,546 mill
Property Tax[33] (2006$)	$ 3 mill	$ 5 mill	$6 mill	$7 mill
Average Household Income (2006$)	$194	$278	$365	$408
Average Dwelling Value (2006$)	$403	$578	$759	$849

In terms of the time scale associated with the presented benefits it is likely that these benefits will be achieved after the completion of the building of the entire system and within two or three years of the start of operation by the Alberta HSR. The benefits will be proportional to the development of the system routes and schedules. It should be noted that the benefits of the system are likely to increase over time in line with growth in the economy as the analysis used the base year economic rent profile not the forecast year economic rent profile. Increases in the economic rent profile will significantly expand these results. If the economy grows by 50 percent by 2050 the estimated benefits will at least increase accordingly.

[30] Jobs identified here are productivity jobs and not construction or operating jobs. These productivity jobs derived from Alberta HSR implementation are estimated in the range of 136-286 thousand person years of work over the 40-year time of the project.

[31] Provincial income tax benefits are calculated by applying the official 2007 provincial tax rate for Alberta (10 percent of taxable income) to the 50 percent of the overall increase in income estimated by Economic Rent model. (In order to be conservative in our estimates we assumed that only half of the income benefits are taxable). 2007 income tax rates in Canadian provinces are provided by Canada Revenue Agency, see: www.cra.gc.ca

[32] Federal income tax benefits were calculated by applying the minimum official federal tax rate for 2007 (15.5% of taxable income) to the 50 percent of the overall increase in income estimated by Economic Rent model. Again, our estimates are very conservative. First, we assume that only half of the income benefits are taxable. Second, we apply the minimum of the existing federal tax rates, adopted for the year 2007 by Canada Revenue Agency. (Federal tax rates are in the range of 15.5 to 29 percent depending on taxable income, see: www.cra.gc.ca)

[33] Property tax benefits are calculated by estimating the share of property to be collected in 2006 in the 2006 equalized assessment (source: Alberta Municipal Affairs) and multiplying this share by property value increase estimated in the frame of Economic Rent model.

Distribution of employment, income and property value benefits by super zones is shown in exhibits 5.16 through 5.18. It is expected that property value benefits represented in Exhibit 5.18 will be distributed between residential property and commercial property[34], as it is shown in Exhibit 5.19.

Exhibit 5.16: Employment Benefits (Job Creation) by Super Zone & Rail Technology

"Super Zone" Center	Talgo (125 mph)	Jet Acela (150 mph)	TGV (200 mph)	Maglev (300 mph)
Calgary	1,475	2,159	2,814	3,125
Edmonton	968	1,414	1,838	2,050
Red Deer	957	1,340	1,755	1,987
Total:	**3,400**	**4,913**	**6,407**	**7,162**

Exhibit 5.17: Income Benefits (in millions of 2006$) by Super Zone & Rail Technology

"Super Zone" Center	Talgo (125 mph)	Jet Acela (150 mph)	TGV (200 mph)	Maglev (300 mph)
Calgary	111.0	160.6	211.8	235.7
Edmonton	68.8	99.7	131.0	146.1
Red Deer	50.6	70.8	92.8	105.0
Total	**$230**	**$331**	**$436**	**$487**

Exhibit 5.18: Property Value Benefits (in millions of 2006$) by Super Zone & Rail Technology

"Super Zone" Center	Talgo (125 mph)	Jet Acela (150 mph)	TGV (200 mph)	Maglev (300 mph)
Calgary	347.6	511.8	661.1	736.1
Edmonton	210.5	311.2	400.7	449.0
Red Deer	173.9	248.3	318.9	360.9
Total	**$732**	**$1,071**	**$1,381**	**$1,546**

Exhibit 5.19: Distribution of Property Benefits Between Residential and Commercial Property by Super Zone [35]

"Super Zone" Center	Residential Property	Commercial Property
Calgary	75%	25%
Edmonton	69%	31%
Red Deer	59%	41%
Alberta Average	**70%**	**30%**

[34] Commercial property includes all types of non-residential property, farmland, machinery & equipment.

[35] Calculated by TEMS, Inc., on the base of 2007 Equalized Assessment Report. Alberta Municipal Affairs. Assessment Services. October 30, 2006. http://municipalaffairs.gov.ab.ca/documents/as/2007_Provincial_Equalized_Assessment_Report_.pdf

To obtain community results, the overall results were disaggregated to the zone level and then community totals were estimated. Derived benefits are different for different rail technologies. Exhibit 5.20 shows the possible range of Economic Rent benefits obtained by major communities. The lowest value represents the benefits from Talgo (125 mph) technology implementation, while the highest value shows the benefits from Maglev (300 mph) technology implementation. Benefits from Jet Acela (150 mph) and TGV (200 mph) are in between.

Exhibit 5.20: Economic Rent Analysis by Community

Name of Community	Employment Value (# Jobs)	Household Income (Millions 2006 $)	Property Value (Millions 2006 $)
Calgary 'Super Zone'			
1st -2nd Tier: The City of Calgary	1,084 – 2,313	88 - 188	259 - 553
3d Tier: Suburbs - Airdrie & Okotoks	170 - 361	9 - 20	31 - 67
4th Tier: Suburbs - Cochrane	87 - 176	7 - 15	27 - 54
4th Tier: Other - Strathmore & Canmore	24 - 47	1 - 2	8 - 16
Other areas in Calgary 'Super Zone'	110 - 228	6 - 11	23 - 46
Total for Calgary 'Super Zone'	**1,475 – 3,125**	**$111 – $236**	**$348 – $736**
Edmonton 'Super Zone'			
1st -2nd Tier: The City of Edmonton, St. Albert & Sherwood Park	735 – 1,556	57 - 120	165 - 351
3d Tier: Suburbs – Spruce Grove	33 - 70	3 - 6	9 - 20
4th Tier: Suburbs – Leduc & Fort Saskatchewan	68 - 146	3 - 7	14 - 30
4th Tier: Other – Wetaskiwin & Camrose	48 - 102	2 - 5	8 - 16
Other areas in Edmonton 'Super Zone'	84 - 176	4 - 8	14 - 32
Total for Edmonton 'Super Zone'	**968 – 2,050**	**$69 - $146**	**$210 - $449**
Red Deer 'Super Zone'			
2nd Tier: The City of Red Deer	735 – 1,525	40 - 82	111 - 229
4th Tier: Lacombe	88 - 182	4 - 9	30 - 63
Other areas in Red Deer 'Super Zone'	134 - 280	7 - 14	33 - 69
Total for Red Deer 'Super Zone'	**957 – 1,987**	**$51 - $105**	**$174 - $361**

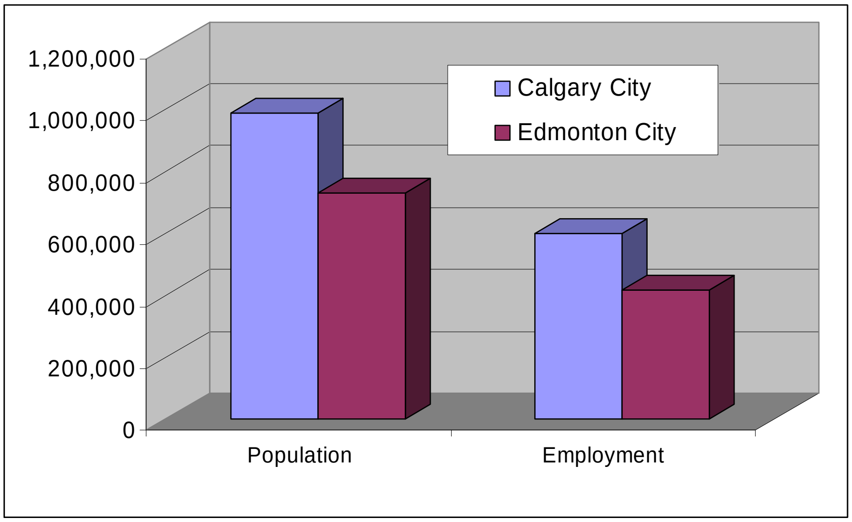
5.4 Assessment Results

The Economic Rent results suggest some marked differences in the benefits identified for each super zone. To validate the results of the analysis the key factors in the analysis were carefully reviewed and assessed. First factor is their socioeconomic characteristics (not only current, but also projected). Second factor is the location of the station and the level of its transportation interaction in terms of possibility to achieve improvement in accessibility after implementation of the Alberta HSR system.

As it is seen from exhibits 5.17 and 5.18 both Calgary and Edmonton super zones derive significant benefits from high-speed rail implementation. Cities of Calgary and Edmonton[36] have the major share (about 75 percent) of the benefits obtained by their super zones. In accordance with the Economic Rent model the absolute value of each particular type of benefit primarily depends on the strength of the economy and the level of accessibility improvement resulted from implementation of high-speed rail. Both factors are stronger in Calgary than in Edmonton.

Socioeconomic analysis shows traditional leadership of the City of Calgary over the City of Edmonton. Current population and employment in Calgary are 35 to 45 percent higher than in Edmonton (see Exhibit 5.21). Being similar in size Calgary also has higher population and employment densities (see Exhibit 5.22) [37]. In addition, the value of accessed property value in Calgary is even higher than in Edmonton than the difference in demographic variables. According to the 2007 Equalized Assessment Report[38] property value is Calgary is almost 80 percent higher than in Edmonton (see Exhibit 5.23). Historic data sets and official projections also show that not only economic and demographic situation in Calgary has been traditionally stronger than in Edmonton economy, but it will continue in the future. The gap is in your official forecasts to widen in the future (see exhibits 5.24 and 5.25).

Exhibit 5.21: 2006 Population and Employment in the Cities of Calgary and Edmonton



[36] The City of Edmonton is represented together with its nearest and largest suburbs – St. Albert and Sherwood Park, see Exhibit 5.20.

[37] Statistics Canada. 2006 Census of Population. http://ceps.statcan.ca/english/census06/release/index.cfm; City of Edmonton, City of Calgary, Applications Management Consulting Ltd.

[38] Alberta Municipal Affairs. .(http://municipalaffairs.gov.ab.ca)

Exhibit 5.22: 2006 Population and Employment Density in the Cities of Calgary and Edmonton

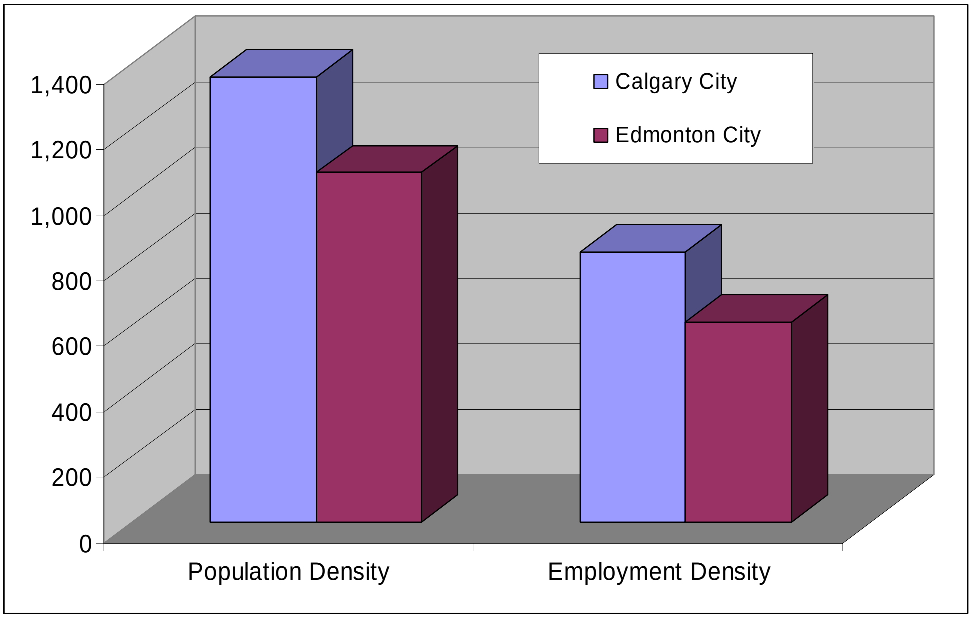


Exhibit 5.23: 2007 Assessed Property Value in the Cities of Calgary and Edmonton (by property type, in 2006$)

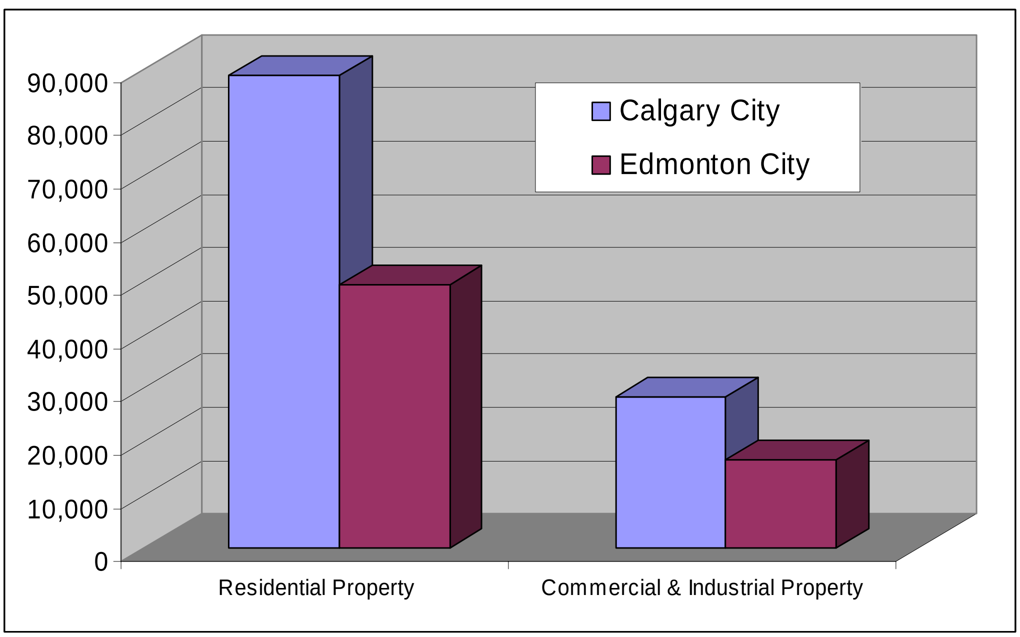


Exhibit 5.24: Historic and Projected Population trends for the Cities of Calgary and Edmonton[39]

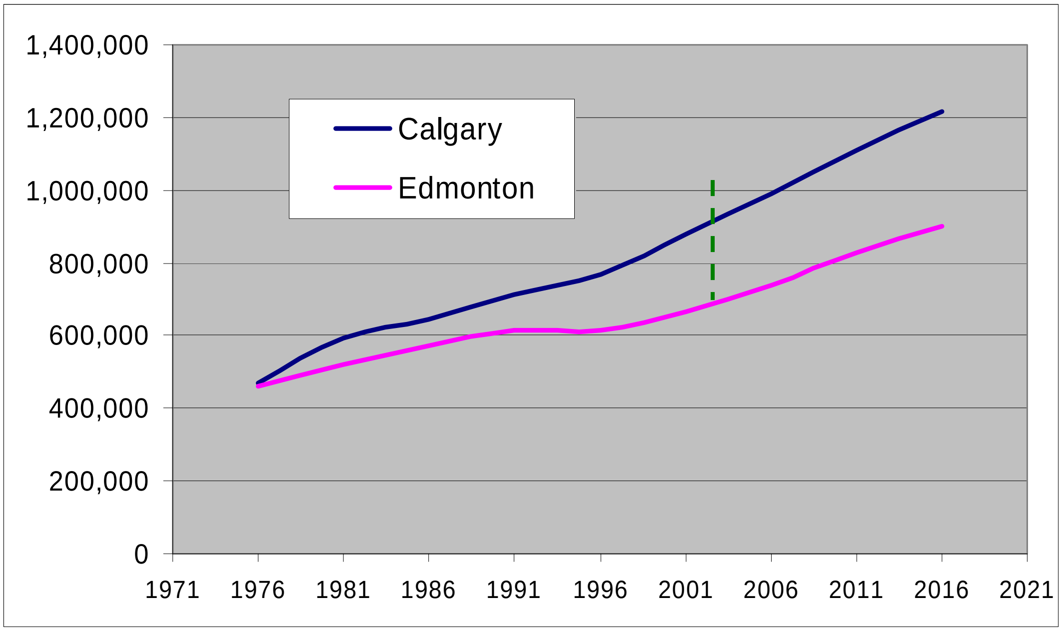
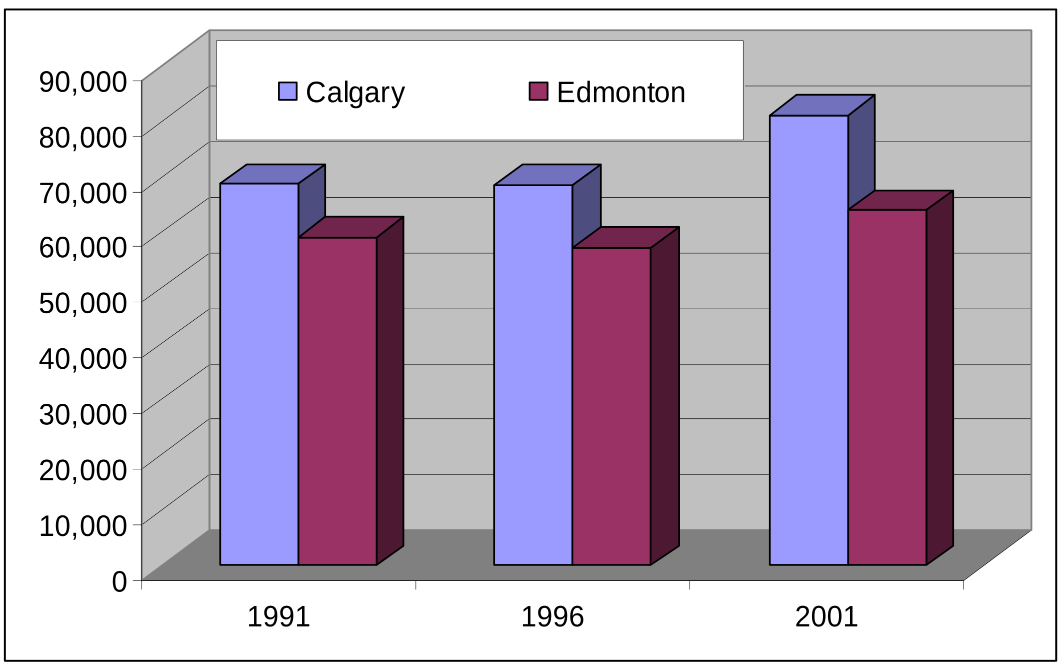


Exhibit 5.25: Historic Average Household Income in the Cities of Calgary and Edmonton (in 2006$)

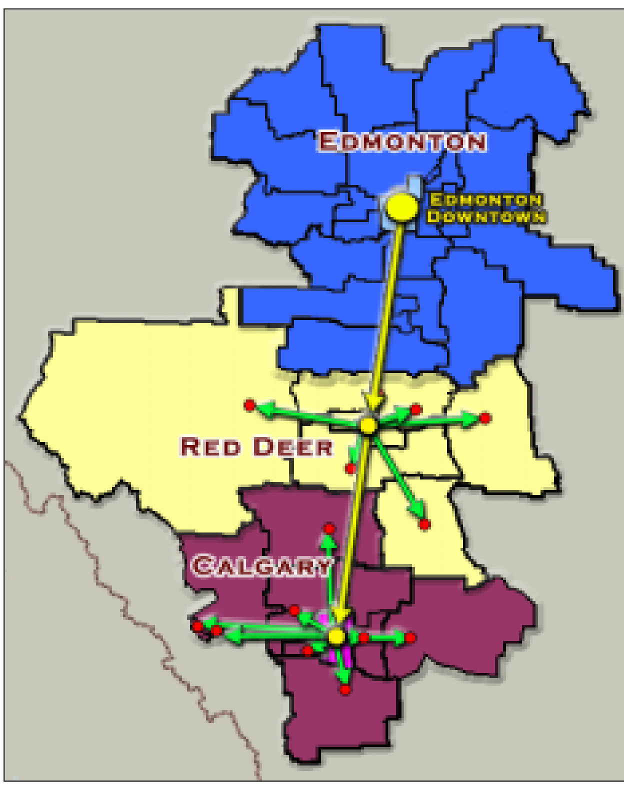


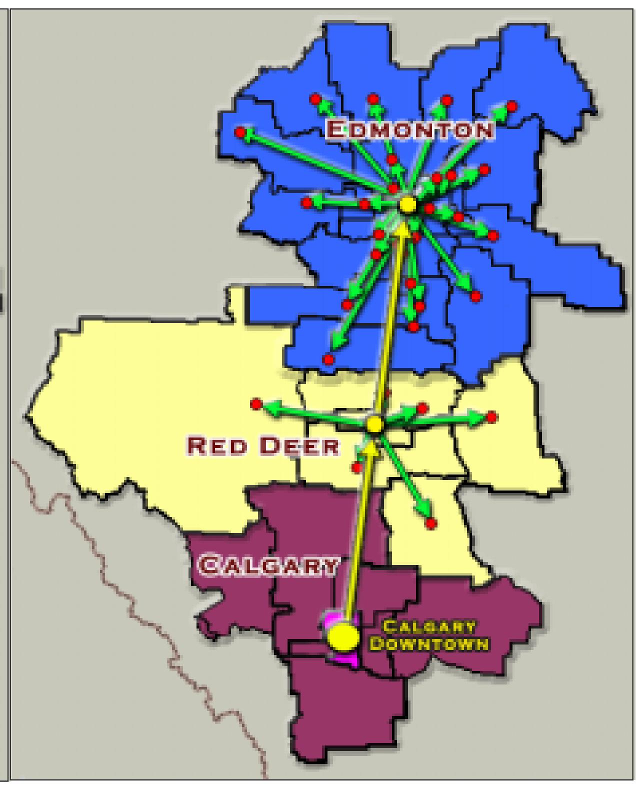
[39] Statistics Canada 1991, 1996, 2001 & 2006 population Census; the City of Edmonton Planning and Development; City of Calgary. 2006 Civic Census Overview; the Calgary and Region Economic Outlook 2007-2012; Alberta Transportation and Infrastructure. Population Forecast - Capital Region Infrastructure Review; Calgary and Region Socio-Economic Outlook 2006-2016.

As to the difference in levels of transportation interaction, analysis of transportation network shows that improvement in accessibility as a result of high-speed rail implementation is higher for Calgary than for Edmonton. Taking example of Jet Acela technology we see that for the City of Edmonton average relative improvement in accessibility (measured in relative change in weighted generalized costs[40]) is 0.13 percent, while for the City of Calgary the corresponding improvement is 0.17 percent. Since both cities have the same number of transportation zones and are similar in size, difference in accessibility improvement is mainly explained by location of the cities in terms of their connectivity to other areas using the high-speed rail system.

Exhibit 5.26 shows the areas that are especially benefit from high-speed rail. According to Economic Rent results Calgary and Edmonton downtowns, each, accumulates 24-25 percent of the total benefits obtained by the Cities of Calgary or Edmonton. If we look at the trips generated in each of the these cities, it is evident that users of high-speed rail have more destinations going by rail to or from the Edmonton region than going by rail to or from the Calgary region and if they travel from (to) downtown Calgary station than if they travel from (to) downtown Edmonton station. This visual observation is also supported by stated preference survey results: the Calgary region would generate more trips to and from the areas accessible by high-speed rail[41] than the Edmonton region will generate.

Exhibit 5.26: High-Speed Rail Trips Generated in The City of Edmonton (left) and in The City of Calgary (right)



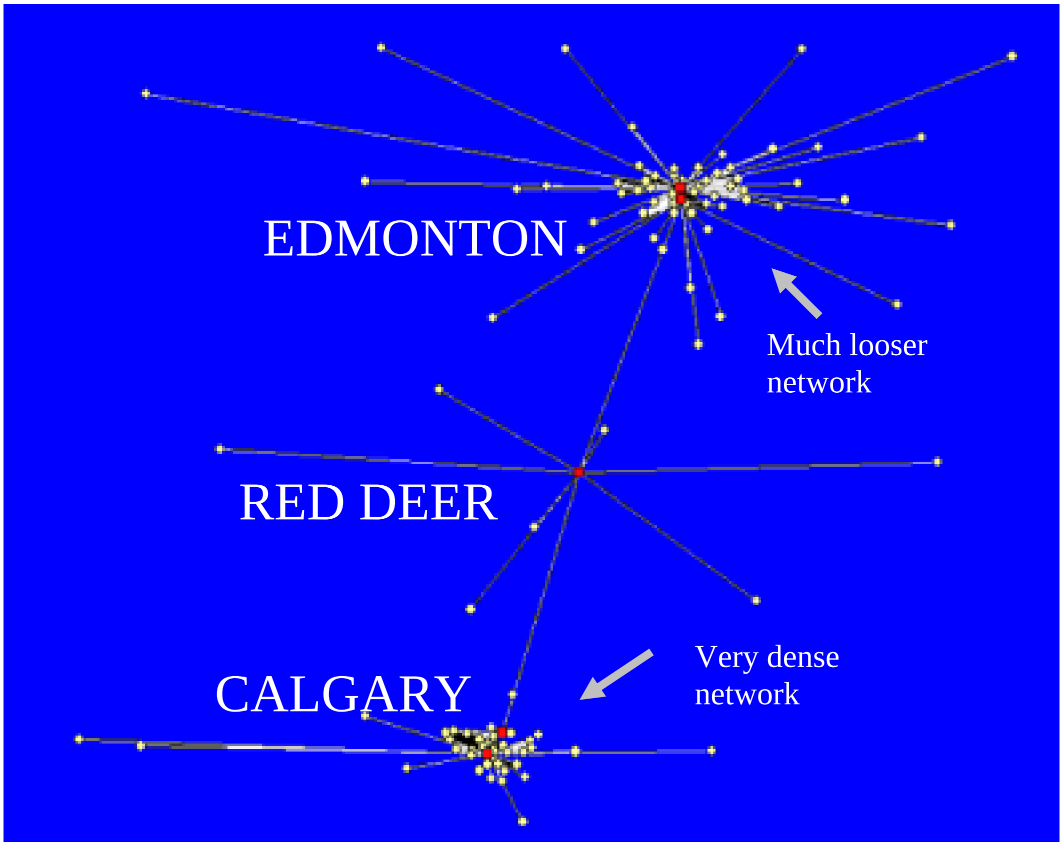


[40] Relative improvement in accessibility in each zone is measured as the fraction between the absolute change in generalized costs (after implementation of HSR system) and the base generalized costs (before HSR system implementation).

[41] We assume that people will use high–speed rail if the distance between origin (destination) and train station is in 60-mile distance.

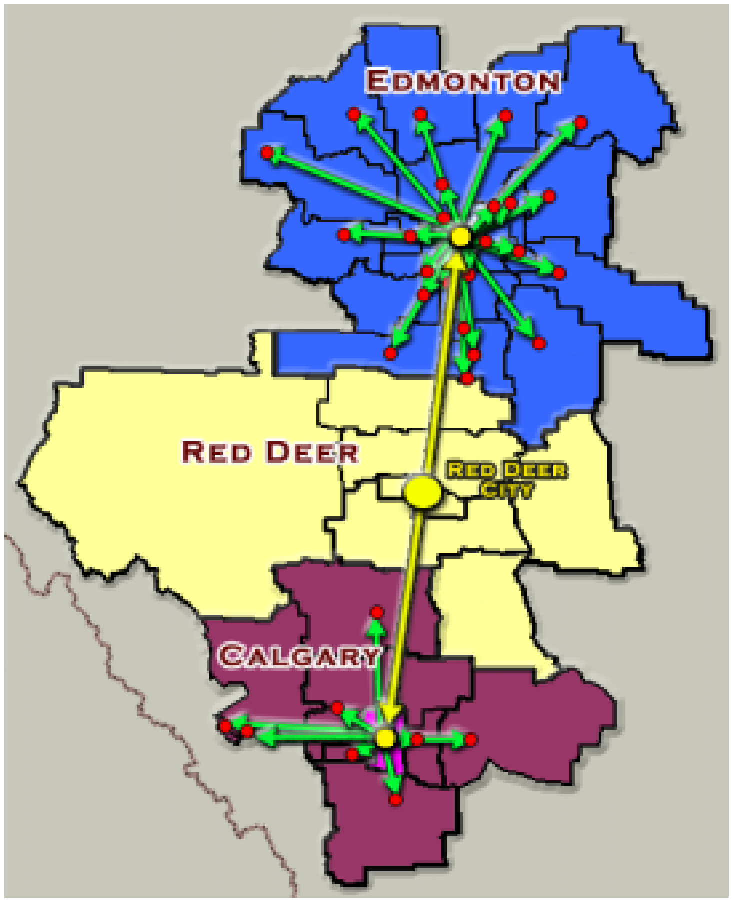
In Calgary and Edmonton super zone areas outside the City of Calgary and the City of Edmonton accumulate one-forth of the overall economic rent benefits obtained by these super zones. In comparison with Calgary super zone (not just city), Edmonton super zone (not just city) has a broader area and a wider distribution of population and employment. As a result, the primary towns (centroids) of the Edmonton super zone are usually further from the rail stations than those of the Calgary super zone (see Exhibit 5.27). In consequence the accessibility improvement for each area outside the city and the main suburbs is lower for Edmonton super zone than for Calgary super zone.

Exhibit 5.27: Rail Network for the Alberta HSR



With respect to the Red Deer super zone, it obtains high economic rent benefits because of the very convenient location. In the Red Deer super zone the City of Red Deer itself accumulates more than 75 percent of the total benefits. Being in the center of Calgary-Edmonton rail corridor the Red Deer stop provides remarkable access to both Calgary and Edmonton, see Exhibit 5.28. For Jet Acela (150 mph) technology the relative improvement in accessibility in the City of Red Deer transportation zone is one percent: that is six to eight times more than in the Cities of Calgary and Edmonton.

Exhibit 5.28: High-Speed Rail Trips Generated in the City of Red Deer



6

Station Development Impacts

6.1 Introduction

An important feature of the development of the Alberta High Speed Rail (Alberta HSR) system is the role of its stations. Alberta HSR stations will be the gateway to communities in the Central and South Alberta. At this "gateway" or "front door," considerable development potential will exist. Active train operations will encourage service industry to locate at the station, and its immediate environs. Such activity will generate both commercial and residential development. Industries looking for a home along the Calgary-Edmonton rail corridor will see it as a good "seeding" ground for business.

As a result, a key output of the Economic Rent analysis is the increase in property values that can be expected at station locations throughout the Alberta HSR system. These can be equated to development opportunities, which will exist in and around the stations. In a North American or European environment this opportunity is frequently recognized by both the private and public sectors that form partnerships to implement such projects. Of the estimated $732 to 1,546 million in development it is anticipated that approximately one-half of this total will come from private sector investments, one-quarter from provincial, county and municipal sources, and the final quarter from the Federal government. These proportions are derived from typical results for passenger rail corridors. However, the exact proportions will depend on the share of risk the private sector is willing to assume and the level of leadership the public sector is willing to take. Typically, the greater the public leadership, the lower the risk for the private sector.

The main factors impacting the development potential included: station location, land availability around the station for development, and community commitment to the station and urban development. The ability of a location to achieve its highest potential is affected by different factors, as mentioned below:

- Level of modal integration at the station;
- Frequency of existing rail and bus services;
- Proximity to highways, connections to local transit systems and availability of parking;
- Accessibility of the station to the community (i.e. walking distance to downtowns, sports & entertainment venues, new developments in their CBDs[42];
- Existing level of connectivity to regional modal networks;
- Level of existing and potential economic development.

[42] CBD – Central Business District

In assessing stations and communities, factors such as community size, proximity of station to major economic markets, current economic base, and density along the corridor were taken into account. Then the potential for each community to realize economic benefits from the Alberta HSR system was determined within the context of the economic rent analysis.

It should be noted that the Economic Rent model uses criteria very similar to those used by the real estate industry in developing an estimate of property value. Whereas the real estate industry uses these criteria to place a current value on properties, the Economic Rent analysis estimates how changes in accessibility will impact the current value. If accessibility improves (due to a transportation investment) the property value improves, if accessibility falls (due to, say, congestion) then property values fall.

6.2 Multimodal Connectivity

The Alberta HSR system station development will bring together many modes of travel – trains, planes, taxis, private automobiles, and regional, inter-city, and airport buses at a single location in order to maximize benefits and efficiencies. Savings in time and increased economic activity will assure the highest output in economic rent, along with an increase in property values and development potential. The multimodal transportation centers will be well located to encourage other joint-use occupancies and help create “smart growth” areas in urban centers.

In the same way that large department stores anchor a shopping center and create trips that stimulate activity in nearby shops, a multimodal transportation center has the potential to stimulate retail, office, and residential development in an urban center. Without the synergies achieved by bringing all modes of transportation together in one location, there are significant negative impacts on the economic development potential. Analysis of different transportation centers indicate that the potential increase in property value and development potential decline by 30 to 50 percent when the station is a single or limited transportation center. Thus, connectivity is critical to success in the station development effort.

The importance of considering all service characteristics can be illustrated by considering the effects of the relocation of downtown terminals in Saskatoon, Ottawa and Quebec City in Canada[43].

- In Ottawa the downtown terminal was relocated in 1967 and Ottawa-Montreal traffic fell by 45 percent in the first year. Later attempts to revive traffic with increased frequencies, but without relocating the station, had a minimal effect on the decline.

- In Quebec City downtown station relocation in 1976 lost 30 percent of Montreal traffic. VIA Rail reopened the downtown station in 1985 after nearly ten years of disuse, and traffic rebounded.

- In 1965 CN[44] relocated the Saskatoon terminal some five miles from the downtown core. This resulted in a 75 percent decline in Regina-Saskatoon traffic within 18 months and daily frequency was subsequently reduced from three trains to one.

These examples illustrate the importance of downtown terminals for the proposed Alberta HSR service.

[43] For more details see: [22]

[44] CN - Canadian National Railway.

6.3 Station Area Development Potential

An intercity high-speed rail system provides considerable development potential at stations. High-speed rail systems developed in Europe and Japan have resulted in very significant joint development projects in which the public/private partnerships have completely changed the character of the urban environment around the station. In France, examples exist in Paris, Lyon and Nantes, while in the UK the redevelopment of Liverpool Street Station, Cannon Street Station and plans for Kings Cross Station in London show the scale of redevelopment possible. At Liverpool Street Station the project completely changed the character of the surrounding urban environment, including massive redevelopment for offices (UBS-PaineWebber headquarters building), housing, and commercial businesses (see Exhibit 6.1). At Kings Cross an eight-billion-dollar project is underway on the existing railway lands, as a result of the development of 150-mph East coast rail service from London to Edinburgh (see Exhibit 6.2). In this case the railroad is providing the railroad lands on which the original station and yards were located, while the private sector will build the station and commercial and residential facilities on this 72-acre site.

In the United States the redevelopment of Washington Union Station in D.C. and the surrounding area is a clear example of the opportunity that high-speed rail can offer for creating a terminal station development (see Exhibit 6.3). Indeed all along the Northeast corridor, station – area redevelopment is showing the ability of high-speed rail service to stimulate increased business activity. The Northeast corridor contrasts strongly with the US Midwest where despite attempts to redevelop stations, the low level of rail activity is such that only Chicago Union Station and some smaller community stations have been able to realize much of an impact.

These examples suggest that in Alberta the impact of high speed rail will generate significant benefits at terminal stations and such that major multimodal facilities should be planned in both Calgary and Edmonton and smaller facilities at the suburban stations and Red Deer. The following section decentres the benefits that will be generated for each station depending on technology selected. In each case a private public partnership can be developed to build and operate each facility.

Exhibit 6.1: Liverpool Street Station, London

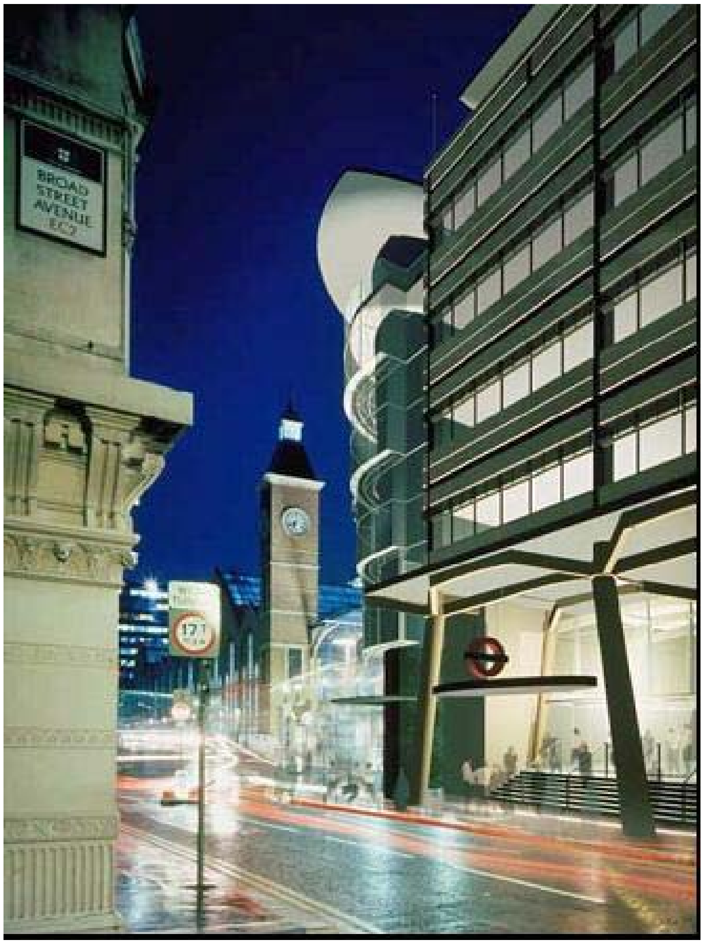


Exhibit 6.2: Kings Cross Station, London

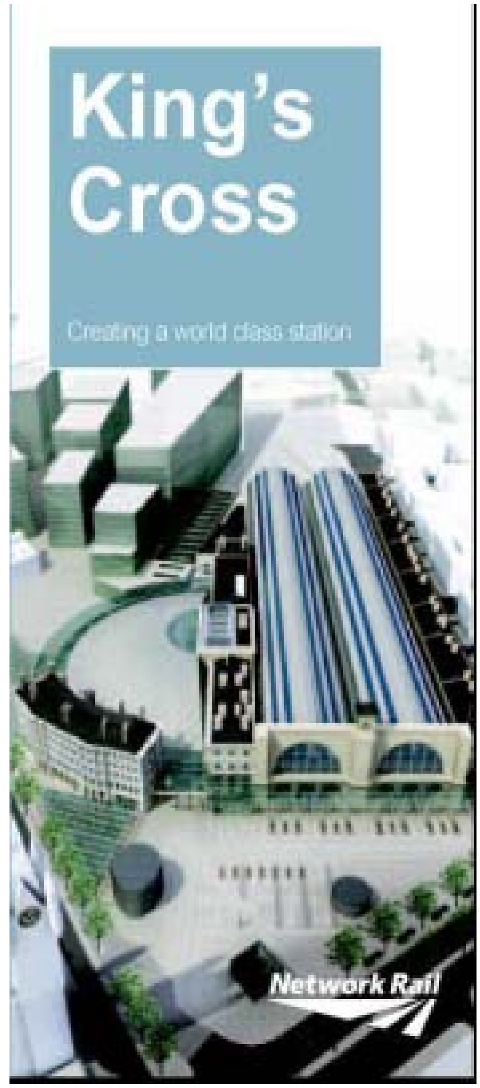


Exhibit 6.3: Washington Union Station
(a typical major station)

6.4 Economic Benefits by Station

Final Economic Rent analysis translates economic benefits calculated for super zones and states into benefits for each rail station. The results of RENTS™ analysis for five Alberta HSR stations are shown in exhibits 6.4 and 6.5. In Exhibit 6.4 the property value development is summarized by level of station in the hierarchy.

Exhibit 6.4: Alberta HSR Stations Development Potential by Technology (Tier Summary)

Tier #	Station Names	# Stations	Development Potential (Millions 2006$)			
			Talgo (125 mph)	Jet Acela (150 mph)	TGV (200 mph)	Maglev (300 mph)
Tier 1 Stations:	Calgary, Edmonton	2	$442	$634	$814	$885
Tier 2 Stations:	Suburban Calgary, Suburban Edmonton, Red Deer	3	$290	$437	$567	$661
Total:	**All Five Stations**	**5**	**$732**	**$1,071**	**$1,381**	**$1,546**

Expected economic benefits by each station measured in terms of increase in employment, household income and property values are presented in exhibits 6.5 through 6.7.

Exhibit 6.5: Alberta HSR Economic Benefits by Station for Talgo (125 mph) Technology

Station Name	Employment (# jobs)	Income (Millions 2006$)	Development Potential (Millions 2006$)
Calgary Downtown	1,000 – 1,335	$75 - 100	$236 - 314
Calgary Suburban	325 - 435	$25 - 33	$77 - 103
Edmonton Downtown	745 - 990	$53 - 70	$162 - 215
Edmonton Suburban	130 - 170	$9 - 12	$28 -37
Red Deer	765 – 1,055	$40 - 56	$139 - 191

Exhibit 6.6: Alberta HSR Economic Benefits by Station for Jet Acela (150 mph) Technology

Station Name	Employment (# jobs)	Income (Millions 2006$)	Development Potential (Millions 2006$)
Calgary Downtown	1,470 – 1,960	$109- 146	$349 - 465
Calgary Suburban	470 - 630	$35 - 47	$112 - 149
Edmonton Downtown	1,010 – 1,345	$71 - 95	$222 - 296
Edmonton Suburban	265 - 350	$19 - 25	$58 - 77
Red Deer	1,070 – 1,475	$57 - 78	$199 - 273

Exhibit 6.7: Alberta HSR Economic Benefits by Station for TGV (200 mph) Technology

Station Name	Employment (# jobs)	Income (Millions 2006$)	Development Potential (Millions 2006$)
Calgary Downtown	1,920 – 2,560	$145 - 193	$451 - 602
Calgary Suburban	610 - 815	$46 - 61	$144 - 192
Edmonton Downtown	1,290 – 1,720	$92 - 122	$281 - 374
Edmonton Suburban	365 - 490	$26 - 35	$80 - 106
Red Deer	1,405 – 1,930	$74 - 102	$255 - 351

Exhibit 6.8: Alberta HSR Economic Benefits by Station for Maglev (300 mph) Technology

Station Name	Employment (# jobs)	Income (Millions 2006$)	Development Potential (Millions 2006$)
Calgary Downtown	2,055 – 2,740	$155 - 207	$484 - 646
Calgary Suburban	757 – 1,010	$57 - 76	$178 - 238
Edmonton Downtown	1,426 – 1,900	$102 - 135	$312 - 416
Edmonton Suburban	420 - 560	$30 - 40	$92 - 122
Red Deer	1,590 – 2,185	$84 - 116	$289 - 397

7

Conclusion

The development of the Alberta High Speed Rail (Alberta HSR) system will provide an integrating force for the communities of the Calgary-Edmonton corridor. It will provide opportunities to fundamentally change the character of business in the corridor while expanding the level of social, personal and tourist interaction in the corridor. In the corridor the project will create a new business environment that will encourage and attract the 'New Economy' businesses. These include high-tech, high value-added industry frequently tied to computer, telecommunications and professional services businesses). It will support existing manufacturing and service industry, while fostering the growth of new small businesses across the corridor because of the improved access to smaller communities in the corridor.

Implementation of the Alberta HSR system will encourage large businesses to distribute their operations more widely and reap the benefit of providing more efficient "back shop" operations in the highly accessible smaller communities. These communities provide a high quality of life for residents in terms of lower cost housing, good schools, friendly secure neighbourhoods, and less congested highway systems. In an environment of rising oil prices, the Alberta HSR system will offer an energy-efficient and cost effective alternative to air and automobile travel that businesses and individuals will be able to use to connect with all of the cities and towns of the Central and South Alberta. Since the rail trip will be highly competitive with air and auto in travel time and provide a level of interaction with all the regions' communities, the Alberta HSR system provides a level of service that will be critical to attracting and developing "New Economy" businesses.

Consumer Surplus: The traditional benefit cost methods developed by Transport Canada shows $4.6 to $33.4 billion economic impacts as a result of building the system (see: Exhibit 7.1). This is due to corridor population density, the distance between cities, and the increasing cost of alternatives, such as air and auto.

Exhibit 7.1: Alberta HSR User Benefits

Rail Technology	Speed (Miles per hour)	User Benefits (Billions of 2006$)
Talgo	125	4.6
Jet Acela	150	8.5
TGV	200	19.5
Maglev	300	33.4

Economic Rent: Given that the demand side benefits generated by the Alberta HSR system are so large, it is not surprising that the long-term supply side benefits are also substantial. The Economic Rent analysis shows supply side benefits of the following:

- 0.2 to 0.5 percent growth in the economy, depending on technology

- 3,400 to 7,162 long-term (40 year) jobs across the province of Alberta, which is equivalent to 136 to 286 thousand person years of work over the 40 years.

- Increase in income between $230 and 490 million per year or $5.6 to 11.7 billion over the life of the project)

- The development potential, assuming full advantage is taken by local communities of the development option available from the Alberta HSR project, is between 0.7 and 1.5 billion dollars, and may be higher with effective planning and urban renewal

- Residential property value increase is $403 to 849 for every dwelling unit

- Expected tax benefits (both income and property taxes) for the province of Alberta are in the range of $15 to 31 million per year (its is equivalent to $0.4 to 0.8 billion over the life of the project)

- Total expected tax benefits (provincial and federal) from the Alberta HSR project implementation are in the range of at least $33 to 69 million per year or $0.8 to 1.7 billion over the life of the project

Analysis of the Alberta High Speed Rail Project shows that the total benefits will be distributed along the corridor in the following way:

- Calgary 'Super Zone' – 40-45 percent
- Edmonton 'Super Zone' – 30-35 percent
- Red Deer 'Super Zone' – 20-25 percent

Overall economic impacts of Alberta HSR system are presented in Exhibit 7.2.

Exhibit 7.2 Demand and Supply Economic Impacts[45] of Alberta HSR System on the Province of Alberta over the Life of the Project (by Rail Technology)

Benefit Parameter	Talgo (125 mph)	Jet Acela (150 mph)	TGV (200 mph)	Maglev (300 mph)
40 years Net Present Value, @ 3 percent, in Billions of $2006				
HSR User Benefits (Consumer Surplus & System Revenues)	$2.6	$5.3	$13.6	$25.2
Resource Savings[46]	$1.9	$3.0	$5.6	$7.8
Emission Savings	$0.1	$0.2	$0.3	$0.4
Income	$5.6	$8.0	$10.5	$11.7
Provincial Income Tax	$0.3	$0.4	$0.5	$0.6
Federal Income Tax	$0.4	$0.6	$0.8	$0.9
Provincial Property Tax	$0.08	$0.11	$0.14	$0.16
Development Potential[47]	$0.7	$1.1	$1.4	$1.5
In 2006$				
Increase in Average Household Income	$194	$278	$365	$408
Increase in Average Dwelling Value	$403	$578	$759	$849
Thousands of person years of work over 40 year life of the project				
Employment (productivity jobs)	136.0	196.5	256.3	286.5

[45] Supply and demand impacts show benefits from different sides. In order to avoid double counting they should not be added.

[46] Presented here benefits include savings from reduced airport and highway congestion, as well as decreased air carrier operating costs (see Chapter 3).

[47] Development potential is the expected increase in property value.

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