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Methodology and Assumptions
for the Financial and Economic
Analysis of the MSAT Program

Econanalysis
Incorporated

Methodology and Assumptions for the Financial and Economic Analysis of the MSAT Program

Report Number 8

of

The Overall Socio-Economic Impact Study

prepared by

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Methodology and Assumptions for the
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This is the eighth milestone report of the "Overall Socio-Economic Impact Study of the MSAT Program." This report indicates how we propose to implement the basic methodology outlined in Report Number 3 entitled "Outline of the Proposed Methodology for the Socio-Economic Impact of MSAT" by means of the computer-based framework that is described in Report Number 4 entitled "Outline of the Proposed Data Base Sytem and Economic Model for the Estimation of the Socio-Economic Impacts of MSAT."

Econanalysis' Report Number 6, "The Socio-Economic Impact Model: Results for a Trial Case Study of the MSAT Program" demonstrated the types of output provided by the computer software, the numerical aspects of the cost/benefit methodology employed, and the kinds of assumptions necessary for such an analysis. However, the Trial Case Study used hypothetical financial and economic data to illustrate the Model. The primary purpose of the eighth report is to indicate specific values and/or procedures for estimating the economic parameters discussed in previous reports.

The proposed study methodology requires a set of annual financial cash flows and their corresponding annual economic costs and benefits for each participant of the MSAT project. These streams of cash flows and economic costs and benefits are discounted at risk adjusted private and social discount rates, respectively, in order to determine:

(a) project attractiveness from a financial perspective;
(b) project attractiveness from an economic perspective;
(c) the amount of government financial assistance (if any)

warranted for the MSAT project.

Section 1 of this report provides a brief overview of the study methodology and the software developed by Econanalysis to perform all required calculations. This is followed by a detailed discussion of the private discount rates, social discount rate, and their associated risk adjustments, which will be used as the benchmarks with which to judge the financial and economic attractiveness of the MSAT project.

Sections 2 - 6 provide detailed explanations of the various economic adjustments and externalities and the economic parameters used to estimate them. The economic adjustments and externalities are added to the annual cash flows to generate annual economic costs and benefits. The externalities discussed are as follows:

(a) foreign exchange, tariff and sales tax externalities (Section 2)

(b) labour externality (Section 3)

(c) user benefits (Section 4)

(d) indirect social benefits (Section 5)

(e) foreign financing externality (Section 6)

Finally, Section 7 outlines the methodology that will be used to determine the amount of government financial assistance (if any) that is both warranted and needed by the MSAT project. This section also contains a detailed discussion of how two types of financial assistance, loan guarantees and rate of return guarantees, can be valued.

Section 1 of Report Number 8

1.0 Discount Rates and the Financial and Economic Analysis of the MSAT Program

1.1 Introduction

1.1.1 Overview of the Study Methodology

The purpose of this section is to review the integrated analytical framework within which the financial and economic assessments of MSAT are performed. The framework is based on an economic cost/benefit analysis methodology that was developed for Canadian applications by Professors Glenn Jenkins and John Evans in conjunction with a number of consultants and departments in the Government of Canada.[1] The overall framework and the steps required to assess the MSAT project are summarized in Figure 1.1.

The overall socio-economic assessment of the MSAT project relies on a number of other studies for detailed marketing, engineering and financial data. The first task was to check the methodology, data and assumptions used by the other contractors to ensure not only their consistency but also their conformity to the overall socio-economic appraisal methodology. A preliminary review of the other contractors' studies was contained in our Report Number 2 entitled: "Review of Other Contractors' Reports, Related Memoranda, Potential Problems and Study Gaps of the MSAT Project." This report identified a number of inconsistencies between the various studies that have by and large been resolved. Thus, we hope to have soon a useable set of marketing, engineering, and financial data that is

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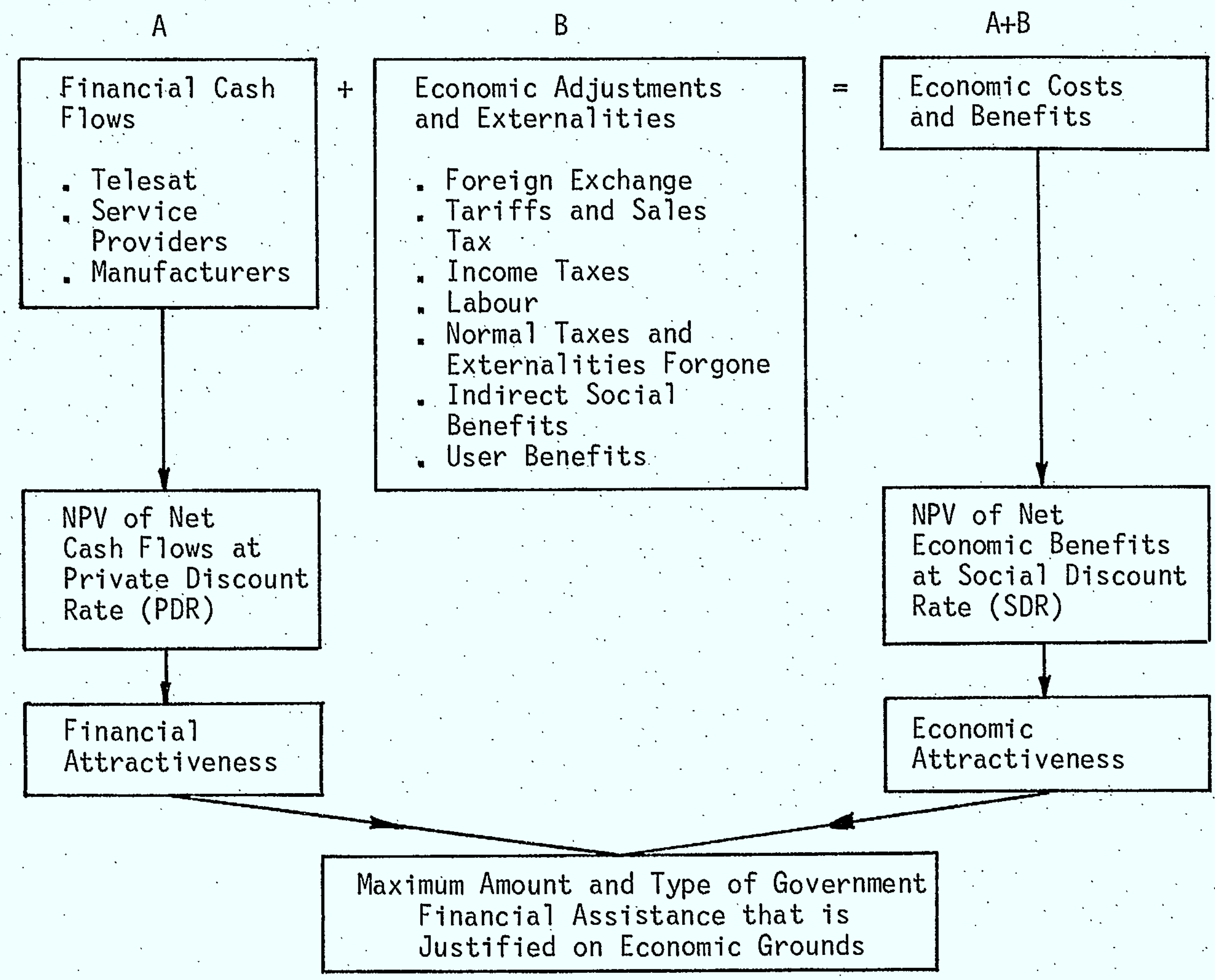
[1] John C. Evans et al., "A Manual for the Analysis and Appraisal of Industrial Projects in Canada," prepared for the Departments of Regional Economic Expansion and Industry, Trade and Commerce (Ottawa, 1983).

Figure 1.1

Overview of the MSAT Economic Analysis Framework



NPV of Incremental Net Economic Benefits at the Social Discount Rate (SDR)

$$= NPV(A)_{SDR} + NPV(B)_{SDR}$$

$$= NPV(A)_{PDR} + NPV(A)_{SDR} - NPV(A)_{PDR} + NPV(B)_{SDR}$$

$$= NPV_{PDR}\ (\text{Telesat, Serv. Prov., Mfrs.}) + NPV\ (\text{Taxes and Externalities Forgone})$$

$$+ NPV_{SDR}\ (\text{Rents, Gross Gov't Revenues, User Benefits, Indirect Social Benefits})$$

available for further analysis.

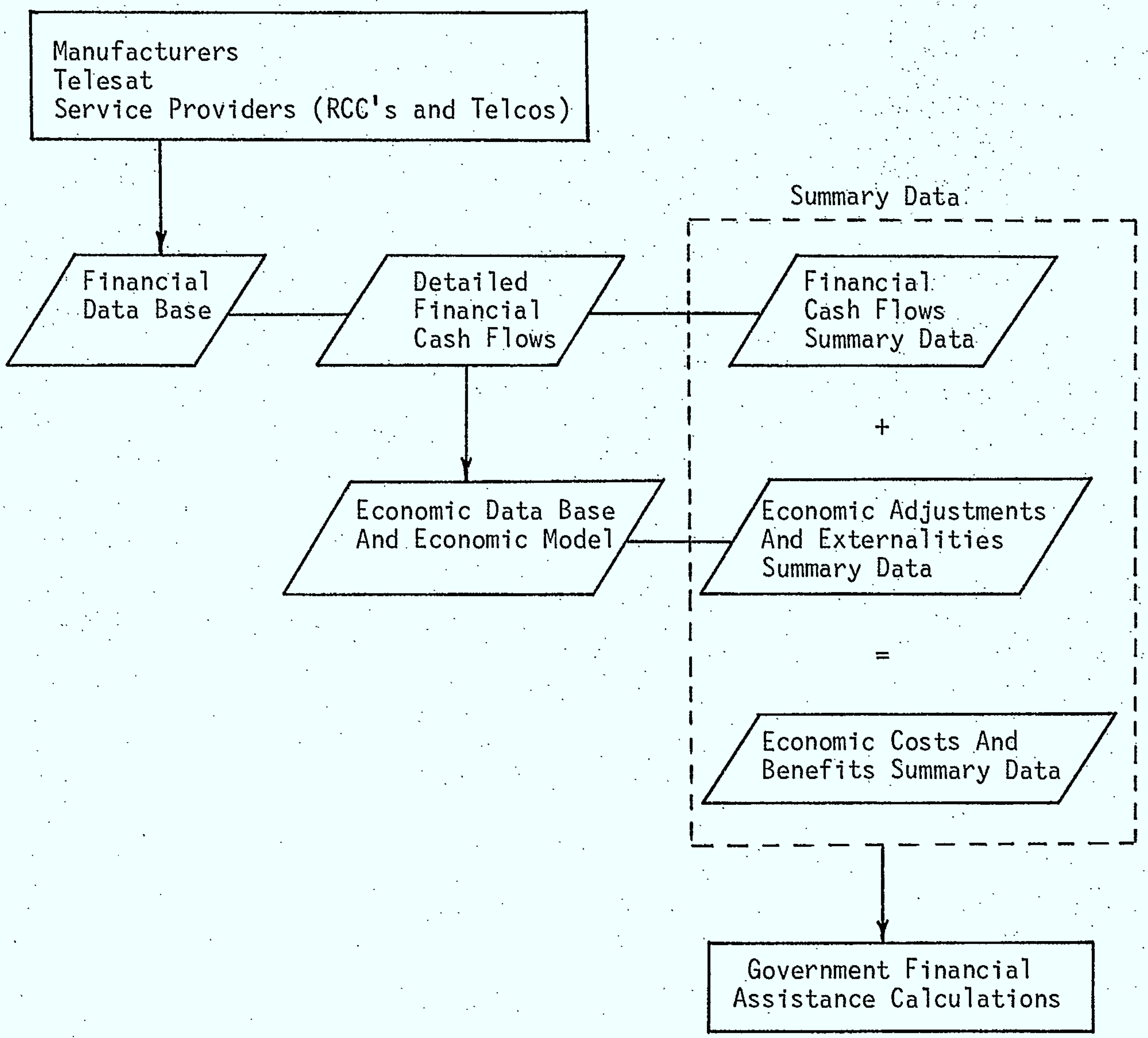
The incremental cash flows from Telesat's Commercial Viability Study and Woods Gordon's Manufacturing Impact Study, and the Service Providers' Study conducted by DOC using the RCC Impact Model provide the basic building blocks for the financial and economic analysis of MSAT. The net present value (NPV) of the incremental net cash flow, calculated using a private discount rate, serves as the basis for assessing MSAT's financial attractiveness for each of the participants. However, in order to measure a project's attractiveness from a public perspective, the financial cash flows must be modified to take account of a number of economic adjustments and externalities. The NPV of the resulting economic benefits and costs, calculated using a social discount rate, provides a measure of economic attractiveness. Thus, the economic cost/benefit analysis of MSAT requires (a) accurate and consistent financial data, and (b) a correct specification and estimation of the economic externalities associated with each phase of the overall project.

1.1.2 Overview of the Financial and Economic Software System

Econanalysis has designed computer software for a financial data base system and economic model referred to as the Socio-Economic Impact Model. The flow chart presented in Figure 1.2 illustrates the sequence of steps executed by the Socio-Economic Impact Model. First raw data from the other contractors is loaded into the financial data base of each participant. The data from the financial data base are then entered into an itemized cash flow on an annual basis. The equations of the economic model then operate item by item on the cash flows to calculate detailed economic adjustments and externalities for each year. Note that the

FIGURE 1.2

Socio-Economic Impact Model Flow Chart



equations of the economic model are the same for all participants, but the variables are different. Annual economic benefits are calculated by combining the cash flows with the appropriate economic adjustments and externalities. Annual summary data for the cash flows, economic adjustments and externalities, and economic benefits and costs by major item are subsequently generated to standardize all results.

The summary for each participant's data are added together on an itemized basis to produce summaries of total MSAT cash flows, economic adjustments and externalities, and economic benefits and costs. Using both normal risk and abnormal risk-adjusted discount rates, NPV's of the net cash flows, externalities, and net economic benefits for each participant and the total MSAT project are calculated from the data summaries. These NPV's form a basis for an estimate of the amount of direct government financial assistance (if any) to the total MSAT project and to each of the participants.

Section 1.2 focuses on one aspect of the financial data base, namely the private discount rate, and all aspects of the economic data base. The primary purpose of this report is to indicate specific values and/or procedures for estimating the economic parameters of the Economic Model.

1.2 Private Discount Rates

The attractiveness of a project from a private financial point of view is measured by the net present value of the incremental net cash flows at a private discount rate (PDR). Since we are dealing with the net cash flow to total capital (debt and equity), the PDR is calculated as a weighted average cost of capital, where the weights are determined by the proportions of the project funded with debt and equity capital. The cost of debt capital is the rate of return required by bondholders, and similarly, the cost of equity capital is the rate of return required by shareholders.

As a benchmark for the real (net of inflation) PDR, we propose to use Professor Glenn Jenkins' estimate of the approximately 5.9 per cent for overall average real rate of return to total capital in Canada.[1] This is largely consistent with a 4 per cent real rate of return on debt capital, a 7 per cent real rate of return on equity capital, and a 40/60 average debt equity ratio. Jenkins' estimate is representive of the broad performance of capital in Canada, becaue it is based on the ex post returns to total capital for public sector and private sector corporations with and without traded shares, i.e., his estimates are not confined to corporations listed on stock exchanges.

More recent research by the Tax Policy and Legislation Branch of the Department of Finance, using a methodology similar to that of Jenkins, suggests that the ex post private real rate of return to productive total capital in non-manufacturing industries from 1965-81 was 5.6 per cent, while in manufacturing industries it was even lower at 4.8 per cent.[2] See Table 1.1. This yields an overall average private real rate of return of approximately 5.3 per cent. The variation in these rates of return, as well as in the rate of return to productive equity, over time is evident from Figures 1.3 and 1.4.

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[1] G.P. Jenkins, Capital in Canada: The Social and Private Performance 1965-1974, (Economic Council of Canada, 1977).

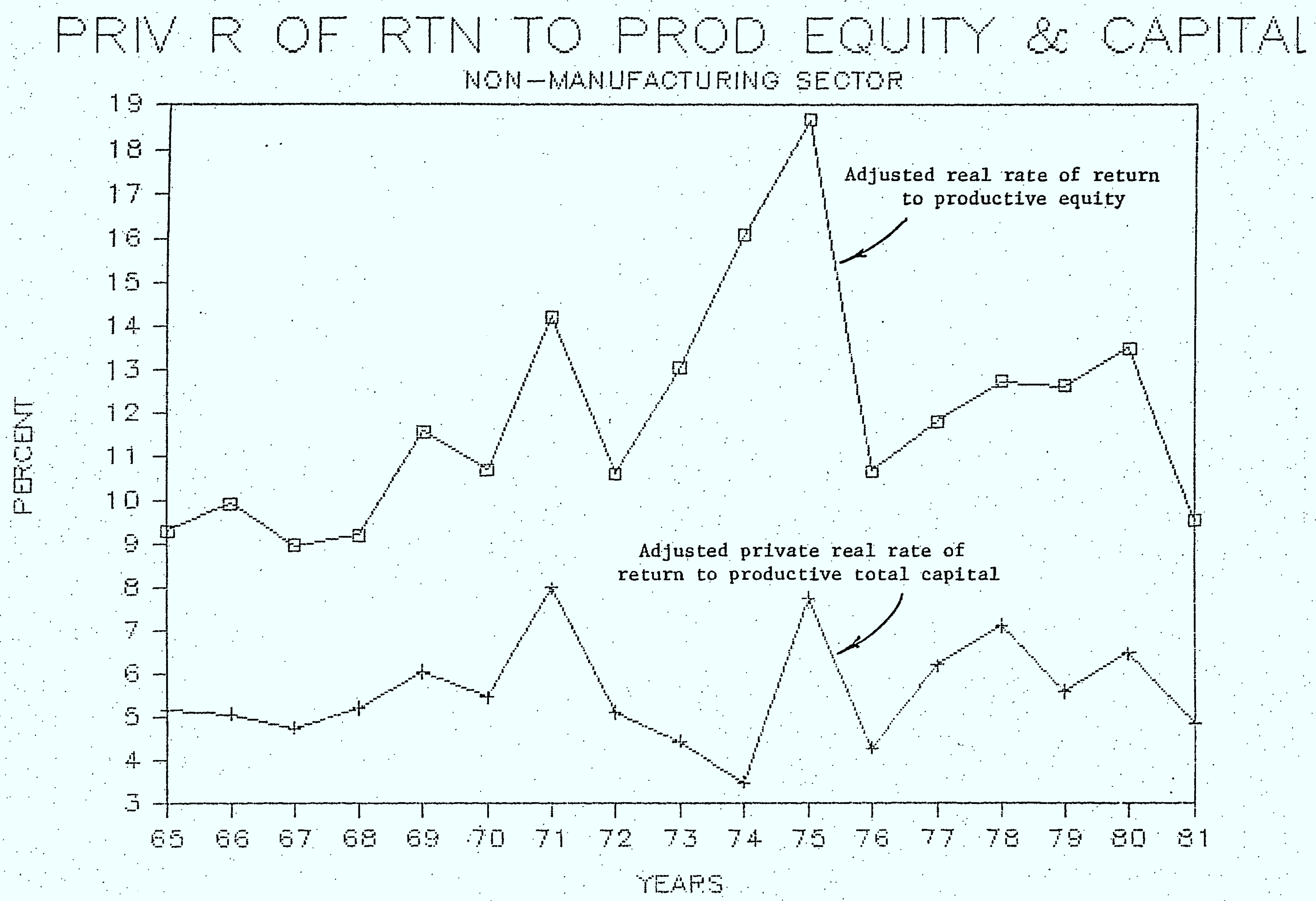
[2] These results were presented at a seminar by the Tax Analysis and Commodity Tax Division using the SOCRAT data base and computer programme (August, 1984).

Table 1.1

PRIVATE RATES OF RETURN TO NET PRODUCTIVE CAPITAL
(PERCENTAGES)

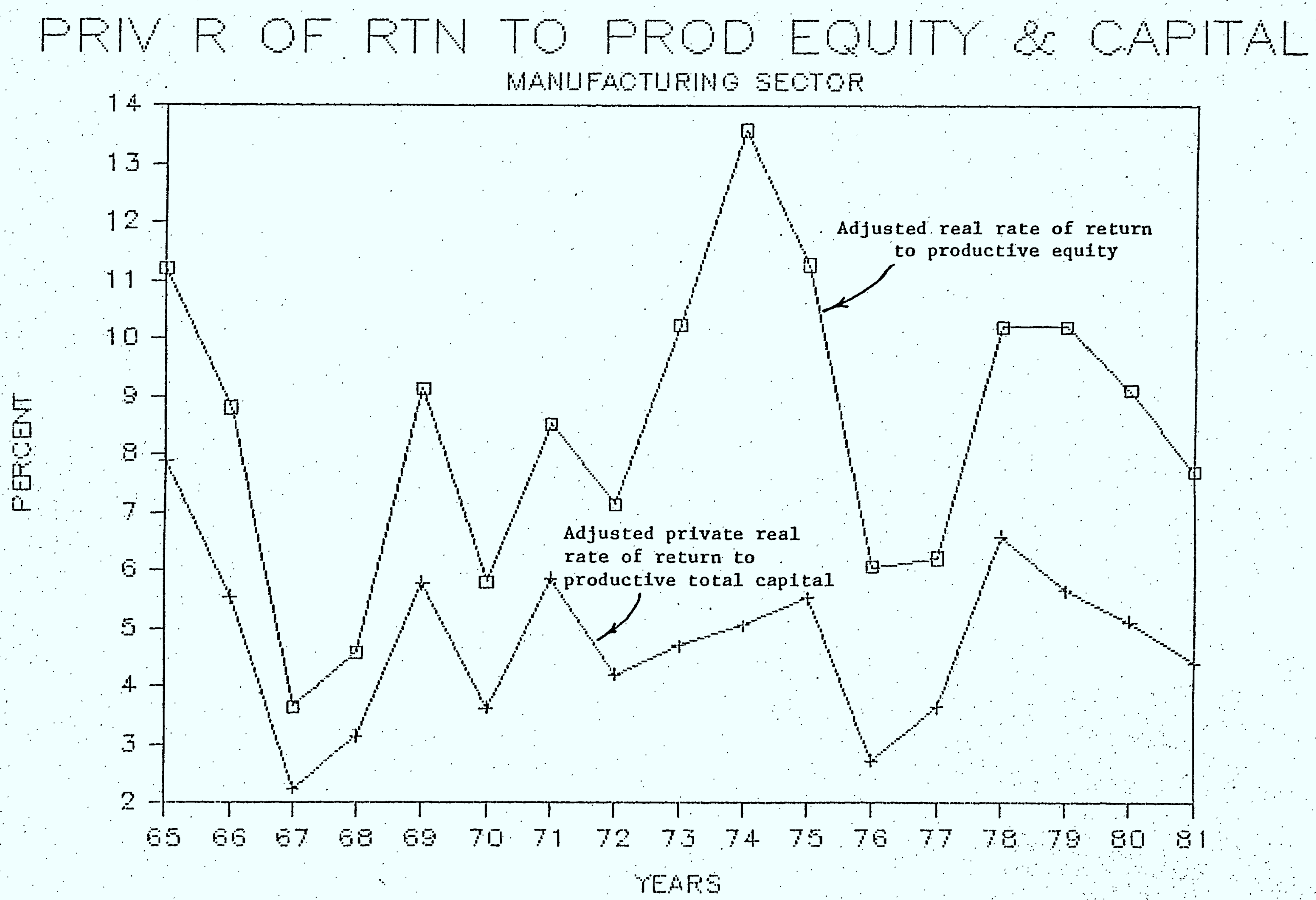
	1965-72	1973-81	1965-81
A. MANUFACTURING (101-399)			
REPORTED NOMINAL	8.6	12.6	10.7
REPORTED REAL	4.6	2.7	3.4
ADJUSTED REAL	5.0	4.9	4.8
% DEBT - REPORTED	51	57	54
- ADJUSTED	45	48	47
B. NON-MANUFACTURING (404-899 EXCL. 712-793)			
REPORTED NOMINAL	7.6	11.7	9.8
REPORTED REAL	3.6	1.9	2.7
ADJUSTED REAL	5.7	5.7	5.6
% DEBT - REPORTED	63	69	66
- ADJUSTED	62	60	61

Figure 1.3



PRIV R OF RTN TO PROD EQUITY &c CAPITAL
NON-MANUFACTURING SECTOR
PERCENT
YEARS
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
Adjusted real rate of return to productive equity
Adjusted private real rate of return to productive total capital

Figure 1.4


PRIV R OF RTN TO PROD EQUITY & CAPITAL
MANUFACTURING SECTOR
PERCENT
YEARS
14
13
12
11
10
9
8
7
6
5
4
3
2
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
Adjusted real rate of return to productive equity
Adjusted private real rate of return to productive total capital

These estimates of ex post private real rate of return across all sectors of the Canadian economy reflect normal business risk. On account of differential risk premia, private rates of return can be expected to vary among firms and sectors of the economy. Also, incremental debt-equity ratios can differ substantially from their average values.

For the purposes of this study, we shall initially assume a 6 per cent private discount rate, unless other study contractors indicate that it should be higher or lower for a particular participant due to higher or lower than normal business and/or financial risk.[1] Telesat's private discount rate appears to be a likely candidate for a risk adjustment based on its perception of greater than normal business risk inherent in the MSAT project. Any sensitivity analysis that is carried out on the private discount rate should probably be done at lower rates in line with the Department of Finance results cited above. A higher PDR, other things being equal, would tend to bias upward the amount of government financial assistance offered to MSAT participants.

1.2.1 Inflation

In our study we propose to conduct the financial and economic analyses in constant dollars, which requires that we discount all constant dollar cash flows and economic benefits at real (net of inflation) discount rates. We are taking this approach because it allows us to check data consistency across the studies of the other MSAT contractors more easily. Note that discounting current dollar cash flows at a nominal (gross of inflation) private discount rate will yield the same NPV as

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[1] This 6 per cent figure is the "rounded" value of Jenkins' 5.9 per cent estimate.

discounting constant dollar cash flows at a real (net of inflation) discount rate provided that both the current dollar projections and the nominal interest rate reflect the same expected rate of inflation.[1]

For example, Telesat in the Task 7 report of its Commercial Viability Study entitled "Economic and Financial Analysis" (August, 1984) employs a 16 per cent cost of capital. Implicit in this figure is an 8 per cent average annual inflation rate. Therefore, the implicit real (net of inflation) discount rate is

$$\left(\left(\frac{1.16}{1.08}\right) - 1\right) \times 100 = 7.41 \text{ per cent.}$$

This figure is somewhat higher than the ex post real rates of return reported for the average performance of productive total capital in Canada.[2] The lion's share of the difference is more than likely due to the greater than average perceived risk of the MSAT project. Note that Telesat has subsequently lowered its nominal discount rate to 14 per cent for the purposes of its forthcoming Business Proposal.

1.2.2 Risk

Although the cost of normal business risk to investors was included in the estimates of discount rates presented above, there was no discussion as to how the cost of risk might be isolated and adjusted to reflect different risk conditions. Recent corporate finance literature

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1 See Econanalysis' Report Number 2, "Preliminary Financial Reporting System" (February, 1984) for a complete discussion of this issue.

2 Or conversely, the 6 per cent real discount rate can be converted to a nominal discount rate with an implicit 8 per cent expected rate of inflation. This would equal (1.06)(1.08) = 14.5 per cent, which is less than Telesat's 16 per cent required rate of return.

has developed a methodology, namely the capital asset pricing model (CAPM), for estimating the supply price of capital and associated risk adjustments explicitly. CAPM is not a definitive approach to risk and is certainly not without flaws, but it does offer insights as to how risk might be dealt with in project evaluation.

CAPM was developed to explain why investors might want to hold different types of assets in their portfolios and how the risk of their portfolios could be lowered by diversification. The starting point of the theory is that risk averse investors will want to be compensated for any additional risk in their portfolios by an increase in the expected rate of return.

The total risk of an individual asset is measured by the variance around its expected rate of return. However, investors can form portfolios of assets, and hence diversify away at least part of that. Therefore, the relevant risk of an asset is its contribution to the risk of a sufficiently diversified portfolio of assets, and not its risk measured in isolation from a diversified portfolio. This measure of risk is termed covariance risk.

Assuming no transactions costs or market imperfections, the key equation in CAPM is as follows:

$$E[R_j] = R_f + [E[R_m] - R_f] B_j \qquad (1.1)$$

where,

$E[R_j]$ = expected rate of return for asset j

R_f = risk-free rate of return

$E[R_m]$ = expected rate of return on the market portfolio

B_j = the "beta" of asset j, a measure of covariance risk

$[E[R_m - R_f]B_j$ = risk premium on asset j.

If investors behave rationally and seek to minimize risk, then according to equation (1.1), the supply price of capital for asset j, R_j, consists of a risk-free rate of return plus a risk premium which is based on the risk of a market portfolio and a beta coefficient which measures the contribution of asset j to the market portfolio's variability. The beta of an asset is measured by its covariance with the market portfolio divided by the variance of the market portfolio itself. Thus, the asset's risk premium is based on covariance risk, i.e., systematic risk that cannot be diversified away in a portfolio.

If asset j's beta equals one in the above equation, then asset j has a risk equal to the market or average risk. In keeping with the terminology used in the discussion of private discount rates, we would say that asset j has normal business and financial risk.

For the purpose of this study we shall initially assume that the expected return on the market portfolio is the same as the average private return to capital in Canada as measured by Jenkins, i.e., $E[R_m]$ = 6 per cent. We shall also assume a long-term, real, risk-free interest rate of 3 per cent.[1]

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[1] In Inflation: Its Financial Impact on Business in Canada (Economic Council of Canada, 1977) Jenkins estimated a long-run real rate of return of 4 per cent on long-term corporate bonds in Canada. On average there appears to be roughly a 1 percentage point differential between the return on long-term corporate bonds and long-term, federal government debt. Thus, we take 3 (=4-1) per cent as our estimate of the long-term, real, risk-free interest rate for the purposes of the MSAT project. Note that the returns on long-term bonds include a return for the risk of inflation. Thus, the real yield of long-term government bonds will exceed that of treasury bills which are usually taken to be the risk-free investment alternative. This distinction becomes important in Section 7 when valuing loan and rate-of-return guarantees.

By substituting the above assumptions into equation (1.1), the normal market business risk premium is roughly 3 per cent (6-3). Recall from Section 1.2.1 that an implicit real discount rate of 7.4 per cent was estimated for Telesat based on its Task 7 Report. This implies that Telesat's MSAT project beta is equal to

$$B_j = \frac{E[R_j] - R_f}{E[R_m] - R_f}$$

$$= \frac{7.41 - 3}{6 - 3} = 1.5$$

i.e., Telesat perceives that the MSAT project is 1.5 times as risky as the average market investment. This may not be an unreasonable assumption given the uncertainty attached to the market projections for MSAT services.

Listed below are industry-wide betas for the electrical products, broadcasting and telephone systems industries that have activities similar to those of participants in the MSAT project. All the betas shown are less than one, indicating less than normal risk in these industries. The betas for broadcasting and telephone systems are substantially lower than those in electrical products, possibly because of the regulated nature of these two industries and the near monopoly status granted to the firms involved.

These beta values are useful only as a point of reference because they are industry-wide averages and most likely not representative of betas specifically for the MSAT project. Since the MSAT project's betas are the items of interest for this study, Telesat's implied MSAT project beta is probably a better guideline to MSAT related risk than the betas shown in Table 1.2.

1.3 The Social Discount Rate

The social discount rate (SDR) measures the time value of a project's economic benefits and costs, and hence is used to calculate the net present value of its net economic benefits.[1] If this NPV were equal to zero, then Canadians would recover their investment in a project and earn an annual rate of return equal to the SDR. In such a case Canadians would neither be better off nor worse off as a result of a project, because they would have received a rate of return equal to that from other activities that would have been undertaken in the absence of a project.

In 1976 the Treasury Board endorsed a 10 per cent SDR for Canada. This estimate was based on the earlier empirical work of Professor Jenkins. Other estimates of the SDR indicate that it lies in the 7-10 per cent range, roughly 1 to 4 percentage points above the average real private rate of return to capital in Canada, measured at approximately 6 per cent.

The 10 per cent estimate of the SDR was initially calculated as a weighted average of the social opportunity cost of capital drawn from various sources in the Canadian economy, where the weights are the proportions of incremental government borrowing that are drawn from each source. Specifically, the SDR was calculated as a weighted average of the economic opportunity cost of forgone domestic consumption (4.14%),

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[1] The discussion in this section is based on J.C. Evans et.al., "A Manual for the Analysis and Appraisal of Industrial Projects in Canada," prepared for the Departments of Regional Economic Expansion and Industry, Trade and Commerce (Ottawa, 1983), Chapter 10.

Table 1.2

Industry-Wide Beta Estimates

	Industry Betas[1] (1977-1981)
Electrical Products	.707 ± .139
Broadcasting	.276 ± .134
Telephone Systems	.259 ± .073

[1] A.L. Calvert and J. Lefoll "Risk and Return on Canadian Capital Markets: Estimation and Sensitivity Analysis (Ottawa: Department of Finance, 1983).

increased foreign investment (6.11%), forgone private industrial investment (12.53%) and forgone private residential construction (7.5%), where the respective weights were 0.05, 0.2, 0.59 and 0.16.

The social discount rate can also be interpreted as the social rate of return that capital would have generated elsewhere in the economy, which includes the private return to capital, corporate income taxes, less personal income taxes, sales taxes, labour and foreign exchange externalities. Thus, taxes and other externalities form the bulk of the "wedge" between the social discount rate and the private return to capital.

For the purpose of this study we shall initially use an SDR of 10 per cent and run sensitivities for the project around this figure. In most instances it will be advisable to vary jointly the private and social discount rates.

Although risk does not entail the use of real resources, it does create a social cost, because uncertainty and risk reduce net economic well-being. For the purposes of this study we will assume that the federal government is no more efficient at diversifying risk than the private sector.

The measure of the SDR at 10 per cent includes normal private business risk, i.e., average business and financial risk which is present in alternate uses of capital. If the activities of MSAT participants give rise to higher or lower than normal levels of business and/or financial risk resulting in abnormal risk premia in their respective private discount rates, then these abnormal risk premiums should also be reflected in the social discount rate. Therefore, if different private discount rates reflecting different risk levels are used to discount the financial cash flows of each MSAT participant, then different social discount rates reflecting different risk levels will also be used to discount the net economic benefits of each MSAT participant.

1.4 Conclusions

Table 1.3 provides reference values for private and social discount rates to be used initially in the overall socio-economic analysis of MSAT. The discount rates vary by participant module in the software system. As explained above, all discount rates, except those of Telesat, incorporate normal business risk. Telesat's private and social discount rates have a 1.41 per cent abnormal risk premium, based on Telesat's apparent perception of MSAT project risk.

We propose to use the discount rates in Table 1.3 as base values around which we will run sensitivities. If more information becomes available on the risk of the MSAT project to the various participants, we shall modify the discount rates acccordingly.

Table 1.3

Initial Real Discount Rates

	Real Private Discount Rate with Normal Risk	Abnormal Risk Premium	Risk-Adjusted Real Private Discount Rate
Manufacturers	6%	-	6%
Telesat	6%	1.41%	7.41%
Service Providers	6%	-	6%

	Real Social Discount Rate with Normal Risk	Abnormal Risk Premium	Risk-Adjusted Real Social Discount Rate
Manufacturers	10%	-	10%
Telesat	10%	1.41%	11.41%
Service Providers	10%	-	10%

Section 2 of Report Number 8

2.0 Foreign Exchange, Tariff and Sales Tax Externalities

2.1 Introduction

Foreign exchange externalities, tariff and tax externalities arise from the commodity inputs and outputs of the various participants of the MSAT project. These externalities are positive when the purchase or sale of a commodity earns or saves foreign exchange, or generates additional tariff and tax revenues. They are negative when a project uses up or forgoes foreign exchange earnings, or forgoes tariff and tax revenues.

In order to calculate tariff, tax and foreign exchange externalities on MSAT commodity inputs and outputs all commodities must first be classified as tradeable or non-tradeable. A commodity is considered tradeable if there exists a well-defined international market for it. Whether it is purchased domestically or abroad is immaterial, as long as the option to purchase or sell abroad is available to the producer.

A further distinction between importable and exportable categories is necessary for tradeable commodities. This distinction is necessary because differences in the types of trade distortions and in the effect of domestic freight costs alter the foreign exchange calculations on importable and exportable commodities. Thus, an exportable commodity is one where domestic industry output satisfies all domestic demand with the residual being exported at the world f.o.b. price. An importable commodity is one where domestic industry output can only partially satisfy domestic demand with the residual being imported at the world c.i.f. price.

The formulae for estimating the externalities associated with the purchase or sale of tradeable commodities were outlined in our third report entitled "Outline of the Proposed Methodology for the Estimation of the Socio-Economic Benefits of MSAT" (June, 1984). Appropriate tariff rates, tax rates, freight rates and trade margins are applied to the market prices of tradeable commodities in order to determine the actual amount of foreign exchange earned or forgone on the sale or purchase of an item, i.e., the amount of foreign exchange in the presence of these market distortions will differ from the amount that appears in a participant's financial cash flow. A foreign exchange premium is applied to the amount of foreign exchange to determine the foreign exchange externality. Tariff rates - where applicable - are also applied to the foreign exchange value of a commodity to determine earned or forgone tariff revenues. Federal and provincial sales tax rates - where applicable - are applied to both tradeable and non-tradeable commodities to determine earned or forgone tax revenues.

The next section provides a brief discussion of the general methodology for the calculation of the foreign exchange externality as well as the empirical estimate of the foreign exchange premium used in this study. The methodologies for the calculation of all economic externalities for importable, exportable and non-tradeable commodities are reviewed in Sections 2.3, 2.4 and 2.5, respectively. Although the discussion addresses only commodity inputs, the methodology is readily extendable to evaluating outputs in all three cases.[1]

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[1] John C. Evans et al., "A Manual for the Analysis and Appraisal of Industrial Projects in Canada," Chapter 11.

2.2 The Foreign Exchange Premium

The formula for calculating the foreign exchange externality is as follows:

$$\begin{pmatrix}\text{Net change in foreign} \\ \text{exchange earnings} \\ \text{caused by MSAT}\end{pmatrix} \times \begin{pmatrix}\text{Foreign exchange} \\ \text{premium}\end{pmatrix}$$

The foreign exchange premium has been estimated at roughly 7 per cent.[1] Thus, for every dollar of foreign exchange earned or saved by MSAT, there is a 7¢ additional benefit to Canada. Conversely, for every dollar of foreign exchange used or forgone by MSAT, there is a 7¢ cost to Canada over and above the cost of foreign exchange as measured by the foreign exchange rate.

The foreign exchange premium captures the indirect effects of foreign exchange earnings on government revenues that arise from tariffs, excise taxes and subsidies on non-MSAT commodities. In other words, whenever foreign exchange is earned by a project, it will cause the Canadian dollar to appreciate and will lower the cost of foreign exchange. This will allow increased domestic expenditures on imports and decrease foreign demand for our exports. This will result in increased tariff and excise tax revenues on imports and decreased subsidy payments on exports. The 7 per cent foreign exchange premium is a weighted average of these changes in government revenue per unit of foreign exchange. Conversely, if a project uses or forgoes foreign exchange, then the opposite exchange rate effects will likely occur, but the premium remains the same.

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[1] Glenn P. Jenkins and Chun-Yan Kuo, "On Measuring the Social Opportunity Cost of Foreign Exchange" (Ottawa: Department of Finance, 1984).

2.3 Importable Commodities

If a tariff rate of t_1 were the only distortion in the market for an importable commodity with a market price of P, than when this commodity is used as an input, it would generate a foreign exchange externality equal to

$$\frac{-f_x \times P}{(1 + t_1)} \qquad (1)$$

and a tariff revenue externality equal to

$$\frac{P \cdot t_1}{(1 + t_1)} \qquad (2)$$

where, P = domestic market price of commodity

t_1 = tariff rate

f_x = foreign exchange premium

All frieght costs, trade margins and other excise taxes are assumed zero.[1]

Note that the foreign exchange and tariff externalities are the same regardless of whether the commodity is directly imported or purchased from a domestic producer. This is made clear in Figure 2.1. A project is shown to increase domestic demand for a commodity by shifting the demand curve from D to D^1. Domestic producers supply Q_s units of the commodity at a market price of $P = P_{cif}(1+t_1)$. The increased demand does not affect the price that domestic producers receive, since P_{cif} is assumed to be determined in world markets. Hence, domestic supply remains fixed at Q_s

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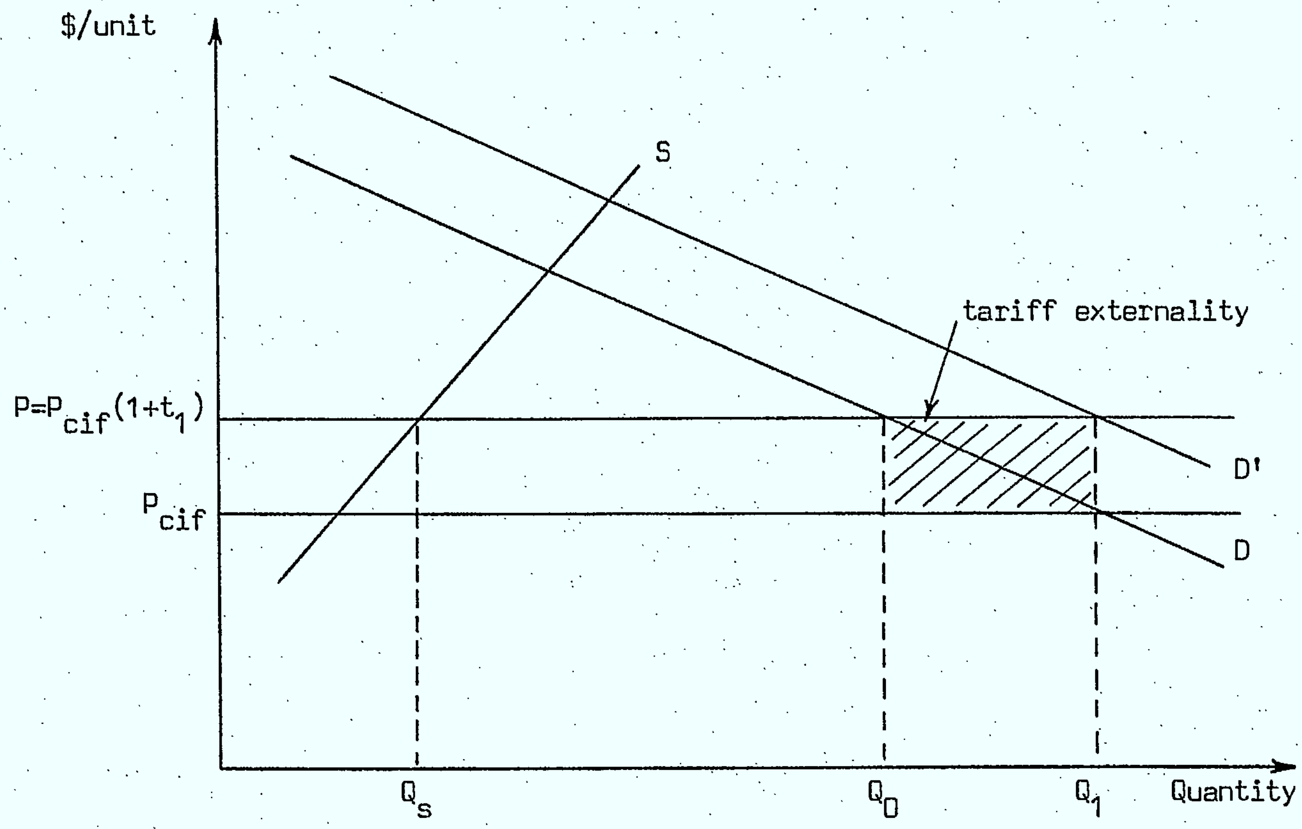
[1] Note that the world c.i.f. price (P_{cif}) is equal in this case to $P/(1+t_1)$.

Figure 2.1

Tariff And Foreign Exchange Externalities For An Importable Project Input



S ≡ domestic industry supply curve
D ≡ domestic demand curve

$Q_1 - Q_0$ ≡ project demand

P_{cif} ≡ world price in Canadian dollars

t_1 ≡ tariff rate

$P=(1+t_1)P_{cif}$ ≡ domestic price in Canadian dollars

f_x ≡ foreign exchange premium

Δ tariff revenues = $(Q_1 - Q_0) \cdot t_1 \cdot P_{cif}$

Foreign Exchange Externality = $-(Q_1 - Q_0) \cdot P_{cif} \cdot f_x$

and the increased demand is ultimately sourced off-shore. This gives rise to a positive externality equal to the additional tariff revenues generated and a negative externality due to the foreign exchange required.

The net externality depends on the relative magnitudes of the tariff and foreign exchange externalities. In this case the net externality would be positive if the tariff rate exceeds the foreign exchange premium. A positive net externality implies that the economic cost of this input would be less than its financial cost.

A similar analysis can be conducted for an importable project output by shifting the supply curve in Figure 2.1 rather than the demand curve.

2.3.1 Trade Margins and Freight Rates

Commodities imported into Canada must generally be shipped from the point of entry to their final destination. Thus a domestic freight cost will be incurred on top of the gross of tariff import price. This cost can also be expressed as a proportion or rate. Furthermore, if a commodity is imported by one commercial entity then sold to another, the gross of tariff import price will be marked up by a trade margin. Freight rates and trade margins can provide an additional degree of protection on top of tariffs to domestic producers of importable commodities.

The economic model in the software system adjusts for freight rates and trade margins in foreign exchange externality calculations on importable commodities. The formula for a foreign exchange externality with tariffs, freight rates, sales taxes and trade margins is equal to

$$\frac{f_x \cdot A \cdot (1 - P_4)}{(1+t_1)(1+t_2)(1+m_1)} \qquad (3)$$

where, A = domestic value of the importable commodity

P_4 = proportion of freight costs

t_1 = tariff rate

t_2 = sales tax rate (if any)

m_1 = trade margin

For the purposes of the Overall Socio-Economic Study we assume freight costs of 5 per cent on all importable items, i.e., P_4 = .05 and negligible trade margins, i.e., $m_1 = 0$. The 5 per cent figure is roughly consistent with freight costs in the computer hardware industry, which bear a rough equivalence to the price and weight of MSAT equipment inputs and outputs.

In addition to the foreign exchange, tariff and tax externalities on importable commodities, there may also be economic rents earned in transporting goods to their destination. These rents arise when the freight costs exceed the resource costs of transportation.

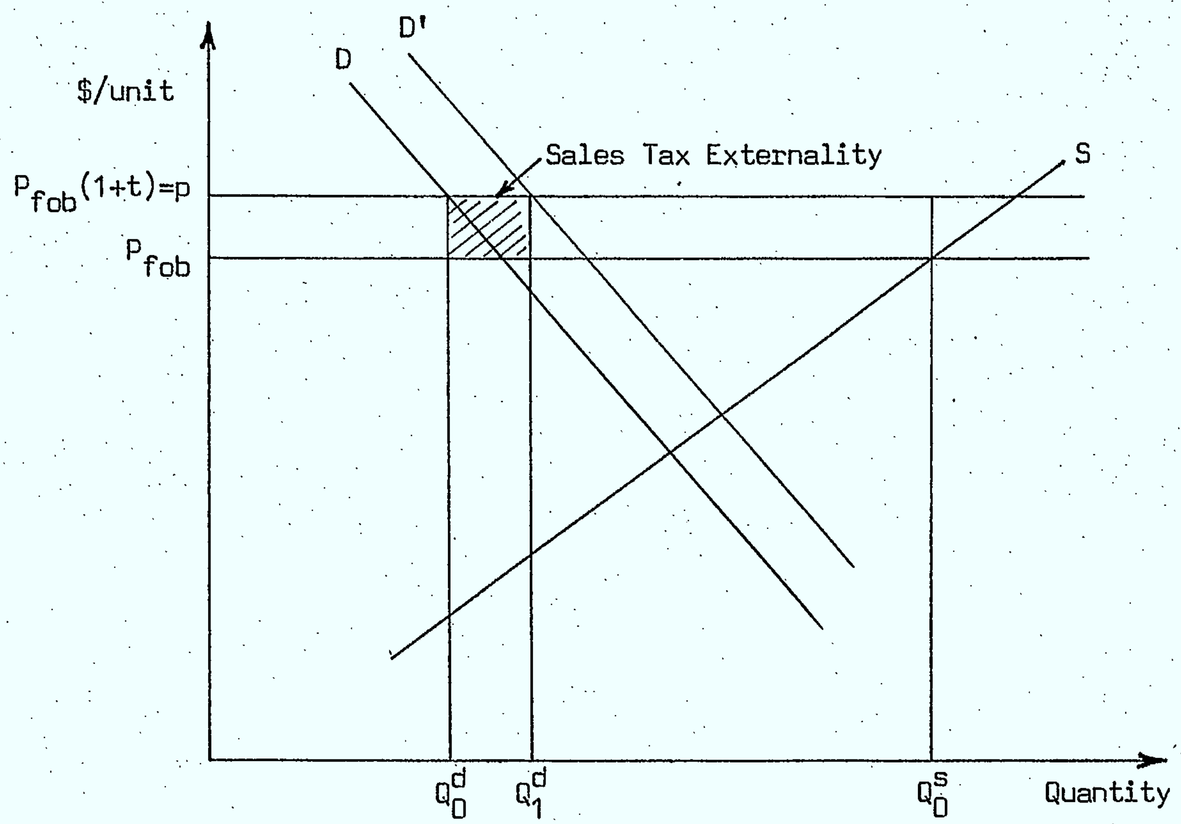
2.4 Exportable Commodities

Figure 2.2 provides a diagrammatic analysis of the externality calculations for exportable commodities. A project is shown to increase domestic demand for a commodity by shifting the demand curve from D to D^1. Domestic producers supply $Q^s{}_o$ units of the commodity at a world price of P^{fob}. The initial volume of exports is equal to $Q_o{}^s - Q_o{}^d$). Sales taxes are not levied on exported items.

The increase in demand caused by the project, $Q_1 - Q_o$, does not affect the world price. Hence, domestic supply remains fixed at $Q_s{}^o$ and the increase in demand is met by an equivalent reduction in exports. This

Figure 2.2

Sales Tax And Foreign Exchange Externality For An Exportable Project Input



$S \equiv$ domestic industry supply curve
$D \equiv$ domestic industry demand curve

$Q_1^d - Q_0^d \equiv$ project demand

$P_{fob} \equiv$ world price in Canadian dollars

$t \equiv$ domestic sales tax rate

$P=(1+t)P_{fob} \equiv$ domestic price in Canadian dollars

$f_x \equiv$ foreign exchange premium

Δtax revenues $= (Q_1^d - Q_0^d)\ t\ P_{fob}$

Foreign Exchange Externality $= -(Q_1^d - Q_0^d) \cdot P_{fob} \cdot f_x$

gives rise to a positive externality equal to the additional sales tax revenues generated and a negative externality due to the foreign exchange earnings that are forgone. The net externality depends on the relative magnitudes of the sales tax and foreign exchange externalities.

It is interesting to note that the magnitude of the foreign exchange externality will be greater for an exportable commodity input than an importable commodity input if the two commodities have identical domestic prices and there are positive sales taxes and tariffs. This point is illustrated by comparing the magnitudes of equations (1) and (2).

$$\frac{P}{(1 + t)} \cdot f_x = \text{foreign exchange externality for an exportable commodity} \qquad (1)$$

$$\frac{P}{(1+t)(1+t_1)} \cdot f_x = \text{foreign exchange premium for an importable commodity} \qquad (2)$$

$t, t_1 \quad 0$

p = price of exportable and importable commodities

t = sales tax rate

t_1 = tariff rate

f_x = foreign exchange premium

All frieght rates and trade margins are assumed zero.

However, given these assumptions, the opposite is true for the value of the sales tax and tariff externalities. Thus the relative magnitudes of the net externality will be indeterminate, until t, t_1 and f_x are known.

A similar type of analysis can be conducted for an exportable project output by shifting the supply curve in Figure 2.2 rather than the demand curve.

2.5 Nontradeable Commodities

Figure 2.3 below provides a diagrammatic analysis of the externality calculations for nontradeable commodities. Recall that a non-tradeable commodity has its price determined solely by domestic market conditions.

Domestic producers are assumed to supply $Q^s{}_o$ units of the commodity at a constant per unit cost of C. A sales tax at a rate of t is levied on the commodity raising its market price to

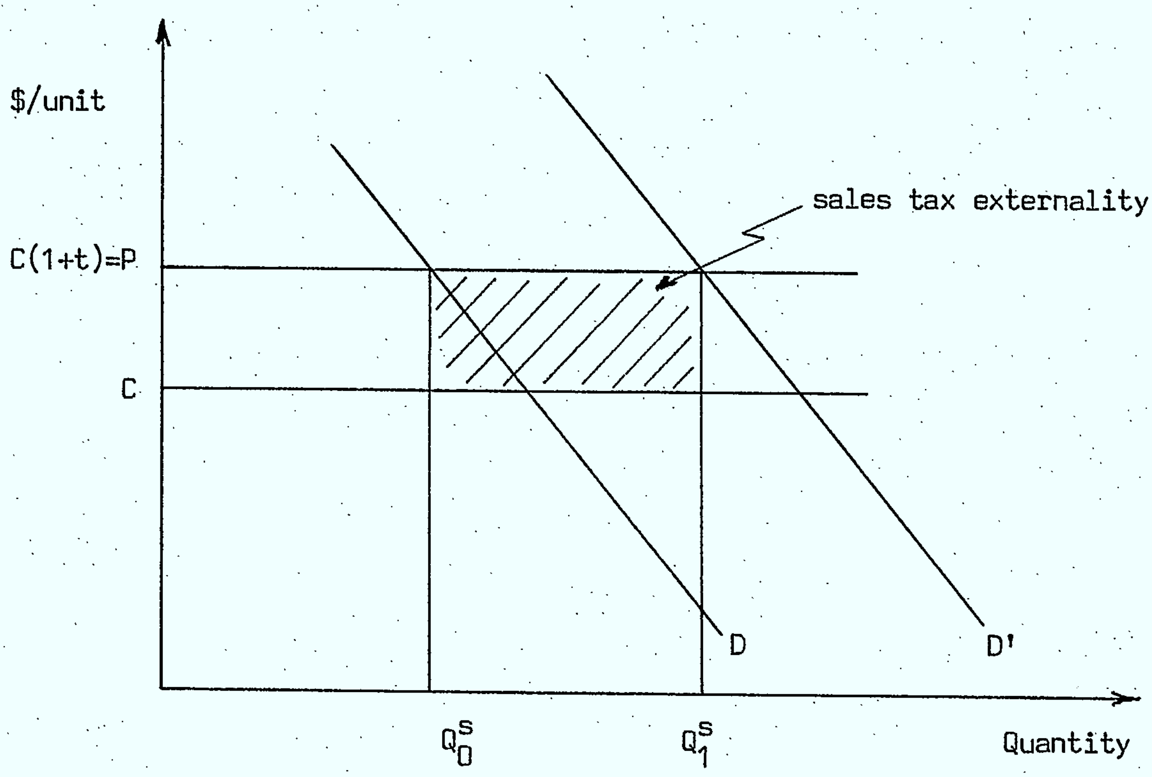
$P = C[1 + t]$. A project is shown to increase demand for the commodity input by shifting the demand curve from D to D^1.

In this case the increase in demand caused by the project is shown to have no effect on the domestic price, which remains fixed at $C[1 + t]$. Yet, while project participants must pay $C[1 +t](Q^s{}_1-Q^s{}_o)$ for their purchases of the commodity, additional tax revenues of $t.C(Q^s{}_1-Q^s{}_o)$ are generated. These tax revenues, while they are a private financial cost, they are not an economic resource cost. Hence, they are counted as a net positive externality, and the economic cost of the input lies below its financial cost.

Note that if a projet causes a decrease in demand for a commodity, then forgone tax revenues are treated as a net negative externality. This type of calculation is performed on commodities appearing in the displaced cash flows of the participants of the MSAT project.

Generally, sales tax externalities will be the only externalities incurred by nontradeable MSAT commodities. The only noteworthy exception to this is the adjustment for consumers' surplus (user benefits) from the consumption of MSAT services.

Figure 2.3



C ≡ domestic industry supply curve :constant cost
D ≡ domestic demand curve

t ≡ sales tax rate

$Q_1^s - Q_0^s$ ≡ project demand

$tc(Q_1^s - Q_0^s)$ ≡ additional tax revenues

2.6 Proposed Assumptions and Economic Variables

2.6.1 Federal and Provincial Sales Tax Rates

In October 1984 the general federal sales tax on all manufactured items (domestic or imported) will rise from 9 to 10 per cent. This tax is applied to all finished commodities at the manufactured level, i.e., as a commodity is sold by its manufacturer or its importer to a wholesaler or other entity. If a commodity is imported, this tax is applied to the gross of tariff value.

Commodities that are direct inputs to the manufacture of another commodity are exempt from the federal sales tax. For example, an integrated circuit, which is either a direct input or a component of a mobile terminal would be exempt from the federal sales tax. However, a central control station sold to Telesat is subject to the tax, as are mobile terminals, base stations and other MSAT ground equipment sold to retailers. These commodities are considered finished manufactured goods.

The only exception is space segment equipment, which under the Customs and Excise Tax Act is considered destined for re-export and thus is exempt from all federal and provincial sales taxes.

The financial data bases will show all MSAT earth segment equipment sold to Telesat and the Service Providers valued gross of the 10 per cent federal sales tax. The federal sales tax externality will be calculated in the Telesat and Retail modules of the software system, not in the Manufacturers' module. The reason is that the sales revenue that appears in the Manufacturers' Study is reported net of the federal sales tax; hence, no sales tax adjustment is required at this stage. Space segment equipment sold by the Manufacturers to Telesat will appear without any federal sales tax in the Telesat financial data base, since the tax is not applicable, as explained above.

In most provinces a sales tax is charged on all goods and services sold at the retail level. This tax varies from a high of 9 per cent of the value of goods and services sold in Newfoundland to zero in Alberta. We chose to employ 7 per cent - the rate charged in Ontario - as the representative rate. Hence, a retail sales tax rate of 7 per cent will be applied to all revenue items in the Retail module of the software system in order to determine the value of this economic externality. This will include all revenues from the sale of MSAT airtime, mobile terminals, repair, installation and other services.

2.6.2 Tariff Rates

Table 2.1 lists nominal tariff rates for commodity classifications which span the range likely for MSAT equipment inputs and outputs. Note that all finished commodities have higher tariff rates than the basic components of which they are comprised. For example, integrated circuits are duty free while finished telecommunications equipment and some intermediate products such as transformers, converters, antennas and headsets have tariff rates ranging from 11.4 to 17.5 per cent.

An important exception to the nominal tariff rates listed in Table 2.1 is that of space related equipment. Satellite or other equipment destined for space is considered to be re-exported according to the Customs and Excise Tax Act and hence is duty free.

Table 2.1

Commodity Classification	Tariff No.	Tariff Rate
Antennas	4453301	0.114
Computer Hardware	4270001	0.114
Computer Software	4141701	0.039
Converters	4452401	0.129
Inductors	4452401	0.129
Integrated Circuits	4454401	0
Operational Software	4141701	0.039
Radio Transmitter-Receivers	4453301	0.114
Semi-Conductors	4454701	0
Telecommunications Equip.	4453301	0.114
Telephone Handsets	4450801	0.175
Transformers	4451401	0.114
Transistors, Resistors, etc.	4454401	0

2.6.3 Assumptions and Economic Variables for Manufacturers

Table 2.2 below presents assumptions for the foreign exchange, tariff and sales tax externality calculations for Manufacturers. All MSAT equipment inputs and final outputs are assumed both tradeable and potentially importable. Note that the term "importable" should not be confused with the term "imported". As indicated previously, the purchase of a domestically produced importable input has the same externalities as the purchase of an imported good.

It appears almost certain that there will be a mobile communications service that will begin operations in the United States at roughly the same time as MSAT is anticipated to begin service in Canada. Negotiations are currently taking place between Canadian and American interests to establish compatible satellite systems that will enable mutual backup. Therefore, it is very likely that Canadian manufacturers of MSAT space and ground segment equipment will face competition from the U.S. They also could be at a competitive disadvantage because U.S. manufacturers may be able to achieve lower production costs as a result of their larger domestic market.

Given the above considerations, MSAT space and ground segment equipment should be considered tradeable since the option would exist to source this equipment from the U.S.. It is more likely that the equipment is importable rather than exportable because of the potentially dominant market position of U.S. manufacturers.

The tariff rates listed in Table 2.2 are actual tariff rates for all single identifiable items and average tariff rates for all items that are

Table 2.2

A. Proposed Assumptions and Economic Variables for Foreign Exchange, Tariff and Sales Tax Externalities

Manufacturers MSAT Equipment: Material Inputs

Woods-Gordon Classification	Proportion Taxable	Proportion Importable	Average Tariff Rate	Average Manf. Sales Tax Rate[1]	Average Retail Sales Tax Rate	Wholesale Retail Trade Margins	Proportion Freight Costs
Satellite	1	1	0	0	0	0	0.05
Central Control Station	1	1	0.065	0	0	0	0.05
Gateway Control Stations	1	1	0.065	0	0	0	0.05
Base Stations (All Types)	1	1	0.065	0	0	0	0.05
Mobile Terminals (All Types)	1	1	0.065	0	0	0	0.05

B. Manufacturers MSAT Equipment: Output

Woods-Gordon Classification	Proportion Taxable	Proportion Importable	Average Tariff Rate	Average Manf. Sales Tax Rate	Average Retail Sales Tax Rate	Wholesale Retail Trade Margins	Proportion Freight Costs
Satellite	1	1	0	0	0	0	0
Central Control Station	1	1	0.114	0	0	0	0
Gateway Earth Stations	1	1	0.114	0	0	0	0
Base Stations (All Types)	1	1	0.114	0	0	0	0
Mobile Terminals (All Types)	1	1	0.114	0	0	0	0

[1] The manufacturers sales tax is incorporated in the Telesat and Service Providers' modules.

composites of different commodities.[1] Note that space segment inputs and outputs have tariff rates of zero because imported satellite equipment is considered destined for re-export.

Table 2.2 reveals that MSAT equipment inputs generally have lower tariff rates than MSAT equipment outputs, because tariffs are higher on finished commodities than on semi or unfinished commodities - see Table 2.1. Almost all finished telecommunications products have a tariff rate of 11.4 per cent, with few exceptions. This is reflected in the tariff rates on MSAT equipment output items.

<u>Example</u>:

A sample calculation of the foreign exchange and tariff externalities for central control station material inputs based on the figures in Table 2.2 is outlined below.

Foreign Exchange Externality for CCS Inputs

$$= (-)\left[\frac{f_x \cdot (1-.05)}{(1+.065)}\right] \times \left(\begin{array}{l}\text{\$ cost of inputs}\\ \text{appearing in Manufacturers'}\\ \text{cash flows}\end{array}\right)$$

Tariff Externality for CCS Inputs

$$= (+)\left[\frac{(1-.05)(.065)}{(1+.065)}\right] \times \left(\begin{array}{l}\text{\$ cost of input}\\ \text{appearing in}\\ \text{Manufacturers'}\\ \text{cash flows}\end{array}\right)$$

f_x = foreign exchange premium

---

[1] Average tariff rates are calculated from the mean of the upper and lower bounds of the nominal tariff rates for all commodities in a composite item. Ideally, the average tariff rate for composite importable items appearing in Table 2.2 should be a price weighted average of the tariff rates of the individual components comprising each item. Mr. Allan Maclatchy (DOC) has indicated that at present there is a great deal of uncertainty regarding the detailed manufacturing costs of MSAT equipment. Since the weights in such a calculation cannot as yet be determined, a simple averaging technique was used.

A calculation of the foreign exchange and tariff externalities for CCS output is conducted in a similar fashion except that the signs on the externalities are reversed and a tariff rate of 11.4 per cent on the finished output is used.

We should perhaps point out that it may be desirable to alter the assumption that MSAT equipment produced by Canadian Manufacturers is tradeable. A non-tradeable assumption might be more appropriate if there were no U.S. mobile communications satellite or if the U.S. satellite were incompatible wth the Canadian system, in which case no foreign exchange and tariff externalities would be calculated on MSAT output.

2.6.4 Assumptions and Economic Variables for Telesat

Table 2.3 lists assumptions and economic variables for the foreign exchange, tariff and sales tax externalities for Telesat. All Telesat equipment purchases are assumed importable and thus subject to a foreign exchange externality. As previously explained, all space related items have zero tariffs. Earth segment items are assumed to fall in the same tariff category as general telecommunications equipment and thus are subject to an 11.4 per cent tariff.

A federal sales tax externality of 10 per cent is calculated on all earth segment equipment purchases; space equipment is exempt. Also, a 5 per cent freight rate is applied to all items, except off-shore purchases that are not domestically transported, in order to determine their foreign exchange value.

Table 2.3

Proposed Assumptions and Economic Variables for Foreign Exchange,

Tariff and Sales Tax Externalities

Telesat Classification	Proportion Taxable	Proportion Importable	Average Tariff Rate	Average Manf. Sales Tax Rate	Average Retail Sales Tax Rate	Wholesale Retail Trade Margins	Proportion Freight Costs
Space Segment							
Spacecraft	1	1	0	0	0	0	0.05
Incentives	1	1	0	0	0	0	0
Launch Vehicle	1	1	0	0	0	0	0
Launch Site Support	1	1	0	0	0	0	0
Upper Stage	1	1	0	0	0	0	0
Launch Insurance	1	1	0	0	0	0	0
Ground Support (MCS)	1	1	0	0	0	0	0
Contingency	1	1	0	0	0	0	0
Earth Segment							
Central Control Station	1	1	0.114	0.1	0	0	0.05

2.6.5 Assumptions and Economic Variables for Service Providers

Table 2.4 lists assumptions and economic variables for the foreign exchange, tariff and sales externalities for Retailers. A 10 per cent federal sales tax externality is calculated for all equipment purchases and a 7 per cent provincial sales tax externality is calculated for all MSAT related sales.[1] No tariff and foreign exchange externalities are calculatd at the retail level, hence no assumptions are made regarding related variables. These externalities are calculated against the items appearing in the manufacturers' cash flows and are excluded here to avoid double-counting.

Note also that MSAT airtime is considered a non-tradeable commodity and hence is not subject to a foreign exchange externality.

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[1]Recall the discussion in Section 2.5.1, which indicated that all equipment sold from manufacturers to retailers would be grossed up by the 10 per cent federal sales tax. For example, if the unit revenue from the sale of a mobile terminal is $4500 for manufacturers, then the cost of this item is $4950 to Service Providers when grossed up by the federal sales tax.

Table 2.4

Proposed Assumptions and Economic Variables for Foreign Exchange, Tariff and Sales Tax Externalities for the Service Providers

Retailers	Proportion Taxable	Proportion Importable	Average Tariff Rate	Average Manf. Sales Tax Rate	Average Retail Sales Tax Rate	Wholesale Retail Trade Margins	Proportion Freight Costs
Cash Receipts (All Items)	NA[1]	NA	NA	NA	0.07	NA	NA
Cash Disbursements:							
Base Stations (All Types)	NA	NA	NA	0.1	0	NA	NA
Gateway Earth Stations	NA	NA	NA	0.1	0	NA	NA
Mobile Terminals (All Types)	NA	NA	NA	0.1	0	NA	NA
Other Equipment (Not covered in the Manufacturers Study)	NA	NA	NA	0.1	0	NA	NA

[1] NA = not applicable

Section 3 of Report Number 8

3.0 The Labour Externality

3.1 Introduction

The labour externality consists of the net change in government revenues arising from direct employment created by a project and any indirect employment created through expenditure multiplier effects that occur as project labour purchases goods and services. The labour externality is measured by net changes in UIC payments, personal income tax revenues plus any rents earned by project labour.

The labour externality for a project is measured as the difference between the wage bill paid by a project and the economic opportunity cost of its labour. The economic opportunity cost of labour will vary by *inter alia* skill level, degree of job permanency, location, local employment opportunities, and degree of worker migration. In the simplest case, for example, the economic opportunity cost of labour (EOCL) is equal to the forgone wage bill in alternative employment plus the value of time while not employed of the workers hired by a project. However, the workers in the economy who ultimately respond to new employment opportunities are not necessarily those directly hired by a project, and hence, the estimation of the EOCL can become quite complex.

Labour productivity and the degree of job permanency are related to the quality of project jobs; the higher the quality of project jobs in relation to the quality of other jobs available in the economy, the higher the labour externality. For example if project jobs have a higher degree of permanency than other jobs, then workers will spend less time unemployed, thereby increasing income tax revenues and lowering UIC payments. Seasonal jobs, part-time jobs and jobs of short duration will have a lower labour externality than long-term full-time jobs.

In order to illustrate the concepts involved in an EOCL calculation we will use a simple partial equilibrium model of the labour market. However, we will draw on EOCL estimates produced by more complex general equilibrium models for the empirical content of this section. The chief difference between the partial and general equilibrium models is that in the former the cost of labour from a particular source (e.g. other employment, unemployment) is calculated with many other factors held constant, whereas in the latter the extent to which project labour is drawn from each source in any year is first solved with a system of simultaneous equations, and the cost of labour is then calculated using the equilibrium values for the adjustment path of the labour market.

3.2 EOCL Estimation Using a Partial Equilibrium Model

Individuals can allocate their time amongst many different types of activities. For the purposes of economic analysis, time is placed into three basic categories:

(a) employed time,

(b) unemployed time (time devoted to job search etc...), and

(c) leisure time

In the simple model under consideration the average economic value of a unit of time of a worker employed by a project is:

$$P^P W^P + (1-P^P)V^P, \qquad (3.1)$$

where

P^P = proportion of labour force time that a worker is employed on a project,

W^P = project wage rate, assumed equal to the marginal product of a worker, and

V^p = marginal value of unemployed time.

If we assume all project jobs are permanent, then $P^p = 1$, and equation 3.1 simply becomes

$$W^p \tag{3.1'}$$

In other words, the value of a unit of time of a worker employed by a project is the project wage rate. This has to be compared to the value of a unit of time of a worker in alternate activities in the labour market.

If project workers are sourced from the general labour force, then the EOCL is the economic value of their time in alternative activities, namely:

$$P^a W^a + (1-P^a)V^a \tag{3.2}$$

where

P^a = proportion of labour force time that a worker is employed in alternative employment,
W^a = wage rate in alternative employment, and
V^a = marginal value of unemployed time.

The labour externality in this case would equal

$$W^P - (P^a W^a + (1-P^a)V^a). \tag{3.3}$$

Since workers' employed time is generally more highly valued than their unemployed time (i.e., $W^a > V^a$), the labour externality becomes smaller as P^a and W^a rise. In other words, more highly skilled workers, who have excellent alternative employment opportunities, will generally have a lower labour externality than low skilled workers.

If workers are hired from outside the labour force, i.e. non-participants, then the EOCL is the value workers place on activities outside the labour force (household activities, and so on.) The value of this time must be at least as great as the value of time in the labour force less any welfare payments (S), i.e.

$$P^aW^a + (1-P^a)W^a - S \qquad (3.4)$$

In this case the labour externality becomes

$$W^P - (P^aW^a + (1-P^a)W^a - S) \qquad (3.5)$$

which is higher than expression (3.3) due to the saving of welfare payments, a positive externality.

This model can be made more realistic by allowing for personal income taxes and unemployment insurance benefits. In a labour-market where workers could determine the proportion of employed time at any given market wage (W^a), the marginal value of unemployed time (V^a) would have the following equilibrium value:

$$V^a = (W^a - U^a)(1-t) \qquad (3.6)$$

where

U^a = unemployment insurance benefits, and
t = personal income tax rate.

Substituting equation (3.6) into equation (3.3), the labour externality would thus become

$$W^P - (P^aW^a + (1-P^a)(W^a-U^a)(1-t))$$
$$= (W^P-W^a) + (1-P^a)U^a(1-t) + (1-P^a)(W^at) \qquad (3.7)$$

In other words, the labour externality would equal any rents workers earn on the project plus the saving in net-of-tax unemployment insurance benefits and the increase in personal income tax revenues.[1]

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[1] A rent is any payment in excess of the minimum amount required to attract incremental amounts of labour to project jobs.

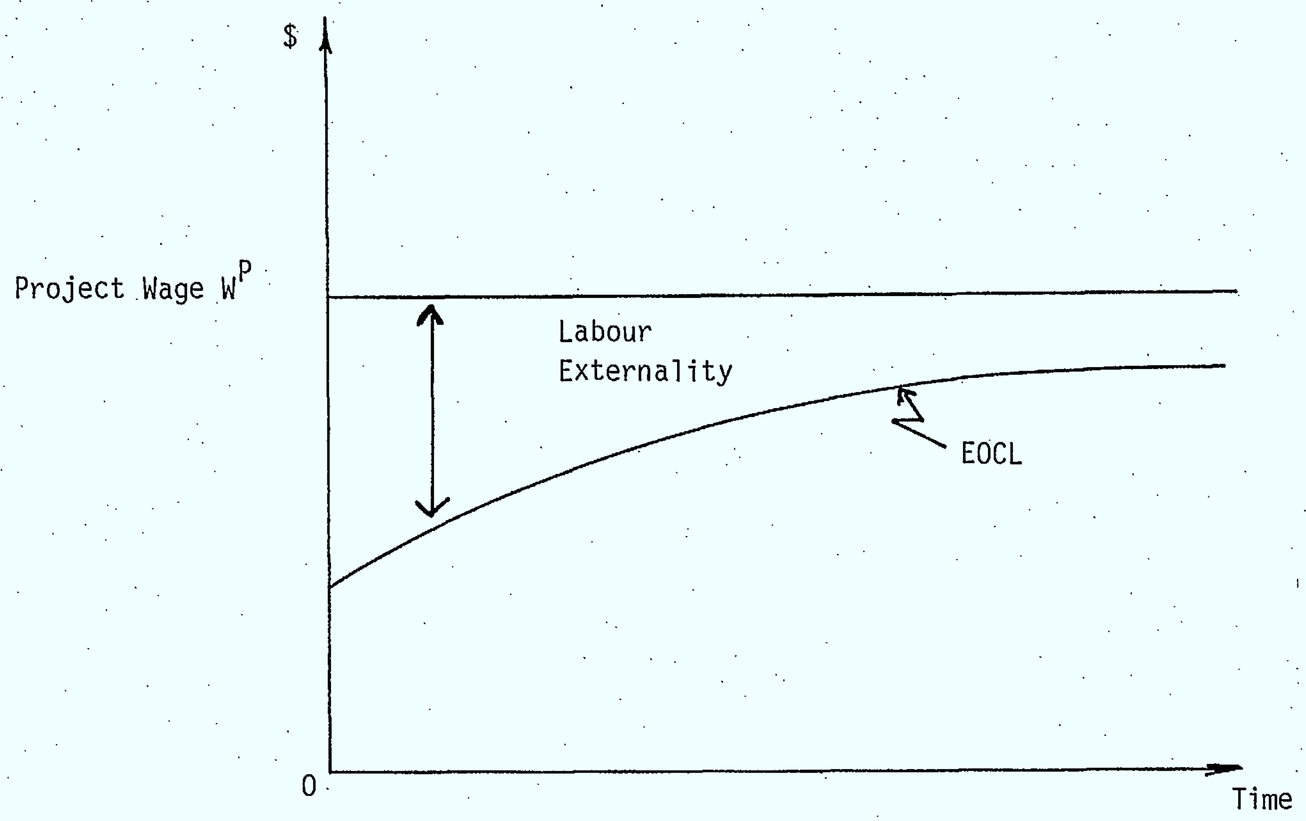
Remember, however, that it is the ultimate source of project labour that is of interest when making EOCL calculations. The dynamics of the labour market will dictate this source and the length of time it takes workers to respond to employment opportunities created by a project. For example, a project may initially hire a worker away from other employment activity. This will create a vacancy to which other workers will respond. The respondents may be other employed workers, unemployed workers, part-time or seasonal workers. In each case the economic opportunity cost of labour for the project depends on the type of worker who ultimately responds to the employment opportunities created.

For example, if project jobs were initially filled by unemployed workers with a relatively low EOCL, the initial labour externality would be quite high. However, as indicated in Figure 3.1 migrant labour might be attracted into the area over time with a corresponding rise in the EOCL and decrease in the labour externality.

If a job created by a project requires specific skills in which a short-run shortage exists, then to fill this job a worker with the appropriate skills must be bid away from employment elsewhere. The economic opportunity cost of labour is therefore the directly forgone wage rate for as long as the vacancy created remains unfilled. The longer the expected duration of the skill shortage, therefore, the higher the economic opportunity cost of creating jobs for workers with these skills.

Figure 3.1

Magnitude of the Labour Externality for Time



3.2.1 Labour Externality from Delayed Lay-offs

If a project delays the lay-off of workers in a firm by preventing a contraction or closure due to a permanent or temporary change in a firm's economic environment, then a positive labour externality can be derived from saving these jobs for some time period. The estimation of the economic opportunity costs of maintaining jobs by delaying a lay-off also requires a dynamic analysis.

When workers are laid off, they become unemployed or find alternative employment. The proportion of time they are expected to be employed will grow over time as they re-establish an employment pattern. In other words, the proportion of time employed in alternate activities (P^a) will increase with time. Hence, their EOCL will also increase.

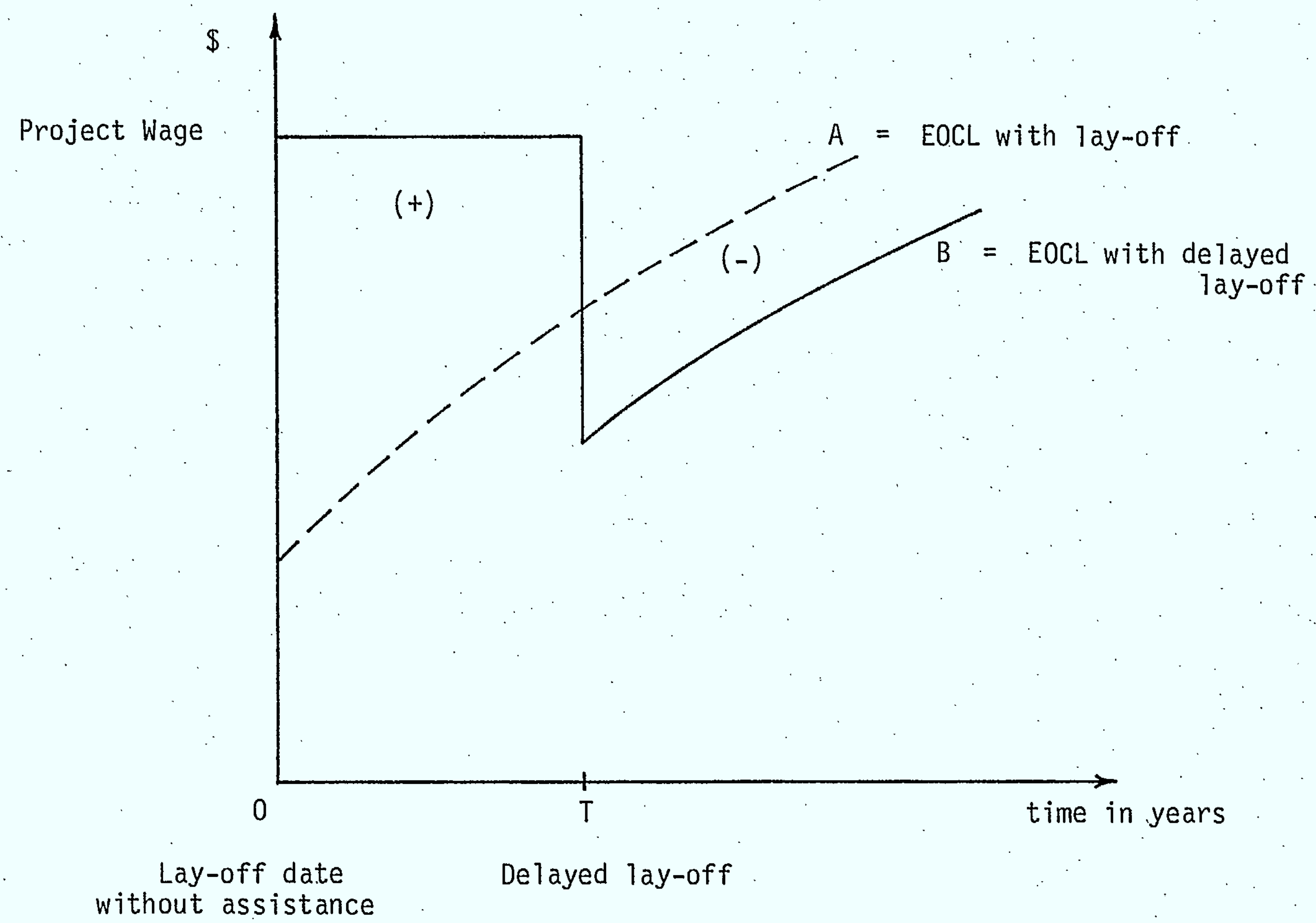
Figure 3.2 illustrates the changing economic opportunity cost of labour and the labour externality gained from saving jobs for T years. Curve A is the economic value of labour without a delayed lay-off, i.e., the economic opportunity cost of saving jobs. Curve B gives the incremental economic value of labour with a delayed lay-off. For the first T years this equals the wage bill, or the private value of the product of the labour. After T years the jobs are lost when assistance is discontinued and the EOCL falls in a discontinuous fashion at this point. Subsequently, it rises as workers begin to find alternative employment.

The present value of the area between the two curves, positive for the first T years and negative afterwards, yields the gross labour externality over the life of the project.

From the above analysis we see that in the presence of lay-offs both the adjustment time for workers to find new jobs and the productivity of

Figure 3.2

Labour Externality from Delayed Lay-offs



alternate employment, as reflected by wage rates, will affect the magnitude of the labour externality. An increase in the former will raise it, while an increase in the latter will lower it.

3.3 EOCL and Labour Externality Estimates

The above analysis indicated that the skill level of workers hired by a project is a major determinant of the labour externality. Highly skilled workers in short supply will have a lower labour externality than less skilled workers in more abundant supply. Three factors account for this:

(a) bidding away highly skilled workers can create extended unfilled vacancies;

(b) highly skilled workers have higher alternative wage rates, and

(c) highly skilled workers can generally find jobs and/or adjust to changing employment conditions more quickly and hence spend less time unemployed.

Note that higher wage rates generate higher income tax externalities, but less unemployed time decreases welfare and unemployment insurance externalities.

Evidence supporting these conclusions is documented in a study on the economic opportunity cost of labour at Pratt and Whitney. It was found that the net present value of the labour externality was 2.1 per cent of the wage bill for skilled workers - management and engineering - and 23.4 per cent for unskilled workers - production related.[1] These empirical

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[1] J. Alam and G. Fletcher, "Social Opportunity Costs of Employment Growth in Pratt and Whitney" (Ottawa: CEIC, August 1983).

observations are particularly relevant, because labour at Pratt and Whitney has similar characteristics to that at SPAR Aerospace. Both are companies in the aerospace industry and have facilities in the Montreal area; thus, both are subject to the same regional labour market.

These estimates for Pratt and Whitney are substantially lower than the average value of .45 for the ratio of the net present value of the labour externality to the wage bill for new jobs created in all industries in the Toronto region.[1] The major source of the differential is most likely the skill characteristics of labour in the aerospace industry, which is no doubt higher on average than that in other industries. Hence, they have better long-run employment prospects than less skilled workers, leading to a higher economic opportunity cost, and a lower labour externality.

Woods Gordon in its report, "MSAT Manufacturing Impact Study, Volume II: System Definition, Industry Capabilities Analysis and Export Market Analysis" (August 1984), states that 25 to 30 per cent of total employment in potential MSAT antenna and satellite manufacturing firms consists of engineering workers. This figure contrasts sharply to only 16 per cent of engineering workers in potential MSAT earth-segment manufacturing firms. The rest of the workers in both cases are primarily production oriented.

These data would suggest that the earth segment labour expenditures will yield a higher proportionate externality than space segment labour expenditures. However, there are two possible mitigating factors to such a conclusion:

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[1] John C. Evans et al., "A Manual for the Analysis and Appraisal of Industrial Projects in Canada" (Ottawa: DRIE, 1983), Chapter 13.

(a) the presence of technological externalities, i.e., new products or production processes developed by engineering labour that are not reflected in wage rates;

(b) the possibility of delayed lay-offs for engineering labour.

Both would act to increae the labour externality for engineering labour.

The first of these mitigating factors is a powerful political argument for promoting or maintaining jobs in high technology industries via projects such as MSAT. However, data presented in the Woods Gordon report suggest that it is unlikely technological externalities would materialize for the MSAT project because MSAT essentially represents a repackaging of existing technologies, many of which have already emerged in the United States, Japan or Europe.

If the MSAT project avoids lay-offs in participating firms, then the labour externality could be higher than it otherwise would be. There is an additional twist to this scenario, which takes the form of a possible "brain-drain" of laid-off skilled workers to other countries. One would presume that a brain-drain would raise the externality for skilled workers in the presence of lay-offs. Indeed it could, but not by as much as is commonly expected.

The loss that Canada incurs from the emigration of skilled workers is the future stream of their forgone personal savings and income tax payments less any unemployment insurance and welfare payments they would have received less any remittances they send back to Canada. This is essentially the difference between their marginal product - equal to their wages - and their consumption of domestic resources less any remittances. It is fallacious to argue that the loss to Canada would be the emigrant's entire marginal product because the cost of the resources they consume is omitted.

In a detailed estimation of the labour externality for the communications industry, the economic cost of emigrant labour could enter the analysis either in determining the loss due to a brain drain or in assessing the net benefit of that portion of the incremental employment that is taken by foreign workers. It is not unusual for firms to recruit highly skilled workers directly from foreign countries, which thus becomes one more source of project labour. Unfortunately, we do not have access to the detailed labour data needed to perform this type of calculation.

3.4 Economic Model Parameters

Given the information available at this time, we propose to calculate a labour externality for the MSAT project equal to the following:

(a) 2.1 per cent of the gross annual wage bill for skilled workers (management and engineering);

(b) 23.4 per cent of the gross annual wage bill for unskilled workers (production related);

(c) 6.4 per cent for other unspecified labour.[1]

If lay-offs are assumed in the presence of a brain-drain then the ratio of the labour externality to the wage bill for skilled workers might approach that of unskilled workers, whose EOC is close to their private supply price.

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[1] Based on estimates in J. Alam and G. Fletcher, "Social Opportunity Costs of Employment Growth in Pratt and Whitney" (Ottawa: CEIC, August 1983.)

We have chosen to base our labour externality calculations on the parameters given above, because the financial and engineering data from the other contractors contain few details regarding the type of jobs to be created by MSAT, the wage rates paid, the degree of permanency, or even the location of employment opportunities. Given these data limitations it is not possible to carry out a thorough analysis of the EOCL using the detailed economic models that are available.

Section 4 of Report Number 8

4.0 A Proposed Methodology for the Estimation of MSAT User Benefits

4.1 Introduction

Woods Gordon has attempted to estimate the net user benefits of MSAT services. In Section 6.0 of their report, "MSAT Market Definition and User Benefit Study" (April 11, 1984), user benefits were estimated for a high price scenario as lying somewhere between $20-$270 million - discounted at 10% over the life of the project. This specific scenario assumed a market of 88,000 users in 2002, with a terminal price of $4,000, an access charge of $200/month, and an airtime price of $2.00/minute.

Since we have already provided DOC with extensive comments on Woods Gordon's User Benefit Study and its implications for our study, it should suffice to summarize the main points, as follows:

1. Taken at face value, the very large range of possible user benefits makes interpretation of Woods Gordon's results not only difficult, but somewhat meaningless.

2. Woods Gordon's results are contingent on a particular set of market assumptions and are not readily extendable to Telesat's market assumptions (or any other set of market assumptions for that matter).

3. Woods Gordon's market data yield little information as to how market demand behaves at high MSAT service prices, i.e., in excess of $2.00/minute. It is the behaviour of demand at very high prices that determines the magnitude of user benefits.

Given the lack of specific information on the behaviour of market demand for MSAT services at high service prices, some general rule-of-thumb becomes the only viable means with which to estimate direct user benefits. A brief introduction to the theoretical basis of a proposed rule-of-thumb, followed by a description of its mechanics, is outlined below.

4.2 Methodology

The demand for MSAT services can be divided into two categories:

(a) displaced demand: users who would otherwise use an alternative communications technology to MSAT in its absence;

(b) new demand: users who either could not afford to use mobile communications at the existing configuration of prices or previously had no access to a viable mobile communications service.

User benefits for displaced demand primarily arise from communications cost savings, while user benefits for new demand will take other forms, e.g., gains in overall organizational efficiency. All this information would be reflected in a correctly estimated aggregate market demand function for MSAT services.

Measuring separately user benefits for new and displaced demand would have been both useful and informative because it would have provided a more concrete picture of the sources of potential benefits. However the sketchiness of information available on market demand precludes this option. Therefore, we shall proceed to measure user benefits in aggregate.[1]

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[1] Note that it is necessary to measure both new and displaced demand, when estimating incremental cash flows attributable to MSAT. Displaced demand gives rise to a forgone cash flow, i.e., the funds displaced users would have paid for an alternative to MSAT services. These forgone cash flows must be subtracted from MSAT cash flows to arrive at incremental cash flows. See Section 2.4 of our "Review of Other Contractors' Reports, Related Memoranda, Potential Problems, and Study Gaps of the MSAT Project", Report Number 2 of the Overall Socio-Economic Impact Study of the MSAT Program, (March, 1984) for a description of a methodology to estimate user benefits of new and displaced demand, separately.

A user of MSAT services faces two decisions:

(a) whether to consume any services at all, i.e., whether to sign on to the system;

(b) once on the system, how much airtime to consume.

The second decision provides a basis for an economic measure of user benefits, termed "consumers' surplus". A user's marginal demand price - the maximum price per minute of additional airtime - is the relevant yardstick with which to compute this measure.

Consumers' surplus is the maximum amount of income MSAT users would willingly forgo in order to be able to purchase airtime at the proposed configuration of airtime prices, access charges and mobile terminal prices rather than at some alternate set of prices over time. If any of these prices were higher, then consumers' surplus would be lower; with lower prices consumers' surplus would be higher. Aggregate consumers' surplus can be measured by the difference between the marginal demand prices indicated by the market demand curve and the market price that all users must pay. This is illustrated below both mathematically and diagrammatically [Figure 4.1].

Given complete knowledge of the market demand function for MSAT services, net user benefits (NUB) in any year are calculated mathematically as follows:

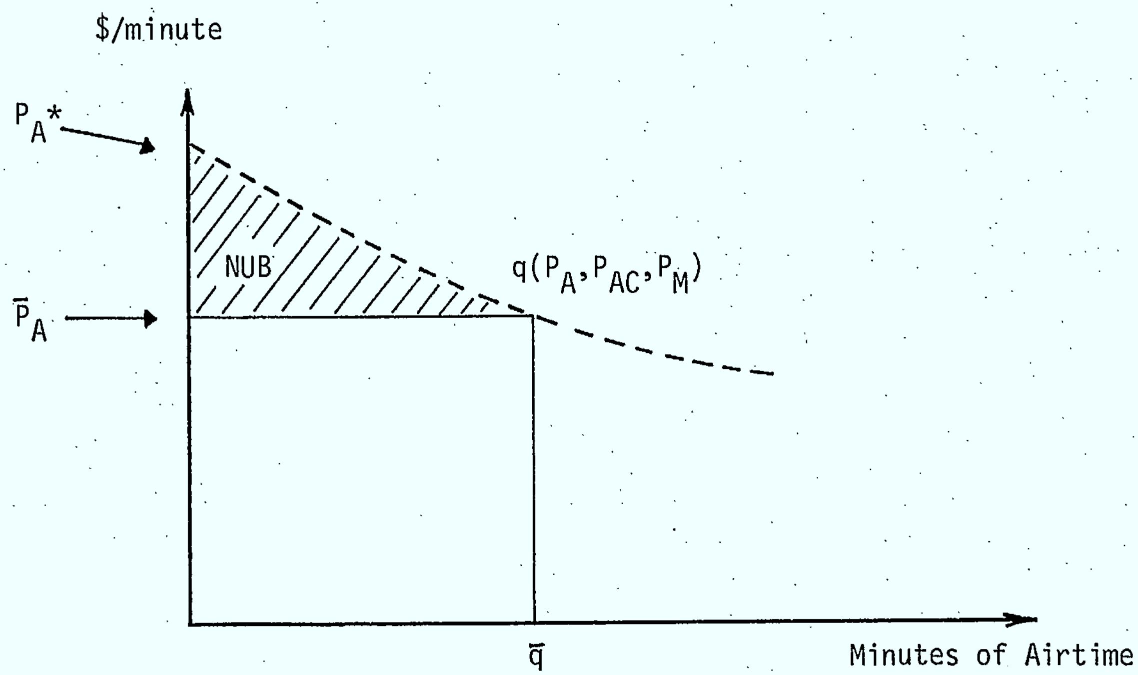
$$NUB = \int_{P_A}^{P^*_A} q\ (P_A,\ P_{AC},\ P_M)\ dP_A \qquad (4.1)$$

where P_A = price of MSAT airtime,

P_{AC} = access charge,

Figure 4.1

Measurement of Consumers' Surplus



$q(P_A, P_{AC}, P_M)$ = market demand function for airtime

P_A = airtime price

P_{AC} = access charge

P_M = mobile terminal price

Note that P_{AC} and P_M are considered fixed at $(\bar{q}, \bar{P}_A)$

P_M = price of mobile terminals,

q = $q(P_A, P_{AC}, P_M)$ = market demand function, for airtime

Equation [4.1] is simply the integral of the demand function from $\overline{P}_A$, the proposed market price of airtime, to P^*_A, the price of airtime at which demand falls to zero, given access charges and terminal prices.

Airtime price is the relevant variable in the market demand function for MSAT services with which to measure consumers' surplus because it is the variable that determines airtime consumption once users are on the MSAT system. To measure consumers' surplus, we ask the question, what is the maximum price MSAT users would pay for each additional minute of airtime over and above the prevailing price for airtime.[1] In other words, we are measuring the benefits to MSAT users over and above what they would pay for the service ($\overline{P}_A$).

If information on the entire market demand function for MSAT services were available, we could directly estimate net user benefits as the area NUB. Unfortunately, as indicated earlier the only information available is an estimate of demand for airtime, q, given prices P_A, P_{AC} and P_M. Thus, we must rely on some simple procedure or rule-of-thumb with which to estimate area NUB.

One approach is based on triangulation. Briefly, some assumptions are necessary on how demand behaves locally around ($\overline{q}$, $\overline{P}_A$), and these are used to linearize the demand curve from the point in question to the

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[1] To obtain an exact measure of consumers' surplus we ought to be holding consumers' level of well-being constant throughout this exercise. If their nominal incomes were held constant instead, then the resulting measure of user benefits would be slightly biased upward on the assumption that communications services are a normal good.

vertical axis. Figure 4.2 depicts this procedure diagrammatically.

This measure of user benefits (NUB') is derived mathematically as follows:

Let $P'_A - \overline{P}_A = \Delta P$ (4.2)

$\overline{q} - 0 = \Delta q$ (4.3)

Slope of tangent at $(\overline{q}, \overline{P}_A)$ is $dp/dq = -\Delta P/\Delta q$,

then

$$NUB' = 1/2 \Delta P \cdot \Delta q$$

$$= 1/2(\Delta P/\Delta q \cdot \overline{q}/\overline{P}_A) \cdot (\Delta q/\overline{q} \cdot \overline{P}_A) \cdot \Delta q$$

$$= 1/2 \cdot |1/\eta| \cdot \overline{q} \cdot \overline{P}_A \quad (4.4)$$

where,

$(\Delta P/\Delta q \cdot \overline{q}/\overline{P}_A) = -dP/dq \cdot \overline{q}/\overline{P}_A = |1/\eta|$, is the inverse of the absolute value of elasticity of demand (η) at $(\overline{q}, \overline{P}_A)$.

$(\Delta q/\overline{q} \cdot \overline{P}_A) \cdot \Delta q = (\overline{q}/\overline{q} \cdot \overline{P}_A) \cdot \overline{q} = (\overline{q} \cdot \overline{P}_A)$, which is simply total airtime revenues.

Equation (4.4) is interpreted as one-half, multiplied by the product of the inverse of the local elasticity of demand and total airtime revenues.[1]

As is evident from Figure 4.2, this method of measuring consumers' surplus likely produces estimates that are biased downward, i.e., area

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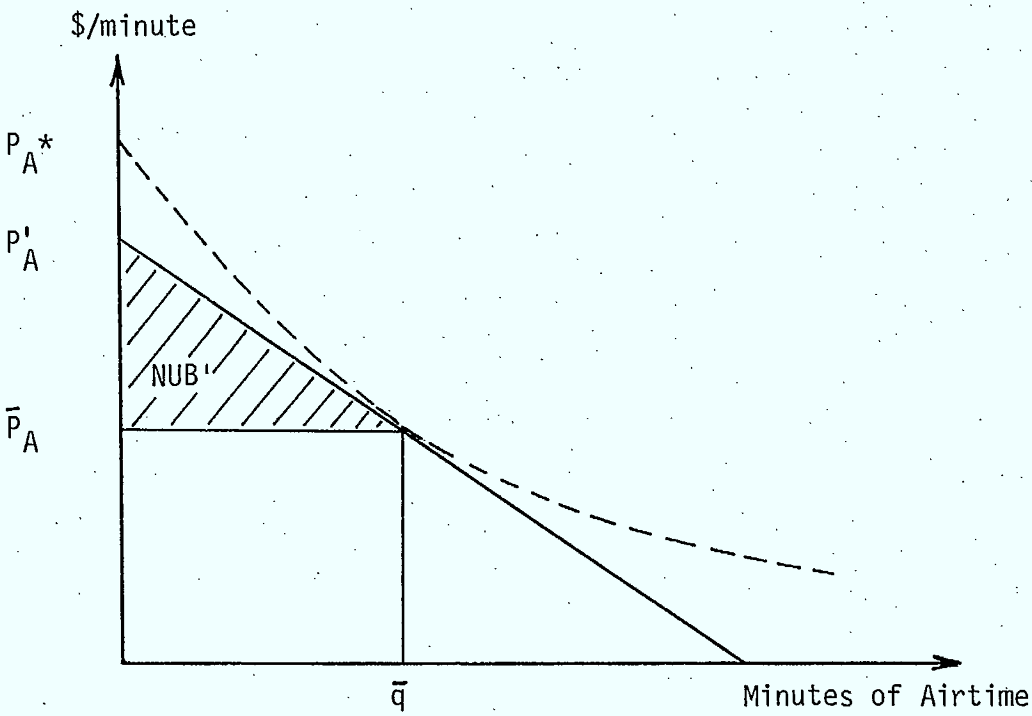
[1] The elasticity of demand is defined as the percentage change in quantity demanded as a result of a one percent change in price. Thus if the elasticity is -.5, then a 1 per cent rise in price will cause demand to fall by one-half of one percent.

Figure 4.2

Approximate Measure of Consumers' Surplus



NUB' is less than area NUB in Figure 4.1. However, at least we know the likely direction of the bias, assuming, of course, that the elasticity of demand and revenue estimates are accurate.

There are a few important points to note about the airtime elasticity used in the proposed methodology for the estimation of user benefits:

(a) the elasticity is itself a function of airtime price, access charge, mobile terminal price and quantity demanded;

(b) the elasticity more than likely varies over time;

(c) an assumption concerning the local elasticity of demand with respect to airtime is the minimum assumption required in order to make a calculation of user benefits, i.e., it requires the least information of any possible methodology.

4.3 Elasticity Estimates

Table 4.1 below provides estimates of airtime demand elasticities based on Woods Gordon MSAT partial price demand data. Appendix A provides a detailed explanation of how the elasticities were calculated.

We see that the Woods Gordon data indicate that demand is relatively inelastic at all service price combinations. This implies that MSAT users are willing to pay high prices for airtime yielding high levels of user benefits. Recall that according to equation 4.4 in the previous section, a lower absolute value for the elasticity of airtime demand will lead to higher user benefits.

Table 4.1

Airtime Elasticity Estimates from Woods Gordon Data

Airtime Price = $1.50/min

		Access Charge/$50	$200
Terminal Cost	$2000	-.265	-.204
	$4000	-.266	-.203

Airtime Price = $2.00/min

		Access Charge/$50	$200
Terminal Cost	$2000	-.388	-.291
	$4000	-.390	-.290

A quick check on the plausibility of the derived Woods Gordon elasticities is possible by calculating an implied average cut-off airtime price, i.e., the airtime price at which the average MSAT customer will consume no airtime (P'_A in Figure 4.2). We calculate the average cut-off price from the following formula:

$$P'_A = P_A(1-1/\eta) \qquad (4.5)$$

where,

P'_A = average cut-off price

P_A = current airtime price

η = elasticity of demand

For example, according to equation 4.5, the average cut-off price for customers consuming airtime at a terminal cost of \$4000, an access charge of \$50 and an airtime price of \$1.50 is \$7.14/minute (= \$1.50(1 - 1/-.266).[1] If a cut-off price of \$7.14/minute is considered too high at the above service price configuration and a number such as \$4.50 is considered more reasonable, then the new implied demand elasticity is -.50, i.e.,

$$\eta = \frac{-P_A}{(P_A-P_A)} = \frac{-1.50}{(4.50-1.50)} = -.50$$

This higher elasticity value will, of course, give rise to a lower level of user benefits. Thus, we see that the choice of a particular elasticity

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[1] Telesat in its Commercial Viability Study assumes an end-user price of airtime at \$1.50 per minute, whereas its wholesale price is \$1.25 per minute. The difference is the Service Providers mark-up. Note that for the purposes of this preliminary analysis we have not included retail sales taxes in the end-user price. We will however include this item in the calculations to be submitted as part of our final report.

implies a certain average cut-off price, and vice versa.

Other considerations that must enter into the choice of elasticities for MSAT user benefit calculations are the effects of time and competing technologies on MSAT demand. Woods Gordon provided partial price demand data for the year 2002, from which elasticities were calculated. There may be reasons to believe that demand is more or less elastic prior to 2002 depending on the status of competing technologies and the types of customers coming on stream.

For example, the presence of an alternate technology will put a ceiling on the cut-off airtime price for MSAT services. Similarly, the presence of more marginal customers on the system in later years will lower the average cut-off price and hence the aggregate elasticity of demand.

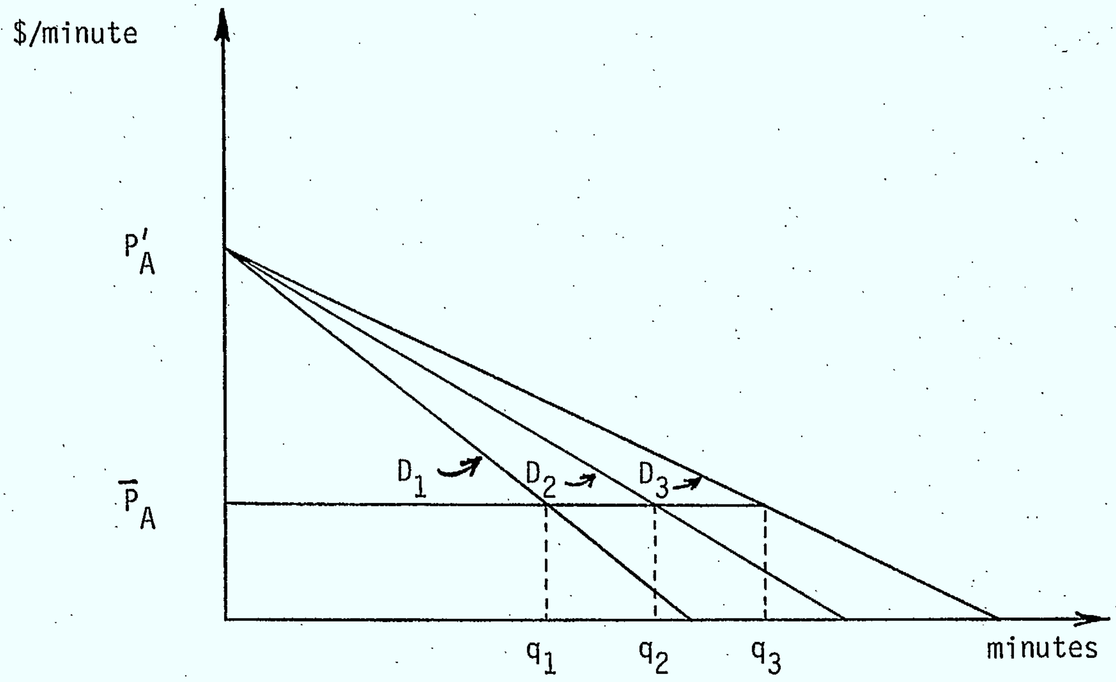
Figure 4.3 provides a diagrammatic illustration of the implications of an assumption of a constant elasticity of demand over time. The aggregate demand curve for MSAT services is shown as rotating over time with its vertical axis intercept, the cut-off price P_A', unchanged. Hence, the demand elasticities at q_1, q_2 and q_3 with constant price P_A will all be equal.

Figure 4.4 shows another possible scenario in which the aggregate demand curve for MSAT services shifts out uniformly over time. This implies a decreasing elasticity of demand at constant price $\overline{P}_A$, and the cut-off price is increasing.

We propose to use an elasticity of -0.266 in order to calculate net user benefits because it is based on an airtime price, access charge and mobile terminal price configuration that most closely approximates the values used in Telesat's commercial viability study.

Figure 4.3

Rotating Aggregate Demand Curve
with Constant Price Elasticity

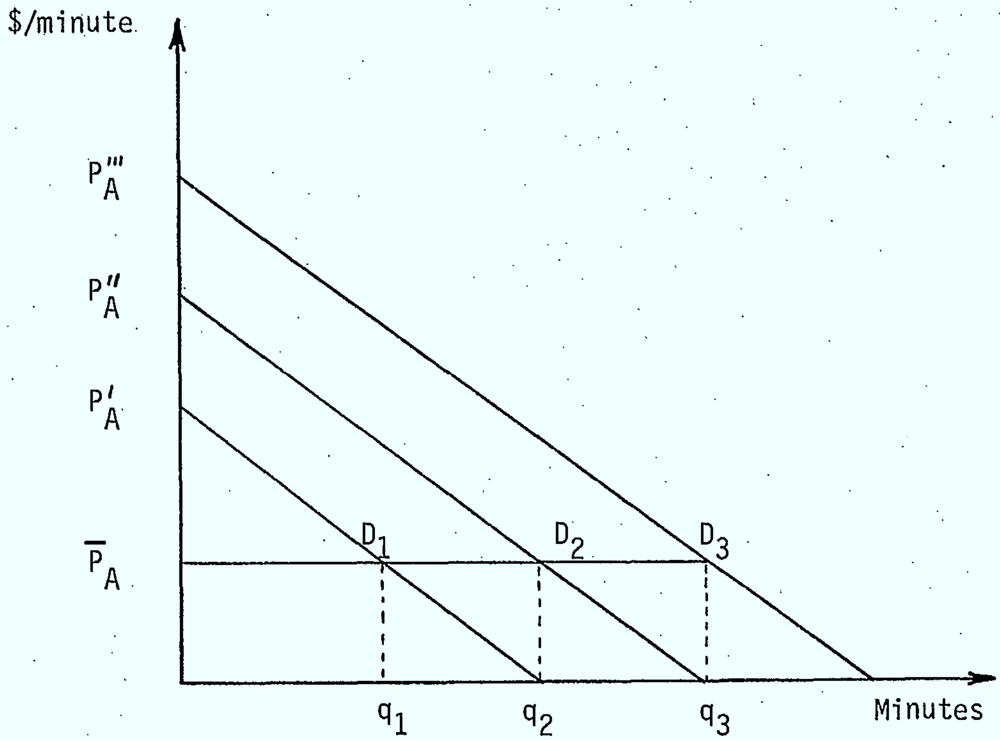


$\eta_1 = \eta_2 = \eta_3$

Figure 4.4

Uniform Shifting Aggregate Demand Curve with

Decreasing Price Elasticity of Demand



$$|\eta_1| > |\eta_2| > |\eta_3|$$

Section 5 of Report Number 8

5.0 Indirect Social Benefits

5.1 The Integration of the Social Impact Study with the Overall Socio-Economic Study

5.2 User Benefits versus Indirect Social Benefits

5.0 Indirect Social Benefits

5.1 The Integration of the Social Impact Study with the Overall Socio-Economic Study

The primary objectives of Wescom Communications Ltd. final Phase 1 report, "MSAT Social Impacts: Qualitative Assessments Final Report: (April, 1984) were as follows:

(a) to assess qualitatively the main social impacts of MSAT;

(b) to indicate the magnitude and likely occurence of selected impacts;

(c) to assess the impact of MSAT on government policy objectives.

As a result of this initial work, Wescom was commissioned to conduct a Phase 2 follow-on study in which it wishes to pursue a quantitative analysis of social impacts in the following areas:

(i) emergency medical services,

(ii) lives lost or saved,

(iii) fire service provision,

(iv) ambulance services,

and to investigate further:

(v) transportation,

(vi) oil rig services,

(vii) forest fire services, and

(viii) wide area paging (rural hospitals).

We recognize that Wescom's Phase 2 study has a much broader set of objectives than assigning monetary values to various types of social benefits caused by the introduction of MSAT services. However, our study takes a much narrower approach to the potential social impacts of MSAT.

Specifically, only the quantifiable monetary values of social benefits can be incorporated into our empirical work. We do not mean to say that non-measurable social impacts are unimportant, but that they are not part of the scope of our work which is to address the impacts of MSAT on an economic basis. Wescom's qualitative results will thus not be integrated fully into the Overall Socio-Economic Impact Study.

5.2 User Benefits Versus Indirect Social Benefits

As explained in Section 4.0, net user benefits are measured on an economic basis by the willingness-to-pay criterion and are defined as the additional amount of income users would willingly pay for MSAT services over and above what they are paying (without altering their well-being). Net user benefits can be estimated from a market demand function by calculating the area under the function that lies above the price line.[1] A properly specified market demand function for MSAT services should reflect all information entering a decision to purchase MSAT services. For example, information regarding communications cost savings, organizational efficiency gains, expanded business opportunities, etc. should be reflected in a market demand function, and hence, in a net user benefit calculation based on the willingness to pay criterion.

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[1] This is actually a calculation of consumers' surplus, mathematically expressed as:

$$\int_{\bar{p}}^{\infty} q(p)dp$$

where,

$\bar{p}$ = prevailing market price
$q(p)$ = a market demand function

Social benefits of MSAT, some of which are being quantified by Wescom, are distinct from user benefits because they do not accrue directly to end-users of MSAT services. They may accrue to third parties affected by the activities of end-users or to society as a whole, hence we refer to them as indirect social benefits.

Judging from the categories of social impacts that Wescom has chosen for further quantitative investigation - emergency medical services, lives saved, fire protection and ambulance services - indirect social benefits will most likely arise from the impacts MSAT may have on the provision of public services. In other words, public service providers can provide more or better services as a result of MSAT. However, a subtle distinction must be made between organizational effects that MSAT may have on public service providers and effects on the recipients of public services themselves. The former are user benefits and may take the form of reduced operational costs and other savings, while the latter are indirect social benefits.

Indirect social benefits do not necessarily have to manifest themselves as a greater or better provision of public services. For example, an owner of a mobile terminal in a remote community may provide other members of the community with greater access to news from the outside world. Thus, third parties - non-users - are indirectly receiving benefits from MSAT services. What these two types of indirect social benefits have in common is that no observable market exists in which the services can be bought and sold, but nevertheless they have value to individuals.

This distinction between indirect social benefits and user benefits is important in order to avoid double-counting. For example, operational savings to public service providers are technically user benefits and should be clearly distinguished from indirect social benefits accruing to the recipients of public services. Implicitly, operational savings would be included in any aggregate estimate of net user benefits; therefore, including this item with indirect social benefits would amount to double-counting.

Where possible, it would be very useful to have information about the mechanism by which indirect social benefits would be achieved. For example, if it is postulated that additional lives could be saved by MSAT services, then this should be supported by strong arguments and examples as to how they would be saved, and the likelihood that these savings would be achieved.

Section 6 of Report Number 8

6.0 Foreign Financing Externality

6.0 Foreign Financing Externality

It appears that Telesat has relied in the past on foreign capital markets for at least part of its debt capital, and MSAT may be no exception in this regard. Foreign financed projects either draw incremental foreign capital into Canada or reallocate the foreign investment already present within the country. In either case it is necessary to estimate the corresponding externality.[1]

For foreign investment to be considered incremental it is necessary that foreign investors wish to finance a project without altering their other intended investments in Canada. In this sense the foreign financing must be incremental to what a project's foreign investors would otherwise invest in Canada. It is also necessary that the foreign financing be project specific, and not just general investment in an industry, and that the initiation of the project be dependent upon obtaining foreign financing.

The adjustment on incremental foreign capital consists primarily of removing the inflows and outflows of foreign funds, discounted at the social discount rate, from the net economic benefits that accrue to Canadians. If foreign investors were earning a rate of return greater than the social discount rate, then the remaining net economic benefits would be lower. The externality on the incremental foreign financing also includes a foreign exchange externality minus a country risk externality due to the country risk premium. (The latter is also present in the

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[1] This discussion is drawn from J.C. Evans et al., "A Manual for the Analysis and Appraisal of Projects in Canada," prepared for the departments of Regional Economic Expansion and Industry Trade and Commerce (Ottawa, 1983), Chapter 17.

estimation of the social discount rate.)

When project foreign financing is non-incremental, it is simply assumed to reallocate the foreign capital already present in Canada away from its alternate uses. Thus, the crucial question is whether the MSAT project would yield foreign investors a greater than normal return. If the project's foreign investors were earning a higher than normal return, then a negative externality would be computed. This externality also includes foreign exchange and country risk externalities. However, if a positive externality were estimated, then it should not be included in the amount of the externalities that will determine the magnitude of government financial assistance. The reason is that government assistance may be designed to bring investors up to a normal rate of return, but if this were achieved, then the positive externality would be eliminated and too much assistance would have been offered. The only way to avoid this circularity is to exclude the positive externality.

It seems more than likely that purchases by foreign investors of bonds that Telesat would issue as a result of the MSAT projet would constitute general portfolio investment. Hence, there is no reason to believe that this investment is specifically tied to the MSAT project. Therefore, we will assume that all foreign debt financing is non-incremental, i.e., it would have occured anyway without MSAT.

The economic externality associated with MSAT related foreign debt calculated by the economic model is equal to:

$$(1+f_x)(1-\gamma)(R-1) \cdot \begin{pmatrix} \text{capital outflows} \\ \text{to foreign investors} \end{pmatrix}, \qquad (6.1)$$

and, $(6.1) = 0$ if $R \geqslant 1$;

where

$$R = \frac{\text{NPV of all foreign capital inflows (debt issued) at 6\%}}{\text{NPV of foreign capital outflows (interest and debt payments) at 6\%}}$$

f_x = foreign exchange premium (.07)

γ = country risk premium (.02)

The foreign financing externality will be negative if foreign investors earn a real (net of inflation) rate of return on Telesat's debt in excess of 6 per cent, which is roughly the average rate of return earned by foreign investors elsewhere in the Canadian economy. A positive externality is excluded for the reasons outlined above.

Section 7 of Report Number 8

7.1 Determining Project Attractiveness and Direct Government Financial Assistance

The NPV of the incremental net cash flow, calculated with a private discount rate, serves as a basis for assessing MSAT's financial attractiveness for each of the participants. A negative NPV measures the minimum amount of assistance that a participant would have to receive in order to induce it to invest.

In order to measure a project's attractiveness from a public perspective, the financial cash flows must be modified to take account of a number of economic adjustments and externalities. The NPV of the resulting incremental economic benefits and costs for the total MSAT project, calculated with a social discount rate, provides a measure of its overall economic attractiveness.

The social discount rate measures the time value of a project's incremental economic benefits and costs, and hence is used to calculate their net present values. Given the same private and social cost of risk, the chief difference between a social and a private discount rate is primarily due to the amount of forgone tax revenue per dollar of capital invested. By using a social discount rate, a project is in essence charged for the normal tax revenue and any other externalities that the capital used to finance a project would have generated if it had been left in the capital market.

The maximum amount of direct financial assistance that Canadians not investing in MSAT (i.e., Canadian taxpayers) would want to make available is measured by the NPV of the incremental net economic externalities discounted by the social discount rate. They are measured as the sum of the incremental net user benefits, net commodity tax revenues, net tariff revenues, net economic rents, net income taxes, plus any externalities on labour and foreign financing, minus the cost of abnormal risk (if any) minus the economic externalities that would have been generated by the capital if it had been invested in the capital market. Note that,

$$\begin{pmatrix}\text{NPV of incremental net}\\ \text{economic externalities}\\ \text{at the social discount}\\ \text{rate}\end{pmatrix} = \begin{pmatrix}\text{NPV of incremental net}\\ \text{economic benefits at}\\ \text{the social discount}\\ \text{rate}\end{pmatrix} - \begin{pmatrix}\text{NPV of incremental}\\ \text{net cash flow to}\\ \text{private investors}\\ \text{at the private}\\ \text{discount rate}\end{pmatrix}$$

$$= \begin{pmatrix}\text{NPV of Gross}\\ \text{Economic}\\ \text{Externalities}\end{pmatrix} - \begin{pmatrix}\text{NPV of Taxes}\\ \text{and}\\ \text{Externalities}\\ \text{Forgone}\end{pmatrix} + \begin{pmatrix}\text{NPV of Net}\\ \text{User}\\ \text{Benefits}\end{pmatrix} + \begin{pmatrix}\text{NPV of Indirect}\\ \text{Social Benefits}\end{pmatrix}$$

Direct government financial assistance should be offered to an MSAT participant only if the NPV of the total project's incremental net economic benefits is positive and if the NPV of the incremental net cash flow of that participant is negative. Each participant should receive only enough assistance to offset any negative NPV of net cash flow at the private discount rate. The maximum amount of direct government financial assistance to all participants is determined by the magnitude of the NPV of net economic externalities defined above.

Once a decision has been made to provide government financial assistance to one or more project participants, the type of financial assistance must also be determined. Two key considerations should enter this decision, namely:

(a) The particular form of financial assistance offered should not alter a participant's behaviour so as to reduce the incremental net economic benefits arising from a project; this is sometimes called incentive compatability.

(b) Since the taxpayers' total cost of financial assistance should not exceed the total amount of net economic externalities generated by the overall project, some types of financial assistance may be ruled out as too expensive. Thus, the cost of each type of financial assistance must be computed.

Table 7.1 provides a handy summary of the effects of various forms of government subsidy on private businesses. Private investors would undoubtedly prefer an unconditional, lump-sum cash grant to any of the alternate forms of assistance contained in Table 7-1, but that is hardly possible when the assistance is firm and project specific. Instead most investors would rank the forms of assistance in decreasing order of preference as they appear in the table. It has also been suggestd that governments would prefer the opposite ranking at least with respect to the effects on the choice of production technique and financial structure. Note, however, that government equity participation can entail a sizeable increase in withdrawals in kind and monitoring costs and a decrease in risk aversion on the part of managers.[1]

As a result of these differences in ranking the types of financial assistance, there may be a tendency for private investors and governments to seek the middle ground of loan or other forms of guarantee. A sales revenue or rate of return guarantee would be particularly attractive to investors considering a project that introduced a new product for which the market forecasts were highly uncertain. Guarantees have also been popular instruments for assistance because they do not require an immediate expenditure of government funds and their cost was usually

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[1] Economic Council of Canada, Intervention and Efficiency, (Ottawa: Ministry of Supply and Services, 1982): 147.

Table 7.1
Effect of Various Forms of Government Subsidy on Businesses in the Private Sector

	Characteristics of the business		Behaviour of managers (agency costs)			Financing	
	Operating risk	Financial risk	Diligence	Attitude toward risk of projects	Withdrawals in kind and monitoring costs	Cash flow	Income tax
Form of Subsidy:							
Investment subsidy[1]	Increase	Decrease (induced effect)	None	None	None	Permanent contribution and increase in borrowing power	Increase
Production subsidy	Increase	Decrease (induced effect)	None	None	None	Permanent cyclical contribution	Increase[2]
Loan	Decrease (induced effect)	Increase	None	Decrease in case of "extreme" indebtedness	Slight increase	Temporary contribution	Decrease
Loan guarantee	Decrease (induced effect)	Increase	None	Decrease in case of "extreme" indebtedness	Slight increase	Temporary contribution	Decrease
Convertible loan	Decrease (induced effect)	Increase (before conversion)	Decrease	None	Increase	Permanent contribution with "success" only	Decrease
Redeemable, preferred share capital	Increase (induced effect)	Increase	None	Decrease	Slight increase	Permanent contribution	None
Common share capital	Decrease (induced effect)	Decrease	Decrease	Decrease	Significant increase	Permanent contribution and increase in borrowing power	None

[1] Compared with a tax-free gift.

[2] If the timing of payments is faster than that of tax depreciation.

Economic Council of Canada, Intervention and Efficiency, (Ottawa: Ministry of Supply and Services, 1982) Table C-1, p.148.

difficult to estimate (nor was their cost incorporated into the sponsoring department's envelope allocation). For these reasons a major part of this section is devoted to evaluating the cost of guarantees to taxpayers. The subsequent discussion of loan guarantees sets the stage for a consideration of rate of return and revenue guarantees later in the section.

7.2 Loan Guarantees

A federal loan guarantee is a transfer of risk from a project's private investors to the federal government, and thus to taxpayers in general. Risk has a cost, and hence the loan guarantee has a cost even though it may never be exercised. Government provision of a loan guarantee is often justified on the basis of spreading the burden of risk over society as a whole, as if this somehow made the risk disappear. However, only a capital market imperfection or failure would cause the social cost of risk to be substantially less than its private cost. In other words, the government is unlikely to be more efficient at diversifying risk than a project's investors when both have access to the same capital market. Thus, an MSAT participant would value a government loan guarantee because it would reduce the expected cost of raising debt capital.

As indicated in Table 7.1, care must be taken in defining the terms of a loan guarantee so that a recipient does not alter his behaviour as a result of such a guarantee, i.e., borrow more money than he otherwise would or engage in riskier ventures that lie outside the scope of the project for which a loan guarantee has been granted. Note that if a firm runs a loss on other ventures, its ability to pay back loans granted for a project will also be affected.

In the sections that follow we outline a methodology for valuing loan guarantees. It is based on the assumption that risk has the same cost whether it is borne by private investors or the federal government.

7.2.1 A General Methodology to Determine the Value of a Loan Guarantee

Black and Scholes suggest that the equity in a levered firm can be thought of as a "call" option, which is an option to buy the assets of a firm at a predetermined price at some point in the future.[1] Analogously, when shareholders issue bonds, it is equivalent to selling the assets of a firm (but not control over them) to bondholders in return for cash and a call option, i.e., the option to repurchase the assets provided all debt can be paid off.

In order to reduce this analogy to its simplest form, assume a firm issues pure discount bonds and that there are no transaction costs or taxes. If on the maturity date the value of the firm exceeds the face value of the bonds, then shareholders will exercise their call option by paying off the bonds and keeping the excess. However, if the value of the firm is less than the face value of the bonds, then shareholders will default on their debt by deciding not to exercise their call option. Therefore, at maturity the value of shareholders' equity is

$$E_T = \text{Max}\ [0, V_T - D_T],$$

---

[1] F. Black and M. Scholes, "The Pricing of Options and Corporate Liabilities" Journal of Political Economy, (May/June 1973). A good overview of option pricing theory is available in T. Copeland and J. Weston, Financial Theory and Corporate Policy (Reading, Mass.: Addison-Welsley Publishing Co., 1983).

and the value of bondholders' wealth is

$$B_T = \text{Min}\ [V_T, D_T]$$

where, V_T = value of assets at maturity,

D_T = face value of debt at maturity,

T = maturity date.

The realization that debt and equity in a firm can be conceptualized as options allows us to use some of the results of options pricing theory to value the debt and equity of a levered firm.

An important result from the options approach to financial asset valuation arises from the option shareholders have to default on bonds. If the value of a firm's assets at maturity is less than the face value of the debt, shareholders will default; they are not legally required to make up any shortfall. The option to default has value and can be viewed as a "put" option, which is an option to sell the assets of a firm at a specified price at some date in the future. Therefore, the value of equity in a firm can be viewed equivalently as either

(a) the value of a call on a firm's assets

or

(b) the current asset value less the present value at a risk-free discount rate of payments to bondholders plus the value of a put option on the assets - the option to sell the firm to bondholders at a price equal to the face value of debt at maturity.

Note that the put option in (b) above is the option of shareholders to sell the firm to bondholders at a price equal to the face value of the debt at maturity. For example, if the firm's assets have a maturity value less than the face value of debt then the put option has a value at maturity equal to this shortfall, i.e., shareholders are conceptually selling (transferring) their obligation to pay off the shortfall back to the bondholders. Thus, we see that debt in (b) must be discounted at the risk-free discount rate, because default risk is incorporated into the value of the put option.

Combining (a) and (b) above yields,

$$E_o = V_o - \frac{D_T}{(1+i_f)^T} + P_o \qquad (7.1)$$

where,
E_o = current value of equity (call option),
V_o = current asset value,
D_T = face value of debt at maturity,
P_o = current value of put option,
i_f = risk-free interest rate,
T = date of maturity.

The market value of the debt and equity of a firm always equals the market value of its assets. This can be expressed as

$$V_o = E_o + B_o, \qquad (7.2)$$

where, B_o = the market value of the debt.

Substituting (7.1) into (7.2) yields the following equation for the current market value of a firm's bonds,

$$B_o = \frac{D_T}{(1+i_f)^T} - P_o \qquad (7.3)$$

Equation (7.3) states that today's market value of bonds is equal to the present value of promised payments to bondholders discounted at a risk-free interest rate less the present value of a put option on the underlying assets of a firm. The value of the put option is the default risk component implicit in the price of the bonds.

Equation (7.3) can be rewritten as

$$\frac{D_T}{(1+i)^T} = \frac{D_T}{(1+i_f)^T} - P_o \quad , \qquad (7.4)$$

or

$$P_o = \frac{D_T}{(1+i_f)^T} - \frac{D_T}{(1+i)^T} \quad ,$$

where i = a firm's risk-adjusted market interest rate.

Equation (7.4) provides us with a conceptual solution to the problem of valuing a loan guarantee. The value of a guarantee is the value of a put option on a firm's assets, which is equal to the present value of the default risk. The value of a loan guarantee is also equal to the value of the bonds with a guarantee less the value of the bonds without a guarantee.

If i, the risk-adjusted market interest rate, is directly observable then the guarantee can be evaluated directly. However, if bondholders' risk adjusted discount is not known then the put option must be evaluated by some other means. The latter case is more likely, since in the presence of a guarantee, i, cannot be observed directly, unless some a priori information is available on the likely value of i.

7.2.2 Value of a Loan Guarantee when Bondholders' Risk-Adjusted Market Interest Rate is Known

When the federal government guarantees loans to bondholders in the private sector, it assumes the financial risk that the bondholders would otherwise assume. Total project risk is not reduced and may even be increased. In the previous section we determined that the value of the loan guarantee to private investors or conversely, the cost of the guarantee to taxpayers is equal to

$$\begin{pmatrix}\text{NPV of principal and} \\ \text{interest payments at} \\ \text{a risk-free discount} \\ \text{rate}\end{pmatrix} - \begin{pmatrix}\text{NPV of principal and} \\ \text{interest payments at a} \\ \text{risk-adjusted discount} \\ \text{rate}\end{pmatrix}$$

The guarantee essentially makes the loan a risk-free prospect to private investors - outside of any inflation risk.

Thus for a pure discount bond, the type of bond used in the examples of the previous section, the value of the guarantee can be expressed as

$$P_o = \left(\frac{1}{(1+i_f)^T} - \frac{1}{(1+i)^T} \right) D_T \qquad (7.5)$$

Clearly, the value of the guarantee increases as the time to maturity, T, increases, and the risk-adjusted discount rate increases. If interest payments and principal payment on the bonds were made prior to maturity, the value of the guarantee would decrease relative to the case of the pure discount bond. The value of the guarantee would decrease if the value of the assets underlying the put option were to rise relative to the outstanding debt;[1] this would also manifest itself as a reduction in i relative to i_f.

The appropriate risk-free interest rate with which to value a federal government loan guarantee would be the yield to maturity on a federal government bond with a term to maturity equal to the expected length of life of the underlying assets since both are subject to inflation risk.[2]

---

[1] Recall equations (7.2) and (7.3).

[2] The yield to maturity on 90 day government treasury bills is usually taken to be a good measure of a risk-free discount rate because the short term to maturity entails negligible inflation risk. In the case of a loan guarantee, however, the government is assuming the default risk on debt whose term is probably matched to the expected length of life of the assets purchased.

Table 7.2 below outlines a sample calculation of the value of a loan guarantee. The analysis is conducted in current dollars with an 8 per cent expected rate of inflation, hence the discount rates are in nominal (gross of inflation) terms. Note the analysis could have just as easily been conducted with real - inflation adjusted - discount rates and still have yielded identical results.

The results show that based on a 14 per cent risk-adjusted discount rate, an 11 per cent risk-free discount rate, and a 17 year maturity on the loan principal, a loan guarantee is valued at 22.6 per cent of the amount borrowed. Figure 7.1 illustrates how the value of the guarantee varies with different risk-adjusted discount rates and the same risk-free discount rate. The relationship appears to be linear.

7.2.3 Value of a Loan Guarantee when Bondholders' Risk-Adjusted Interest Rate is Not Known

When bondholders' risk-adjusted interest rate is not known, then the value of the default option - the put - on a firm's assets must be determined indirectly. Black and Scholes provide a closed-form solution for the valuation of European puts and calls that can be used for this purpose.[1] They recognized that a risk-free-hedge portfolio can be formed consisting of a long position in an asset and a short position in a European call written on the asset. Also, a risk-free-hedge portfolio can be formed consisting of a long position in an asset and a long position in a put on the asset. In market equilibrium the rate of return on the

---

[1] See F. Black and M. Scholes, op.cit. European options can only be exercised on a fixed maturity date. American options can be exercised at any time. It can be shown that for given parameters an American option will always be worth more than a European option.

Table 7.2

Sample Calculation of the Value of A Loan Guarantee when Bondholders' Risk-Adjusted Discount Rate is Known

Assumptions:

1. Cost of Debt = 14%

2. Risk Free Interest Rate = 11%

3. $100M is borrowed for 17 years, interest is paid at 14% per year for 17 years at which time the entire principal is paid back.

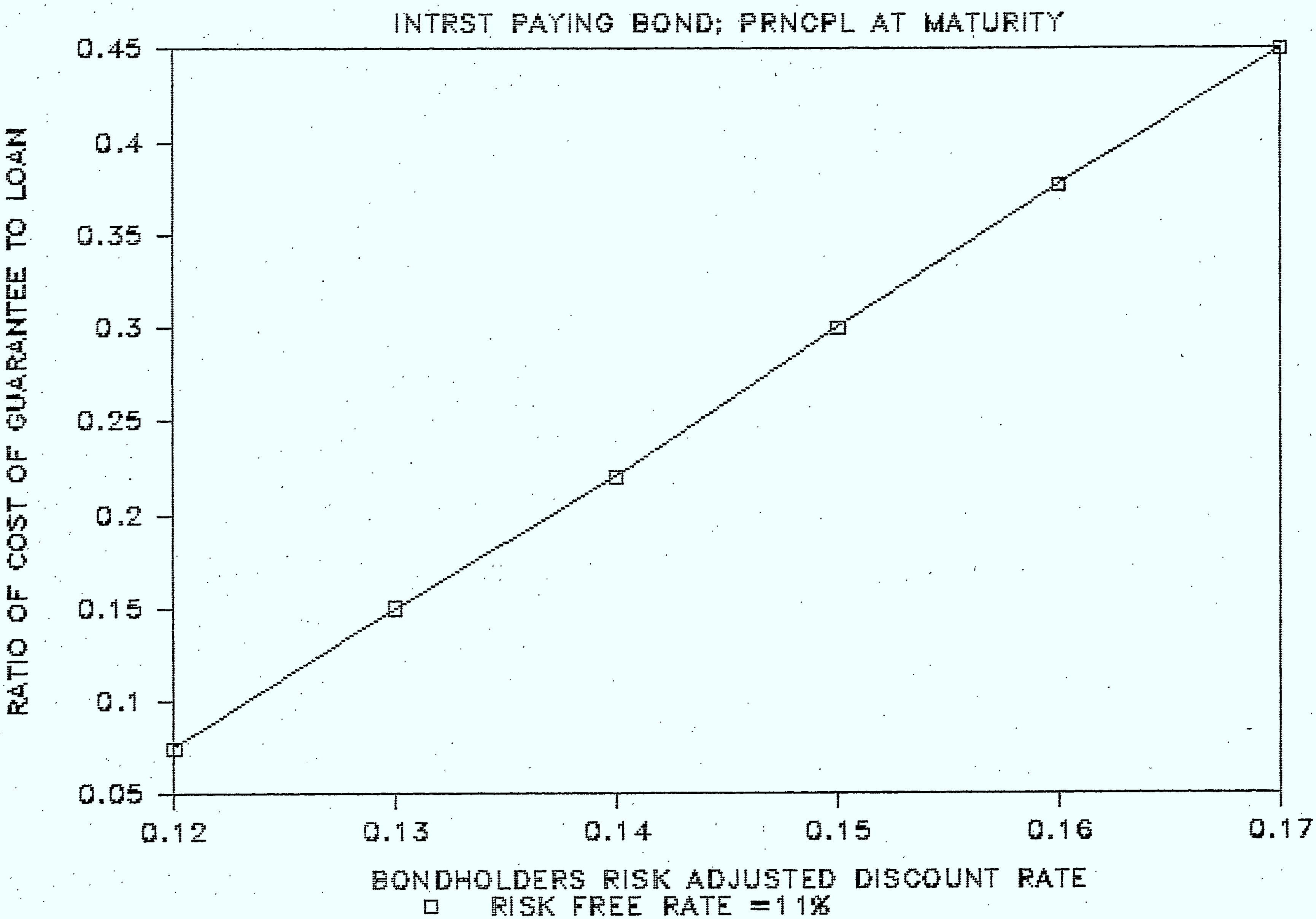
4. Time profile of payments

+100M	+14M	+14M	. . . . . .	+114m
t_o	t_1	t_2	. . . . . .	t_{17}

NPV of Principal and Interest Payments at 11% − NPV of Principal and Interest Payments at 14% = Cost of Guarantee

= 122.6M − 100M = 22.6M

FIGURE 7.1


INTRST PAYING BOND; PRNCPL AT MATURITY
RATIO OF COST OF GUARANTEE TO LOAN
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0.12
0.13
0.14
0.15
0.16
0.17
BONDHOLDERS RISK ADJUSTED DISCOUNT RATE
RISK FREE RATE =11%

risk-free-hedge portfolio in both these cases will duplicate the return on a risk-free asset such as a government bond. Black and Scholes postulate that the price of an asset obeys a geometric Brownian motion process - the continuous time analogue of a random walk with drift - that can be specified as follows:

$$\frac{dV/dt}{V} = \mu + \sigma\, dz/dt \qquad (7.6)$$

Equation (7.6) can be interpreted as the instantaneous rate of return on a firm's assets being equal to a mean rate of return, , plus a white noise error term . z/dt . It shall be noted the (7.6) implies a log normal distribution for the value of an asset with a variance that increases with time.

Black and Scholes derive the following solution for the price of a European put based on the above assumptions, namely:

$$P_o = (1 - N(d_1))\ V_o + (1 - N(d_2))\ D_T e^{-i_f T} \qquad (7.7)$$

$$N(d_1) = \frac{\ln(V_o/D_T) + i_f\ T}{\sigma\sqrt{T}} + 1/2\sigma\sqrt{T} \qquad (7.8)$$

$$N(d_2) = d_1 - \sigma\sqrt{T}$$

The functions $N(d_1)$ and $N(d_2)$ are cumulative probabilities for a unit normal random variable

P_o = value of the put

V_o = current asset value

D_T = exercise price of a put option

i_f = risk-free interest rate

T = time to maturity

σ^2 = variance of asset rate of return

From (7.7) it can be shown that the value of the put increaes as the exercise price increases, the time to maturity increases, and the variance of the asset rate of return increases.

Equation (7.7) can be used to calculate the value of the default risk on a firm's pure discount bonds by assuming the following:

(a) D_T = the exercise price of a put option = the face value of a firm's bonds at maturity, and

(b) V_o = current asset value = current market value of a firm's assets.

The value of the default risk can then be estimated for different values of σ^2, the variance of the rate of return on the assets.

Equation (7.7) can also be used in the context of project evaluation by setting V_o equal to $1 and D_T equal to the face value of bonds at maturity per $\$(D_o/V_o)$ of debt issued at the start of a project, where (D_o/V_o) is the debt-asset ratio of project funding. Thus P_o is interpreted as the value of the default risk per $\$(D_o/V_o)$ of debt issued. Table 7.3 provides some sample calculations based on the use of the Black and Scholes model.

From Table 7.3 we see that the value of the default risk as a proportion of debt issued increases as the variance on the asset rate of return increases.[1] Higher face values of debt at maturity will also generate higher values of default risk.

Figure 7.2 provides a graphical illustration of how the cost of a loan guarantee changes with the variance of a project's rate of return.

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[1] The reason the default-risk ratios are in excess of one at very high variances is that the face value of debt discounted at the risk-free discount rate is greater than the principal on the loan.

Table 7.3

Estimates of the Value of a Loan Guarantee

Using Black and Scholes Model

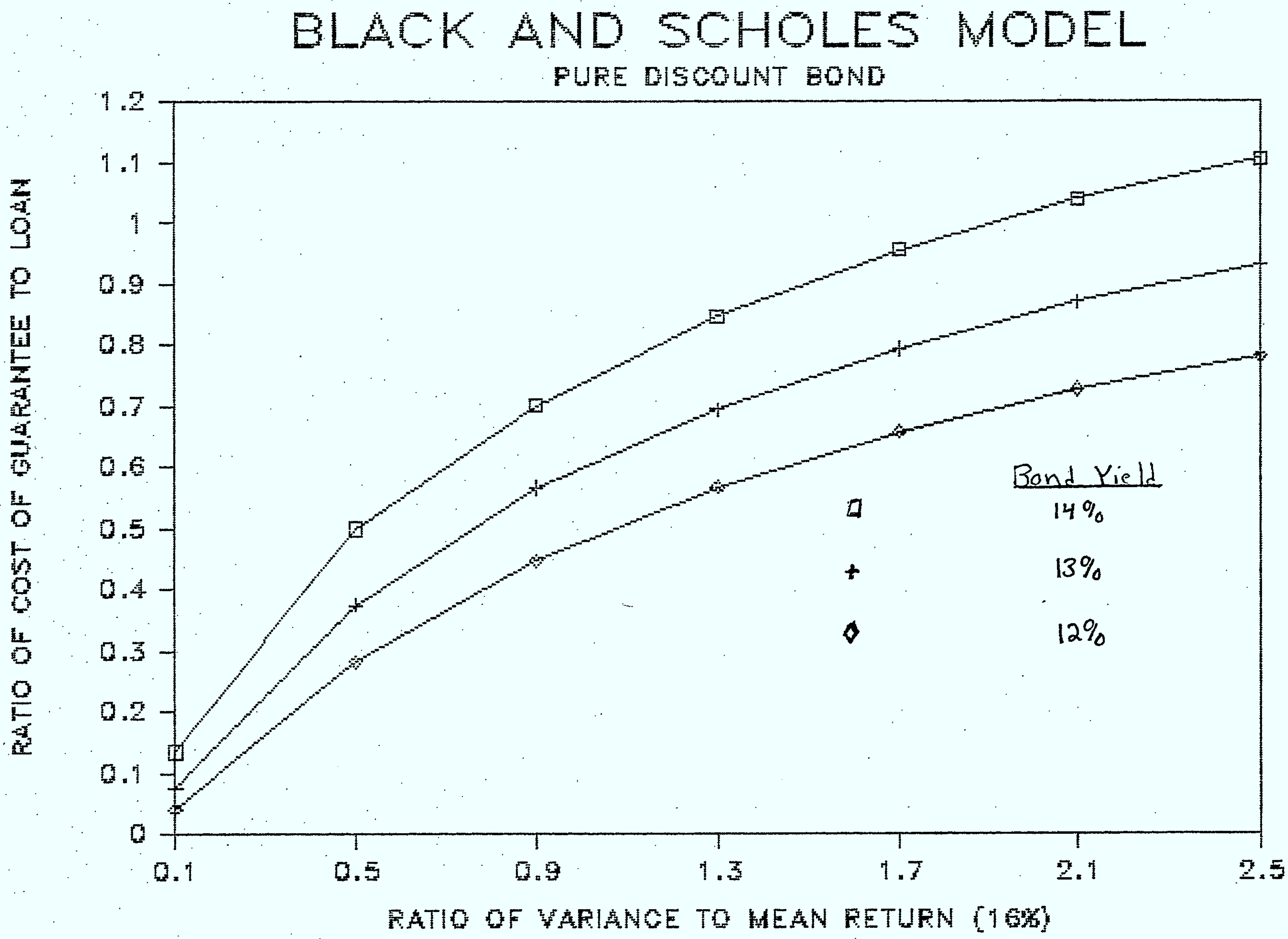
Ratio of Variance To Mean Rate of Return	Value of Default Risk Per Dollar of Debt Issued (Po/(Do/Vo))
0.10	0.14
0.50	0.50
0.90	0.70
1.30	0.85
1.70	0.96
2.10	1.04
2.50	1.11

T = 17 years
Vo = 1
Do/Vo = .50, i.e., 50 cents of every investment dollar spent on a project is financed by debt

$D_T = .50(1+.14)^{17} = 4.64$, face value of 50 cents of debt in 17 years, constructed as a pure discount bond

u = mean rate of return on the project's assets = 16%

FIGURE 7.2


BLACK AND SCHOLES MODEL
PURE DISCOUNT BOND
RATIO OF COST OF GUARANTEE TO LOAN
RATIO OF VARIANCE TO MEAN RETURN (16%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
0.1
0.5
0.9
1.3
1.7
2.1
2.5
Bond Yield
14%
13%
12%

Results are presented for pure discount bonds with yields of 12, 13 and 14 per cent in the presence of an 11 per cent risk-free rate of return, i.e., for risk premia of approximately 1, 2, and 3 per cent, respectively. Note that the costs of the guarantees appear high, because no interest is paid until maturity.

In Figure 7.3 another set of graphs is constructed with identical bond yields, but with interest payments allowed prior to maturity. This more realistic assumption generates lower costs for loan guarantees for every level of variance of a project's rate of return.

Caution is advised in extending the results of Figure 7.3 to the cost of federal government loan guarantee for Telesat on the MSAT project because

(a) a 16 per cent nominal rate of return in the presence of an 8 per cent expected rate of infation on a project's assets is assumed in Figure 7.3.

(b) the Black and Scholes model assumes a symmetrical probability distribution about the mean rate of return, i.e., returns in excess of 16 per cent are equally likely as low or negative returns.

Altering either assumption (a) or (b) above will change the cost of the guarantee. For example, if the expectd mean rate of return on the project is lower, the cost of the guarantee will be higher. Similarly, if the probability distribution on the mean rate of return is skewed downwards, then the cost of the guarantee will be higher.

Figures 7.4 and 7.5 give examples of symmetrical and skewed probability distributions for a project's rate of return. The distributions in Figure 7.4 have a mean value equal to the modal value - the most likely value. However, the skewed distribution in Figure 7.5 has a modal value higher than the mean, i.e., the most likely outcome is

FIGURE 7.3

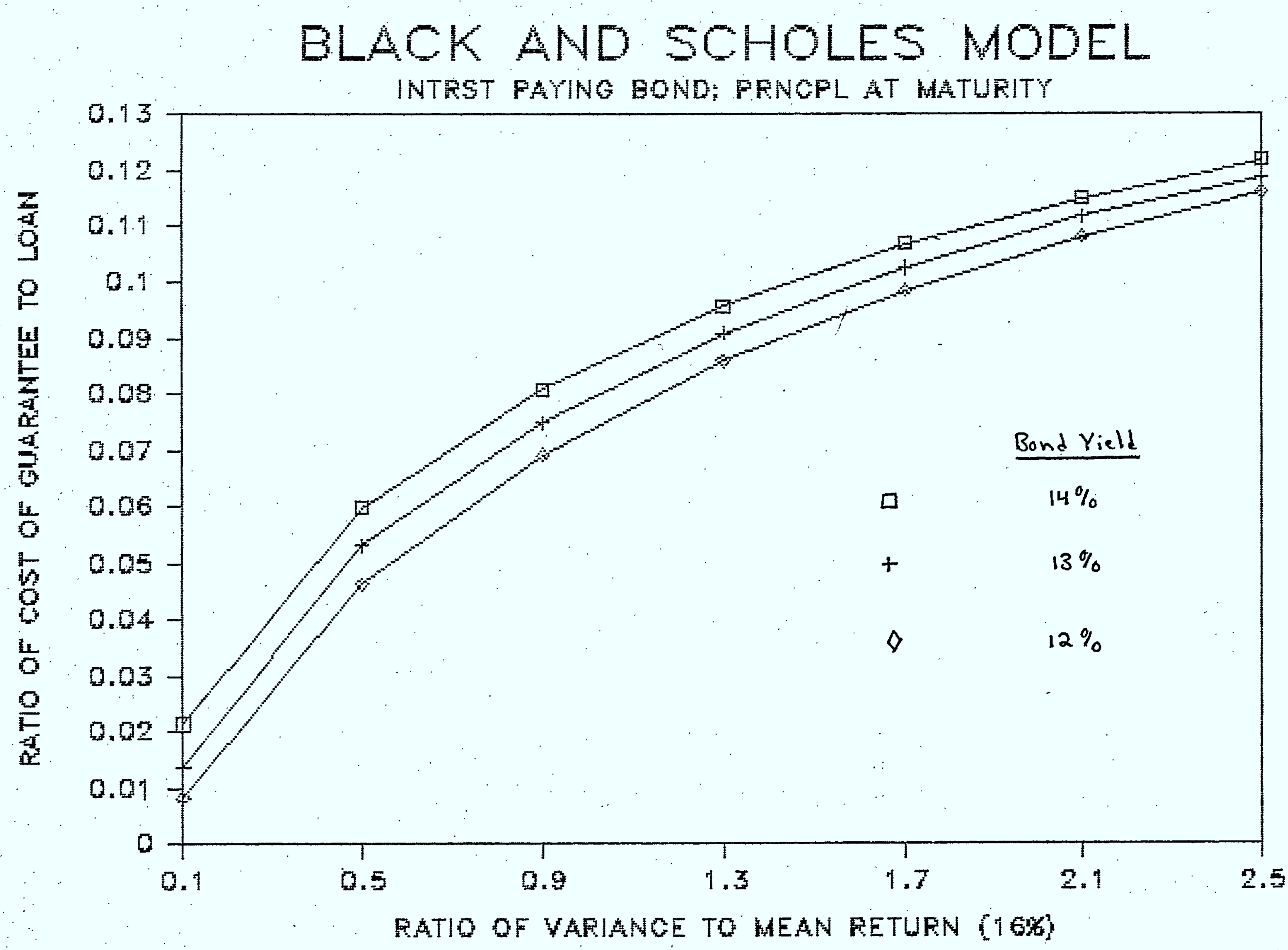

BLACK AND SCHOLES MODEL
INTRST PAYING BOND; PRNCPL AT MATURITY
RATIO OF COST OF GUARANTEE TO LOAN
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
0.12
0.13
0.1
0.5
0.9
1.3
1.7
2.1
2.5
RATIO OF VARIANCE TO MEAN RETURN (16%)
Bond Yield
14%
13%
12%

Figure 7.4

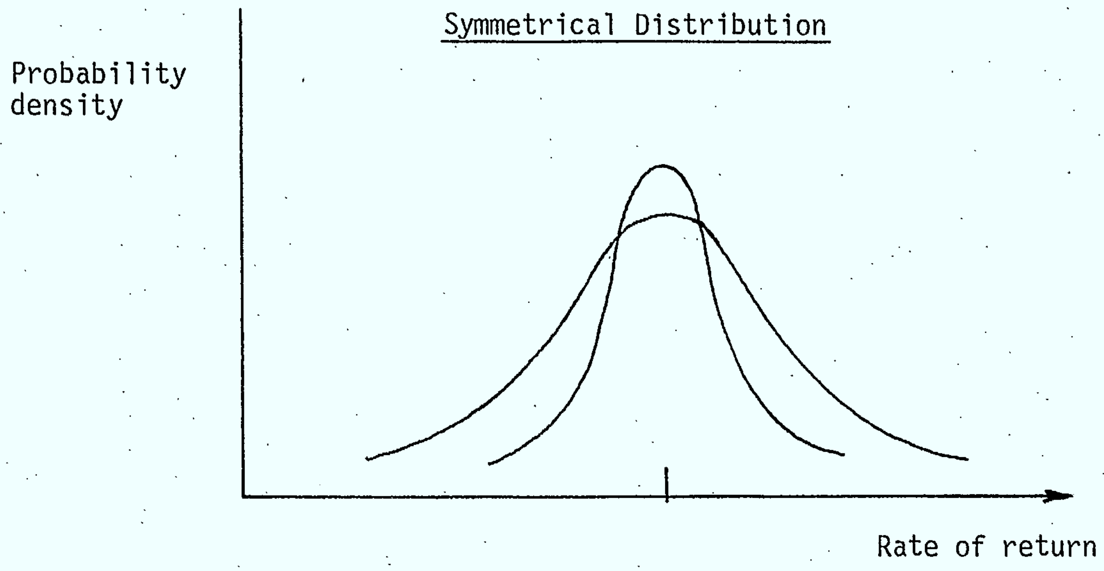
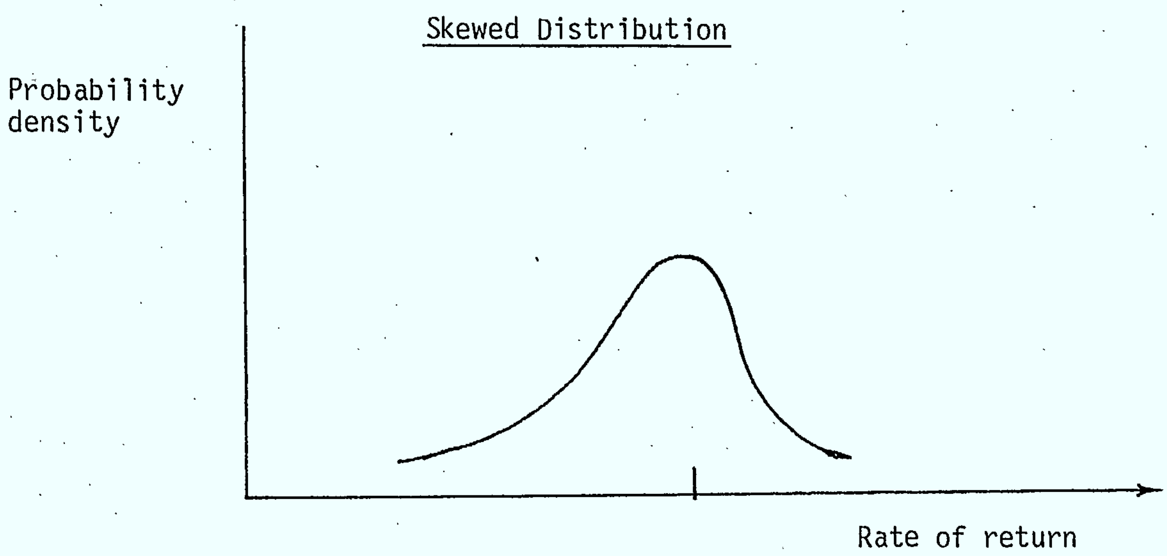


Figure 7.5



higher than the mean outcome.

The Black and Scholes approach to option pricing suffers from a number of simplifying assumptions that must be made regarding the model parameters, such as those concerning the probability distribution of a project's rate of return and the type of debt that can be issued. More sophisticated versions of the basic Black and Scholes model exist, but the computer software required to run these models is costly and the informational requirements for the input parameters are considerably heavier.[1]

7.2.4 Summary

We have demonstrated that the value of a loan guarantee is dependent on:

(a) the timing of loan principal and interest payments,

(b) private investors perceptions towards risk, and

(c) the time to maturity on the loan.

The value of a loan guarantee will be higher the later principal and interest payments are made on a loan, the higher are private investors perceptions towards risk and the longer the time to maturity on the loan.

We suggest that Telesat's postulated 14 per cent cost of debt capital in the presence of an eight per cent expected rate of inflation provides a good starting point for a risk-adjusted discount rate on Telesat's MSAT related debt. Therefore, the difference in the NPV's of Telesat's debt and interest payments at 14 per cent and at an appropriate risk-free

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[1] The Department of Finance has such a model that can be used to value government loan guarantees. Iain Henderson and Vijay Jog from the Department of Finance have applied this model to a number of projects.

discount rate can be viewed as a good first approximation to the cost of a government loan guarantee.[1]

If there are reasons to believe that Telesat's perceptions of investor risk are incorrect, then we can use the Black and Scholes model to simulate how the market might cost default risk on debt in the presence of a variety of assumptions concerning a project's expected rate of return and its associated probability distribution. Alternatively, we can use the Capital Asset Pricing Model - discussed in Section 1 - to calculate various risk premia based on assumptions regarding the risk of the MSAT project in relation to normal business risk. However, we caution that such techniques are a poor substitute for knowing informed investors' actual risk-adjusted discount rates.

7.3 Rate of Return Guarantee

If the federal government guarantees Telesat a predetermined rate of return on capital invested in the MSAT project, then the project becomes a riskless venture for Telesat, i.e., no matter what happens Telesat will receive a guaranteed rate of return. A rate of return guarantee effectively transfers project risk from Telesat to the federal government.

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[1] If a 3 per cent real risk-free discount rate is used, as suggested in Section 1, then this translates into a 11.2 per cent nominal discount rate in the presence of an 8 per cent expected rate of inflation.

Conceptually, there is no difficulty in valuing a rate of return guarantee. Based on the methodology presented in Section 7.2, a riskless asset should receive the risk-free rate of return available on other riskless assets, such as government bonds. Thus, the guaranteed rate of return should equal the risk-free rate of return.

Under these assumptions, calculation of the value of a rate of return guarantee is analagous to that of a loan guarantee when the lenders' risk-adjusted discount rate is known, namely:

$$\begin{pmatrix}\text{NPV of net cash flows} \\ \text{at risk-free discount} \\ \text{rate}\end{pmatrix} - \begin{pmatrix}\text{NPV if net cash flows} \\ \text{at a risk-adjusted discount} \\ \text{rate}\end{pmatrix}$$

Note that if the guaranteed rate of return is higher than the risk-free interest rate, then the additional returns in excess of the risk-free rate should be discounted at the risk-free rate and added to the cost of the guarantee. The logic behind this adjustment rests on the assumption that these additional returns are also riskless and hence represent a bonus to a project participant.

Most of the problems inherent in a rate of return guarantee arise from difficulties in arriving at an appropriate contractual definition of the terms of the guarantee. For example, the capital expenditures on which the rate of return is calculated must be appropriately defined. This is analagous to the definition of a "rate base" for regulated utilities. Since a rate of return is calculated net of all operating expenditures, taxes and interest payments, these must also be defined.

All the types of problems inherent in defining and monitoring a rate base rate of return for regulated utilities will surface when defining institutional and contractual arrangements for a rate of return guarantee for a project.

7.4 Sales Revenue Guarantee

A sales revenue guarantee for a project also represents a transfer of risk from private investors to the federal government. The government is liable for any shortfall of revenues below an agreed upon forecast level. A sales revenue guarantee can be valued in a manner similar to that of a loan guarantee or rate of return guarantee, when the risk-adjusted discount rate is known, namely:

$$\begin{pmatrix}\text{Value of a Sales}\\ \text{Revenue Guarantee}\end{pmatrix} = \begin{pmatrix}\text{NPV of Expected}\\ \text{Forecast of Sales}\\ \text{Revenue at a}\\ \text{Risk-Free Discount}\\ \text{Rate}\end{pmatrix} - \begin{pmatrix}\text{NPV of Expected}\\ \text{Forecast of Sales}\\ \text{Revenue at a}\\ \text{Risk-Adjusted Discount}\\ \text{Rate}\end{pmatrix}$$

With a guarantee the forecasted stream of sales services becomes riskless to private investors and hence is discounted at an appropriate risk-free discount rate. The risk is transferred to the federal government and has a value equal to the difference between the NPV of sales revenues at a risk free and a risk-adjusted discount rate.

Note that a sales revenue guarantee is equivalent in concept to a rate of return guarantee, except that capital and operating expenditures are included in the latter. With a sales revenue guarantee the government assumes the risk on the revenue stream, while private investors assume the risk on capital and operating expenditures. This increases the managers' incentive to minimize costs and thereby reduces monitoring costs by the federal government.

The choice of an appropriate risk-free discount rate depends on the contractual aspects of a sales revenue guarantee. If the guarantee is set according to a predetermined current dollar value of sales, then investors assume any inflation risk. An unanticipated increase in the rate of inflation will erode the purchasing power of the guarantee, i.e., lower its constant dollar value.

The type of inflation risk in a current dollar sales revenue guarantee is similar to the inflation risk private investors assume when purchasing long-term government bonds, i.e., even though the coupon yield on the bonds is riskless an unanticipated increase in the inflation rate will reduce the constant dollar value of the bonds. Thus, when investors assume inflation risk - in that a guarantee is fixed in current dollars - the appropriate risk-free interest rate is the long-run yield on long-term government bonds.

A possible contractual option on a sales revenue guarantee is to index the revenues to the rate of inflation and hence protect private investors from inflation risk. This requires that the constant dollar value of the sales revenue guarantee be fixed, but the current dollar value is allowed to float year by year according to the current rate of inflation. In this case the appropriate risk-free interest rate would be the long-run average yield on Treasury Bills, which are short term financial instruments and therefore subject to minimal inflation risk.

Recall from Section 1, that the long-run average real - net of inflation - yield on long-term government bonds was estimated at 3 per cent. This figure includes inflation risk and implies that a long run nominal - gross of inflation and inflation risk - interest rate for a project is equal to:

100 X [1 - (1.03) x (1 + expected rate of inflation during life of project)] - 1

e.g., 100 X [1 - (1.03) x (1 + .08)] - 1 = 11.2%

The long-run average real yield on Treasury Bills would be below 3 per cent, because it excludes inflation risk.

Note that the value of the guarantee is the same whether it is estimated in current dollars at nominal risk-free and risk-adjusted discount rates or constant dollars at real risk-free and risk-adjusted discount rates. The choice of the appropriate risk-free discount rate depends on whether the guarantee is indexed to protect private investors from inflation risk.

In the above discussions we have implicitly assumed that a sales revenue guarantee will not affect the behaviour of a project participant. In other words in the presence of such a guarantee a participant is assumed to operate just as efficiently with the guarantee as without it. This requires that the guarantee does not affect a participant's efforts and expenditures devoted to marketing, customer service, capital equipment and so on. Clearly, contractual arrangements regarding this type of guarantee should be structured to ensure a recipient has no incentive to alter his behaviour.

7.5 Capital Grant

This type of financial assistance is easier to cost and monitor than a guarantee, and it will not affect a participant's behaviour if, as in the case of Telesat, there is little opportunity to substitute capital for labour in production. A recipient of this type of financial assistance has every incentive to operate efficiently once a project is underway. Any reduction in the depreciation tax shield and increase in income taxes should be taken into account when valuing this type of assistance from a participant's perspective.

Appendix A

Elasticity Estimates

Elasticity Estimates

We have prepared estimates of local elasticities of demand from the partial price demand data supplied by Woods Gordon. The elasticity estimates are listed in Table A.1.

A local elasticity of demand is theoretically defined by the following equation:

$$\eta_i = dq/dpi^{pi}/q \qquad (1)$$

where, $q = q(p_i \ldots p_n)$. a demand function

p_i = a price parameter affecting demand.

The above equation is interpreted as the inverse of the slope of a demand curve multiplied by the ratio of price to quantity. A local elasticity of demand provides a convenient summary statistic of the responsiveness of demand to small changes in a price parameter. It measures the percentage change in demand caused by a one per cent change in price.

We have chosen to estimate local demand elasticities from the Woods-Gordon data by linearizing the demand curve, computing the inverse of the implied slope, and multiplying by the ratio of price to quantity. This translates into the following formulas:

$$\eta_i^o = \left(\frac{q^o - q^1}{p_i^o - p_i^1}\right) \cdot \frac{p_i}{q^o} \qquad (2)$$

$$\eta_i^1 = \left(\frac{q^o - q^1}{p_i^o - p_i^1}\right) \cdot \frac{p_i}{q^1} \qquad (3)$$

where (q^o, p_i) and (q^1, p^1) denote partial price-quantity pairs. Note the

η_i^o is the estimated partial elasticity at (q^o,p^o) and η^1 is the estimated partial elasticity at (q^1,p^1).

Woods Gordon has provided three observations for each partial price demand curve, i.e., three partial price-quantity pairs, thus yielding two possible slope estimates for the middle observation. We have chosen to drop the observation with the lowest price from each of the partial demand curves, leaving only two observations per curve. Referring to the curves in Figure A.1, the first observation reading from left to right was dropped.

Aside from simplifying the elasticity calculations, dropping these observations also eliminates some perverse results from the data set. For example, three pairs of partial price demand curves cross each other in Woods Gordon's diagrams, two slope upward, and eleven display concavity rather than convexity. This would appear to indicate that there exists some response bias in Woods Gordon's survey data set. Dropping the inconsistent data provides a tractable solution to the problem.

The elasticity estimates themselves appear broadly consistent with estimates from econometric studies conducted on mobile telephone and long distance telephone demand. These econometric studies indicate that demand tends to be inelastic, i.e., the demand elasticity with respect to price is less than one in absolute value. For example, Taylor in a study on long distance telephone demand in the United States, estimates mean toll price-demand elasticities in the range of -.65 to -.75.[1]

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[1] L.D. Taylor, "Problems and Issues in Modelling Telecommunications Demand" in L. Courville et al. (eds.) Economic Analysis of Telecommunications: Theory and Applications (New York: North-Holland, 1983).

Table A.1

IMPLIED LOCAL POINT ELASTICITIES FROM WOODS GORDON DATA

/AIRTIME CHARGE		$1.00			$1.50			$2.00		
TERMINAL COST	ACCESS CHARGE	TERMINAL ELASTICITY	ACCESS ELASTICITY	AIRTIME ELASTICITY	TERMINAL ELASTICITY	ACCESS ELASTICITY	AIRTIME ELASTICITY	TERMINAL ELASTICITY	ACCESS ELASTICITY	AIRTIME ELASTICITY
	$20	NA	NA	NA	NA	NA	-0.262	NA	NA	-0.382
$1,000	$50	NA	-0.045	NA	NA	-0.054	-0.238	NA	-0.051	-0.345
	$200	NA	-0.208	NA	NA	-0.261	-0.204	NA	-0.241	-0.292
	$20	-0.020	NA	NA	-0.026	NA	-0.289	-0.021	NA	-0.426
$2,000	$50	-0.018	-0.043	NA	-0.023	-0.042	-0.265	-0.024	-0.036	-0.388
	$200	-0.001	-0.196	NA	-0.009	-0.194	-0.204	-0.008	-0.161	-0.291
	$20	-0.041	NA	NA	-0.054	NA	-0.273	-0.042	NA	-0.401
$4,000	$50	-0.036	-0.038	NA	-0.047	-0.038	-0.266	-0.048	-0.031	-0.390
	$200	-0.002	-0.170	NA	-0.018	-0.172	-0.203	-0.017	-0.138	-0.290

Figure A.1

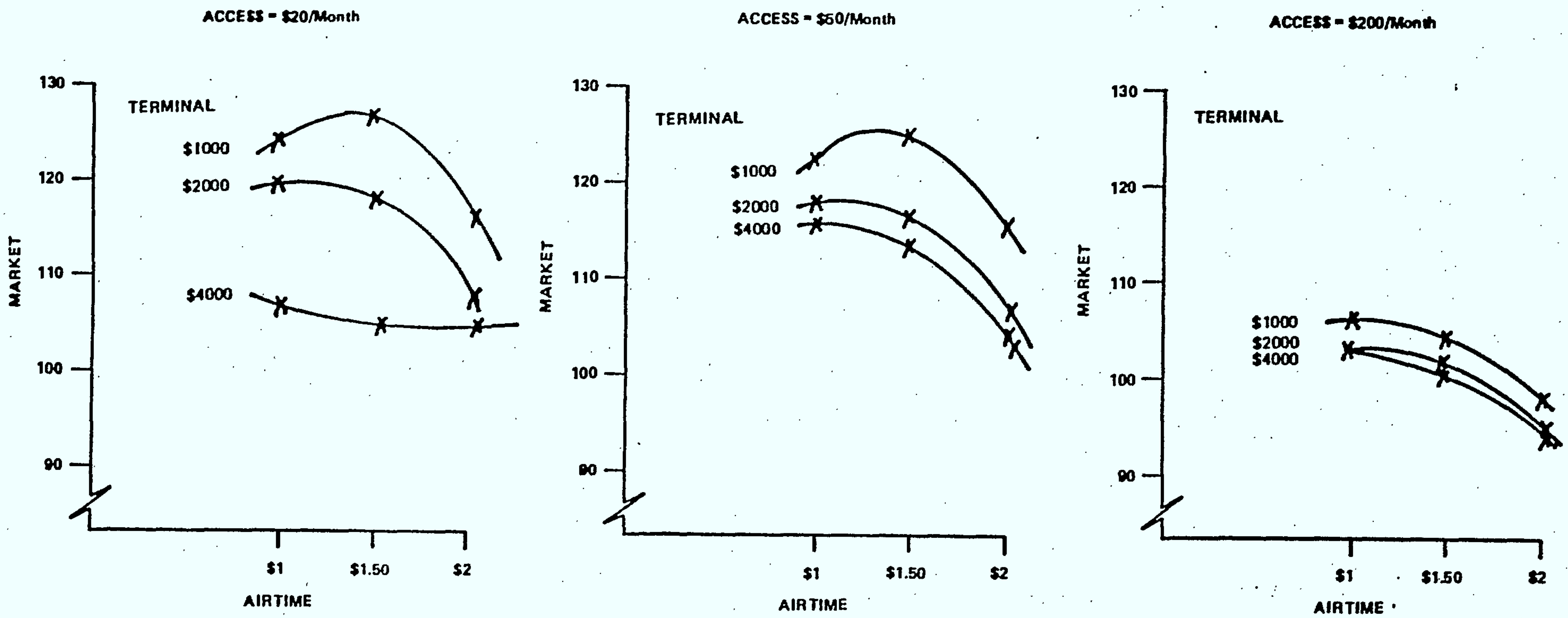
Woods Gordon MSAT Phase B Market Study

Price Sensitivity Charts

Woods Gordon

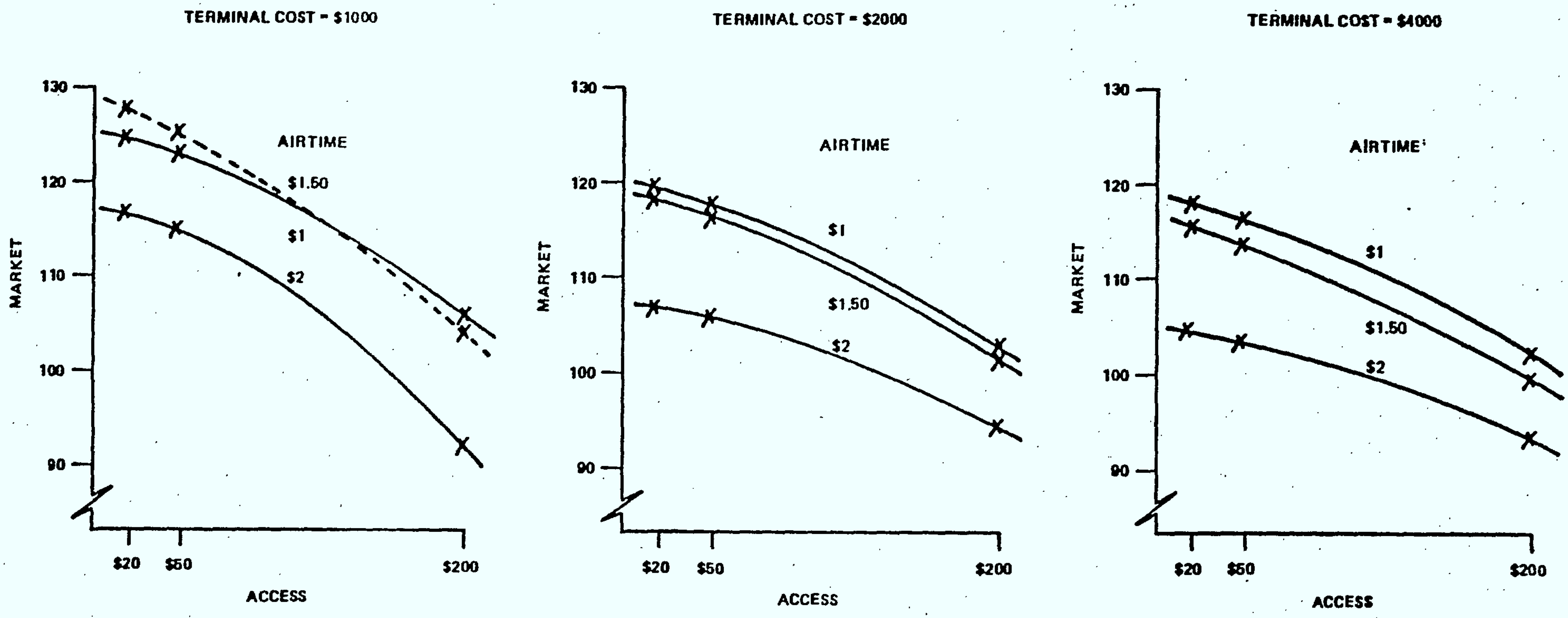
MSAT POTENTIAL MARKET —

SENSITIVITY TO VARIATIONS IN PRICE OF AIRTIME PER MINUTE



N.B. 1. 'Market' means thousands of potential MSAT mobiles in 2002.
It includes MRS (discounted as in the Feb. 1984 report) and MTS mobiles.
2. A 10% blockage rate is assumed.
3. LPC voice quality is assumed for MRS, ACSB for MTS.

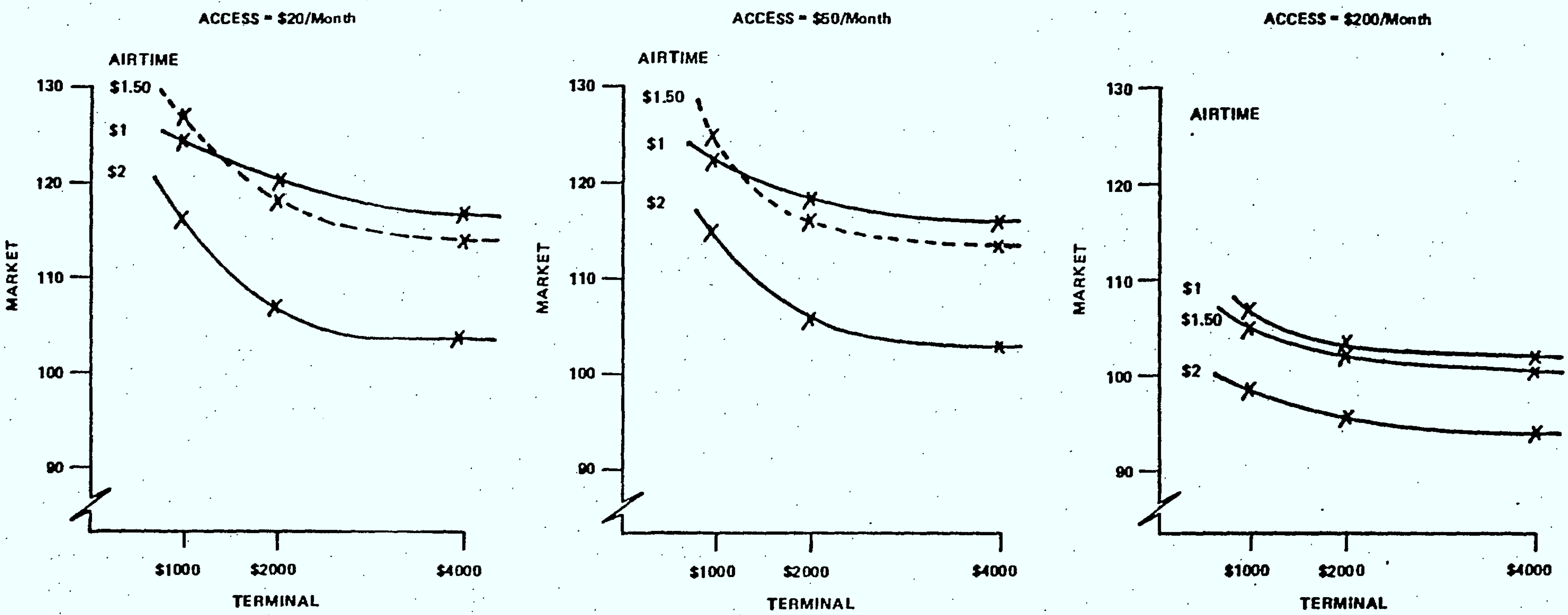
MSAT POTENTIAL MARKET —
SENSITIVITY TO VARIATIONS IN PRICE OF MONTHLY ACCESS



N.B. 1. 'Market' means thousands of potential MSAT mobiles in 2002.
It includes MRS (discounted as in the Feb. 1984 report) and MTS mobiles.
2. A 10% blockage rate is assumed.
3. LPC voice quality is assumed for MRS, ACSB for MTS.

MSAT POTENTIAL MARKET –

SENSITIVITY TO VARIATIONS IN PRICE OF USER TERMINALS



N.B. 1. 'Market' means thousands of potential MSAT mobiles in 2002.
It includes MRS (discounted as in the Feb. 1984 report) and MTS mobiles.
2. A 10% blockage rate is assumed.
3. LPC voice quality is assumed for MRS, ACSB for MTS.