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# Risk-adjusted Discount Rates for Public Sector Investments
*- with illustrations for transportation -*

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**Abstract**

There is a well-known yet inconclusive debate in the public investment literature concerning risk-adjustments to the discount rate applied to publicly funded investment. Theoretical contributions to the debate range from the proposition that the risk of public investment is so completely diversified that no risk premium is called for (Arrow and Lind) to the view that public investments should be evaluated on the same basis as private projects with similar risk characteristics (Hirschleifer and Bailey).

This paper proposes a new definition of the risk of public sector investment together with an empirical methodology to estimate such risk in order to assign a risk-adjustment to the discount rate. The concept is based on observable measures of the *use* of public sector assets; for a specific investment, the correlation between the use-measure and real GDP provides an index of socially-relevant risk similar to the Capital Asset Pricing Model. Parameters of the model are the riskless Social Opportunity Cost of Capital and the computed cost of public capital for the investment with "average" risk.

The paper presents estimates of risk-adjusted discount rates for 10 specific categories of public sector investment in Canadian transportation infrastructure.

Introduction

In an earlier work we estimated the social opportunity cost of capital (SOCC) in Canada to be 7.3 percent.[1] That value is a weighted average cost of capital drawn from three sources: Canadian savings (or deferred consumption), displaced private sector investment and foreign borrowing. The SOCC is the primary reference for evaluating public sector investment in Canada. Since it is a discount rate that represents a broad average of social costs associated with an unspecified average investment, the SOCC implicitly incorporates a premium for the risk associated with a public sector investment of average risk.

A "riskless SOCC" ($SOCC_f$) can be derived from the general equation for SOCC. The parameter values that generate SOCC equal to 7.3 percent correspond to a $SOCC_f$ equal to 4.7 percent. From the social perspective, the risk premium for an investment of average risk is SOCC minus $SOCC_f$ or 2.6 percent.[2]

Private sector financial asset pricing, represented by the Capital Asset Pricing Model, involves comparable concepts of average risky return, riskless return and a risk premium, the three market-based asset pricing parameters. The capital market puts a "price" on risk in the form of extra points of return required to compensate investors for the risk they bear.

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1. Brean et al (2005). Our current estimate of the social opportunity cost of capital in Canada is based on the methodology applied by Jenkins, G. (1977) which in turn drew substantially from Harberger (1973).

2. Following Bailey and Jensen (1972) for determining the risk-free social opportunity cost of capital, $SOCC_f = r_f\ ((1-t_p)\partial S/\partial B - (1/1-t_c))\partial I/\partial B + \partial F/\partial B\}$ where $r_f$ is the risk free real interest rate, $t_p$ is the personal tax rate, $t_c$ is the corporate tax rate and $\partial S/\partial B$, $\partial I/\partial B$ and $\partial F/\partial B$ are the partial effects of increased government borrowing on domestic savings, private investment and net foreign funding respectively. In Canada, a risk free social opportunity cost rate of 4.7 percent equates to a risk-free real interest rate of 3.85 percent. A standard measure of the risk free interest rate is the yield on real return bonds which over 1990-2004 has varied from a low of 2.4 percent to a high of 4.9 percent.

Risk for private sector securities is measured by the variance of asset-specific returns. However, when less-than-perfectly-correlated risky assets are held in a portfolio, the overall risk of the diversified portfolio equates to something less than the simple sum of the variances of the individual securities. The contribution of each individual asset to the risk of the portfolio is mitigated by its covariance with the other assets. The risk of individual securities that *cannot* be diversified away is referred to as "systematic" risk since it relates directly to the variance-generating process of the market as a whole, the "system". In the modern theory of financial asset pricing, only systematic risk is rewarded with additional points of return above the riskless return.

The return that private investors require for average risk and the return they earn on the riskless asset combine to generate a required average risky return that, with low inflationary expectations, is remarkably similar to our estimate of the SOCC. With the current return on the riskless financial asset (Government of Canada 10+ year bonds) of 4.7 percent and an equity risk premium of 4.5 percent, the required return on an equity-financed capital expenditure of average risk is 9.2 percent. The use of corporate debt for a typical 40 percent of the finance of a capital expenditure results in a weighted average corporate cost of capital (WACC) that is similar to the real return of 7.3 percent proposed for the SOCC.

Although the SOCC framework and the CAPM represent different processes and generate their results in fundamentally different ways, the CAPM sheds light on the nature of empirical problems that arise in developing risk measures that can be applied in estimating an array of discount rates for risky public sector investments.

In the CAPM, the asset-specific (or risk-class) index of systematic risk is typically a regression coefficient in the regression of time-series data for …

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_i [r_{m,t} - r_{f,t}] + e_{i,t}$$

where $r_{i,t}$ = return on asset "i" in period t

$r_{f,t}$ = return on the risk-free asset (e.g., a Treasury Bill)

$r_{m,t}$ = return on the market index (e.g., the TSX/S&P)

$e_{i,t}$ = an error term; $E[e_{i,t}, e_{i,t-1}] = 0$

To compute the measure of systematic risk of asset "i":

$$\beta_i = [\sigma_i / \sigma_m] \rho_{i,m}$$

where $\sigma_i$ = standard deviation of the return on asset "i"

$\sigma_m$ = standard deviation of the return on the market index

$\rho_{i,m}$ = correlation coefficient between the return on asset "i" and the return on the market index

The average value of $\beta_i$ is one which corresponds to the average amount of risk in the "system", i.e., the risk associated with the market portfolio. A value of $\beta_i$ greater (less) than one corresponds to asset-specific risk that is proportionately greater (or less) than the risk of the market.

From a social perspective, one can similarly assume that risks are spread over a large number of individuals and hence the appropriate focus is on that component of risk that cannot be diversified away. As with the analysis of the risk of financial assets, the practical empirical issue for risky public sector investments is to devise a measure that reflects varying degrees of undiversifiable risk associated with specific assets in which the public has an ownership interest. That is the focus of this paper.

## Socially Relevant Risk and its Empirical Representation

### *An Illustrative Approach*

An empirical measure of risk of public sector investment must satisfy two fundamental conditions:

1. It must reflect risk from a *social* perspective.
2. The measure of risk must be comparable across different categories of investment.

A public sector investment that bears average risk calls for an average risk premium applied to the social opportunity cost of the capital used in the project. On the other hand, a riskless public sector investment requires no premium for risk. In that case the riskless social opportunity cost of capital is the relevant discount rate.

Inasmuch as average risk and zero risk represent relevant benchmarks, what defines "average"? Or "riskless"? A useful reference is GDP, the most fundamental measure of economic performance. The variance of GDP is a basic measure of economic risk. The variance of GDP is axiomatically the *average* risk in the economy. Relevant measures of risk of specific public sector investments must be tied to the variance of GDP.

Specific public sector assets yield a social return based on their economic use. Roads, harbours or airports, for example, provide economically important services. The risk of investment in such assets, from a public perspective, is that the road, the harbour or the airport may fail to generate a socially justifiable level of use. The uncertainty of whether a specific asset will be fully used through its life is reflected in the volatility of use of that category of asset.

The empirical focus of risk is thus on the relation between the use of a specific asset and real overall economic activity. An estimate of the correlation of asset use to fluctuations in economic activity provides a measure of risk that satisfies the two criteria identified above.

There are various ways to measure the correlation between public-sector asset use and total economic activity. The basic issues, however, can be illustrated by a simple regression of the form:

$$Lx_t = \beta_0 + \beta_1 Ly_t + u_t$$

$Lx_t$ is the logarithm of the measure of use of the public-sector asset. $Ly_t$ is the logarithm of real GDP. $u_t$ is the error term.

$\beta_1$ measures the impact of a change in $Ly_t$ on $Lx_t$ and may be interpreted as the sensitivity of asset-use to variations in the total economic activity. In practical terms, the results suggest that if:

$\beta_1 = 1$ ➔ percentage change in $y_t$ = percentage change in GDP

$\beta_1 > 1$ ➔ percentage change in $y_t$ > percentage change in GDP

$\beta_1 < 1$ ➔ percentage change in $y_t$ < percentage change in GDP

As an empirical measure of risk, $\beta_1$ has number of desirable features. First, it is consistent through time and across assets. Second, it captures the social risk of assets regardless of whether ownership is public or private/commercial. Third, the measure is in the form of an index that readily indicates whether a specific asset has high, average or low risk. Finally, and perhaps most important, the index of risk is directly applicable to known parameters – the SOCC and $SOCC_f$ – that enable computation of asset-specific, risk-adjusted social opportunity costs of capital. The index is amenable to estimation with readily available data.

Useful reference values of $\beta_1$ are 0 and 1. An estimate of $\beta_1$ equal to zero indicates the absence of a statistical relation between the use of the specific asset - whose activity is measured by $x_t$ - and real GDP. A potential explanation for $\beta_1$ equal to zero is that asset use ($x_t$) is stable in the face of varying real GDP. On the other hand, asset-use ($x_t$ ) and real GDP may both vary but may do so independently with a resulting zero estimate for $\beta_1$. Regardless, in terms of social risk in asset-use, $\beta_1$ equal to zero indicates a riskless investment.

An estimate of $\beta_1$ equal to one indicates a statistical relation between the use of the specific asset and real GDP. When $\beta_1$ equals one, a given percentage change in GDP corresponds to a similar percentage change in $x_t$ . If $\beta_1$ is greater than one, a given percentage change in real GDP, say quarter-to-quarter, is associated with an even greater percentage change in $x_t$. In other words, the ups and downs of activity $x_t$ exceed the ups and downs of real GDP, where the latter is the reference for average risk.

While this representation of the risk of public sector investments has obvious similarity to the Capital Asset Pricing Model, there are important differences between social and private perspectives on risk.

The CAPM is concerned with private after-tax returns to equity capital. The CAPM is built on the reasonable assumptions – for market-traded financial assets – that the securities markets are informationally efficient, liquid and readily accessible to a large number of informed investors. The CAPM risk measure is a company-specific "$\beta_i$" obtained by regressing a time-series of returns on company i equity against the contemporaneous returns on a diversified market portfolio of equities. $\beta_i$ captures risk as undiversifiable covariance between an individual stock's return and the market. The return on the market portfolio, of course, is an ever-present opportunity for a private-sector investor in risky assets. Similar to our depiction of social risk, a CAPM $\beta$ equal to one indicates "average" private-sector risk. CAPM $\beta_i$ greater (less) than one indicates more (or less) than average market risk.

In measuring the risk of public sector investment, the focus is on the risk that the investment may provide an unstable flow of services. The risk is not inherently financial. Instead, the socially-relevant concern is for the likelihood that public sector resources are committed to a project that may turn out to have been wasted.

In the CAPM the index of the "system", and hence the defining basis of systematic risk, is a broad equity market portfolio such as the S&P/TSX or the S&P 500. In the social risk framework, the index is real GDP, a macroeconomic accounting measure. The CAPM is a model of equilibrium prices of financial assets traded continuously in highly liquid markets. In the SOCC framework, risk-adjusted discount rates are not market determined equilibrium values, except for the anchoring points of the risk-free SOCC and the SOCC with average risk

Issues in Measuring Social Risk

A number of issues must be addressed in calculating risk-adjusted discount rates. First, we must identify the appropriate measure of asset-specific use, $x_{t,}$, in the model. Second, the most appropriate way to estimate $\beta_1$ must be determined. Third, the process for translating the calculated risk measure into a risk-adjusted discount rate must be determined.

These issues are examined below. The next section looks at the third issue involving the computation of risk–adjusted discount rates from the beta estimated in the modeling exercise. Following this, we examine the issues involved in implementing a methodology to derive empirically sound measures of the systematic risk for different transport assets.

Computing Risk-adjusted Discount Rates

With estimated activity-based measures of asset-use defined relative to average risk, the measure can be incorporated into the social opportunity cost of capital framework as follows:[3]

$$r_i = SOCC_f + \beta_1 (SOCC - SOCC_f)$$

$r_i$ is the risk-adjusted discount rate. SOCC is the average-risk-inclusive social opportunity cost of capital. $SOCC_f$ is the risk-free social opportunity cost of capital.

The activity-based index of risk is the regression coefficient $\beta_1$ obtained in a model estimating the relation between asset-use and fluctuations in real GDP. The value of $\beta_1$

3. The relation of the social risk premium to the market risk premium is described in Bailey and Jensen (1972). Under the formula they outline, the social risk premium is proportional to the market risk premium, with the proportionality factor being a weighted average of the net of tax risk premium for savings, the pre-tax risk premium for each category of investment and the marginal social cost of incremental risk bearing supplied by foreigners.

for an asset with average risk is one. The value of $\beta_1$ for a riskless asset is zero. An estimate of $\beta_1$ used as a risk-adjustment index must be checked for statistical significance against both zero and one. A non-zero, non-one point estimate should be used to compute a risk-adjusted discount rate only if the point estimate is statistically significantly different from both zero and one. If the estimate of $\beta_1$ is statistically different from zero but not from one, one should be used. If the estimate of $\beta_1$ is statistically different from one but not from zero, zero should be used.

Our estimate of the "average" social opportunity cost of capital is 7.3 percent. The corresponding risk-free social opportunity cost of capital is 4.7 percent. Considering a range of $\beta_1$ from 0 to 2, the risk-adjusted social opportunity cost of capital at each level of $\beta_1$ is given below:

Table 1

The Risk Adjustment Index and Corresponding Asset-specific Social Discount Rates

| $\beta_1$ | *Asset-Specific SOCC* |
|---|---|
| 0.00 | 4.70 |
| 0.10 | 4.96 |
| 0.20 | 5.22 |
| 0.30 | 5.48 |
| 0.40 | 5.74 |
| 0.50 | 6.00 |
| 0.60 | 6.26 |
| 0.70 | 6.52 |
| 0.80 | 6.78 |
| 0.90 | 7.04 |
| 1.00 | 7.30 |
| 1.10 | 7.56 |
| 1.20 | 7.82 |
| 1.30 | 8.08 |
| 1.40 | 8.34 |
| 1.50 | 8.60 |
| 1.60 | 8.86 |
| 1.70 | 9.12 |
| 1.80 | 9.38 |
| 1.90 | 9.64 |
| 2.00 | 9.90 |

Table 1 sets out a mapping system that can be directly applied where an appropriate degree of confidence emerges from risk measurement calculations. Unfortunately such confidence is often unwarranted. A more general approach is to divide assets into categories of low, medium and high risk and apply an SOCC appropriate to each category. When questions concerning the specifics of the risk adjustment calculations arise, analysts may be comfortable identifying whether an activity is high, low or medium risk. Based on how the risk-adjusted SOCC relates to the calculated beta, reasonable SOCC for different categories of transport assets are presented in Table 2.

Table 2

SOCC by Risk Category

| ***Risk*** | ***Risk Adjusted SOCC*** |
|---|---|
| Low | 6.0 percent |
| Average | 7.3 percent |
| High | 8.6 percent |

The remainder of the paper illustrates the application of use-based measures of risk in determining risk-adjusted discount rates for investments in the Canadian transport sector.

## Implementation Issues in Measuring Asset-Specific Risk

### *The Use Measure*

In implementing a risk adjustment methodology, careful consideration must be given to the activity indicator, $x_t$ , used in empirical analysis. Risk derives from the uncertainty of use. The risk of the social return from a specific investment is measured by the covariance of the *use* of the asset and the socially-relevant measure of income, real GDP. For example, the socially relevant risk of a public-sector investment in an airport is measured by the covariance of the use of the airport and real GDP. The focus then turns to the socially-relevant and observable measure of use.

A number of proposed activity indicators are described in Table 3. Quarterly or monthly data are needed to estimate the risk coefficients. This limits the choice of activity indicators. The proposed indicators are based mainly on data that are (or should be) available monthly or quarterly, although, in some instances, numbers are published in raw form and need to be seasonally adjusted. For a number of assets, the most appropriate indicator is the corresponding industry quarterly, seasonally adjusted real output measure published by Statistics Canada. In some cases, such as rail transport, where the Statistics Canada numbers are not sufficiently disaggregated, the proposed output measures are similar to the component indices (i.e. for passenger and freight) that comprise the published Statistics Canada published measure.

In a few cases, additional analysis is required to construct the appropriate output measure. For private trucking, information on the importance of own-activity trucking in different industries is needed to develop the base year weights for the proposed output measure. This information is available, but it would require a special analysis of the information contained within Statistics Canada's input-output database. In the case of roads, an index depicting the imputed real value of toll revenue would serve as a reasonable output measure. The required quarterly output index could be constructed using information on the tolls charged by a commercial operator, published monthly data on vehicle fuel sales and available data on vehicle fuel use.[4]

With the exception of airports, our activity indicators are industry-based. In some cases, it may be useful to examine the risk profile of sub-components of an industry although in such cases data are difficult to assemble.

4. Tolls are potentially an indicator of the services roads provide to different types of transport vehicles – cars, small trucks, trucks with heavy axle weight. Their role would be to provide weights for distinguishing kilometers of road use by different types or classes of vehicles.

Table 3

## ACTIVITY INDICATORS FOR RISK ANALYSIS

| ***Asset*** | ***Proposed Indicator*** |
|---|---|
| *Aircraft* | Real, quarterly, seasonally adjusted GDP for air transportation industry (# 481). |
| *Major airports, NAV Canada* (Toronto, Vancouver, Montreal, Calgary, Edmonton. Ottawa, Winnipeg, Victoria) | Quarterly, seasonally adjusted landings and takeoffs, weighted by base year major airport average landing and takeoff fees. |
| *Other airports* | Quarterly, seasonally adjusted landings and takeoffs, weighted by base year "other airport" average landing and takeoff fees. |
| *Freight rail- vehicles and track* | Quarterly, seasonally adjusted tonne kms for major commodities weighted by base year revenue per tonne km of each commodity. |
| *Passenger rail assets* | Quarterly, seasonally adjusted passenger kms for short, medium and long-haul trips multiplied by a base year average revenue per passenger km. for each trip category. |
| *Domestic shipping fleet* | Real, quarterly, seasonally adjusted GDP for water transport (# 483) is reasonable (although, ideally, ferries, which are part of industry 483, would be separated out). |
| *Inland ports* | Quarterly, seasonally adjusted domestic cargo by major commodity in tonnes multiplied by base year port revenue per cargo tonne for each commodity group. |
| *Major international ports* | Quarterly, seasonally adjusted international cargo in tonnes by major commodity multiplied by base year average port revenue per cargo tonne handled for each commodity group. |
| *For-hire trucks* | Real, quarterly, seasonally adjusted GDP for truck transportation (# 484). |
| *Private trucking fleet* | Quarterly, seasonally adjusted data on constant dollar shipments of industries that are major users of private trucking weighted by base year data on private trucking costs of each industry. Base year data on importance of private trucking by industry should be available from input-output statistics |

| | |
|---|---|
| *Passenger vehicles* | Quarterly, seasonally adjusted passenger vehicle kms.<br><br>Data on vehicle kms are available from the Canada Vehicle Survey but cover a short period and are not seasonally adjusted.<br><br>Data on monthly gasoline sales can be translated into a measure of passenger vehicle km. using annual data on the percentage of gasoline consumed by passenger vehicles, passenger fleet composition and average litres/100 km. by vehicle type (The annual data can be calculated from data made available for 1990 – 2002 on the NRCan Office of Energy Efficiency website). Gasoline sales data need initially to be turned into a seasonally adjusted quarterly time series. |
| *Roads, bridges* | Quarterly, seasonally adjusted data on imputed passenger and freight vehicle toll revenues. Passenger vehicles kms can be calculated as above. Using a similar procedure and available data on gasoline and diesel fuel sales, freight vehicle kms. can be calculated and translated into a seasonally adjusted, quarterly time series. A combined indicator of passenger and freight road usage can be calculated by weighting each series by a representative measure of the base year tolls charged by commercial operators. |
| *Urban transit assets* | Real, quarterly, seasonally adjusted GDP for urban transit systems (# 4851). |
| *Interurban and rural buses* | Real, quarterly, seasonally adjusted GDP for interurban and rural bus transportation (# 4852). |
| *Courier and messenger vehicles* | Real, quarterly, seasonally adjusted GDP for courier & messenger services (# 492) |

Model Specification

The illustrative model in Section 2 represents one way to test the sensitivity of transport activities to fluctuations in economic activity. In this section, we examine two alternative specifications.

Since we are interested in measuring the sensitivity of transport activities to fluctuations in economic activity, it is reasonable to consider a model based on growth rates. Growth rates measure short-run variations in the relevant variables and therefore represent fluctuations in activity.

The second specification is given by:

$$\Delta x_t = \beta_0 + \beta_1 \Delta y_t + u_t$$

where $x_t$ again represents the activity measure and $y_t$ is real GDP. However, both variables are now expressed in first-differences. The variables may be interpreted as growth rates since the variables are expressed in logarithmic form. The model provides a measure of $\beta_1$ that can be used to compute risk-adjusted SOCC rates similar to the approach outlined in Section 3.

The third model is represented by the following specification:

$$Lx_t = \beta_0 + \beta_1 (Ly_t - Ly_t^*) + u_t$$

where $Lx_t$ and $Ly_t$ are defined as in first model and $u_t$ is the error term. $Ly_t^*$ is the potential or maximum value of $Ly_t$., representing the long-run value of $Ly_t$. In other words, the focus of risk is represented by fluctuations of $Ly_t$ with respect to its long-run value. This empirical specification isolates the cyclical component of GDP, which is of particular interest since the intention of the exercise is to measure the sensitivity of transport activities to the business cycle. The variable $Ly_t^*$ is calculated using the filter proposed by

Hodrick and Prescott (1997), a technique widely used in macroeconomics and macro-econometrics.[5]

Alternative specifications can be evaluated partly on the basis of the standard tests that are used to assess the adequacy and performance of regressions. In addition, a judgment is required as to how well particular specifications address the specific question that is being examined.

The three specifications are applied to transport data (which we describe in the next section) and evaluated using standard statistical tests. One obvious measure of the quality of the regression is the $R^2$, which measures the explanatory power of the independent variables. In addition, the performance of the residuals of each regression was examined in order to check for the presence of autocorrelation. Another issue that was evaluated was the normality of the estimated residuals of each regression. The empirical results for the third specification are presented in Table 4.

Overall, the first model and third model perform better than the second. The first and third specifications rate higher on standard statistical tests and yield results that are more robust and credible. The specifications were tested using regressions that involve not only different transport variables but also alternative independent variables – with total GDP being replaced by sectoral-GDP for business goods, business services and non-business goods and services sectors. In regressions using the first and third specification, the signs of the estimated coefficients are generally correct and the estimates seem reasonable.

As noted above, models should be judged not only by their statistical qualities but also in terms of their explanatory power, given the particular issue in question. On this latter basis, there is reason to prefer the third specification. Since the objective of the exercise is to measure the sensitivity of transport activities to fluctuations in economic activity, it

5. This technique for separating a time series into its cyclical and trend components is often employed in OECD business cycle studies. See, for example, Chapter 5 ("Ongoing Changes in the Business Cycle") of OECD Economic Outlook No. 71, June 2002.

is desirable to have a model in which the independent variable has been adjusted to remove the trend component of the real GDP time series. Using the third specification and data that has been properly adjusted for seasonal and other structural changes, it is possible to focus on the correlation between transport activities and cyclical changes in economic activity.

Illustrative Calculations of Risk-adjusted Discount Rates

In this section, we apply the proposed methodology involving the preferred model specification to develop illustrative calculations of risk-adjusted social opportunity costs of capital for a range of investments in assets in the Canadian transportation sector. These initial calculations are based on readily available monthly and quarterly transport data. With improvement in asset-use data, the estimates are likely to improve in accuracy and reliability,

For six of the ten transport activities examined, the data are the seasonally adjusted constant dollar industry output data published by Statistics Canada. For five of six industries (air, interurban & rural bus, urban transit, for-hire trucking and water transport) this is consistent with the recommendations in Table 3. Published industry output measures were also used for rail. Although the Statistics Canada real output measure includes both freight and passenger rail, the domination of the freight segment suggests that the freight numbers best reflect rail activity. While current industry GDP series could be used for for-hire trucking, for the other five industries a time series of the desired length is only available from a discontinued GDP series that ends in mid-2001.

For the remaining four transport sectors (airports, ocean shipping, passenger rail and passenger vehicles) the dependent asset-use variable is based on available measures of output volume – itinerant movements, tonnes, kilometres, revenue tonne kilometres. In the case of passenger vehicles, we develop the activity indicator identified in Table 4. Generally, however, these one-dimensional measures are inferior to multidimensional measures of industry output such as industry-GDP.[6] They will provide a misleading indicator of trends in industries that consist of a range of different activities that are changing in different ways. Changes in the main outputs of the air, passenger rail and ocean shipping industries are likely correlated, so that the proposed volume measures reasonably represent industry activity. It would be wise to confirm this in subsequent research through the development of more sophisticated industry output measures.

Table 4

**Transport Measure Used in Estimations**

| *Transport Variable* | *Measurement Unit* | *Measurement Period* |
|---|---|---|
| Air transport | Millions of $1992 | 1981:1 – 2001:2 |
| Interurban & rural trans. | Millions of $1992 | 1981:1 – 2001:2 |
| Railway | Millions of $1992 | 1981:1 – 2001:2 |
| Urban transit systems | Millions of $1992 | 1981:1 – 2001:2 |
| Water transport | Millions of $1992 | 1981:1 – 2001:2 |
| For-hire Trucking | Millions of $1997 | 1981:1 – 2004:4 |
| Airports | Itinerant Movements | 1995:4 – 2004:4 |
| Ocean shipping | Millions of tonnes | 1990:1 – 1999:4 |
| Passenger rail | Millions of rev. pass. kms. | 1981:1 – 1995:4 |
| Passenger road/auto | Millions of kms. | 1993:1 – 2003:4 |

### *Data Adjustments*

To isolate the impact of cyclical fluctuations in economic activity, it is preferable to adjust for other factors influencing transport activity, including seasonal and structural changes as well as growth trends. Since these latter factors are not part of the systematic risk associated with transport investment, they should not be incorporated in the

6. As discussed above, constant dollar industry GDP data are typically derived by aggregating an industry's sub-outputs using base year prices or value added as weights.

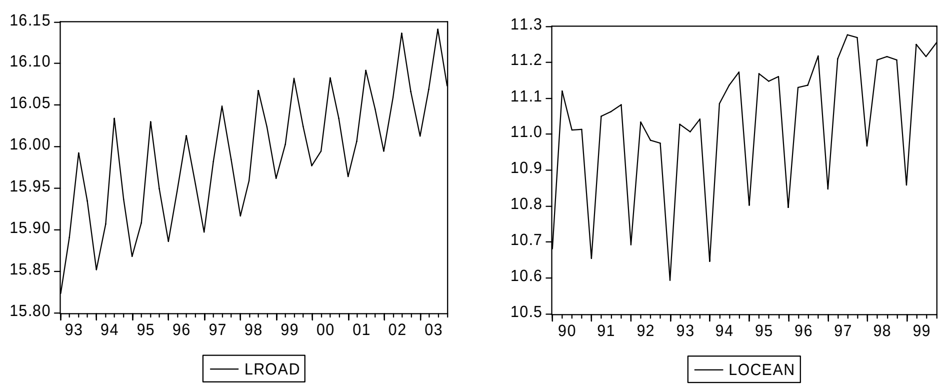
measurement of the beta. The model being applied will "filter out" the influence of growth trends, but additional adjustments may be needed to take account of the presence of seasonal and structural factors.

Since the industry GDP data derived from Statistics Canada are seasonally adjusted, attention to seasonal factors is needed only for those transport activities measured using volume indicators. Figure 1 below illustrates the importance of seasonal factors for two such activities, passenger road and ocean transport. For all unadjusted data, seasonal components were captured in the regressions using centered dummy variables.

Figure 1

**PASSENGER ROAD AND OCEAN SHIPPING ACTIVITY**

*(Data in Logarithms)*



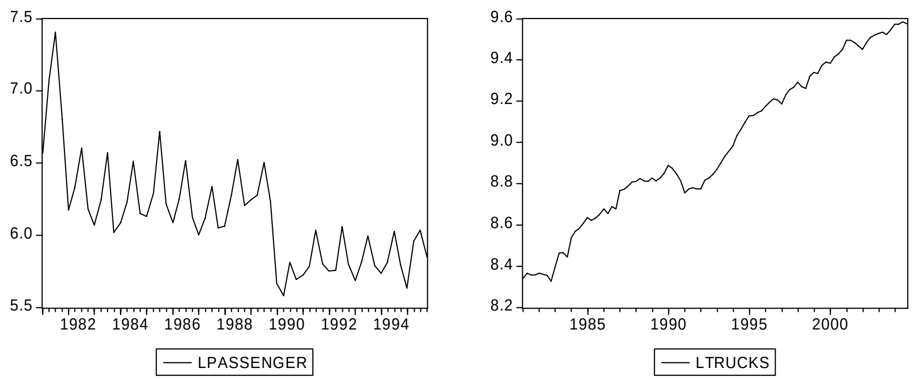

A number of transport industries have experienced significant structural changes over the period being examined. Sudden increases or decreases in activity have resulted from policy changes or other developments unrelated to the business cycle. The significant structural changes experienced by the passenger rail and for-hire trucking sectors can be seen in Figure 2.

Structural changes were captured using dummy variables. Dummies were applied to adjust for outliers among the individual quarterly data and for periods characterized by structural change. Adjustments were applied to the trucking data for 1984:1, 1987:1 and the period 1990:1 to 2004:4; the urban transit data for 2001:2; the passenger rail data for 1990:1 to 1995:4; and the air transport data for 2003:2 and 2003:3.[7]

Figure 2

**PASSENGER RAIL AND FOR-HIRE TRUCKING ACTIVITY**

*(Data in Logarithms)*




***Results***

Table 5 presents the results of activity-based risk estimates for a number of transport industries using the preferred model: $Lx_t = \beta_0 + \beta_1(Ly_t - Ly_t^*) + u_t$. The last four columns present standard statistical tests relating to "goodness of fit" and the performance of residuals. A p-value greater than 5.0 percent indicates that it is reasonable not to reject the corresponding null hypothesis. The regressions perform well, as indicated by their relatively high explanatory power and p-values for the three residual tests.

7. Dummy variables to capture structural change over time intervals generally affect the intercept of the regression. In some cases, such as passenger rail, where the dummy variable was related to the explanatory variable, the purpose is to control for changes in the regression slope.

The second column provides the coefficient measuring the sensitivity of the transport activity to fluctuations in overall economic activity. The p-values corresponding to the null hypotheses that the true coefficient is equal to zero and unity are shown in the following two columns. A p-value less than or equal to 10 percent calls for rejection of the corresponding null hypothesis.

Table 5

**ESTIMATION RESULTS**

| ***Type of transportation*** | ***Estimated β*** | ***p-value (t-stat β=0)*** | ***p-value (t-stat β=1)*** | $\bar{R}^2$ | ***AR (1-4) (p-value)*** | ***JB (p-value)*** | ***ARCH (1) (p-value)*** |
|---|---|---|---|---|---|---|---|
| *Air transport* | 3.137 | 0.000 | 0.003 | 0.887 | 2.460 (0.054) | 4.831 (0.089) | 3.534 (0.064) |
| *Interurban/ rural bus* | 3.255 | 0.000 | 0.008 | 0.992 | 2.194 (0.078) | 0.393 (0.822) | 1.999 (0.161) |
| *Railway* | 2.595 | 0.000 | 0.015 | 0.962 | 2.220 (0.075) | 0.152 (0.927) | 0.609 (0.437) |
| *Urban transit systems* | 1.215 | 0.023 | 0.682 | 0.972 | 1.201 (0.318) | 5.260 (0.072) | 2.796 (0.099) |
| *Water Transport* | 1.587 | 0.050 | 0.465 | 0.769 | 0.601 (0.663) | 3.989 (0.136) | 0.293 (0.590) |
| *Airports* | 0.453 | 0.706 | 0.648 | 0.958 | 0.213 (0.929) | 0.546 (0.761) | 1.256 (0.270) |
| *Ocean shipping* | 2.709 | 0.064 | 0.235 | 0.954 | 0.652 (0.630) | 0.069 (0.966) | 0.033 (0.856) |
| *Passenger rail* | -0.615 | 0.512 | 0.090 | 0.938 | 0.673 (0.615) | 0.133 (0.935) | 0.964 (0.330) |
| *Trucking* | 2.089 | 0.000 | 0.000 | 0.997 | 0.420 (0.793) | 0.559 (0.756) | 3.023 (0.085) |
| *Passenger vehicles* | 0.167 | 0.430 | 0.000 | 0.965 | 1.165 (0.344) | 1.702 (0.427) | 0.670 (0.417) |

In the case of urban transit, water transport and ocean shipping, the coefficients are statistically different from 0 but not from 1. This suggests that these activities fluctuate in pace with overall economic activity and that the corresponding assets – urban transit vehicles, Canadian ships, ocean ports – have an average degree of risk. The estimated coefficients for air transport, interurban & rural bus, rail transport and for-hire trucking are well above one. For these industries, p-values are statistically different from both 0 and 1 and the results point to a relatively high degree of systematic risk. At the other extreme are passenger rail and passenger road (and vehicle), where the estimated coefficients are not significantly different from zero. For airports, neither of the alternative null hypotheses could be rejected and it was not possible to derive a reasonable estimate for the coefficient. One might expect that the risk level for airports would approximate that for the air transport sector, but it is not possible to statistically confirm this without a larger airport data sample.

Results for rail and trucking accord with the *a priori* view that systematic risk tends to be relatively high for transport sectors involved in goods movement. Similarly, the results for passenger rail and autos are consistent with the view that these modes are much less sensitive to fluctuations in economic activity. Ocean shipping activity depends on economic conditions not only in Canada but also in offshore export markets, so it is reasonable to expect this sector to be less affected by the business cycle than rail and trucking. The relatively high risk for airline transport is also reasonable since business and leisure travelers, while unlikely to significantly alter their auto use in response to changing economic circumstances, can be expected to adjust the amount of their air travel.

In Table 6, the results are assigned to broad categories of risk-adjusted SOCC measures. Risk-adjusted SOCC should be 8.6 percent for transport assets in the four higher-risk sectors (air, freight rail, for-hire trucking, and interurban & rural bus), 7.3 percent for assets employed in the three sectors with average risk (urban transit, water transport and ocean shipping), and 4.7 percent for assets associated with the two activities having below average systematic risk (passenger rail transport and automobile travel).

Table 6

**RISK-ADJUSTED SOCCs FOR TRANSPORT ACTIVITIES**

| ***Industry*** | ***Assets*** | ***Estimated β*** | ***Risk Level*** | ***Risk-Adjusted SOCC ( percent)*** |
|---|---|---|---|---|
| *Air transport* | Aircraft | 3.137 | High | 8.6 |
| *Interurban/ rural bus* | Buses | 3.255 | High | 8.6 |
| *Railway* | Freight cars, track | 2.595 | High | 8.6 |
| *Urban transit systems* | Buses, subways | 1.215 | Average | 7.3 |
| *Water Transport* | Ships, Inland ports | 1.587 | Average | 7.3 |
| *Airports* | Terminals, runways | 0.453 | n.a | n.a |
| *Ocean shipping* | Ocean ports | 2.709 | Average | 7.3 |
| *Passenger rail* | Passenger rail cars | -0.615 | Low | 4.7 |
| *Trucking* | For-hire trucks | 2.089 | High | 8.6 |
| *Passenger vehicles* | Autos, SUVs | 0.167 | Low | 4.7 |

## Conclusion

This paper developed and illustrated a methodology for measuring the socially relevant risk of investments in Canadian transportation assets. Like the CAPM used in financial analysis, the methodology is directed at measuring systematic risk. The focus in the current exercise, however, is on social risk, which is quite different from the private sector financial risk that motivates the application of the CAPM. The proposed risk measure for transport assets is a sector-specific activity-based index that focuses on the covariance of asset usage and real GDP. The index of risk is economically relevant, comparable across assets and independent of (public or private) ownership.

While different models can be adopted to measure risk, the preferred approach involves a filtering process to distinguish the cyclical from the trend components of GDP. This model is well suited to measuring the sensitivity of transport activities to fluctuations in overall economic activity. Where necessary, adjustments should also be incorporated in the model for seasonal and other structural influences on transport activity. The model was applied using quarterly data that measure changes over time in the real output of a number of major transport industries. While the preference was for composite output indicators that take account of the sub-activities within different sectors, for lack of anything better, single-dimensional volume-based indicators were used as the dependent variable in some regressions.

The model generates reasonable results that can be useful for classifying transport assets into risk categories with corresponding risk-adjusted social discount rates. The methodology for transforming risk coefficients derived from the model calculations into a measure of risk-adjusted social opportunity cost was initially suggested by Bailey and Jensen (1972). Based on the mapping system that results from applying this methodology, average social opportunity cost rates were developed for assets in “high”, “low” and “average” risk categories.

The empirical illustrations indicate substantial variation in risk and the social opportunity cost of capital for investments in Canada's transportation sector. The illustrative calculations suggest that assets employed by the air, freight rail, for-hire trucking and interurban bus industry tend to have above average risk, while the assets involved in urban transit, water transport and ocean shipping have average risk. The private automobile and assets involved in passenger rail transport belong in the low risk category according to the results of these initial calculations.

Discount rates for public sector investment are based on estimates of the social opportunity cost of capital. In this paper, our estimate of the SDR provides the benchmark estimate of the capital cost adjusted for systematic risk associated with transport assets. The question of whether to apply risk adjustments to the discount rate has generated significant discussion in the literature. With public as with private investment, if asset returns are influenced by the business cycle and correlated with national income, systematic risk ought to be taken into account explicitly through adjustment of the discount rate. To not do so is misleading. Risk is factored into the investment decisions of private sector firms and, to promote competitive neutrality, the opportunity cost of capital for public assets ought to incorporate a comparable risk adjustment.

To derive an updated baseline measure of social opportunity cost, estimates were made of the costs and relative importance of the different activities likely to be displaced by transport investment. The returns that could have been earned if resources were instead directed to private sector investment were estimated using a "top down" productivity-based approach to calculate pre-tax returns on capital employed by the aggregate business sector. This methodology suggests that through the 1960s to the 1990s, returns to capital in the business sector have been remarkably stable, averaging just over 10 percent, or just over 11 percent when allowance is made for property tax payments. Residential investment, which accounts for about 20 percent of total investment, earned a somewhat lower return. When this is incorporated in the estimate, the average pre-tax return on private sector investment comes out to 10.3 percent. Alternative methodologies result in lower estimates, but the evidence suggests that real pre-tax returns on marginal investment are at least 8 percent or higher.

Public sector investment will displace consumption rather than private investment to the extent the interest rate increases resulting from this investment cause individuals to spend less and save more. The real after-tax return on incremental saving, which is a measure of the value individuals place on postponed consumption, is about 4 percent. Since the responsiveness of saving to higher interest rates tends to be quite low, displaced consumption has a much lower weight than displaced investment in calculations of the social opportunity costs of capital.

The other major source of funding for public sector investment is foreign borrowing. While Canada has access to well-integrated international capital markets, higher interest rates are needed to attract the additional foreign resources required to fund public sector investments. The responsiveness of foreign funding to interest rates was calculated using available evidence on "saving retention coefficients," which measure the impact of exogenous increases in national savings on investment. With information on savings retention coefficients and an understanding of the responsiveness of domestic saving and investment to interest rates, it is possible to indirectly come to an assessment of the relative importance of foreign funding as a source of the additional resources required for transport investment. Foreign borrowing costs less than displaced private sector investment and more than displaced private consumption; based on what foreign investors require to fund investment in Canada, the estimated real cost of this component of the social discount rate is 6 percent.

The SOCC was calculated for a range of saving retention coefficients and for real pre-tax private investment returns of between 8 percent and 10 percent. The resulting estimates of the SOCC range from 6.5 percent to 8.7 percent. Applying a reasonable mid-range savings retention coefficient and a 9 percent pre-tax return on investment, 50 percent of the resources required for additional transport investment come from displaced private investment, 10 percent from displaced private consumption, and 40 percent foreign sources. The implied value of the SOCC is 7.3 percent.

To develop risk adjustments that could be applied to the SOCC, an approach was adopted that is similar to private sector techniques of risk measurement based on the traditional capital asset pricing model. The purpose of this approach is to understand the relation between the use of a specific asset and real GDP. By regressing activity levels against GDP, it can be determined whether the relevant assets have a high or low degree of systematic risk and the SOCC should accordingly be adjusted upwards or downwards. There is a need to identify an appropriate output indicator (or indicators) for which suitable data is available, but the proposed methodology is economically relevant, independent of whether an asset is publicly or privately owned and relatively easily computed. Since the benchmark SOCC incorporates the average degree of risk in the economy, assets will have a SOCC above (below) the preferred rate of 7.3 percent only if they are subject to greater (lesser) than average risk. Given the margin of error that is necessarily associated with risk calculations, the appropriate focus is not on the specific risk estimate but the general finding on whether transport assets are being employed in an activity characterized by high, low or average systematic risk.

Illustrative calculations of systematic risk were made for a number of transport industries using quarterly seasonally adjusted real output data as the activity indicator. Systematic risks were estimated using a model that allows the cyclical component of GDP to be separated from the trend component. Estimates could then be made of the sensitivity of various transport activities to fluctuations in real output. Based on these calculations and the proposed system for categorizing assets, there are some high risk assets, such as freight rail and for-hire trucking, for which the proposed risk-adjusted SOCC should be 8.6 percent and some relatively low risk assets, such as the automobile, for which the adjusted SOCC should be 6.0 percent. The general implications of this analysis is that there are substantial differences in risk among transport assets that should be taken into account and the proposed methodology provides a reasonable means for adjusting the proposed updated measure of SOCC to derive risk adjusted rates that are appropriate for application in a full cost accounting system.

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