JORDAN FISCAL REFORM II

Economic Analysis of the Amman-Zarqa Light Railway System Project

October 2010

This document was produced for review by the United States Agency for International Development. It was prepared by Development Alternatives, Inc.

JORDAN FISCAL REFORM II

Economic Analysis of the Amman-Zarqa Light Railway System Project

Program Title:	**Jordan Fiscal Reform II Project**
Sponsoring USAID Office:	**USAID/Jordan Economic Growth Office**
Contract Number:	**EEM-I-00-07-00009-00** **Order No. EEM-I-08-07-00009-00**
Contractor:	**DAI**
Date of Publication:	**Oct. 2010**

Prepared by: Juan J. Buttari

The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

Table of Contents

Executive Summary 6

ECONOMIC ANALYSIS OF THE AMMAN-ZARQA LIGHT RAILWAY SYSTEM (AZLRS) PROJECT 7

1. Rationale 7

2. Context 7

3. Project History and Current Design 8

4. Methodology 9

6. Project Costs and Benefits 11

7. Assumptions and Financial Flows 14

8. Quantitative Analysis Results 15

Economic Benefits: The Value of Productive Factors Released 16

Economic Benefits: Adding Pollution Effects 17

Economic Benefits: LRS Induced Decrease In Traffic Deaths And Injured 21

Economic Benefits: Savings from Reduced Travel Time 24

How do these results fare relative to previous AZLRS studies? 24

9. Sensitivity Analysis 25

10. Economic Assessment of the AZLRS 28

11. The AZLRS and Potential Project Alternatives or Complements 29

12. Conclusions and Recommendations 31

13. Main Tables 32

Table 1: Project Assumptions 32

Table 2: Financial Costs and Revenue Flows 33

Table 3: Concessionaire Income Statement Highlights 35

Table 4: Highlights from Cash Flow Statement Highlights 37

Table 5: Value of Economic Output and Economic Cost Flows, First Approximation 39

Table 6: Estimates of Total Value of Trips by Transportation Modes (no LRS) 41

Table 7: Total Value of Trips and Trips Captured by LRS 42

Table 8: Economic Net Benefits: Value of Productive Inputs minus Costs 43

Table 9: Economic Net Benefits: Value of Productive Inputs Freed plus Pollution Savings 44

Table 10: Economic Net Benefits: Value of Productive Inputs Freed plus Pollution Savings plus Savings from Reduction in Road Accidents minus Costs* 45

Table 11: Benefits in terms of Travel Time Savings as a Result of LRS 46

Table 12: Economic Net Benefits: Value of Productive Inputs Freed plus Pollution Savings plus Savings from Reduction in Road Accidents plus Savings from Reduction in Travel Time minus Costs* 47

Table 13: Benefits Impact: Economic Rates of Return and Present Values under Different Gross Benefits Scenarios 48

Table 14: Sensitivity Results.....49

Acknowledgments

The author gratefully acknowledges the support of many individuals in carrying out the analysis for this work. Ammar Jarrar, Mark Gallagher, Abedelhakim Shibli, Khalid Al Hmoud and Christina Erickson, all FRPII officials, provided useful insights on Jordan's transportation issues and the economy, as well as reactions to drafts or oral presentations on findings and methods. Messrs. Ahmad Qatarneh, Hamzah Jaradat, Laith H Dababneh, Mohannad S Qudah, Nayef Rawashdeh and Sami Jiries Halaseh, all high-level Government of Jordan officials, generously shared their time and their viewpoints on relevant issues to the study. It goes without saying, any errors or omissions are the author's.

Executive Summary

The project makes economic sense because it addresses a real social need, has the potential to create more value than it uses up, and benefits largely low income population groups. Nonetheless, the light rail project involves a high level of risk in light of the record of similar projects, the high price elasticity of demand for transport services in the corridor, the existence of flexible competing services, and the concentration of significant benefits in a single effect, travel time savings.

Accordingly, it is recommended that the authorities measure the light rail project against project alternatives such as bus rapid transit or road enhancement schemes before making a go no-go decision on the project. The alternative that meets the objective of alleviating traffic congestion in the corridor in the most cost-effective way is probably the best candidate for adoption.

Were the project to be implemented it is important that the light rail schedules be met punctually, comfort standards met, and awareness of the advantages of the system versus transport alternatives be promoted. Ensuring a willing, stable and substantial ridership is essential for the achievement of the economic benefits identified.

Depending on assumptions, the project's economic internal rate of return lies within a range of 10 to 14 percent with positive present values to the flows of net economic benefits only after accounting for savings from reduced travel time. While the point estimate of the internal rate of return, 12 percent, is acceptable in light of Millennium Challenge Corporation criteria and the standards used by other international development organizations, such rate is somewhat below the rates estimated in previous analyses of the light rail project. To a considerable extent, this reflects the strong impact of the, probably wise, upward adjustment to estimates of initial investment requirements made during the last round of project design.

Next to savings from reduced travel time, but of much less importance, the other economic benefits of significance are the value of productive resources freed by the AZLRS for use elsewhere in the economy. Social savings from reduced pollution and decreased road accidents, although with positive effects, involve very small net benefits.

The financial rate of return to a private concessionaire is estimated at around 14 percent on the assumption of a heavy inflow of Government of Jordan's financial assistance. Availability payments account for most of the concessionaire's revenues with revenues from ticket sales a distant second. Projected revenues from ticket sales cover projected operating costs, something not usual for this type of project.

ECONOMIC ANALYSIS OF THE AMMAN-ZARQA LIGHT RAILWAY SYSTEM (AZLRS) PROJECT

Juan J Buttari

As used here a light-rail system (LRS) consists in an urban public rail transportation structure that, especially when compared with heavy-rail, operates at lower speed, carries relatively light passenger loads, and runs on its own right-of-way. Heavy rail includes high-speed rail, freight, commuter and regional trains, and metro-subway and elevated systems. A third category, tramways or street cars, involves even lighter passenger loads than light-rail.

1. Rationale

Light rail services are not a pure public good as users can be excluded through pricing, and subtractability may occur at low levels -- the use by a consumer may affect the ability of other users to consume the service (example: whether a passenger train is crowded or not affects the decision and ability to use the train). Instead, light rail transportation is a good with considerable public good characteristics due to potentially strong positive external effects – also called externalities or spillovers. [1] Because of positive externalities, the private supply of this type of transportation is likely to fall below what is socially optimal. And that is a case for public sector participation in the provision of these services.

A rationale for LRS is the need for high population mobility along relatively large distances in metropolitan areas, and for minimizing the social costs of traffic congestion and pollution. Accordingly, when LRSs are proposed they are frequently justified to meet increasing passenger traffic requirements, reduce travel time, reduce air pollutants and greenhouse emissions from motorized vehicles, and to increase transportation efficiency. However the quantification of some of these effects, and their importance, are issues of contention.

2. Context

The land corridor between Amman and Zarqa is an important traffic artery connecting by far the most populous city in Jordan, Amman, with Zarqa, Jordan's third largest city and the country's industrial center. Together the two cities account for about 50 percent of Jordan's population.

[1] An externality is an effect that falls on third parties not involved in a transaction and that is not reflected through free market prices.

Present Amman-Zarqa traffic takes place on a main road that is substantially congested at various times during the work week, especially during early, late and mid-day commutes. Current passenger traffic is estimated at over 400,000 trips daily with large buses and coaster vehicles accounting for more than half of the passenger load. Other transportation means are private cars, almost a third of the passengers, with taxis and minibuses accounting for the rest.

Under existing roads, projections presage an increasingly deteriorating traffic situation. While Jordan's population growth for 2010-2043 is projected at annual rates between 0.6 and 1.8 percent, population growth in Amman and Zarqa is estimated at higher rates that range from 1 to 2.5 percent. Likewise, the growth in the demand for public transport between Amman and Zarqa is projected at annual rates above 2 percent for most of the period with significant car ownership growth. Clearly, traffic congestion is a problem that requires policy attention in terms of modern facilities for transport and its infrastructure.

Most of the users of the current transport system facilities are young Jordanians with modest income means. The majority of users pay fares that are close to the fares envisioned for the AZLRS. While, in recent years, the authorities have constrained the supply of services by restricting the number of licensed transport operators in the corridor to make room for the AZLRS, as the demand for transportation services in the corridor continues to grow, services by unlicensed transport operators have expanded.

3. Project History and Current Design

The AZRLS was conceived more than eleven years ago to help meet the growing demand for transportation services in the Amman-Zarqa corridor. The system would operate using electric light rail vehicles on a standard gauge double-track line. The original estimates forecast close to 100,000 passengers per day (both directions) initially, with weekday peak ridership of between 4000 and 6000 passengers per hour in each direction.

The concept called for private sector development of the project under a public-private partnership build-operate-transfer (BOT) arrangement. Under the arrangement a private sector consortium would design, build, partly finance, operate and maintain the AZLRS for 25 years during which the consortium could claim the operating revenues. Afterward, the project assets and operations would be transferred back to the government.

There have been a number of tender rounds thus far unsuccessful. This outcome led over time to government reassessments of the basic terms in part with the objective of making the project more attractive to the private sector. A concern has been to avoid such a high level of revenue risk to the private operator that the project does not attract worthwhile bidders. Nonetheless, such concern has been tempered by the need to

balance social costs and benefits and by fiscal constraints. The most recent reassessment and redesign of the project, and the one used in the present report, ended in June 2010 and led to the current concept of the project's structure that includes:

(1) Fixed installation and construction costs of about JD 324 million -- which more than tripled original estimates
(2) Financing of the installation and construction costs by a combination of a capital infrastructure grant by the GOJ of JD 60 million and other external funding;
(3) Annual availability payments by the GOJ of some JD 39 million starting on the first year of operations -- adjustable by inflation and additional needs of rolling stock. (An availability payment is a payment made by the government to the concessionaire for delivering the service agreed upon. The payments are not contingent on the numbers of users of the AZLRS.)
(4) A minimum annual revenue guarantee of JD 13 million adjustable by inflation;
(5) A significant allocation of land for commercial development; and
(6) Freedom to set fares subject to a pre-set fare cap.

In addition, among other modifications, the new project design calls for six substations -- instead of the 11 to 12 originally considered -- and significantly lowered the estimates of the Amman-Zarqa corridor riders who would switch from other transportation means to AZLRS.

4. Methodology

The methodology is oriented to determining whether the AZLRS benefits to the Jordanian society outweigh the costs imposed on it. While distributional considerations are not ignored, the focus of the analysis is on economic efficiency. Essentially, this means that the basic criterion used in the present work for assessing the AZLRS worthiness is whether the light rail project results in a net increase in the value of goods and services produced throughout the economy. Accordingly, the project's stance – that is the perspective from which it analyses the project's worthiness – is that of the country as a whole. It is not a regional or private sector perspective.

To compare benefits and costs over time it becomes necessary to express both in a common denominator – monetary values, Jordanian dinars. Most monetary figures in the present analysis are in 2010 prices, that is, differences in monetary values over time reflect real differences and so the effects of inflation have been excluded.

The analysis relies on two main measures of project merit or worth: the economic internal rate of return and the present value of the net flow of project benefits and costs. The former is the rate that makes the net present value of the incremental flow of net economic benefits equal to zero. To arrive at present values a rate of discount of 10

percent has been the base rate of discount used. Nonetheless, for sensitivity assessment results with a 6 percent discount rate are also presented.

The approach used to determine the value of the services produced, or costs incurred, is based on the notion of Jordanian's willingness to pay. In other words, the monetary value attached to benefits indicates that, in the aggregate, Jordanians are willing to pay a maximum amount equivalent to the value of the benefits identified rather than do without them. Likewise, for the costs, this means that Jordanians, in the aggregate, are willing to pay up to the costs levels (no more than that) rather than give up the goods and services that would be foregone if the AZLRS is undertaken. If the value of benefits exceeds the value of costs this is taken to mean that the general welfare of the Jordanian society is enhanced.

Data and general information sources used consisted in analyses done in different rounds of the AZLRS project development, Government of Jordan statistical publications, interviews with Jordanian specialists, and the general transportation and light rail literature. To the extent possible, given time constraints, the assumptions and figures have been checked with Jordanian officials familiar with the project.

A basic approach used for identifying project effects relied on comparing with-project and without-project scenarios. For the latter, the assumption has been that traffic between Amman and Zarqa would continue on the existing system.

Thus, for instance, as further elaborated below, a first layer of benefits consists in the value of transportation resources released to the rest of the economy. Such value is given by the output of those resources in the without scenario. Similarly, the pollution benefits for the AZLRS is the difference in pollution between a project- and a without project scenario as calculated by GOJ engineers (see section on benefits below). An analogous reasoning applies to other benefits considered here. Project costs represent the incremental gross costs to Jordan associated with the AZLRS.

Assumptions regarding the nature or quantification of benefits and costs are detailed in the sections dealing with the specific items. As mentioned elsewhere, capital costs used are based on estimates arrived at during the project 2009-2010 redesign made with International Finance Corporation assistance. Likewise, the study relied on the IFC-supported demand and other finance-related figures.

The procedures used in the analysis involved the following steps:

1. Identification and listing of all various effects of the AZLRS

2. Classification of such effects into economic-efficiency benefits (desirable project outputs) and costs (the productive resources used in the project).

3. Identification of the major income distributional effect.

4. Quantification of the major economic-efficiency benefit and costs as feasible.

5. Results presentation and report drafting.

In view of the inexistence of severe overall price distortions in the Jordanian economy at present shadow pricing was not considered necessary. In any case, the effects of shadow pricing in a previous AZLRS assessment were very small.[2]

To test for the sensitivity of results to basic assumptions, the analysis carried out a number of sensitivity tests that also shed light on switching values (see sensitivity analysis section). This provided a basis for elaborating on the project's riskiness.

6. Project Costs and Benefits

Costs flows were based on costs in the financial statements resulting from the 2009-2010 project design revision. Such financial costs consisted in:

1. Construction, installation and equipment
2. Operations
    a. Personnel
    b. Energy
    c. Maintenance
    d. Other utilities
    e. Insurance
    f. Other Operating
3. Depreciation and amortization
4. Availability payments to the concessionaire
5. Minimum revenue guarantee
6. Interest

Costs relevant for the economic analysis were those that reflected the additional use of productive resources by the AZLRS. This means that the costs considered in the present economic analysis were those that reflect potential output forgone given the use of productive resources by the AZLRS project. Accordingly, for the economic analysis the following financial costs were not taken into account:

> Depreciation and amortization: These are accounting costs. They are not relevant for the economic analysis because their magnitude is already counted in the flow of real resources represented by construction, installation and equipment costs, as well as by the residual or salvage value when assets are released for another use at the end of the project life.

[2] Austria Rail Engineering (ARE), Light Railway System Jordan, March 1966

Availability payments: These were excluded from consideration in the economic analysis for they do not decrease or increase the availability of real resources to Jordan. As these payments just transfer command over resources from a segment of the Jordanian society (taxpayers) to another -- the AZLRS riders and the concessionaire -- they do not involve a reduction or increase of resources to the economy as a whole.

Interest payments: These payments do not represent a use of real resources. They are just a transfer back to the lender of command over real resources and are implicit in the cost of capital represented in other capital flows -- as in the cost of fixed assets, for example.

Minimum revenue guarantees: These are also a transfer of command over resources with no addition or subtraction of resources.

All the other costs in the financial statements are relevant for the economic analysis. In addition, the present analysis included an allowance for land costs and considered the impact of physical contingencies as part of its investigation on the sensitivity of results.

Land costs (estimated at JD900, 000 in year 1) were considered relevant on the assumption that their use in the project represents foregoing the contribution of land to national output in an alternative use. Physical contingencies reflect the value of additional resources that may be required beyond a base cost. They thus stand for the contribution of such resources to output in alternative uses that is forgone when additional resources are used in the project. The fact that project designs frequently underestimate the actual costs of a project due to unanticipated events justifies allowing for this type of cost.

Finally, costs reflecting the disruption of potential business and other activity during construction and installation were considered. Nonetheless, these costs were deemed not significant and therefore no attempt was made to quantify them.

As to benefits, the effects that are relevant for the present analysis are those that enhance the wellbeing of the Jordanian population at large. Thus economic effects that translate in the enhancement of the productive capacity of the economy are those that count as benefits. This is the natural counterpart to the concept of costs -- foregone production -- as the analysis involves comparing benefits and costs.

The economic benefits considered in this report, along with pertinent comments on how the present report addressed them, were the following:

1. <u>Value of productive resources</u> freed for use in other, similar or not, productive activities (as the AZLRS essentially would partially replace other transportation services, especially buses).

2. Savings from potential decreases in net pollution costs (decreased road pollution minus AZLRS pollution).
3. Savings from a net decrease in road accidents (decrease in road accidents resulting from lower-volume traffic minus AZLRS accidents).
4. Savings from reduced road maintenance costs. However, after consulting with specialists at the Ministry of Public Works, these savings were deemed not significant and no effort was made to quantify them.
5. Time savings from shortened travel time per passenger trip.
6. Greater comfort and convenience to previous riders who shift to the AZLRS at essentially the same price as for buses (can be thought of as "increased consumer surplus")[3]. In addition, the generation of a new consumer surplus from persons who usually did not travel in the corridor but would be encouraged to do so because of a better ride –an induced rider effect. It was not possible to directly quantify these effects. Accordingly, the tack taken in the present report was to test for sensitivity assuming that the combined consumer surplus effects would be equivalent to a 10 percent rise in ticket revenues. (More on the justification for such tack is presented in the sensitivity analysis section below. As noted in that section, the sensitivity of project merit indicators to the introduction of the concept of consumer surplus was small but potentially significant.)
7. Value of capital assets that would revert to the government of Jordan at the end of the project's economic life – this is equivalent to a salvage value. Three assets were considered: facilities, rolling stock, and land. For the first two it was assumed that the value at the end of project would equal an amount equivalent to ten percent of their initial cost. The value of land was assumed to increase in real terms (that is after inflation) at a rate of one percent per year. (Adjustment for these values made no significant difference in the results.)

Consequential with the concept of benefit used in this report, some effects used in at least a previous analysis as AZLRS benefits, were not considered here. In particular this analysis did not attempt to:

- Quantify "job creation" as a distinct benefit because payments to labor (as to any other production factor) are entered as a cost and it would therefore be inconsistent to somehow add them as benefits. This does not mean that labor market impact is not relevant; on the contrary, when possible, it should be described as information relevant for policymaking, as are distributional and social implications for example. Moreover, the inclusion of arbitrary estimates of indirect job effects is a practice that has been much misused.
- Measure decrease in fossil fuel reductions as a benefit because such effect is already incorporated in the value of the productive resources

[3] Approximately, consumer surplus is the difference between what all purchasers would be willing to pay for a particular amount of a good rather than to be without it and the amount they actually have to pay on the market.

freed for use elsewhere in the economy. Accordingly treating them separately would be double counting.

Moreover, because their effects were deemed as not significant by specialists in Jordan's traffic issues, the present report did not consider impacts on costs of road repairs or costs from disruptions of business activities during a construction and installation period.

7. Assumptions and Financial Flows

Table 1 summarizes the main project assumptions inherent in the projections used in the present analysis. The construction-installation period is planned to take two years with operations starting on the third year and lasting for 23 consecutive years. Accordingly 25 years is taken as the economic life of this project.

The table indicates that the present value of forecast revenues including availability payments to the concessionaire cover capital expenditures and operating costs (JD 482 million versus JD 463 million at a 10 percent discount rate). Moreover, the present value of the revenues from sales of tickets exceeds the present value of operating costs.

Availability payments account for some 66 percent of the concessionaire's revenues with revenues from ticket sales accounting for only 32 percent of the revenues. Note that availability payments are meant as a critical incentive to the concessionaire.

Capital costs are over three times operating costs. Annual growth in operating costs is projected to rise at some 2 per cent yearly -- presumably about at the same rate as inflation and, possibly, an optimistic assumption for a relatively long-lived project. Fares are capped at JD 0.50 (2010 prices).

Table 2 presents the project's cost and revenue flows. Inflows are more than twice the contemplated outflows with positive net cash flows (inflows minus outflows) in all years except the first two. The net flows have a positive net present value above three hundred million -- an indicator of the project's relatively high financial load.

The sizeable volume of inflows reflects essentially the large weight of availability payments. Such payments account for about 52 percent of inflows, with revenues from ticket sales, the second largest source of inflows, accounting for some 29 percent.

Excluding inflows from ticket sales and "other revenues from operations" (i.e., JD 2047 million minus JD592 million minus JD33 million), that leaves a remainder of JD1422 million, an amount some 60 percent above total capital outflows and an indicator of the level of public financial support for the project. This is a backdrop to a key question the

economic analysis must address: Are the economic benefits to the project large enough to justify the costs to the society?

As Table 3 on the concessionaire income statement shows, total revenues from operations are over four times operations costs. In fact, ticket revenues are more than enough to cover operating costs, something not usual in this project type.

If availability payments were excluded the remaining revenues would amount to JD 625 million (i.e. 1680 minus 1055), still more than enough to cover the costs of operations but seemingly not enough to cover financing obligations. Net revenues from operations (revenues minus expenses) are projected to be always positive once operations start. The financial internal rate of return to the concessionaire is estimated at around 14 percent.

Personnel costs account for only 14 percent of operating costs -- an amount illustrating the capital intensiveness of the project.

As shown on Table 4 relating to cash flows, a positive cash flow to the concessionaire from operations is barely sufficient to cover negative cash flows from investments and financing. Still the net cash low is positive in most years and has a positive net present value.

8. Quantitative Analysis Results

The procedures involved in measuring the significance of benefits consisted in adding layers of benefits in successive rounds (see below), subtracting economic costs to obtain net economic benefits at each round and then estimating benefit-cost criteria to assess the soundness of the project from an economic perspective. This approach made it possible to assess the effects of different benefits on the measures that summarize economic worthiness.

Before dealing with the benefits just mentioned, an exploratory and quick way of getting a sense of how benefits and costs compare consisted in using the value of the services provided by AZLRS (indicated by ticket sales and advertising) as a proxy for benefits and comparing them over time with the flow of economic costs. The results are shown on Table 5.

The net flows (i.e. benefits minus costs) have negative present values even discounting at much less than 10 percent. Including a salvage value of 10 percent of the initial rail system cost at the end of the project's life raises the present value marginally and therefore does not make any material difference in the results.

The negative present value reflects the huge weight of the capital costs of the first two years and highlights the compensating burden that such effects as reduced travel time, decreased pollution and less road injuries, would have to meet in order to make the project economically worthwhile.

Economic Benefits: The Value of Productive Factors Released

While the approach based on using the value of outputs as benefits is telling, there is a better way of assessing the value to Jordan of the economic net benefits of the AZLRS project. The correct approach is to start by measuring benefits as the value of the productive resources released by the project for use in the rest of the economy. The reason is that AZLRS essentially will replace some of the current means of traveling within the corridor.

In other words, by far most of the people who would use AZLRS are presently using other transportation means or would do so in the absence of AZLRS. Except for presumed gains in travel time, comfort and timeliness, aspects to be taken into account below, users would be substituting AZLRS services for what buses, taxis, servis, and private cars now provide. Accordingly, once the substitution takes place such vehicles, and the capital associated, with them may be allocated to the rest of the economy.

The methods applied involved:

1. Projecting the number of passenger trips per year. To this end existing daily estimates of present and projected passenger traffic were used. Those estimates were developed in the project's feasibility and design analyses of June 2010.
   Daily estimates of passenger traffic by vehicle type were converted to annual figures by an annualization coefficient developed during the 2010 project redesign.
2. The yearly estimates assume a 2.1 percent annual rate of growth in the number of passengers -- a rate used in the 2010 redesign.
3. Multiplying estimates of the average fare paid by the passengers by vehicle-type times the number of passenger trips gave the value of such trips by vehicle type. As per the IFC-supported report recommendations, the average values for the transportation mode used were: large bus trip = JD 0.47; business taxi = JD 1.00; regular taxi = JD 0.63; and private car = JD 0.90.
4. Adding across vehicle types gave the total value of the trips.
5. Multiplying the total value of the trips by a coefficient for the proportion of other vehicle transportation services that would be diverted to, or replaced
   by the AZLRS gave the total value of trips replaced. The IFC-recommended coefficient used (also referred in this report as the capture or take-over rate) 0.172 is a weighted average of the proportions of replacement by vehicle type.

These proportions were as follows:

Large buses and coasters…….27 percent

Service taxi……..… 35 percent

Regular taxi…… 11 percent

Minibus……8 percent

Private car……5 percent

As mentioned, it is noteworthy that the 2010 redesign assumed a much lower capture rate than previous analyses. In the early studies and designs one finds reference to proportions even higher than 40 percent as the relative number of riders who would shift from other transportation means to AZLRS.

The procedure used to value the resources freed to the rest of the economy involves the assumption of no abnormal profits in the provision of these transportation services and therefore that the prices are a good proxy for the economic costs or values of such services. The calculation steps are shown on Tables 6 and 7.

The yearly flows of net economic benefits (i.e., economic benefits as measured by the value of productive inputs released minus economic costs) are shown on Table 8. While most years after year 2 exhibit positive values, their present value is negative regardless of the discount rate used. This outcome again reflects the decisive weight of the negative values associated with years 1 and 2 capital expenditures. The negative present value of the net economic benefits flows suggests that, at least in terms of the value of productive factors released relative to costs, up to this point, the project's economic worthiness was questionable.

The issue then becomes what happens when other benefits are factored in.

Economic Benefits: Adding Pollution Effects

Contributing to the reduction of vehicle emissions is an AZLRS objective. Those emissions are considered an important source of air pollution -- contamination by carbon dioxide is frequently mentioned among the main noxious gases -- and therefore a health hazard. Moreover, it is reasoned, after adjusting for passenger load light rail produces less pollution than road vehicles.

An underlying concept is that motor road vehicles produce a negative externality in the form of air pollution. A consequence is that the social costs of road travel are larger than the private costs borne by the vehicle users and owners.

Placing a monetary value on pollution reduction is very imprecise. Even the principles of measuring such an effect are seemingly not universally accepted.[4] Moreover, official planning figures on the monetary costs of pollution per ton do not seem to exist. The present study explores the issue under the assumption that even a sense of the magnitudes involved helps.

The base approach used was to rely on pollution estimates from projections of vehicles that would use the Amman-Zarqa corridor and valuing the social or economic cost of the pollution on the basis of prices for pollution allowances permits in international auctions.[5] There are at least two problems with this approach. The first one is that the prices for the permits show wide dispersion over time. The second is that such prices may reflect region or industry specific conditions that do not mirror well conditions in Jordan.

Nonetheless, the use of significantly different prices makes it possible to test the sensitivity of project-merit indicators to price variation. If significant price differences do not dramatically change the basic results then one can have some confidence in the conclusions.

A second approach consisted in extrapolating and adjusting to Jordan estimates from the cost of pollution in a high population density area in the United States. The results of both approaches are described next.

The pollution estimates used in the pollution-permit allowance approach are based on early 2000s estimates by engineers at Jordan's Ministry of Transport. The estimates include the net annual reductions in CO_2 emissions resulting from the AZLRS for years 2003 through 2031.

For these estimates the engineers calculated total emissions by vehicle-type from vehicles transporting passengers within the corridor and added emissions from buses transporting corridor passengers beyond the corridor. Then they estimated, by year, the number of passengers that would divert from other transportation means to the AZLRS.

After adjusting for emissions for the AZLRS itself, the engineers arrived at estimates of pollution avoided. The present study used such estimates and extrapolated them for a few years more at the same growth rate that had been used in the engineering calculations. [6]

---

[4] For a brief review of approaches see Haripriya Gundimeda, Hedonic Price Method -- A Concept Note at http://coe.mse.ac.in/dp/hedonic%20price.pdf

[5] As this anchors the present analysis on official pollution calculations this has been the preferred approach used in the present analysis.

[6] The capture rate used in the estimates is higher than the 2010 recommended in the 2010 project redesign. While this biases upward the estimates of pollution reduced this did not make any material difference to the conclusions of the present study.

As mentioned, the price for pollution permits varies widely. For example, an October 2006 report indicates that CO_2 emission-per-ton permits under the European Union Emissions Trading Scheme were trading at the equivalent of JD 23 per permit.[7] That report used, however, a price of JD 7.18 -- following technical advice. During the summer of 2008 the price of the same permits had been quoted at the equivalent of some JD 27. Nonetheless by January 2009 the price had fallen below JD 11.[8] Moreover, by September 2009 the expectation was that the permits would trade for less than the equivalent of JD 7.[9] Finally in the United States carbon dioxide permits were trading at about the equivalent of JD 2.19 per ton around October 2008.[10]

The present analysis has used two alternative prices for the permits: a high price of JD 14.29 and a low price of JD 2.19 per CO_2 ton. The results are as follows.

- Regardless of which of the two pollution prices is used, the discounted present value of the flow of net economic benefits taking into account the value of productive resources freed plus the reduction in pollution are negative.
- The net present value of the flow of net benefits rises from a negative JD 277 million when using the low price for permits to a negative JD 262 million when using the high one -- a 5 percent difference.
- As compared with the scenario when only the value of the resourced freed up are considered, when adding the benefits from reduced pollution (high price for permits) the present value of the net benefits flow rises from approximately a negative JD 280 million to a negative JD 262 million.

The results for adding the pollution benefits (high pollution permits case) to the previous layer of benefits are shown on Table 9.

For sensitivity the present analysis explored with a different approach that built on estimates of the costs of pollution for a fleet of vehicles in California (herein Small and Kazimi).[11] The authors projected pollution costs-per-mile estimates (at 1992 prices) to year 2000 for post-1977 vehicles. The estimate they arrived at was US$ 1.61 per-vehicle-mile. As the trend in emissions standards controls has clearly been towards emissions reduction, the authors' figures are likely to overstate today the magnitude of vehicle emissions.

Converting the Small and Kazimi estimate to Jordanian dinars, one arrives at JD 1.13 per mile in year 2000 at 1992 prices. To obtain the cost at 2010 prices the present

---

[7] Environmental Impact Assessment (EIA) Study for Light Railway System Project, Socio-Economic Component Study, October 2006, page 47.
[8] Spiegel On Line, ttp://www.spiegel.de/international/europe/0,1518,603521,00.html.

7 Scitizen (http://scitizen.com/climate-change, 28 September 2009.

[10] University of Virginia, http://www.virginia.edu/uvatoday/newsRelease.php?id=6565.
[11] Kenneth A. Small and Camilla Kazimi, On The Costs of Air Pollution from Motor Vehicles, Department of Economics, UCLA, September 14, 1994. The results of these additional exercises are reported but not shown in tables. Detailed calculations are available upon demand.

analysis relied on price indices published by the Central Bank of Jordan. That resulted in a pollution cost per-mile of JD 2.07. Converting that amount to a per-kilometer basis resulted in a cost of JD 1.28 per-kilometer at 2010 prices.

As the economic costs of pollution to a society are most frequently transmitted via the effects of pollution on health, and the consequent loss of domestic output resulting from poor health, it was necessary to adjust such estimates by relative gross national income per capita in Jordan relative to the United States. According to purchasing-power-parity estimates by the World Bank for 2008, Jordan's income per capita was 12 percent of the United State's.[12]

That would make the pollution costs per vehicle-kilometer some JD 0.15 (i.e., 1.28 x 0.12). The present analysis used a higher estimate of such cost and placed the cost in Jordan at JD 0.26 (i.e., 1.28 x 0.20). This figure was used in preliminary work for the present report to test an alternative approach. It stood for the pollution cost of the average vehicle traveling a kilometer in the Amman-Zarqa corridor.

The next steps consisted in estimating the total costs involved and the likely pollution savings from the AZLRS. For such purpose the study used the project's 2010 redesign estimates of passengers per vehicle type. Taking each passenger as a trip gave a flow of passenger-trips per vehicle per year.

As vehicles carry more than one passenger, the study derived the number of trips per vehicle by dividing the number of passenger-trips per vehicle by an average passenger load for each vehicle type. The loads used are consistent with loads used in prior AZLRS-related analyses. They were:

- 40 passengers for large buses and 20 passengers for small buses
- 3 passengers per car
- 2.1 as the average passenger load for regular and business taxis

By assuming that the average distance per trip is 20 kilometers (only slightly over 50 percent of the riders make the full Amman Zarqa trip) the analysis estimated the number of kilometers traveled by each vehicle type. The pollution costs per vehicle costs were arrived at by multiplying the kilometers by the pollution cost per-kilometer.

By using the proportion of travel taken over by the AZLRS, it was possible to obtain the pollution savings per year made possible the AZLRS.

The addition of savings from reduced pollution calculated as explained above raises the present value of net economic benefits by some 37 percent. When the value of productive inputs released to the rest of the economy was the only benefit considered

[12] Purchasing power parity involves a technique to estimate how much of a given basket of goods different currencies can buy. The method is useful to derive purchasing power exchange rates that are more appropriate than market exchange rates when the objective is to compare standards of living or purchasing power across countries.

the present value of the flow of net benefits was approximately a negative JD 280 million at a 10 percent rate of discount. However, when the reduction in pollution costs was considered the present value of the flow of net benefits increased to minus JD 177 million. Moreover the economic internal rate of return rose slightly above a positive 1 percent.

The conclusion from this exercise was that even using generous estimates for valuing pollution reduction effects by themselves such reductions are not sufficient to justify the project. This result is consistent with the findings of the 2010 redesign.[13]

Economic Benefits: LRS Induced Decrease In Traffic Deaths And Injured

The assumption in this analysis is that light rail is likely to involve a reduction in the number of traffic accidents as passengers shift away from road transportation. However, this is not a foregone conclusion. Also, here the evidence is mixed because of accidents within the rail system itself. For example, the table below shows transportation fatalities in the United States for a number of transportation modes.

U.S. Transportation Fatalities (1999)

	Deaths	Deaths per Billion Veh. Miles	Deaths per Billion Pass. Miles
Passenger Car Occupants	20818	13.4	8.4
Motorcycle Passengers	2472	242.4	220
Transit Bus -- Total	91	39.6	3.7
Commuter Rail -- Total	95	358.5	10.0
Light Rail Transit -- Total	17	395.3	15.7

Source: Victoria Transport Policy Institute, Transportation Cost and Benefit Analysis II – Safety and Health Costs, page 5.3-1, June 4, 2010 (www.vtpi.org/tca/tca0503.pdf)

The point of the table is not that light rail is associated with a larger number of fatalities than the other transportation modes (on the contrary, in absolute terms it has the lowest fatalities), but that in relative figures some of the other modes may do as well or better. Hence, for assessing savings from a potential reduction in traffic accidents because of

[13] See Amman Zarqa Light Rail System, Demand and Revenue Forecasts Report, June 2010, appendix C.

light rail, it is necessary to adjust for accidents within the light rail system itself.[14] This has not always been done in this type of analysis.

In the present analysis, the base approach for assessing benefits in terms of reduced losses from road accidents in Amman-Zarqa builds on with and without estimates presented in the 2006 Socio-Economic Study already mentioned. That analysis relied on year 2004 road accident data for Jordan from which the number of accidents, fatalities and injured in the Amman-Zarqa corridor were derived. The study used data on the average aggregate cost of the accidents in terms of property damage, and lost income as a result of fatalities and injuries. The product of number of accidents and average loss from accidents gave total loss.

Under a without-project scenario, the present analysis projected the cost to year three of the AZLRS life, assuming a yearly growth rate of three percent, estimated losses after AZLRS started and derived loss savings that reflected the light rail system impact. The capture rate used was 17.2 percent as suggested in the 2010 project redesign, a rate much lower than assumed in the 2006 Socio-Economic Study.

The results are presented on Table10. When the benefits of reduced loss traffic accidents are added to the benefits represented by the value of productive resources freed and the reduction in pollution costs, the discounted present value of the flow of net benefits, while still negative, increases from a minus JD 277 million to a minus JD 250 million -- a rise of some 9 percent.

For sensitivity testing the present analysis also tried a different approach to assess economic impact from reduced road accidents. This approach consisted in approximating the loss in national output resulting from deaths and injuries.

Direct information on the monetary losses from the accidents was not found. Nonetheless, as it is reported that 2 persons die and other 50 persons are injured daily during work days in Jordan as a result of road accidents, this translates into a total of approximately 660 persons killed and 16,500 persons injured per year.

Bearing in mind that Amman and Zarqa together account for some 67 percent of vehicles in Jordan it was possible, under additional assumptions, to estimate the number of deaths and injured in the Amman-Zarqa corridor. (The assumption far overstated the proportion of accidents attributable to Amman-Zarqa but this partially compensates for the lack of information on property damage losses.)

Taking 15 years as the age after which many persons *de facto* start work activities, and as some 36 percent of the Jordanian population is under 15 years of age, it was estimated that 95 of the deaths are minors (264 x 0.36). Therefore 169 of the deaths

[14] An example in which rail does show lower relative crash costs than car or bus transportation is found in Emile Quinet, "The Social Costs of Transport: Evaluation and Links With Internalization Policies," in Internalising the Social Costs of Transport, OECD, 1994, page 38 (www.oecd.org). Yet, while lower, the rail costs are significant.

are older than 15 years. Moreover, it was assumed that their median age was 22 years, about the median age for Jordan.

As the labor force participation rate for Jordan (the proportion of able working-age persons who work or seek work) is 40.1 percent, it is reasonable to assume that some 68 of the deaths were of persons in the labor force (169 x 0.401). As the employment rate (i.e., the proportion of the labor force that is employed) for Jordan is around 87 percent it was estimated that some 59 employed worker die yearly (68 x 0.87).

An amount of JD 4,086 was used as the average per-death yearly output loss to the country -- as JD 4,086 is the purchasing parity gross national income per capita for Jordan. Multiplying the loss per death times the number of deaths the study estimated the yearly losses as a result of deaths. The yearly losses times a capture rate by AZLRS (adjusted for ZALRS deaths -- assumed one AZLRS death for every three on the road) gave the savings from the AZLRS in terms of net deaths avoided. While the use of purchasing power parity values may bias upward the loss in contribution to GDP, this also serves to compensate for the lack of data on property damage from accidents.[15]

The procedures for the loss from road injuries not resulting in death were similar. Multiplying the number of injured times the proportion of injured in the Amman-Zarqa corridor gave the number of injured in the corridor (16,500 x 0.40 = 6,600).

Multiplying the corridor injured times the proportion of adults (6,600 x 0.64 = 4,224) gave the number of injured adults in the corridor. The product of the injured adults and the labor force participation rate (4,224 x 0.401 = 1694) gave the number of injured in the labor force. Adjusting by the employment rate (1,694 x 0.87 = 1,474) gave the number of employed workers injured.

Assuming that injured workers cannot work 14 workdays per year as a result of an injury, the total of work days lost was estimated (1,474 x 14 = 20, 636). Multiplying times labor income per day gave total income lost from accidents. Using the AZLRS passenger traffic capture rate the savings from reduced accidents were derived.

The result did not materially change the results arrived at via the basic method. The present value of the flow of net economic benefits increased but still remained in deep negative territory. As before, until this point the project did not seem justifiable in economic terms.

[15] Perhaps more importantly benefits derived from purchasing power parity prices cannot strictly be compared with costs based on market or official exchange rates.

Economic Benefits: Savings from Reduced Travel Time

In principle traveling from Amman to Zarqa using light rail should involve time savings for a passenger making the same journey on congested roads. The estimates of likely time saved for such journey range from seven to eleven minutes.

But there are secondary effects. Because of somewhat less congested road traffic, under an AZLRS scenario there should be an additional travel time savings on the road – that is for passengers not traveling in the AZLRS. On the other hand, light rail passengers whose point of destination is not close to the train station might find that, relative to the light rail, other transportation modes leave them closer to where they intend to go. Accordingly, once start and end-destination points are considered, there might be a partial offset to time savings in just moving from station to station.

It is not clear how the designs of feeder bus systems that should complement the AZLRS would attenuate this potential secondary time savings effect within the AZLRS, nor about the net result of the secondary effects. In the present report these secondary effects are assumed to cancel out and the analysis is based on station-to-station time involved. The base case assumes a savings of nine minutes per trip.

The product of number of trips and time saved per trip gives the total amount of time saved. To value such time the analysis used an average of the labor income per hour. The average used was JD 1.5 per hour -- a value estimated by adjusting to year 2010 prices the value used in the 2006 Socio-Economic analysis.

The number of trips, hours saved per year and the JD savings resulting from such time savings are shown on Table 11. The footnotes to the table explain how the numbers were arrived at. The hours saved calculation follows the procedures used in the Socio Economic Survey of 2006.

The results of adding travel time savings to the other benefits are shown in Table 12. When added to the previous layers of benefits, savings from reductions in travel time make a significant difference. The economic internal rate of return becomes 12 percent with, naturally, a positive and material present value attached to the flow of net economic benefits. That travel time savings result in being the significant benefit is probably not a cause for surprise. After all, a main driver of advances in transportation technology is to economize on travel time.

How do these results fare relative to previous AZLRS studies?

Compared to the results of previous AZLRS studies the base rate estimated in the present study is somewhat lower but still within the range of the rates for such studies. For instance, the early reports by ARE show rates that vary, depending on scenarios or

assumptions, between 14.5 and 15.1 percent, with a rate of 10.5 percent for their L Irbid scenario.[16] A study by The Royal Scientific Society shows the highest rates with a range between 15 and 31 percent.[17] Other analyses reported financial rates of return (ranging from approximately 9 to 16 percent) but no economic rate of return.[18]

An overview of the results with the four layers of benefits quantified in the present study is provided in Table 13.

9. Sensitivity Analysis

Information is generally not complete and data have degrees of reliability. Moreover, the present type of analysis has to in part rely on assumptions. How would project worthiness, as measured by such criteria of project merit as the economic rate of return and the project present value, change under different assumptions? What is the risk -- especially the downside risk -- that actual values differ from projected values?

To explore these issues the present analysis carried out "what if" exercises whose results are summarized on Table 14. Each exercise involves a scenario where selected benefits or costs differ from the base case assumptions used in this report. The figures express the direction and percentage change in the values of project merit criteria and the changes under which those criteria reveal a switch in pro0ject worthiness from acceptable to non-acceptable. Where applicable, sensitivity ratios – percentage change in merit criteria over percentage change in benefits or costs – indicate the volatility of results. Ratio values significantly below one indicate relative stability of project worthiness to change in a variable, while ratios above one indicate the reverse. Comparisons are relative to the base case scenario and assume that everything else in the base scenario remains equal. The results follow.

A difference of some 20 percent in savings from reduced time on trips has significant impacts on both the internal rate of return and the project present value. If the per-trip time saved were to be 2 minutes less than anticipated (seven rather than nine) the project would not pass efficiency tests, as the economic rate of return falls below the social discount rate (9 versus 10 percent). Naturally, time savings above 9 minutes per trip would make for a stronger economic case for the project.

Project worthiness would suffer significantly if costs were to be 10 percent higher than expected, or if one adjusted upward costs by 10 percent to account for physical contingencies. The internal rate of return would fall below minimally acceptable levels.

---

[16] See Austria Rail Engineering (ARE), Light Railway System Jordan, March 1996. One should note however, that due to differences in methodologies and data sources the results are not strictly comparable across studies.

[17] Royal Scientific Society and Environmental Research Centre, Environmental Impact Assessment (EIA) Study for Light Railway System Project, October 2006.

[18] PADECO Co., Light Rail System Amman to Zarqa, August 1998.

Unfortunately, the record of big physical public infrastructure projects is replete with examples of project plans that underestimated costs much more than 10 percent. The high sensitivity of project criteria to cost levels indicates a high level of downside risk.

The relatively small contributions to overall benefits of reduction in net pollution and road traffic accidents is highlighted in the table. Doubling or eliminating such benefits would not significantly change the project indicators of merit.

Finally, the table illustrates the weight of changes in consumer surplus. The meaning of an increase in the surplus is illustrated in the graph below. The fundamental points to remember are that:

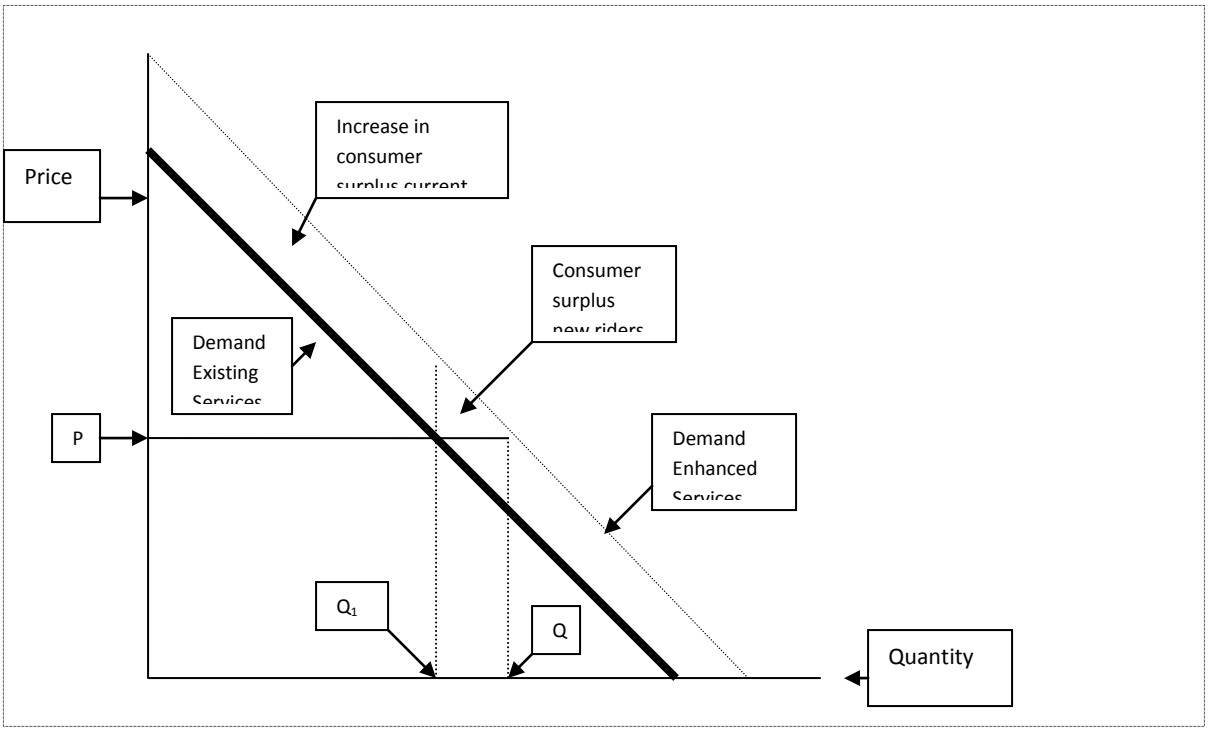
1. The area under a demand function measures the utility derived from the use of the reference good.
2. As previously mentioned, consumer surplus relates to benefits users receive and would be willing to pay for but do not have to.

In the graph, the thick sloped line in the graph stands for the demand for transportation along the Amman-Zarqa corridor, as it exists now. The thinner dotted line above it represents the new demand for higher quality transportation services in the corridor – this line might stand for the demand associated with AZLRS services.

Given that prices are capped at level P, with the new demand function total quantity demanded increases by an amount equal to Q_1Q. The change in consumer surplus is the area between both demand functions between the origin and Q. Such changes can be apportioned between benefits to riders who shift from other services to AZLRS and the creation of consumer surplus for new riders – persons who did not travel before the light rail but are willing to travel in transportation that is more attractive.

The existence of an increase in consumer surplus resulting from the project is implicitly suggested by work done during the 2009-2010 design. Such work indicated that the "revenue maximizing" rates would be above the planned AZLRS fares. Accordingly, as willingness to pay is a proxy for the value placed on goods and services, the existence of such favorable change in surplus is a reasonable assumption.[19]

[19] The issue of how willing users are to pay for enhanced services, however, is not totally clear. This is common. Surveys done for the 2006 environmental assessment for the Amman Zarqa Light Rail did not reveal a willingness to pay higher rates for light rail than for buses. Nonetheless, such surveys can be very unreliable because persons may have an interest in not revealing their true preferences.



Moreover, the 2010 demand study indicated that although an increase in the base fare by 50 percent resulted in a large drop in the quantity demanded (that is, number of rides), total fare revenue would rise nonetheless. In fact, such study estimated that the application of a "revenue optimizing" fare would result in annual revenues 5 to 15 percent higher than if fares remained at the base level.[20] Accordingly, on a willingness to pay basis, one may infer that the light rail system is likely to generate a change in consumer surplus between 5 and 15 percent of fare revenues.

Given that the impact or value of reduced travel time has already been quantified in this study, the remaining factors that may account for an increase in consumer surplus resulting from the AZLRS are factors relating to a more comfortable and reliable ride – cleanliness and schedule punctuality, for example. As shown on the sensitivity table an increase in consumer surplus approaching the equivalent of 50 percent of fares paid would spell an internal rate of return around 14 percent, with a change in surplus of only 10 percent making only a small difference. The attainment of such increases in consumer surplus obviously would depend on AZLRS management quality.

In a nutshell, while the introduction of benefits under the concept of an increase in consumer surplus from the AZLRS reinforces the economic case for the project, overall the effects are likely to be small.

To conclude, the results of the sensitivity analysis indicate that, depending on assumptions, the project's economic internal rate of return is likely to fall within a range

[20] Steer Davies Gleave, Amman Zarqa Light Rail System Demand and Revenue Forecasts, June 2010, page 59.

of 10 to 14 percent with 12 percent as the best point estimate of such rate. While the range sets the boundaries for the project most probable outcome, as shown in the sensitivity table, the possibility of rates of return below 10 percent cannot be dismissed as insignificant.

10. Economic Assessment of the AZLRS

As explained above, when all relevant benefits are counted the project's present value is positive and the point estimate of the internal rate of return is 12 percent. Both criteria indicate that the AZLRS creates more value than it uses up. Subject to caveats below on project risk, it does make economic sense. Moreover, the economic case for the project is reinforced when one takes into account that the main project beneficiaries are low income population groups. Accordingly, distribution or fairness considerations are an argument for the project that policy decision-makers might want to take into account.

Yet, using the range midpoint as the base rate of return, how good is a rate of return of 12 percent? A perspective for the answer is provided by Millennium Challenge Corporation (MCC) criteria for a minimum acceptable economic rate of return. The MCC establishes that such minimum rate of return is to be the greater of: (a) two times the average real growth rate of GDP for the country for the most recent three years for which data is available; (b) two times the average real growth rate of GDP for all the MCC eligible countries for each country for the most recent three years for which data is available.

From year 2006 through year 2009 Jordan's gross domestic product grew at an annual real compound rate of some 6 percent. Likewise the most recent information has the MCC using a hurdle (minimum acceptable) rate of 12.4 percent. Accordingly, based on the benefits taken into account until this point, the project just meets the MCC minimum acceptable economic rate of return. Moreover, this assessment is consistent with a generalized practice among international development institutions of using rates between 10 and 14 percent as the minimally acceptable in efficiency terms.

Nonetheless, as Jordan's authorities are operating under tight budget constraints it behooves the country that the decision to go ahead with the AZLRS be taken after measuring this project against project alternatives. Once all economically sensible and feasible projects that meet the desired objectives are considered, the most cost effective one should be selected.

Moreover, the results of the present study have additional policy implications. The key determinant of the project's added value potential to Jordan is the savings in terms of travel time. This means that any recurrent delay in the timeliness of train performance would negate the main source benefits associated with the system. Even more generally, any factor that discourages ridership would endanger the achievement of the

perceived benefits. One such factor, the price reaction of transportation competitors with the AZLRS, has received scant attention. What is the risk to the AZLRS if competing services cut their prices?

While, as noted earlier, Jordan's Public Transport Regulatory Commission has attempted to facilitate the eventual adoption of the AZLRS by constraining the supply of new licensed transport operators in the corridor, the increased demand for the services has been met by a rising number of unlicensed operators. This indicates that potential AZLRS competitors are likely to respond to AZLRS competition by promoting their services. To the extent possible, this competition could take the form of some price cutting and more flexible services by competitors. (Bus systems can be altered at lower costs and buses operate very flexibly at present with no standards for stops, for example.)

The reaction of potential AZLRS riders to competitive price pressures on the AZLRS can be surmised on the basis of existing estimates of the price elasticity of the demand for transportation services. According to the IFC supported analysis, the fare elasticity of transportation services in the corridor is somewhat above -0.6 which makes it relatively high compared to other transit systems.[21] This relatively high elasticity is not surprising given that most potential users of public transport systems in the corridor are persons of low incomes for whom transportation costs likely represent a sizeable budget expense. This means that the ridership of the AZLRS cannot be taken for granted.

Moreover, given that the benefits to Jordan of a scheme such as the AZLRS revolve around a central source of benefits, savings in travel time, any factor that reduces such ridership below projected levels is likely to have strong adverse impacts on project worthiness. This came through in the sensitivity analysis.

Furthermore, if in addition to the previous considerations, one takes into account the mixed record (see below) of light rail schemes and the high up-front costs that the project involves, one can conclude that the project's value at risk is high.

11. The AZLRS and Potential Project Alternatives or Complements

As previously mentioned, traffic congestion in the Amman-Zarqa corridor is already a problem that left unaddressed will become worse with escalating social costs. Accordingly, policies to help attenuate such costs are needed.

In principle, there are three basic ways to meet traffic challenges in the Amman-Zarqa corridor. Alone or in combination, they are:

[21] Steer Davies Gleave, "Amman Zarqa Light Rail System, Demand and Revenue Forecasts," (2010), page 58.

- A rail system such as the AZLR
- A bus rapid transit (BRT) system involving an enhancement of the Amman-Zarqa road route
- Facilitating increased auto use

Results of comparing the operating costs of BRT and LRS are mixed. [22] Light rail tends to have higher capital costs. Yet, while bus systems have been found to generally have lower operating costs, there is no clear pattern on operating costs per trip. Moreover, the performance record does not clearly favor one system over the other.[23]

Bus Rapid Transit is frequently seen as providing a more flexible approach than Light Rail because buses can be routed to eliminate transfers. On the other hand, some analysts think that, because LRSs are seen as more permanent once they are established in a corridor, light rail may have stronger economic development effects. Besides, in general, in some metropolitan areas, buses may have a poor public image. Yet, there is a viewpoint that, in Amman Zarqa, bus poor public image may not be an issue, and familiarity of the riders with buses and the like, but not with light rail, may be a factor.

All in all, however, there is work that indicates that riders do not have an inherent preference for either rail or bus when service quality -- e.g., travel time, dependability, and number of transfers -- is comparable.[24] This suggests that riders would adapt easily if quality is evident.

Regarding automobile and general road use, analyses on what happens in various parts of the United States have argued that, given trends in automobile fuel efficiency, energy savings from light rail relative to automobile use are very small. Likewise, the issue of travel time savings from using light rail relative to roads has been a subject of controversy with some experts alleging that relative light-rail time savings are miniscule – if they exist at all.[25]

Advocates of road transit establish an implicit cause-effect relationship arguing, for example, that United States metropolitan areas are the world's most mobile by virtue high levels of automobile ownership and superior roadways and that "such mobility helps make America's metropolitan areas the most productive in the world".[26]

---

[22] A review of the light rail literature can be found on Clifford Winston and Vikram Maheshri, "On the Social Desirability of Urban Rail Transit Systems," Journal of Urban Economics, Vol 62, No. 2 (September 2007), pp. 362-382.
[23] United States General Accounting Office, Mass Transit Bus Rapid Transit Shows Promise, September 2001.
[24] Washington Post, January 8, 2009.
[25] Wendell Cox, Washington's War on Cars and the Suburbs: Secretary LaHood's False Claims on Roads and Transit, Heritage Foundation, 2010.
[26] Cox, Washington's Wars…page 13.

In summary, the record of LRS over competing transportation systems is ambiguous and opinions regarding the relative merits of different systems differ. In part, those differences reflect rival interpretations of empirical data.

Moreover, as public transportation, by whatever system, usually involves a heavy component of public sector financing, much of this literature stems from parties -- such as transportation enterprises and lobbying associations -- that have financial interests in specific outcomes. Hence, reported results must be reviewed cautiously.

Common issues revolve around such aspects as the up-front costs of competing systems and the overall costs per passenger, network effects (the increase in the value of a product or service to users as more people avail themselves of the good or service), the cost-effectiveness of pollution-reducing effects, time-saving effects, and the differing impacts on injuries and fatalities.

The point is that it is not enough to analyze the relative benefits of a light rail system between Amman and Zarqa and the *status quo* but that is also necessary to compare the economic worthiness of the potential solution alternatives. This would enable Jordan's society to identify the most cost-effective alternative to successfully address the transportation issue in the corridor. However, at the time of this writing, besides the AZLRS, until now apparently there is little publicly available material on other potential alternatives to existing Amman-Zarqa transportation systems. This may be changing as the authorities are reported to be contemplating such type of analyses.

Given the large magnitudes of capital resources involved such analyses should be very helpful. Of particular interest would be the identification of alternative or complementary solutions and the evaluation of the respective economic net benefits. Such alternatives might involve the widening of existing roads, new roads, and BRT with dedicated lanes

12. Conclusions and Recommendations

The Light Rail Project has the potential to significantly alleviate traffic congestion in the Amman Zarqa corridor and makes economic sense. However, its high level of risk, and the existence of potential alternatives that may also meet the same key objective of alleviating traffic congestion, makes it desirable that the authorities explore the relative economic worthiness of the alternatives versus the light rail project.

Were the project to be implemented it is important that the light rail train schedules be met punctually, comfort standards fulfilled, and awareness of the advantages of the system versus transport alternatives be promoted. The costs of awareness promotion among the AZLRS potential clientele is surely small, and ensuring a willing, stable and substantial ridership is essential for the achievement of the economic benefits identified.

13. Main Tables

Table 1: Project Assumptions

(Monetary Values in million JD's)		Present Values discounted at	
		6%	**10%**
Project Life	**25 years**		
Capital Period	2 years (years 1 & 2)		
Operating Period	23 years (years 3 to 25)		
Revenues from sales of tickets (present value)		250	155
Revenues to concessionaire from GOJ availability payments (present value)		483	317
Total operational revenues to concessionanaire (present value, includes other revenue sources)		748	482
Capital Expenditures (includes maintenance; present value)		404	358
Operating Costs (present value discounted at 10%)		168	105
Total costs (capital plus operating)		572	463
Initial year estimate of operating costs (year 3)	9.6		
Annual growth in operating costs	2%		
GOJ Financial Support			
Capital Grant	60		
Availability Payment (present value discounted at 10%)		484	317
Initial year 3 availability payment	39.3		
Annual Growth Rate in Nominal Yearly Availability Payments	1.60%		
Annual Minimum Revenue Guarantee	13		
Number of stations	6		
Amman-Zarqa is fixed and capped at JD 0.50, 2010 prices			

Table 2: Financial Costs and Revenue Flows

(In million JD's)

Year	Civil Works and Equipment Costs[a]	Maintenance Costs[b]	Operations Costs[c]	Interest Payments on Loans[d]	Total Capital Outflows	Loan (ECA and Others)[f]	GOJ Capital Grant	GOJ Availability Payments[g]	Ticket Sales[g]	Other Revenues from operations[h]	GOJ Minimum Revenue Guarantee[i]	Interest Earned on Funds[g]	Total Capital Inflows	Net Cash Flow	Present Value (discounted at 6 %)[l]	Present Value (discounted at 10%)[l]
1	181.9				181.90	157.90	24.00						181.90	(0.00)	(0.00)	(0.00)
2	142.5				142.50	106.47	36.00						142.47	(0.03)	(0.03)	(0.03)
3		3.39	6.14	15.97	25.51			39.31	11.69	0.71	1.42	0.39	53.50	28.00	24.92	23.14
4		3.48	6.30	15.06	24.83			39.53	13.95	0.80		0.96	55.24	30.40	25.53	22.84
5		3.56	6.46	14.14	24.16			39.75	16.42	0.91		1.59	58.68	34.51	27.34	23.57
6		4.75	7.91	14.69	27.35			41.28	17.26	0.96		2.31	61.81	34.46	25.75	21.40
7		4.87	8.11	13.62	26.60			41.52	18.13	1.01		3.01	63.67	37.07	26.13	20.92
8		4.99	8.31	12.54	25.84			41.76	19.03	1.06		2.96	64.81	38.97	25.92	20.00
9		5.12	8.52	11.44	25.08			42.01	19.96	1.11		3.14	66.23	41.15	25.82	19.20
10		5.24	8.73	10.33	24.30			42.27	20.94	1.17		3.42	67.79	43.48	25.74	18.44
11		5.37	8.95	9.19	23.51			42.53	21.94	1.22		3.83	69.52	46.01	25.69	17.74
12		5.51	9.17	8.03	22.71			42.80	22.99	1.28		2.43	69.50	46.79	24.65	16.40
13		5.65	9.89	9.16	24.69			46.24	24.05	1.34		0.84	72.46	47.77	23.74	15.22
14		5.79	10.14	8.00	23.93			46.52	25.15	1.40		1.01	74.08	50.15	23.51	14.53
15		5.93	10.39	6.82	23.14			46.81	26.29	1.47		1.19	75.75	52.61	23.27	13.85
16		7.49	11.91	5.61	25.01			47.11	27.47	1.54		1.36	77.47	52.46	21.89	12.56
17		7.67	12.21	4.37	24.26			47.41	28.69	1.60		1.53	79.23	54.97	21.64	11.96

18		7.86	12.52	3.11	23.49			47.72	29.96	1.68		1.65	81.01	57.52	21.36	11.38
19		8.06	12.83	1.80	22.69			48.04	31.27	1.75		1.77	82.83	60.14	21.07	10.82
20		8.26	13.15	0.46	21.87			48.37	32.63	1.83		1.87	84.70	62.82	20.76	10.27
21		8.47	13.48	0.00	21.95			48.71	34.04	1.91		2.00	86.65	64.70	20.17	9.62
22		8.68	13.82	0.00	22.50			49.05	35.49	1.99		1.14	87.67	65.17	19.17	8.81
23		8.90	14.97	0.74	24.61			55.24	36.84	2.06		0.63	94.77	70.16	19.47	8.62
24		9.12	15.35	0.52	24.98			55.60	38.23	2.14		1.19	97.16	72.18	18.90	8.06
25		11.10	17.29	0.27	28.66			55.60	39.67	2.22		1.40	98.90	70.24	17.35	7.13
Total[e]	**324.4**	**149.27**	**246.55**	**165.86**	**886.09**	**264.37**	**60.00**	**1055.16**	**592.07**	**33.17**	**1.42**	**41.60**	**2047.79**	**1161.70**	**529.74**	**346.44**

Notes

[a] Derived from concessionaire's balance sheet "work in progress"

[b] Taken from concessionaire's income statement "maintenance expenses" -- I conjecture that this item includes future vehicle and refurbishment needs

[c] Estimated as total operating expenses minus maintenance expenses from concessionaire's income statement

[d] Interest paid on long term debt as shown in concessionaire's income statement

[e] Totals may not add up due to rounding

f From concessionaire's cash flow from financing minus GOJ grant

[g] Taken from concessionaire's income statement

[h] Taken from concessionaire's income statement and equals total revenues from operations minus ticket revenues and availability payments; these revenues are from advertising and rents

[I] As GOJ guarantees a minimum level of fare sales of JD 13million payments in this column represent the difference between MRG and forecast sales

[k] From concessionaire's income statement

[l] Year 1 flows are not discounted. Year 2 flows are discounted by a factor of 1/(1+i); year 3 flows are discounted by a factor of 1/(1+i)^2, and so on

Table 3: Concessionaire Income Statement Highlights

(In million JD's)

	Revenues Associated to Operations					Expenses	Net Revenues and Present Values			
Year	Ticket Revenues	Availability Payments	Rental Revenues	Revenues from Advertising	Total Revenues from Operations	Total operating expenses	Net Revenues Associated to Operations	Flow of net revenues if the initial cost of capital is included	Flow of net revenues inclusive of the initial cost of capital &discounted at 6%	Flow of net revenues inclusive of the initial cost of capital &discounted at 10%
1	0	0	0	0	0	0.00	0.00	(181.90)	(181.90)	(181.90)
2	0	0	0	0	0	0.00	0.00	(142.50)	(134.43)	(129.55)
3	11.69	39.31	0.23	0.47	51.70	9.54	42.16	42.16	37.53	34.85
4	13.95	39.53	0.24	0.57	54.28	9.78	44.50	44.50	37.37	33.44
5	16.42	39.75	0.24	0.67	57.09	10.02	47.07	47.07	37.28	32.15
6	17.26	41.28	0.25	0.71	59.50	12.66	46.84	46.84	35.00	29.08
7	18.13	41.52	0.26	0.75	60.66	12.98	47.68	47.68	33.61	26.91
8	19.03	41.76	0.26	0.80	61.85	13.30	48.55	48.55	32.29	24.91
9	19.96	42.01	0.27	0.84	63.09	13.63	49.46	49.46	31.03	23.07
10	20.94	42.27	0.28	0.89	64.37	13.98	50.40	50.40	29.83	21.37
11	21.94	42.53	0.28	0.94	65.70	14.32	51.37	51.37	28.69	19.81
12	22.99	42.80	0.29	0.99	67.07	14.68	52.39	52.39	27.60	18.36
13	24.05	46.24	0.30	1.04	71.63	15.54	56.09	56.09	27.87	17.87
14	25.15	46.52	0.31	1.10	73.07	15.93	57.14	57.14	26.79	16.55
15	26.29	46.81	0.31	1.16	74.56	16.33	58.24	58.24	25.76	15.34
16		47.11			76.11	19.40	56.71	56.71	23.66	13.58

	27.47		0.32	1.21						
17	28.69	47.41	0.33	1.28	77.70	19.88	57.82	57.82	22.76	12.58
18	29.96	47.72	0.34	1.34	79.35	20.38	58.97	58.97	21.90	11.67
19	31.27	48.04	0.35	1.40	81.06	20.89	60.17	60.17	21.08	10.82
20	32.63	48.37	0.35	1.47	82.82	21.41	61.41	61.41	20.30	10.04
21	34.04	48.71	0.36	1.54	84.65	21.95	62.70	62.70	19.55	9.32
22	35.49	49.05	0.37	1.62	86.53	22.50	64.03	64.03	18.84	8.65
23	36.84	55.24	0.38	1.68	94.14	23.87	70.27	70.27	19.50	8.63
24	38.23	55.60	0.39	1.75	95.97	24.47	71.51	71.51	18.72	7.99
25	39.67	55.60	0.40	1.82	97.50	28.39	69.10	69.10	17.07	7.02
Total	**592.07**	**1,055.16**	**7.13**	**26.05**	**1,680.40**	**395.83**	**1,284.57**	**960.17**	**297.68**	**102.56**
Financial IRR to Concessionaire								**14%**		

Notes

[a] Year 1 flows are not discounted. Year 2 flows are discounted by a factor of 1/(1+i); year 3 flows are discounted by a factor of 1/(1+i)^2, and so on

Table 4: Highlights from Cash Flow Statement Highlights

(In million JD's)

Year	Cash flow from operations	Cashflow from investments*	Cashflow from financing	Net Cashflow	Present Value of Net Cashflow discounted at 6%[ab]	Present Value of Net Cashflow discounted at 10%[ab]
1	0	(181.90)	181.90	(0.00)	(0.00)	(0.00)
2	0	(142.47)	142.47	(0.00)	(0.00)	(0.00)
3	27.81	0.00	(10.14)	17.67	15.73	14.60
4	30.43	0.00	(10.14)	20.29	17.03	15.24
5	34.53	0.00	(10.14)	24.39	19.32	16.66
6	34.82	(14.58)	2.90	23.14	17.29	14.37
7	37.10	0.00	(52.17)	(15.06)	(10.62)	(8.50)
8	39.01	(0.02)	(42.90)	(3.92)	(2.60)	(2.01)
9	41.19	(0.02)	(39.35)	1.82	1.14	0.85
10	43.52	(0.61)	(35.22)	7.69	4.55	3.26
11	46.05	(0.62)	(35.73)	9.70	5.42	3.74
12	46.83	(43.57)	(38.48)	(35.22)	(18.55)	(12.34)
13	47.88	(68.50)	(19.21)	(39.83)	(19.80)	(12.69)
14	50.20	(1.42)	(44.46)	4.32	2.02	1.25
15	52.65	(1.46)	(46.73)	4.47	1.98	1.18
16	52.87	(1.47)	(47.09)	4.31	1.80	1.03
17	55.03	(1.50)	(49.40)	4.13	1.63	0.90
18	57.58	(2.23)	(52.17)	3.18	1.18	0.63
19	60.20	(2.29)	(55.02)	2.89	1.01	0.52
20	62.89	(2.35)	(57.95)	2.59	0.86	0.42
21	64.76	(1.51)	(59.97)	3.28	1.02	0.49
22	65.24	(23.92)	(54.92)	(13.60)	(4.00)	(1.84)

23	70.34	(24.80)	(31.28)	14.26	3.96	1.75
24	72.25	(3.26)	(39.34)	29.66	7.76	3.31
25	67.49	(3.34)	(134.32)	(70.17)	(17.33)	(7.12)
Total &Present value	**1160.68**	**(521.84)**	**(638.86)**		**30.80**	**35.69**

Notes

***** This column includes figures only for additions to fixed assets; it does not include figures in the original concessionaire cash flows for "transfer to maintenance reserve" or "used for maintenance". Transfer to maintenance reserve seems to be only an accounting construct that doesn't involve cash disbursements. The "used for maintenance" items contains in many instances amounts exactly the same as those in the the "addition to fixed items" category. Accordingly it may be that "used for maintenance" is an account to pay for both new equipment and maintenance of old equipment. Check on the soundness of these interpretations

[a]The larger value of the present value of the net cash flow when discounted at the higher 10% discount rate (relative to the 6% rate) occurs because the negative net flows have a lower negative present value when discounted at the higher rate. Because when using a 6% discount the present value becomes lower reflects the impact of the higher discounted negative values -- as for example in year 13.

[b] Year 1 flows are not discounted. Year 2 flows are discounted by a factor of 1/(1+i); year 3 flows are discounted by a factor of 1/(1+i)^2, and so on

Table 5: Value of Economic Output and Economic Cost Flows, First Approximation

(In million JD's)

Economic Output				Costs										
Year	Fare Revenues *	Advertising	**Total**	Civil Works and Equipment	Maintenance during Operational Phase	Personnel during Operations	Energy during Operations	Other Utilities during Operations	Insurance during Operations	Other Operating Costs	**Total**	Net Economic Benefits	Present Value of Net Economic Benefits discounted at 6%[a]	Present Value of Net Economic Benefits discounted at 10%[a]
1	0.00	0.00	**0.00**	181.9	0.00	0.00	0.00	0.00	0.00	0.00	**181.90**	(181.90)	(181.90)	(181.90)
2	0.00	0.00	**0.00**	142.5	0.00	0.00	0.00	0.00	0.00	0.00	**142.50**	(142.50)	(134.43)	(129.55)
3	11.69	0.47	**12.16**		3.39	1.63	1.58	0.94	1.43	0.57	**9.54**	2.63	2.34	2.17
4	13.95	0.57	**14.51**		3.48	1.67	1.62	0.96	1.47	0.58	**9.78**	4.74	3.98	3.56
5	16.42	0.67	**17.09**		3.56	1.71	1.66	0.99	1.50	0.60	**10.02**	7.07	5.60	4.83
6	17.26	0.71	**17.97**		4.75	1.86	2.09	1.31	1.85	0.79	**12.66**	5.31	3.97	3.30
7	18.13	0.75	**18.88**		4.87	1.90	2.15	1.35	1.90	0.81	**12.98**	5.90	4.16	3.33
8	19.03	0.80	**19.83**		4.99	1.95	2.20	1.38	1.94	0.83	**13.30**	6.52	4.34	3.35
9	19.96	0.84	**20.81**		5.12	2.00	2.25	1.42	1.99	0.86	**13.63**	7.17	4.50	3.35
10	20.94	0.89	**21.83**		5.24	2.05	2.31	1.45	2.04	0.88	**13.98**	7.85	4.65	3.33
11	21.94	0.94	**22.88**		5.37	2.10	2.37	1.49	2.09	0.90	**14.32**	8.56	4.78	3.30
12	22.99	0.99	**23.98**		5.51	2.15	2.43	1.52	2.15	0.92	**14.68**	9.30	4.90	3.26
13	24.05	1.04	**25.09**		5.65	2.21	2.49	1.56	2.69	0.94	**15.54**	9.55	4.75	3.04
14	25.15	1.10	**26.24**		5.79	2.26	2.55	1.60	2.76	0.97	**15.93**	10.32	4.84	2.99
15	26.29	1.16	**27.44**		5.93	2.32	2.61	1.64	2.83	0.99	**16.33**	11.11	4.92	2.93
16	27.47	1.21	**28.68**		7.49	2.51	3.18	2.07	2.90	1.25	**19.40**	9.28	3.87	2.22

17	28.69	1.28	**29.96**		7.67	2.58	3.26	2.12	2.97	1.28	**19.88**	10.08	3.97	2.19
18	29.96	1.34	**31.29**		7.86	2.64	3.34	2.18	3.04	1.31	**20.38**	10.91	4.05	2.16
19	31.27	1.40	**32.67**		8.06	2.71	3.43	2.23	3.12	1.35	**20.89**	11.78	4.13	2.12
20	32.63	1.47	**34.10**		8.26	2.77	3.51	2.29	3.20	1.38	**21.41**	12.69	4.19	2.07
21	34.04	1.54	**35.58**		8.47	2.84	3.60	2.34	3.28	1.42	**21.95**	13.63	4.25	2.03
22	35.49	1.62	**37.11**		8.68	2.92	3.69	2.40	3.36	1.45	**22.50**	14.61	4.30	1.97
23	36.84	1.68	**38.52**		8.90	3.01	3.78	2.46	4.22	1.49	**23.87**	14.66	4.07	1.80
24	38.23	1.75	**39.99**		9.12	3.09	3.88	2.52	4.33	1.52	**24.47**	15.52	4.06	1.73
25	39.67	1.82	**41.50**		11.10	3.32	4.60	3.07	4.44	1.86	**28.39**	13.11	3.24	1.33
Total	592.07	26.05	**618.12**	324.40	149.27	54.21	64.59	41.30	61.49	24.95	**720.23**		(218.50)	(249.09)

Notes

***** From prices charged (using prices subject to a cap)

[a] Year 1 flows are not discounted. Year 2 flows are discounted by a factor of 1/(1+i); year 3 flows are discounted by a factor of 1/(1+i)^2, and so on

Table 6: Estimates of Total Value of Trips by Transportation Modes (no LRS)

	Large Bus			Service Taxis			Regular Taxi			Minibus			Private Car		
Year	Passenger Trips	Value per Trip	**Total Value**	Passenger Trips	Value per Trip	**Total Value**	Passenger Trips	Value per Trip	**Total Value**	Passenger Trips	Value per Trip	**Total Value**	Passenger Trips	Value per Trip	**Total Value**
1	81,215,578	0.47	**38,171,321**	2,515,024	1	**2,515,024**	4,064,769	0.63	**2,560,805**	11,479,121	0.35	**4,017,692**	44,506,747	0.9	**40,056,073**
2	82,921,105	0.47	**38,972,919**	2,567,840	1	**2,567,840**	4,150,129	0.63	**2,614,582**	11,720,182	0.35	**4,102,064**	45,441,389	0.9	**40,897,250**
3	84,662,448	0.47	**39,791,351**	2,621,765	1	**2,621,765**	4,237,282	0.63	**2,669,488**	11,966,306	0.35	**4,188,207**	46,395,658	0.9	**41,756,092**
4	86,440,359	0.47	**40,626,969**	2,676,822	1	**2,676,822**	4,326,265	0.63	**2,725,547**	12,217,598	0.35	**4,276,159**	47,369,967	0.9	**42,632,970**
5	88,255,607	0.47	**41,480,135**	2,733,035	1	**2,733,035**	4,417,117	0.63	**2,782,784**	12,474,168	0.35	**4,365,959**	48,364,736	0.9	**43,528,263**
6	90,108,975	0.47	**42,351,218**	2,790,429	1	**2,790,429**	4,509,876	0.63	**2,841,222**	12,736,125	0.35	**4,457,644**	49,380,396	0.9	**44,442,356**
7	92,001,263	0.47	**43,240,594**	2,849,028	1	**2,849,028**	4,604,584	0.63	**2,900,888**	13,003,584	0.35	**4,551,254**	50,417,384	0.9	**45,375,646**
8	93,933,290	0.47	**44,148,646**	2,908,857	1	**2,908,857**	4,701,280	0.63	**2,961,806**	13,276,659	0.35	**4,646,831**	51,476,149	0.9	**46,328,534**
9	95,905,889	0.47	**45,075,768**	2,969,943	1	**2,969,943**	4,800,007	0.63	**3,024,004**	13,555,469	0.35	**4,744,414**	52,557,148	0.9	**47,301,434**
10	97,919,912	0.47	**46,022,359**	3,032,312	1	**3,032,312**	4,900,807	0.63	**3,087,508**	13,840,134	0.35	**4,844,047**	53,660,849	0.9	**48,294,764**
11	99,976,230	0.47	**46,988,828**	3,095,991	1	**3,095,991**	5,003,724	0.63	**3,152,346**	14,130,777	0.35	**4,945,772**	54,787,726	0.9	**49,308,954**
12	102,075,731	0.47	**47,975,594**	3,161,006	1	**3,161,006**	5,108,802	0.63	**3,218,545**	14,427,523	0.35	**5,049,633**	55,938,269	0.9	**50,344,442**
13	104,219,322	0.47	**48,983,081**	3,227,388	1	**3,227,388**	5,216,087	0.63	**3,286,135**	14,730,501	0.35	**5,155,675**	57,112,972	0.9	**51,401,675**
14	106,407,927	0.47	**50,011,726**	3,295,163	1	**3,295,163**	5,325,625	0.63	**3,355,144**	15,039,842	0.35	**5,263,945**	58,312,345	0.9	**52,481,110**
15	108,642,494	0.47	**51,061,972**	3,364,361	1	**3,364,361**	5,437,463	0.63	**3,425,602**	15,355,678	0.35	**5,374,487**	59,536,904	0.9	**53,583,214**
16	110,923,986	0.47	**52,134,274**	3,435,013	1	**3,435,013**	5,551,649	0.63	**3,497,539**	15,678,148	0.35	**5,487,352**	60,787,179	0.9	**54,708,461**
17	113,253,390	0.47	**53,229,093**	3,507,148	1	**3,507,148**	5,668,234	0.63	**3,570,987**	16,007,389	0.35	**5,602,586**	62,063,710	0.9	**55,857,339**
18	115,631,711	0.47	**54,346,904**	3,580,798	1	**3,580,798**	5,787,267	0.63	**3,645,978**	16,343,544	0.35	**5,720,240**	63,367,048	0.9	**57,030,343**
19	118,059,977	0.47	**55,488,189**	3,655,995	1	**3,655,995**	5,908,800	0.63	**3,722,544**	16,686,758	0.35	**5,840,365**	64,697,756	0.9	**58,227,980**
20	120,539,237	0.47	**56,653,441**	3,732,771	1	**3,732,771**	6,032,884	0.63	**3,800,717**	17,037,180	0.35	**5,963,013**	66,056,408	0.9	**59,450,768**
21	123,070,561	0.47	**57,843,163**	3,811,159	1	**3,811,159**	6,159,575	0.63	**3,880,532**	17,394,961	0.35	**6,088,236**	67,443,593	0.9	**60,699,234**
22	125,655,042	0.47	**59,057,870**	3,891,193	1	**3,891,193**	6,288,926	0.63	**3,962,023**	17,760,255	0.35	**6,216,089**	68,859,908	0.9	**61,973,918**
23	128,293,798	0.47	**60,298,085**	3,972,908	1	**3,972,908**	6,420,994	0.63	**4,045,226**	18,133,220	0.35	**6,346,627**	70,305,967	0.9	**63,275,370**
24	130,987,968	0.47	**61,564,345**	4,056,339	1	**4,056,339**	6,555,834	0.63	**4,130,176**	18,514,018	0.35	**6,479,906**	71,782,392	0.9	**64,604,153**
25	133,738,715	0.47	**62,857,196**	4,141,522	1	**4,141,522**	6,693,507	0.63	**4,216,909**	18,902,812	0.35	**6,615,984**	73,289,822	0.9	**65,960,840**

Table 7: Total Value of Trips and Trips Captured by LRS

Year	Value of Total Trips No LRS (JDs)	Average Capture Rate by LRS	Value of Trips Captured by LRS=Value of Resources Released by LRS (JDs)
1	87,320,915	0	0
2	89,154,655	0	0
3	91,026,902	0.172	15,656,627
4	92,938,467	0.172	15,985,416
5	94,890,175	0.172	16,321,110
6	96,882,869	0.172	16,663,853
7	98,917,409	0.172	17,013,794
8	100,994,675	0.172	17,371,084
9	103,115,563	0.172	17,735,877
10	105,280,990	0.172	18,108,330
11	107,491,891	0.172	18,488,605
12	109,749,220	0.172	18,876,866
13	112,053,954	0.172	19,273,280
14	114,407,087	0.172	19,678,019
15	116,809,636	0.172	20,091,257
16	119,262,638	0.172	20,513,174
17	121,767,153	0.172	20,943,950
18	124,324,264	0.172	21,383,773
19	126,935,073	0.172	21,832,833
20	129,600,710	0.172	22,291,322
21	132,322,325	0.172	22,759,440
22	135,101,093	0.172	23,237,388
23	137,938,216	0.172	23,725,373
24	140,834,919	0.172	24,223,606
25	143,792,452	0.172	24,732,302

Table 8: Economic Net Benefits: Value of Productive Inputs minus Costs

(In million JD's)

Year	Value of Productive Inputs Released[a]	Economic Costs [c]	Net Economic Benefits	Present Value of Net Economic Benefits discounted at 6%	Present Value of Net Economic Benefits discounted at 10%
1	0.00	182.80	(182.80)	(182.80)	(181.90)
2	0.00	142.50	(142.50)	(134.43)	(129.55)
3	15.66	9.54	6.12	5.45	5.06
4	15.99	9.78	6.21	5.21	4.67
5	16.32	10.02	6.30	4.99	4.30
6	16.66	12.66	4.00	2.99	2.49
7	17.01	12.98	4.04	2.85	2.28
8	17.37	13.30	4.07	2.71	2.09
9	17.74	13.63	4.10	2.57	1.91
10	18.11	13.98	4.13	2.45	1.75
11	18.49	14.32	4.16	2.33	1.61
12	18.88	14.68	4.19	2.21	1.47
13	19.27	15.54	3.73	1.86	1.19
14	19.68	15.93	3.75	1.76	1.09
15	20.09	16.33	3.77	1.67	0.99
16	20.51	19.40	1.11	0.46	0.27
17	20.94	19.88	1.06	0.42	0.23
18	21.38	20.38	1.00	0.37	0.20
19	21.83	20.89	0.94	0.33	0.17
20	22.29	21.41	0.88	0.29	0.14
21	22.76	21.95	0.81	0.25	0.12
22	23.24	22.50	0.74	0.22	0.10
23	23.73	23.87	(0.14)	(0.04)	(0.02)
24	24.22	24.47	(0.24)	(0.06)	(0.03)
25	46.29	28.39	17.90	4.42	1.82
Present Value				**(271.54)**	**(277.56)**

Notes

[a] Measured by the value of Trips Captured by LRS; includes JD20.44 million as salvage value (10% of 63% CAPEX) and land recovery on year 25 valued at the JD 900000 of year 1 and assumed its value to grow in real terms at 1% per year

[b] Year 1 flows are not discounted. Year 2 flows are discounted by a factor of 1/(1+i); year 3 flows are discounted by a factor of 1/(1+i)^2, and so on

c Includes land cost of JD 900,000 in year 1

Table 9: Economic Net Benefits: Value of Productive Inputs Freed plus Pollution Savings

(In million JD's/ high price pollution permit[a])

Year	Value of Productive Inputs Released	Pollution Savings b	Total Benefits	Economic Costs	Net Economic Benefits	Present Value of Net Economic Benefits discounted at 6%	Present Value of Net Economic Benefits discounted at 10%
1	0	0.00	0.00	182.80	(182.80)	(182.80)	(181.90)
2	0	0.00	0.00	142.50	(142.50)	(134.43)	(129.55)
3	15.66	1.19	16.85	9.54	7.31	6.51	6.04
4	15.99	1.27	17.26	9.78	7.48	6.28	5.62
5	16.32	1.36	17.68	10.02	7.66	6.07	5.23
6	16.66	1.45	18.11	12.66	5.45	4.07	3.38
7	17.01	1.54	18.56	12.98	5.58	3.93	3.15
8	17.37	1.64	19.01	13.30	5.71	3.80	2.93
9	17.74	1.75	19.49	13.63	5.85	3.67	2.73
10	18.11	1.87	19.98	13.98	6.00	3.55	2.55
11	18.49	1.99	20.48	14.32	6.16	3.44	2.37
12	18.88	2.12	21.00	14.68	6.32	3.33	2.21
13	19.27	2.26	21.54	15.54	6.00	2.98	1.91
14	19.68	2.41	22.09	15.93	6.16	2.89	1.79
15	20.09	2.57	22.66	16.33	6.34	2.80	1.67
16	20.51	2.74	23.25	19.40	3.86	1.61	0.92
17	20.94	2.92	23.87	19.88	3.98	1.57	0.87
18	21.38	3.12	24.50	20.38	4.12	1.53	0.81
19	21.83	3.32	25.15	20.89	4.26	1.49	0.77
20	22.29	3.54	25.83	21.41	4.42	1.46	0.72
21	22.76	3.78	26.53	21.95	4.58	1.43	0.68
22	23.24	4.02	27.26	22.50	4.76	1.40	0.64
23	23.73	4.29	28.02	23.87	4.15	1.15	0.51
24	24.22	4.57	28.80	24.47	4.33	1.13	0.48
25	46.29	4.88	51.17	28.39	22.78	5.63	2.31
Present Value						**(245.51)**	**(261.13)**

Notes

a Includes adjustment for land cost and salvage value see table benefit layer 1; year 1 flows not discounted

b High price pollution permit= US$20 in year 1 thus JD14.29

Table 10: Economic Net Benefits: Value of Productive Inputs Freed plus Pollution Savings plus Savings from Reduction in Road Accidents minus Costs*

(In million JD's/ high price pollution permit[a])

Year	Value of Productive Inputs Released	Pollution Savings b	Savings from Accidents Reduced Accidents c	Total Benefits	Economic Costs	Net Economic Benefits	Present Value of Net Economic Benefits discounted at 6%	Present Value of Net Economic Benefits discounted at 10%
1	0	0.00	0.00	0.00	182.80	(182.80)	(182.80)	(182.80)
2	0	0.00	0.00	0.00	142.50	(142.50)	(134.43)	(129.55)
3	15.66	1.19	1.21	18.06	9.54	8.52	7.59	7.05
4	15.99	1.27	1.25	18.51	9.78	8.73	7.33	6.56
5	16.32	1.36	1.28	18.96	10.02	8.94	7.08	6.11
6	16.66	1.45	1.32	19.43	12.66	6.77	5.06	4.21
7	17.01	1.54	1.36	19.92	12.98	6.94	4.89	3.92
8	17.37	1.64	1.40	20.42	13.30	7.12	4.73	3.65
9	17.74	1.75	1.45	20.93	13.63	7.30	4.58	3.41
10	18.11	1.87	1.49	21.47	13.98	7.49	4.43	3.18
11	18.49	1.99	1.53	22.01	14.32	7.69	4.29	2.96
12	18.88	2.12	1.58	22.58	14.68	7.90	4.16	2.77
13	19.27	2.26	1.63	23.16	15.54	7.63	3.79	2.43
14	19.68	2.41	1.68	23.77	15.93	7.84	3.68	2.27
15	20.09	2.57	1.73	24.39	16.33	8.06	3.57	2.12
16	20.51	2.74	1.78	25.03	19.40	5.63	2.35	1.35
17	20.94	2.92	1.83	25.70	19.88	5.81	2.29	1.27
18	21.38	3.12	1.89	26.39	20.38	6.00	2.23	1.19
19	21.83	3.32	1.94	27.10	20.89	6.21	2.17	1.12
20	22.29	3.54	2.00	27.83	21.41	6.42	2.12	1.05
21	22.76	3.78	2.06	28.60	21.95	6.65	2.07	0.99
22	23.24	4.02	2.12	29.39	22.50	6.89	2.03	0.93
23	23.73	4.29	2.19	30.20	23.87	6.33	1.76	0.78
24	24.22	4.57	2.25	31.05	24.47	6.58	1.72	0.74
25	46.29	4.88	2.32	53.49	28.39	25.10	6.20	2.55
Present Value							**(227.10)**	**(249.77)**

Notes

* Adjusted for salvage and land values

[a] Measured by the value of Trips Captured by LRS

b medium $20-JD14.29 per ton price for pollution permits

c Based on Socio-Economic Report adjusted for accidents within AZLRS

Table 11: Benefits in terms of Travel Time Savings as a Result of LRS

Year	Number of Total Trips [a]	Minutes Saved Per Trip [b]	Hours Saved Per Year [c]	Wage Per Hour JD d	Savings in Reductions in Lost Travel Time per Year in JDs	Savings in Reductions in Lost Travel Time per Year in million JDs
1	143,781,239	0	0	1.5	0	0.00
2	146,800,645	0	0	1.5	0	0.00
3	149,883,459	9	20,608,976	1.5	30,913,463	30.91
4	153,031,012	9	21,041,764	1.5	31,562,646	31.56
5	156,244,663	9	21,483,641	1.5	32,225,462	32.23
6	159,525,801	9	21,934,798	1.5	32,902,196	32.90
7	162,875,843	9	22,395,428	1.5	33,593,143	33.59
8	166,296,235	9	22,865,732	1.5	34,298,599	34.30
9	169,788,456	9	23,345,913	1.5	35,018,869	35.02
10	173,354,014	9	23,836,177	1.5	35,754,265	35.75
11	176,994,448	9	24,336,737	1.5	36,505,105	36.51
12	180,711,331	9	24,847,808	1.5	37,271,712	37.27
13	184,506,269	9	25,369,612	1.5	38,054,418	38.05
14	188,380,901	9	25,902,374	1.5	38,853,561	38.85
15	192,336,900	9	26,446,324	1.5	39,669,486	39.67
16	196,375,975	9	27,001,697	1.5	40,502,545	40.50
17	200,499,870	9	27,568,732	1.5	41,353,098	41.35
18	204,710,368	9	28,147,676	1.5	42,221,513	42.22
19	209,009,285	9	28,738,777	1.5	43,108,165	43.11
20	213,398,480	9	29,342,291	1.5	44,013,437	44.01
21	217,879,848	9	29,958,479	1.5	44,937,719	44.94
22	222,455,325	9	30,587,607	1.5	45,881,411	45.88
23	227,126,887	9	31,229,947	1.5	46,844,920	46.84
24	231,896,552	9	31,885,776	1.5	47,828,664	47.83
25	236,766,379	9	32,555,377	1.5	48,833,066	48.83

Notes

a All vehicles

b Arrived at 9 minutes by using the 7 minutes per trip from the Socio-Economic Study and adding 2 minutes to reflect general feeling that 7 minutes underestimate time saving and to adjust for faster traffic on the road with AZLRS

[c] ((Minutes per Trip * Trips per Year)/60)*(300/360)

[d] Wage per hour used was taken from the Socio Economic Survey extrapolated to year 2010 and rounded to JD1.5 to allow for slight increase in real income

Table 12: Economic Net Benefits: Value of Productive Inputs Freed plus Pollution Savings plus Savings from Reduction in Road Accidents plus Savings from Reduction in Travel Time minus Costs*

(In million JD's/ high price pollution permit[a])

Year	Value of Productive Inputs Released	Pollution Savings b	Savings from Accidents Reduced Accidents c	Savings from Reduced Travel Time d	Total Benefits	Economic Costs	Net Economic Benefits	Present Value of Net Economic Benefits discounted at 6%	Present Value of Net Economic Benefits discounted at 10%
1	0.00	0.00	0.00	0.00	0.00	182.80	(182.80)	(182.80)	(182.80)
2	0.00	0.00	0.00	0.00	0.00	142.50	(142.50)	(134.43)	(129.55)
3	15.66	1.19	1.21	30.91	48.98	9.54	39.44	35.10	32.59
4	15.99	1.27	1.25	31.56	50.07	9.78	40.29	33.83	30.27
5	16.32	1.36	1.28	32.23	51.19	10.02	41.17	32.61	28.12
6	16.66	1.45	1.32	32.90	52.34	12.66	39.68	29.65	24.64
7	17.01	1.54	1.36	33.59	53.51	12.98	40.54	28.58	22.88
8	17.37	1.64	1.40	34.30	54.72	13.30	41.42	27.54	21.25
9	17.74	1.75	1.45	35.02	55.95	13.63	42.32	26.55	19.74
10	18.11	1.87	1.49	35.75	57.22	13.98	43.25	25.60	18.34
11	18.49	1.99	1.53	36.51	58.52	14.32	44.19	24.68	17.04
12	18.88	2.12	1.58	37.27	59.85	14.68	45.17	23.79	15.83
13	19.27	2.26	1.63	38.05	61.22	15.54	45.68	22.70	14.55
14	19.68	2.41	1.68	38.85	62.62	15.93	46.69	21.89	13.53
15	20.09	2.57	1.73	39.67	64.06	16.33	47.73	21.11	12.57
16	20.51	2.74	1.78	40.50	65.54	19.40	46.14	19.25	11.04
17	20.94	2.92	1.83	41.35	67.05	19.88	47.17	18.57	10.26
18	21.38	3.12	1.89	42.22	68.61	20.38	48.23	17.91	9.54
19	21.83	3.32	1.94	43.11	70.21	20.89	49.31	17.28	8.87
20	22.29	3.54	2.00	44.01	71.85	21.41	50.43	16.67	8.25
21	22.76	3.78	2.06	44.94	73.53	21.95	51.58	16.08	7.67
22	23.24	4.02	2.12	45.88	75.27	22.50	52.77	15.52	7.13
23	23.73	4.29	2.19	46.84	77.05	23.87	53.18	14.76	6.53
24	24.22	4.57	2.25	47.83	78.88	24.47	54.41	14.25	6.08
25	46.29	4.88	2.32	48.83	102.32	28.39	73.93	18.26	7.51
IRR (pollution permits at JD14.29)				**12%**					
Present Value								**204.94**	**41.89**

Notes

***** Adjusted for salvage value and land values; year 1 flows not discounted

[a] Measured by the value of Trips Captured by LRS

b medium $20-JD14.29 per ton price for pollution permits

c Based on Socio-Economic Report adjusted for accidents within AZLRS

d Time valued at JD 1.5 per hour

Table 13: Benefits Impact: Economic Rates of Return and Present Values under Different Gross Benefits Scenarios

Scenario	Economic Internal Rate of Return (%)	Present Value of Net Economic Benefits (million JDs) [a]	Comments
Benefits Layer 1:Value of Productive Resources Freed plus	negative/not defined	-280	If benefits at this level are measured by revenues from ticket sales and advertisements the results would not be materially different
Benefits Layer 2:Savings from Decreased Pollution Costs [b] plus	negative/not defined	-277	Pollution costs established as reduction in CO2 tons times value of CO2 permit allowance per ton valued at JD 14.29
Benefits Layer 3: Savings from Decreased Road Accidents [c] plus	negative/not defined	-251	Three effects were considered: property damage, fatalities, and deaths. Reference study provided no decomposition of effects. However, monetarily the loss from property damage seems to be the strongest.
Benefits Layer 4: Savings from Reduction in Travel Time [d]	**12.00**	**41**	The reduction in average time by 9 minutes relative to alternative transportation and including 2 minutes of time savings on the road

Notes

[a] Discounted at 10 percent

[b] Based on a cost per kilometer of 0.26 JD

c Based on Socio-Economic Component Estimates of Damages Fatalities and Injured

[d] Assumes 9 minutes time savings for average trip

Table 14: Sensitivity Results

What if scenario *	Base Case EIRR %	Base Case Present Value @10% Discount (JD million)	Base Case Present Value @ 6% Discount (JD Million)	% Change in Variable	New EIRR (%)	% Change in EIRR	Sensitivity Ratio [a]	% Change in Project Present Value @10% Discount	Sensitivity Ratio [a]	% Change in Project Present Value @ 6% Discount	Sensitivity Ratio [a]	Assessment of Likelihood and Comments
Base Case	11.51	41	200									
Time saved per trip is 11 minutes				22	13.77	19.64	0.88	156	7.02	48	2.15	Knowledgeable officials see this as reasonable and reachable. Would require excellent management of train schedules.
Time saved per trip is 7 minutes[b]				-22	9.05	-21.37	0.97	-160	7	-48	2.18	Highly probable if train schedules are not observed. Switching value. Key benefits lost would jeopardize project economic validity.
Costs are 10% higher [b]				10	9.92	-13.81	-1.38	-105	-10.53	-25	-2.47	High probability given empirical record. Switching value, EIRR falls under critical value.
There is an increase in consumer surplus equal to 10% of fare revenues [c]				not defined	12.1	5.13	not defined	42	not defined	13	not defined	Likely scenario because of capped fares. Although small difference in project merit indicators, positive change underlines the importance of meeting comfort and punctuality standards for riders.

There is an increase in consumer surplus equal to 50% of fare revenues				not defined	14.33	24.50	not defined	211	not defined	66	not defined	Possible but unlikely although consistent with 2010 project design willingness to pay for high quality ride.
If benefits from pollution and traffic accident reduction are doubled				100	12.51	8.69	0.09	71	0.71	22	0.22	Unlikely. Even if it happened underlines the relatively small effect if these variables.
Value of inputs released and time savings are the only benefits considered				not defined	10.46	-9.12	not defined	-70.64	not defined	-22.17	not defined	Unlikely as, while small there are to be some socially positive net effects in terms of less pollution and some reduction in road accidents.

Notes

[*] Comparisons are with base case scenario and the assumption is that everything else in the base case scenario remains equal

[a] The sensitivity ratio is defined as the percentage change in the project merit criterium divided by the percentage change in a variable

[b] Indicates that at this level the economic rate of return falls below the social discount rate (10%) or the project present value becomes negative

[c] As revenue from fares was not used to measure economic benefits sensitivity ratios are not defined