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Transport Research Support

ROAD PROJECTS COST BENEFIT ANALYSIS: SCENARIO ANALYSIS OF THE EFFECT OF VARYING INPUTS

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DFID Department for International Development

KOJI TSUNOKAWA

©2010 The International Bank for Reconstruction and Development / The World Bank
1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org
E-mail: feedback@worldbank.org

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ROAD PROJECTS COST BENEFIT ANALYSIS: SCENARIO ANALYSIS OF THE EFFECT OF VARYING INPUTS

The Transport Research Support program is a joint World Bank/ DFID initiative focusing on emerging issues in the transport sector. Its goal is to generate knowledge in high priority areas of the transport sector and to disseminate to practitioners and decision-makers in developing countries.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

The "*Road Projects Cost Benefit Analysis*:*Scenario Analysis of the Effect of Varying Inputs*" has been prepared for the World Bank Transport Anchor group (TWITR) in Washington which administers and manages the Transport Research Support Program, TRSP, a financing of **DFID**, the Department for International Development of the United Kingdom Government.

We would like to express our thanks to Koji Tsunokawa who was contracted to provide the framework and the technical content. Rodrigo Archondo Callao, Senior Highway Engineer, ECSS5, provided guidance and advice throughout the preparation of the study.

EXECUTIVE SUMMARY

Six projects from six countries were selected as the cases for detailed analysis in this study. They are from Argentina, Botswana, India, Kenya, Lao PDR and Paraguay, representing a wide range of geographical distribution. Also, the extent of the effect of economic downturn which these countries experienced ranges a wide variety. These projects were selected considering the availability of the World Bank's official or semiofficial documents describing the cost benefit analyses conducted as part of project preparation. Diverse project alternatives were compared in the economic analyses of these projects including improvement, rehabilitation and reseal for paved roads and re-gravelling for unpaved roads.

The methodology adopted in this study for identifying the effect of economic downturn is to compare the results of the economic analyses of the two cases: one is that of original cost benefit analyses that were conducted without the knowledge of economic downturn, and another of a hypothetical case where all relevant effects of economic downturn on the inputs of the analyses were assumed to be known at the time the analyses. The effect of economic downturn on the viability of projects can be identified as the difference in the outputs of these analyses in terms of economic summary indices such as net present values (NPV), NPV per unit length of road (NPV/km), economic internal rate of return (ERR), etc.

In order to create the HDM-4 data for the hypothetical case (called Case B Data), the data representing the original case (called Case A Data) were modified by incorporating different information. Traffic growth rates were modified by using the actual and predicted GDP growth rates of the countries available from IMF's World Economic Outlook. Price data were modified by incorporating three price adjustment factors, i.e., those of GDP, fuel price and wage rate adjustment.

The comparison of the HDM-4 outputs with Case A Data and Case B Data was conducted in two different ways. One is the comparison by country/project and another by means of cross sectional statistic analyses with pooled data. Since the number and the variety of subprojects included in each project/country are limited, studies in country analyses were limited to qualitative analyses. A general relationship between the extent of the effect of economic downturn and the degree of change in NVP, NVP/km and ERR was observed in the country analyses. More specifically, the pattern of arrows representing the changes in ERR and NPV/km of subprojects from Case A to Case B in ERR-NPV/km plane is closely linked with the changes in input variables. Also, although not very decisively, it was found that the viability of project alternatives that involve high investments tends to be more affected by economic downturn than alternatives of other types.

The regression analysis of pooled data revealed that indicators representing the economic viability of subprojects after economic downturn, $(\mathbf{NPV/km})_B$ **and** $\mathbf{ERR}_B$, can be estimated with high precisions given the values of these indicators before (or without) the economic downturn,

$(\mathbf{NPV/km})_A$ **and** $\mathbf{ERR}_{A,}$ and the values of the indicators representing the extent of the effect of economic downturn on traffic demand and relative change in factor prices. Two indicators were found to be significant in representing these effects: traffic adjustment factor (TAF) and variance of price adjustment factors (VPA). These models may be used in conducting quick sensitivity analyses of the economic viability of projects without resorting to elaborate HDM-4 analyses.

The fact that the regression models fit the pooled data very well with very high $\mathbf{R}^2$ values without including country specific or project specific variables indicate that the relationships obtained are general enough to be used with wide range of countries and projects. However, an elaborate statistical analysis revealed that "improvement" type project alternatives are more sensitive to changes in the values of TAF and VPA. This is consistent with one of the findings in country analyses, and indicates that the use of the regression models in the analysis of projects with project alternatives of improvement type merits a caution.

1 INTRODUCTION

1.1 Objective of the Study

In an economic downturn, uncertainties increase with many inputs of road projects Cost Benefit Analysis (CBA), including fuel prices, levels of demand, investment costs and maintenance availability. Also, important parameters of project evaluation such as discount rate and value of time need to be more carefully scrutinized. Therefore, it is very important for the developing countries to have good understanding about the effects of the variability of these inputs/parameters on project viability and the ranking of road investments. It is a role of the developing agencies to conduct a systematic analysis of these effects and disseminate the findings and knowledge obtained. To conduct such studies, a good tool for evaluating the impacts of input variables and parameters on project feasibility is indispensable. Fortunately, the Highway Development and Management Model (HDM-4) is available in the road sector for such purposes.

The objective of the study is to obtain insights regarding the effects of varying inputs and parameters on the viability of road projects through case studies using HDM-4, thereby to facilitate the formulation and implementation of road projects that increase the welfare of the society under the environment of increased uncertainty in an economic downturn. The results of the study will be summarized in a Transport Note as a discrete knowledge product and disseminated among various stakeholders including developing agencies staff, government officials and donor communities.

1.2 Outline of HDM-4[1]

The HDM-4 model is based on the concept of pavement life-cycle analysis and uses three sets of models: (a) road deterioration - which predicts pavement deterioration; (b) works effects - which simulate the effects of road works on pavement condition and determines the corresponding costs; and (c) road user effects - which determine costs of vehicle operation and travel time.

These models work on data relating to the characteristics of the roads and the vehicle fleet, and defined road maintenance and improvement standards,

[1] Source: Draft Staff Appraisal Report for Road Sector Project in Lao PRD.

together with their unit costs. In the case of unsealed roads the modelling of road deterioration involves the type and thickness of surface material, gradient, climate and traffic loading. Maintenance effects are modelled in terms of spot regravelling, gravel resurfacing and grading. In the case of sealed roads pavement deterioration is modelled in terms of a number of defects including; pavement cracking, rutting, ravelling, and potholes. The rate of deterioration is as a function of the initial pavement construction standard, traffic loading, maintenance standards, and the effects of the environment. The amount of maintenance carried out in a given year depends on user-specified maintenance standards and the predicted road condition. The key indicator of road condition is surface roughness, measured in terms of the International Roughness Index (IRI) [2], which has a major impact on vehicle speeds and operating costs.

The HDM-4 model predicts the consumption of resources for each component of vehicle operating cost, such as the number of litres of fuel consumed and amount of tyre wear, per kilometre, for each category of vehicles. When multiplied by the appropriate unit prices, such as $ per litre of fuel and $ per tyre, this consumption is converted to a cost per kilometre. The total of costs for all components is the vehicle operating cost (VOC). Time costs are calculated from the predicted speeds. Average speeds are determined as part of the VOC calculation from the characteristics of vehicles, and road conditions, such as roughness, gradient and curvature.

In this way the model simulates for each road section, year-by-year, the road condition and resources used for maintenance under a specified strategy, as well as the vehicle speeds and physical resources consumed by vehicle operation. Then user-specified prices and unit costs are applied to the physical quantities involved to determine the costs involved in monetary terms. Benefits are calculated for different options by comparing the costs in the "project case" options with the costs in the "base case". Finally present value and rate of return computations are carried out to indicate the economic viability of project options. Thus, the economic returns from road investment are determined from the level of the construction and road maintenance costs, and savings in road user costs due to the provision of a better road facility.

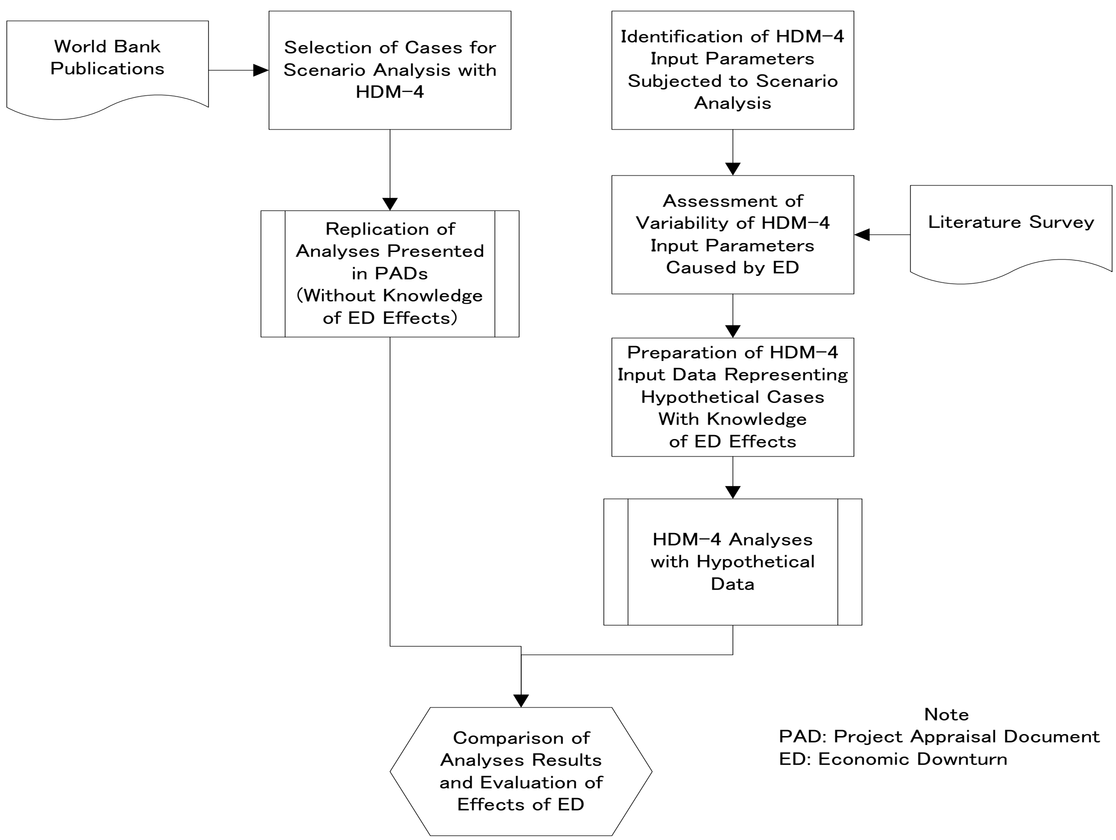
1.3 Methodology

Fig. 1 depicts the analysis procedure adopted in this study for identifying the effects of economic downturn (ED, hereinafter) on roads cost benefit analyses. Several project level HDM-4 studies are selected for this study from recent World Bank projects. In doing so, the availability of HDM-4 workspace data and official or semi-official World Bank Project Appraisal Documents or the

[2] The International Road Roughness Index (IRI) is measured in meters per kilometer.

like (PADs, hereinafter) is considered essential and regional distribution of projects as well as the variety of road investments analyzed are also contemplated. The selected HDM-4 workspace data are consolidated to coincide with the analyses presented in respective PADs and run with HDM-4 to replicate the PADs analyses as much as possible. The consolidated data will be called Case A Data, hereinafter. Naturally, they represent the analyses conducted without the knowledge of ED effects.

Figure 1-Analysis Procedure



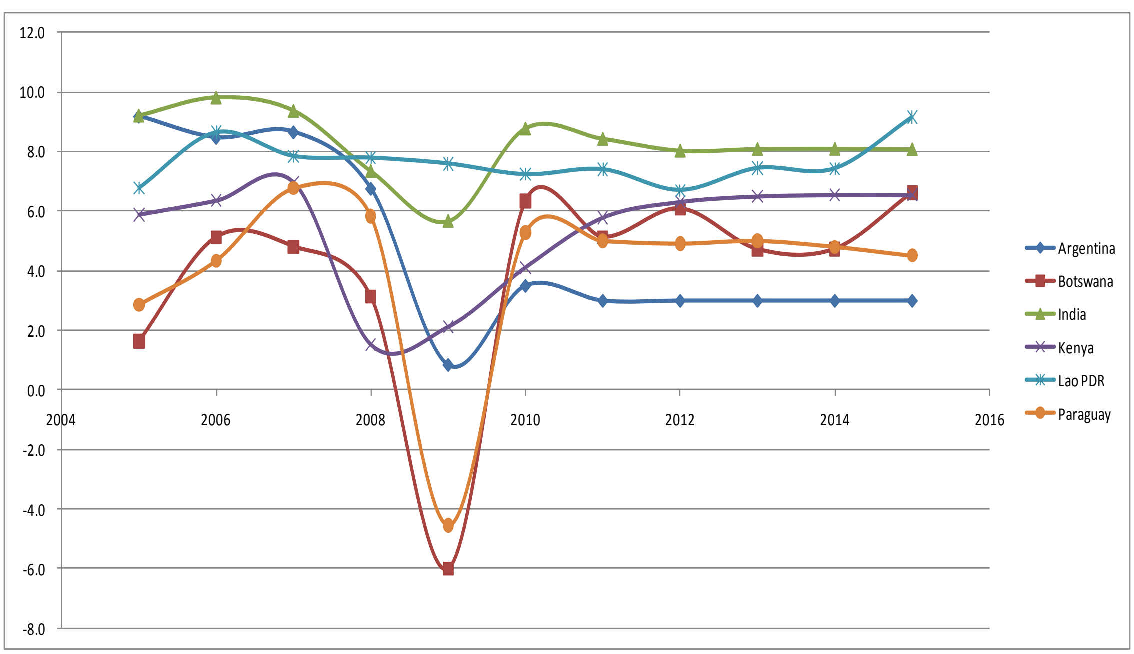
These results will be compared with the results of hypothetical analyses where ED effects are assumed to be known when the analyses were conducted. It is expected that the feasibility of some projects will be affected by lower traffic demands, different relative prices, etc. caused by ED, and the extent of the effect of ED may be identified by comparing the two results. In order to establish such hypothetical cases, all input parameters that are deemed to be affected by ED, called Focal Parameters, hereinafter, are first identified.

Next, available published documents are reviewed to determine the ranges of the variability of Focal Parameters due to ED. Finally, with this information, the values of Focal Parameters of Case A Data are modified to set up the hypothetical cases and run with HDM-4. The modified data will be called Case B Data, hereinafter.

1.4 Selection of Projects for Scenario Analyses with HDM-4

To identify the effects of ED on roads cost benefit analyses, six projects from six countries, Argentina, Botswana, India, Kenya, Lao PDR and Paraguay, were selected as the cases for the study of this report. They are from Latin America, Africa, South Asia and East Asia, representing a wide geographical distribution. The degree to which these countries are affected by ED in recent years is different as represented by the time trajectories of GDP growth rate shown in Figure 2. The GDP growth rates used in this figure is adopted from World Economic Outlook April 2010 (WEO, hereinafter) of IMF[3]. Among these countries, Botswana and Paraguay had the deepest reduction in GDP growth rate in 2009, but quickly recovered to pre-ED level in 2010. While Argentina did not experience so severe a reduction in GDP growth rate as these countries in 2009, the recovery is very modest in 2010 and predicted to stay that way for some more years to come. Kenya experienced a similar degree of GDP growth rate reduction to Argentina, but faster recovery is recorded and predicted. Lao and India experienced least severe effects from ED.

Figure 2: Time trajectories of real GDP growth rates of Case Countries



Source: World Economic Outlook April 2010, International Monetary Fund

[3] The GDP growth rates given in WEO for years 2009-2015 are predicted values for all these countries except for Argentina and Lao PDR for which real growth rates are given for 2009.

The six projects were selected based on the availability of HDM-4 workspace data and PADs. The selected projects are listed in Table 1 along with the PADs document types and their dates. They consist of 138 subprojects altogether which were analyzed with wide range of project alternatives in the PADs including widening, bypass construction, reconstruction, overlay, resealing, and other maintenance works for paved and non-paved roads.

TABLE 1: PROJECTS SELECTED FOR THE STUDY+

Country	Project Title	Date	Document Type	Report No
Argentina	Province of Santa Fe Road Infrastructure Project	09-Jan-07	Project Appraisal Document	38464-AR
Botswana	Integrated Transport Project	01-May-09	Project Appraisal Document	46757-BW
India	Karnataka State Highway Improvement Project 2	n.a.	Draft PAD	n.a.
Kenya	Northern Corridor Transport Improvement Project	05-Mar-09	Project Paper	43537-KE
Lao PDR	Road Sector Project	n.a.	Draft PAD	n.a.
Paraguay	Road Maintenance	n.a.	Draft PAD	n.a.

HDM-4 cost benefit analyses were conducted with two sets of data for each project in this study. The analysis with Case A Data assumes no knowledge of the effects of ED, which is essentially the replication of the study recorded in each PAD. The analysis with Case B Data is a hypothetical analysis where what happened through the ED is assumed to be known at the time of the analysis. In both cases, the same analysis periods were used as the PADs analyses so that the effects of ED may be identified by comparing these results. Table 2 shows the analysis periods used in the PADs cost benefit analyses along with other essential parameters of the analyses.

TABLE 2 : ANALYSIS PARAMETERS OF PADS COST BENEFIT ANALYSES

COUNTRY	START_YEAR	END_YEAR	CURRENCY	EXCHANGE RATE	DISC_RATE
ARGENTINA	2007	2034	US Dollar	1	12.00
BOTSWANA	2008	2027	US Dollar	1	12.00
KARNATAKA (Run 1)	2008	2027	Rupee	1 USD = 46 Rupee	12.00
KARNATAKA (Run 2)	2009	2028			
KENYA	2008	2027	US Dollar	1	12.00
LAO	2010	2029	US Dollar	1	12.00
PARAGUAY	2006	2020	US Dolllar	1	12.00

1.5 IDENTIFICATION OF FOCAL PARAMETERS SUBJECTED TO SCENARIO ANALYSES

As the first step toward creating Case B Data, the HDM-4 input parameters that are deemed to be affected by the ED were identified. They are called Focal Parameters which include the following:

- traffic growth rate,
- civil works costs including costs of improvements and maintenance treatments,

- parameters related to vehicle operating cost including new vehicle price, fuel price, value of time, etc., and
- social discount rate.

The values of the Focal Parameters in Case A Data are summarized in Annex A for all case projects.

Volume Five of The HDM-4 Series Documentation classifies all HDM-4 input parameters into four sensitivity classes depending on the importance of the parameters in their effects on the outputs of HDM-4 analyses. New vehicle price and traffic growth rate (volume) are the only Focal Parameters classified as high sensitivity class.

1.6 Classification of Focal Parameters for Modification

Case B Data are created by modifying the values of Focal Parameters of Case A Data with the knowledge of the effects of ED. The second step is to determine how the Focal Parameters should be modified. For this purpose various published documents and reports were reviewed including the following:

- World Development Indicators, The World Bank, http://data.worldbank.org/indicator
- Global Economic Prospects, The World Bank, http://web.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTDECPROSPECTS/GEPEXT/EXTGEP2010/0,,menuPK:6665259~pagePK:64167702~piPK:64167676~theSitePK:6665253,00.html
- Short-Term Energy Outlook – Real Petroleum Prices, U.S. Energy Information Administration, http://www.eia.doe.gov/emeu/steo/pub/fsheets/real_prices.html
- International Fuel Prices, GTZ, http://www.gtz.de/en/themen/29957.htm
- Minimum Wage Database, ILO, http://www.ilo.org/travaildatabase/servlet/minimumwages?ComingFromMenu=true&pageClass=org.ilo.legislation.work.web.CategorySearchPage
- World Economic Outlook Database, International Monetary Fund,
- http://www.imf.org/external/pubs/ft/weo/2010/01/weodata/weoselco.+aspx?g=2505&sg=All+countries+%2f+Emerging+and+developing+economies+%2f+Developing+Asia

The literature revealed that GDP related indices and fuel prices are readily available for modifying Focal Parameters to represent the reduction in traffic demand and the relative change of factor prices due to ED. Also, wage rate related parameters may be modified by using GDP per capita. Considering the availability of these indices, Focal Parameters are classified into five groups as indicated below and in Table 3.

- Group 1 (GDP related parameters): traffic growth rate per period, annual overhead costs, and value of time for cargo delay;
- Group 2 (fuel price related parameters): fuel price, and lubricating oil price;
- Group 3 (wage rate related parameters): maintenance labor cost, crew wages, value of time of passengers for both working and non-working time, and accident costs; and
- Group 4 (composite parameters): maintenance and improvement works costs
- Group 5 (none of the above): discount rate, new vehicle prices, replacement tire price, and annual interest rate.

As maintenance and improvement works costs consist of material, fuel and labor related components, they will be modified using all three indices, i.e., GDP, fuel and wage rates, and called composite parameters. Given the absence of good basis in the literature, discount rate, new vehicle prices, replacement tire price and annual interest rate will not be modified.

TABLE 3: C CLASSIFICATION OF HDM-4 INPUT PARAMETERS FOR MODIFICATION

Category	HDM-4 Input Parameters	Classification (Group)	Key Variables for Determining Variability
Discount Rate	Discount rate	5	n.a.
Traffic volume	Growth rate per growth period	1	G
Maintenance Costs		4	G,F,W
Improvement Costs		4	G,F,W
Vehicle Related Costs	New vehicle price	5	n.a.
	Replacement tyre price	5	n.a.
	Fuel price	2	F
	Lubricating oil price	2	F
	Maintenance labor cost	3	W
	Crew wages	3	W
	Annual overhead costs	1	G
	Annual interest	5	n.a.
	Value of time: passenger working time	3	W
	Value of time: passenger non-working	3	W
	Value of time: cost of cargo delay	1	G
Note:			
n.a.: Key variables are not available for modifying the HDM-4 inputs.			
G: The HDM-4 inputs are modified by using GDP related statistics			
F: The HDM-4 inputs are modified by using Fuel price related statistics.			
W: The HDM-4 inputs are modified by using Wage rate related statistics.			

1.7 Modification of Focal Parameters Representing Decreased Traffic Demand Due to Economic Downturn

Traffic growth rate is the only Focal Parameter classified as high sensitivity variable in Volume Five of The HDM-4 Series Documentation. As it is well known that traffic demand is closely correlated with GDP, traffic volume is modified by using available GDP related indicators in Case B Data. Specifically, noting the fact that actual and predicted GDP growth rates are available for all countries for each year until 2015 in WEO, the traffic growth rates in Case B Data are created as follows:

For the period starting from the analysis start year till 2015, GDP growth rates given in WEO are assumed as the traffic growth rates each year. If multiple traffic growth rates are used in Case A Data for different vehicle types, the weighted average of such rates is assumed to coincide with the GDP growth rate each year. The traffic growth rates of different vehicle types are then determined by "prorating" the GDP growth rates.

For the rest of the analysis period after 2015, no change is made from Case A Data.

The rationale behind this modification is that no better prediction about the speed of countries' recovery from ED is available than those given in WEO. Moreover, in the absence of GDP predictions for the years after 2015 in WEO, the traffic growth rates assumed in Case A Data for these years are still the best estimate even after ED. Annex B lists the values of modified traffic growth rates in Case B Data for the six case countries along with the description of the detailed procedure used in determining them.

1.8 Modification of Focal Parameters Representing Relative Change in Factor Prices Due to Economic Downturn

Effects of the relative change in factor prices caused by ED may be analyzed by multiplying appropriate Price Adjustment Factors (PAFs, hereinafter) to Focal Parameters (except for traffic growth rate) of Case A Data according to the abovementioned classification scheme. Note that the Focal Parameters of Group 5 are not modified without a good basis. The Group 4 Focal Parameters are modified by multiplying the composite adjustment factor, which is the average of the three PAFs, in the absence of the precise knowledge of their price structure. The PAFs of the three key indices, GDP, fuel and wage, are determined by the time series data of these indices and the analysis start year of each project. Tables 4-6 show the time series data of these indices and the PAFs determined for each country/project along with the notes explaining the computational procedure.

The rationale behind the adopted computation of the PAFs is that the factor prices as of 2008 may be assumed as best represent those prevailed during ED, and the factor prices used in Case A Data may be assumed as those of one year prior to the analysis start year.

TABLE 4: TIME-SERIES DATA AND PRICE ADJUSTMENT FACTOR: GDP

	GDP (constant 2000 US$)										
Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	Analysis Start Year	Adjustment Factor
Argentina	2.84E+11	2.72E+11	2.42E+11	2.63E+11	2.87E+11	3.14E+11	3.4E+11	3.7E+11	3.95E+11	2007	1.16
Botswana	6.18E+09	6.5E+09	6.72E+09	7.14E+09	7.6E+09	7.96E+09	8.2E+09	8.39E+09	8.64E+09	2008	1.03
India	4.6E+11	4.84E+11	5.02E+11	5.44E+11	5.9E+11	6.45E+11	7.07E+11	7.71E+11	8.18E+11	2009	1.00
Kenya	1.27E+10	1.32E+10	1.32E+10	1.36E+10	1.43E+10	1.52E+10	1.61E+10	1.73E+10	1.76E+10	2008	1.02
Lao PDR	1.74E+09	1.84E+09	1.94E+09	2.06E+09	2.19E+09	2.35E+09	2.55E+09	2.74E+09	2.95E+09	2010	1.00
Paraguay	7.07E+09	7.22E+09	7.21E+09	7.49E+09	7.8E+09	8.02E+09	8.37E+09	8.94E+09	9.45E+09	2006	1.18
	Source:	WDI 2009, The World Bank									
	Note:	Adjustment Factor=		1 If Analysis start year >=2009							
		Adjustment Factor=		(GDP 2008)/(GDP one year before analysis start year) If Analysis start year < 2009							

TABLE 5: TIME-SERIES DATA AND PRICE ADJUSTMENT FACTOR: PER CAPITA GDP AS A SURROGATE OF WAGE RATE

	GDP per capita (constant 2000 US$)										
Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	Analysis Start Year	Adjustment Factor
Argentina	7694	7280	6425	6929	7486	8097	8699	9360	9894	2007	1.14
Botswana	3586	3716	3790	3979	4189	4328	4395	4435	4497	2008	1.01
India	453	469	479	512	546	589	637	686	718	2009	1.00
Kenya	404	408	400	401	411	424	439	458	453	2008	0.99
Lao PDR	321	333	347	362	380	400	426	450	475	2010	1.00
Paraguay	1322	1322	1295	1318	1347	1359	1392	1459	1516	2006	1.12
	Source:	WDI 2009, The World Bank									
	Note:	Adjustment Factor =		1 If Analysis start year >=2009							
		Adjustment Factor =		(GDPPC 2008)/(GDPPC one year before analysis start year) If Analysis start year < 200							

TABLE 6: TIME-SERIES DATA AND PRICE ADJUSTMENT FACTOR: FUEL PRICE

	Diesel Fuel Retail Price					
			[Current year US cents/litre]			
	2000	2002	2004	2006	2008	Adjustment Factor
Argentina	52	46	49	48	58	1.05
Botswana	39	38	61	74	102	2.42
India	39	41	62	75	70	2.27
Kenya	60	56	76	98	114	1.14
Lao PDR	32	30	48	73	76	0.99
Paraguay	34	34	51	77	96	1.27
Source:	International Fuel Prices 2009, GTZ					
	(last survey 15-17 November 2008)					

Note: Detailed explanation of the procedure for determining the diesel price adjustment factors for each country is provided in Annex C.

Table 7 summarizes all PAFs thus determined for all countries/projects. All values of the Focal Parameters in Case B Data created by multiplying appropriate PAFs to Case A counterparts are shown in Annex D.

TABLE 7 : PRICE ADJUSTMENT FACTORS FOR RELATIVE CHANGE IN FACTOR PRICES

Country	GDP adjustment factor	Wage adjustment factor	Fuel price adjustment factor	Composite adjustment factor*
Argentina	1.16	1.14	1.05	1.12
Botswana	1.03	1.01	2.42	1.49
India	1.00	1.00	2.27	1.42
Kenya	1.02	0.99	1.14	1.05
Lao PDR	1.00	1.00	0.99	1.00
Paraguay	1.18	1.12	1.27	1.19

Note: *Composite adjustment factor = Average of all three factors

2 COUNTRY ANALYSES

2.1 COUNTRY ANALYSIS: ARGENTINA

2.1.1 SUMMARY OF PAD ANALYSIS

The HDM-4 analysis of Province of Santa Fe Road Infrastructure Project dealt with the upgrading of a 129.4 km stretch of National Road 19 consisting of six homogeneous road sections. The cost benefit analysis examined the economic feasibility of the following project alternatives: widening from 2 lanes to 4 lanes at one section, the construction of parallel 2 lane roads at three sections, and the construction of 4 lane bypasses at two sections. These options were compared with a without-project-alternative that includes routine maintenance and rehabilitating the existing carriageway when roughness reaches 6.0 IRI, m/km. Two project alternatives, one with asphalt pavement and another with concrete pavement, were considered with each new construction alternative. The analysis period was twenty-eight years starting from 2007, and the assumed discount rate was 12 %. The result of the HDM-4 analysis with Case A Data is presented in Table 8 under the caption of Case A. It shows that the widening alternative and the constructions of parallel 2 lane roads and 4 lane bypasses, all with concrete pavements, are economically efficient with overall Net Present Value (NPV) of US$ 52.8 million and Economic Rate of Return (ERR) of 18%.

TABLE 8 : RESULTS OF HDM-4 ANALYSIS WITH CASE A AND CASE B DATA (ARGENTINA)

Road section	Section length (km)	Work description	Case A			Case B		
			Base Cost (M US$)	NPV (M US$)	EIRR (%)	Base Cost (M US$)	NPV (M US$)	EIRR (%)
RPN 11 – End Widening	9.0	Widening to 4L (Asphalt)	10.1	7.6	24%	11.3	6.9	22%
End Widening – RPN 6	20.4	New 2L (Concrete)	20.6	5.0	16%	23.1	3.0	14%
RPN 6 – RNN 34, 2L sections	37.6	New 2L (Concrete)	36.1	1.3	13%	40.4	-2.7	11%
RNN 34 – Angelica	44.7	New 2L (Concrete)	32.2	9.2	16%	36.0	6.1	15%
S. Jeronimo & S. Pereyra Bypass	8.3	4L Bypass (Concrete)	15.6	4.5	17%	17.5	1.1	13%
San Franciso Bypass	9.4	4L Bypass (Concrete)	13.5	25.2	35%	15.2	25.0	33%
Project total	129.4		128.1	52.8	18%	143.5	39.4	16%

2.1.2 MODELING THE EFFECTS OF ECONOMIC DOWNTURN

The traffic growth rates assumed in Case A Data and the actual and predicted GDP growth rates given in WEO are as shown in Fig. 3. In the HDM-4 analysis of the subject project in Argentina, same traffic growth rates were assumed for all vehicle types. No generated traffic was considered. To mimic the situation where the effects of ED were known at the time of the HDM-4 analysis, the traffic growth rates of normal traffic were modified in Case B Data to coincide with the actual and predicted GDP growth rates given in WEO for the period

2007-2015, which are substantially lower than those in Case A Data. Argentina is one of the countries that were most severely affected by ED with a slow recovery. Consequently, such lower traffic growth rates would have been used if ED was anticipated and its effects were known at the time of the cost benefit analysis.

FIGURE 3 TRAFFIC GROWTH RATE OF CASE A DATA AND GDP GROWTH RATE OF WEO (ARGENTINA)

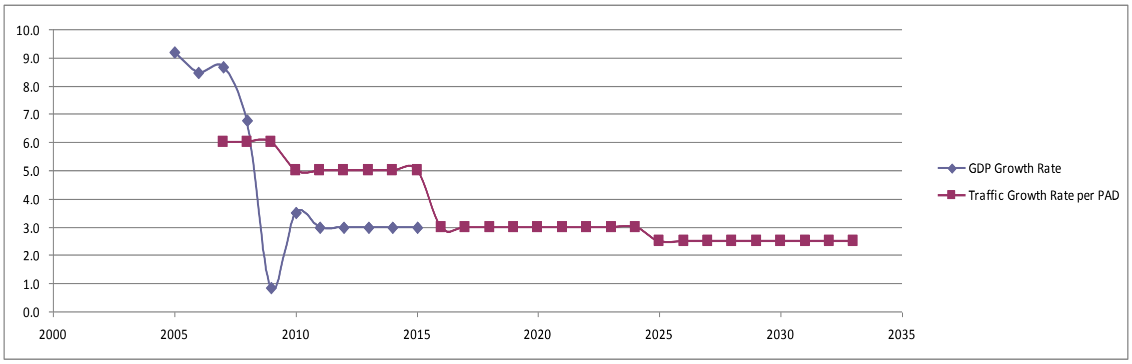
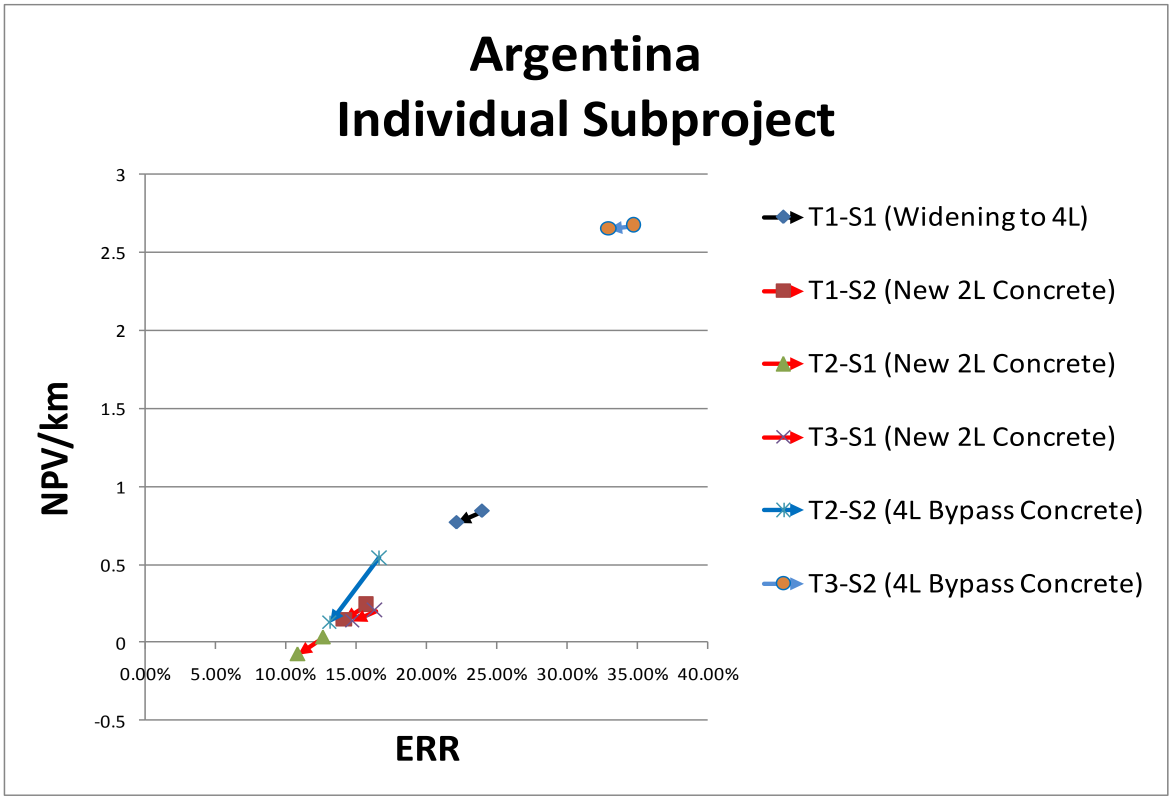


Table 7 shows that the GDP adjustment factor and wage adjustment factor for Argentina are slightly higher as compared with other countries (except for Paraguay), but they are of a similar magnitude to the fuel price adjustment factor, implying little effects from the relative change in factor prices.

2.1.3 COMPARISON OF THE RESULTS OF CASES A AND B

The result of the HDM-4 analysis with Case B Data are summarized in Table 8 under Case B. It shows that the number of feasible subprojects reduced from 6 to 5, mainly due to the decrease in traffic. However, there was no change in the most economically efficient alternative of the subprojects involving the choice between asphalt pavement and concrete pavement. That is the alternatives with concrete pavement had the larger NPV values also in Case B. Effects of ED on individual subprojects are illustrated in Fig. 4. It indicates that both NPV/km (NPV divided by the length of the section), and ERR decreased from Case A to Case B with all cases. It is interesting to note that the arrows representing the changes in ERR and NPV/km, or (ΔERR, ΔNPV/km), in ERR-NPV/km plane tend to have larger slopes (in absolute values) with subprojects of smaller ERR values. It implies that with subprojects of smaller ERR and NPV/km, which tend to be correlated, the reduction in NPV/km is larger than that of ERR in the event of ED which causes reduction in traffic demand. As will be discussed, different countries display different patterns of these arrows (arrow patterns, hereinafter) characterizing the effects of ED in respective countries. The abovementioned arrow pattern will be called Pattern "A" and compared with other patterns. The overall project NPV and ERR reduced to 39.4 million US dollars and 16%, respectively.

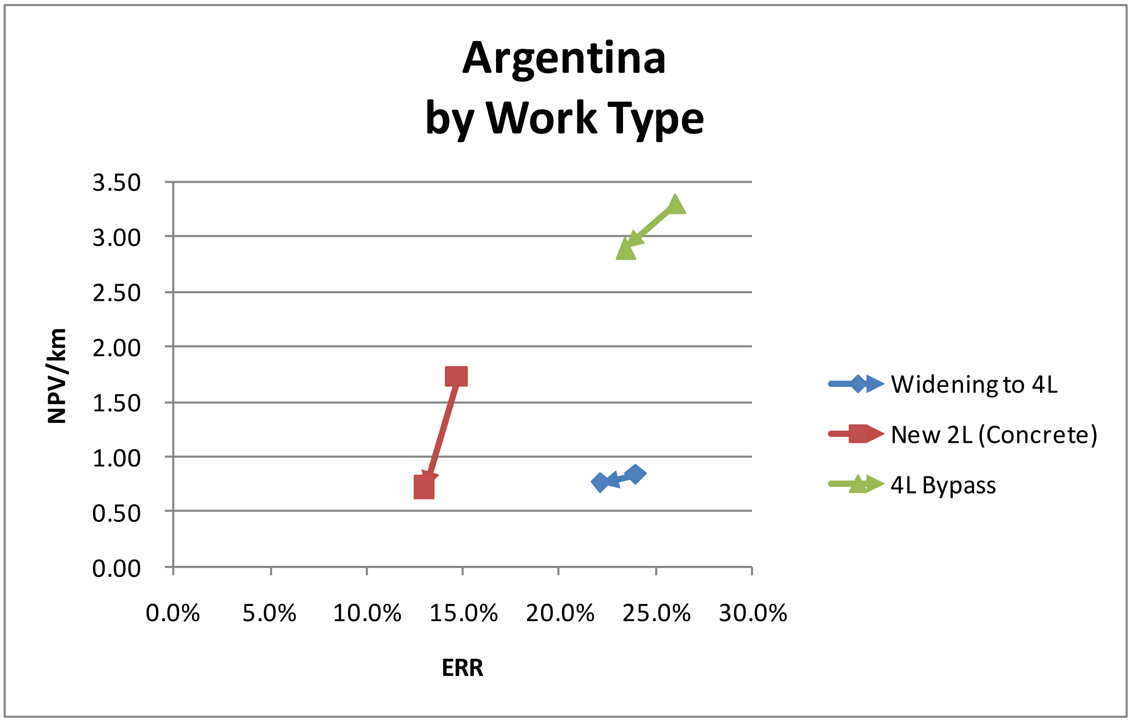
FIGURE 4 : EFFECTS OF ECONOMIC DOWNTURN ON INDIVIDUAL SUBPROJECTS (ARGENTINA)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

Fig. 5 illustrates the effects of ED by the type of subprojects. Pattern "A" is also observed here. Table 9 presents the reduction in the number of feasible subprojects, NPV/km and ERR from Case A to Case B, in percentages, for each subproject alternative type. The table indicates that the subproject type involving the construction of parallel 2 lane road had the largest reduction in all three indices. The reason for this is that, as indicated in Fig.4, which shows the type of subprojects by different arrow colors, all three subprojects belonging to this type were marginal even in Case A.

FIGURE 5 : EFFECTS OF ECONOMIC DOWNTURN BY ALTERNATIVE TYPE (ARGENTINA)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

TABLE 9: PERCENT REDUCTION FROM CASE A TO CASE B BY ALTERNATIVE TYPE (ARGENTINE)

Road section	Section length (km)	Work description	Case A			Case B		
			Base Cost (M US$)	NPV (M US$)	EIRR (%)	Base Cost (M US$)	NPV (M US$)	EIRR (%)
RPN 11 – End Widening	9.0	Widening to 4L (Asphalt)	10.1	7.6	24%	11.3	6.9	22%
End Widening – RPN 6	20.4	New 2L (Concrete)	20.6	5.0	16%	23.1	3.0	14%
RPN 6 – RNN 34, 2L sections	37.6	New 2L (Concrete)	36.1	1.3	13%	40.4	-2.7	11%
RNN 34 – Angelica	44.7	New 2L (Concrete)	32.2	9.2	16%	36.0	6.1	15%
S. Jeronimo & S. Pereyra Bypass	8.3	4L Bypass (Concrete)	15.6	4.5	17%	17.5	1.1	13%
San Francisco Bypass	9.4	4L Bypass (Concrete)	13.5	25.2	35%	15.2	25.0	33%
Project total	129.4		128.1	52.8	18%	143.5	39.4	16%

2.2 COUNTRY ANALYSIS: BOTSWANA

2.2.1 SUMMARY OF PAD ANALYSIS

The HDM-4 economic analysis of Integrated Transport Project covered 828 km of roads included in the Pilot Road Asset Management component (Component B) of the project. These roads consist of 24 homogeneous road sections. The HDM-4 analysis examined the economic feasibility of the OPRC (Output and Performance Based Road Contracting) road management strategies applied at these road sections. Nine different types of OPRC strategies were considered in the analysis consisting of overlay, reseal, fog seal and "reconstruction and widening" for paved roads, and regravelling and "upgrading to a paved road" for unpaved roads. One suitable strategy out of the nine was predetermined for each road section and compared with do-minimum strategies which are mostly routine maintenance. While the analysis period was 20 years starting from 2008, all maintenance/ improvement works included in the OPRC strategies were specified to be applied during the first 10 years. The discount rate used was 12 percent. The results of the analysis are summarized in Table 10 under Case A. The analysis found that the OPRC strategies were economically feasible (i.e., with positive NPVs) for 23 road sections (out of 24 sections). The overall NPV and ERR of all OPRC strategies were found to be 85.2 million US dollars and 31%, respectively.

TABLE 10 : RESULTS OF HDM-4 ANALYSIS WITH CASE A AND CASE B DATA (BOTSWANA)

Road section	Section length (km)	Work description	Case A			Case B		
			Base Cost (M US$)	NPV (M US$)	EIRR (%)	Base Cost (M US$)	NPV (M US$)	EIRR (%)
A1-1	45.0	Overlay & Reseal	3.7	6.8	25%	5.5	0.1	12%
A2-5	74.0	Overlay & Reseal	6.1	8.5	39%	9.0	2.2	20%
B101-2	26.4	Overlay & Reseal	2.2	0.5	17%	3.2	-1.0	3%
B105-1	49.0	Overlay & Reseal	3.5	5.2	22%	5.3	-0.7	11%
B108-1	6.5	Overlay & Reseal	0.5	0.4	19%	0.8	-0.3	8%
B111-2	7.3	Reseal & Overlay	0.2	0.4	20%	0.3	-0.2	7%
A2-4	7.6	Reseal & Overlay	0.2	0.7	69%	0.3	0.2	33%
B202-1	88.8	Reseal & Fog Seal	2.5	3.1	19%	3.7	-1.2	9%
B101-3	41.7	Reseal & Fog Seal	1.2	0.4	17%	1.7	-0.6	2%
B102-1	38.2	Reseal & Fog Seal	1.1	-0.4	-1%	1.6	-0.8	-16%
B111-1	19.7	Reseal & Fog Seal	0.6	0.9	21%	0.8	-0.1	11%
B111-3	36.2	Reseal & Fog Seal	1.0	1.7	21%	1.5	-0.2	11%
B201-1	12.4	Reseal & Fog Seal	0.4	0.8	23%	0.5	0.0	12%
A2-1	9.9	Fog Seal & Reseal	0.1	0.8	30%	0.1	0.1	15%
A3-6	71.3	Fog Seal & Reseal	0.6	13	41%	0.8	4.6	24%
A2-3	15.5	Fog Seal & Reseal	0.1	6.9	69%	0.2	3.5	40%
B202-2	13.4	Fog Seal & Overlay	0.1	4.9	83%	0.2	0.9	33%
A2-2	36.0	Reconstruction & Reseal	10.4	12	35%	15.4	-0.5	-18%
A10-1	43.1	Overlay & Overlay	2.3	10.9	65%	3.4	3.1	29%
B102-2	85.8	Regravelling & Regravelling	5.2	1.4	17%	7.7	-2.1	7%
B101-1	15.5	Regravelling & Regravelling	0.9	0.4	20%	1.4	-0.2	9%
B108-2	17.1	Regravelling & Regravelling	2.2	0.9	21%	3.3	-0.3	10%
B201-2	10.8	Regravelling & Regravelling	0.1	1.5	>100%	0.1	1.3	>100%
B101-4	56.8	Regravelling & Upgrade to paved road	2.8	3.5	22%	4.2	-5.5	3%
Project total	827.8		47.8	85.2	31%	71.1	2.2	13%

2.2.2 MODELING THE EFFECTS OF ECONOMIC DOWNTURN

The traffic growth rates assumed in Case A Data and the actual and predicted GDP growth rates given in WEO are compared in Fig. 6. In the HDM-4 analysis of the subject project in Botswana, same traffic growth rates are assumed for vehicles of all types. Also, generated traffic is assumed as twenty percent of normal traffic for vehicles of all types. Botswana is one of the most severely affected countries by ED with a deep reduction in GDP growth rate in 2009. Therefore, substantially lower traffic growth rates would have been used if ED was anticipated and its effects were known at the time of the cost benefit analysis. In Case B Data, the traffic growth rates of normal traffic were modified to coincide with the actual and predicted GDP growth rates for the period 2008-2015.

FIGURE 6 : TRAFFIC GROWTH RATE OF CASE A DATA AND GDP GROWTH RATE OF WEO (BOTSWANA)

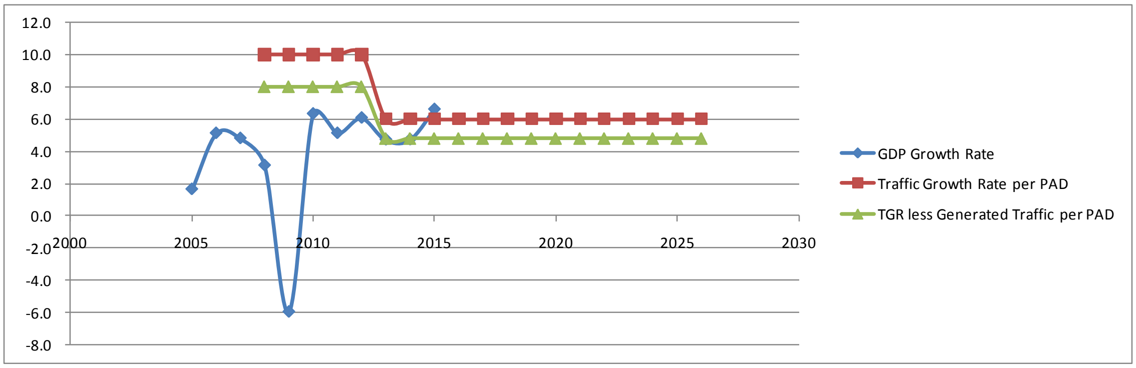
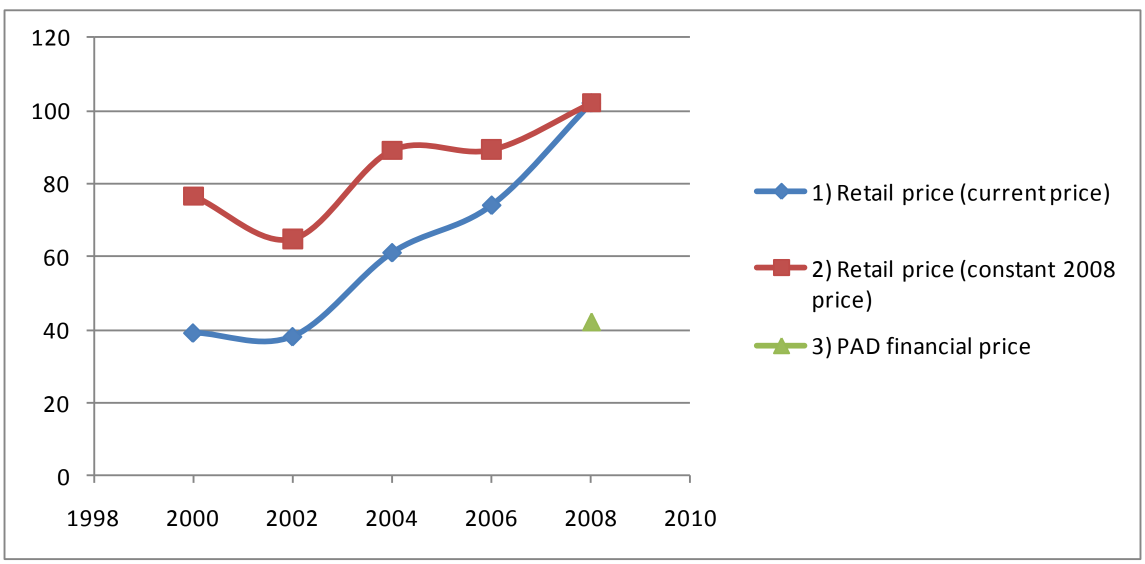


Table 7 shows that the fuel price adjustment factor for Botswana is very high as compared with other countries. This is due to the fact that the recent hike of fuel price was very rapid in Botswana while a relatively low price was assumed in Case A Data as depicted in Fig. 7. Coupled with the fact that the GDP related price adjustment factors are not very different from unity, the analysis with Case B Data is also deemed to reveal the effect of ED through the relative change in factor prices.

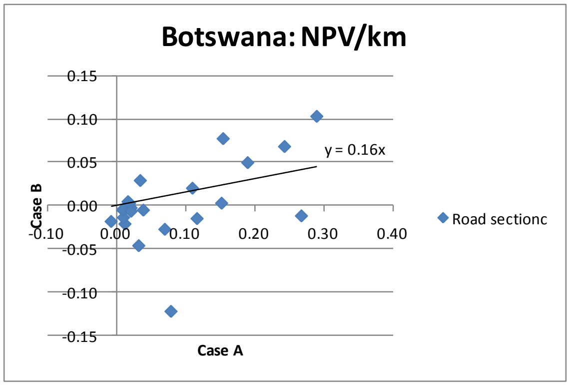
FIGURE 7 :HISTORICAL FUEL PRICES AND ASSUMED FUEL PRICE IN CASE A DATA (BOTSWANA)

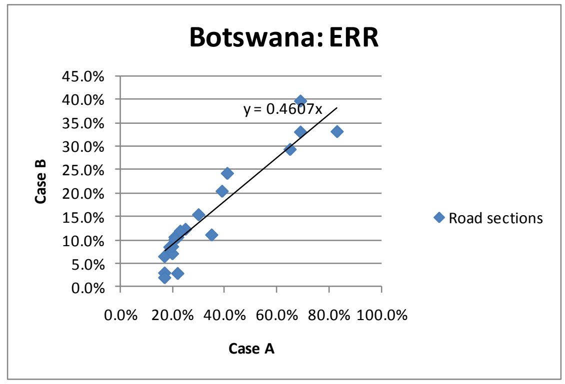


2.2.3 COMPARISON OF THE RESULTS OF CASES A AND B

The results of the analysis are summarized in Table 10 under Case B. It shows that the number of road sections where OPRC strategies are feasible decreased to 9 from 23, due to a stark reduction in traffic demand and the relative change in factor prices. Effects on individual subprojects are illustrated in Fig.8. These figures indicate that NPV/km and ERR values of all OPRC strategies drastically decreased.

FIGURE 8 : EFFECTS OF ECONOMIC DOWNTURN ON INDIVIDUAL SUBPROJECTS (BOTSWANA)





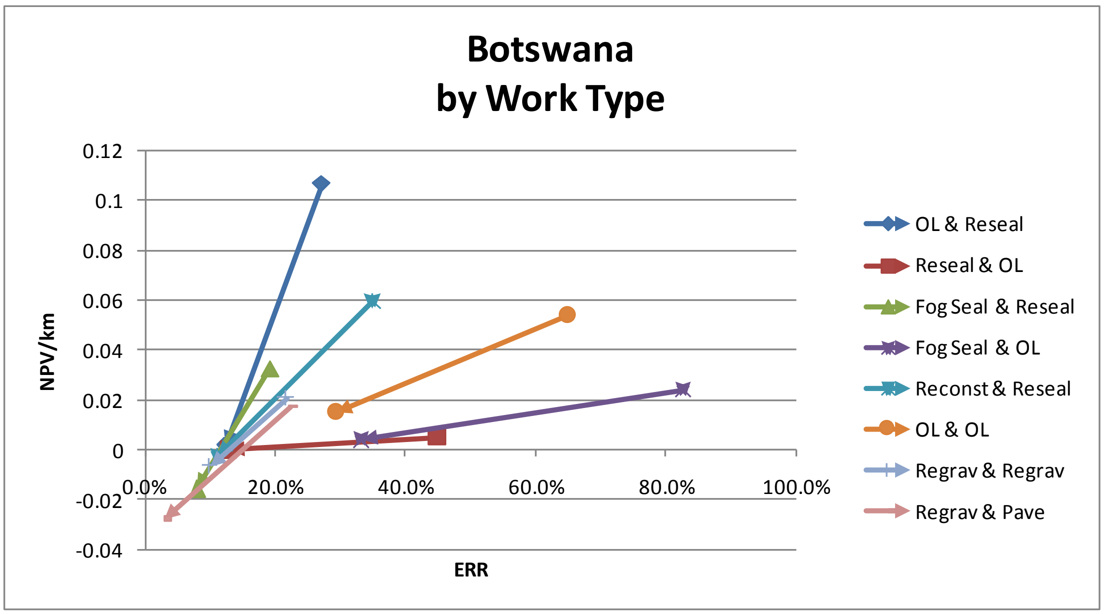
The total NPV of all OPRC strategies reduced to 2.2 million US dollars, which is only 3% of the Case A value, and the ERR to 13%, which is 42% of the Case A value. These reductions in NPV and ERR values somewhat exaggerate the effects of ED, because the contributions of infeasible OPRC strategies are included in the computation of these values. Even if infeasible ones are excluded, however, NPV and ERR amount to 16.1 million US dollars and 22%, respectively, which are still 19% and 71% of the Case A values .

Fig. 9 illustrates the effects of ED by the type of OPRC strategies. It is interesting to note that the figure also displays Pattern "A" discussed in Argentina analysis. To examine more closely, the reductions in the number of feasible road sections, NPV/km and EIRR from Case A to Case B are computed in percentages for each OPRC strategy and shown in Table 11. It indicates that the OPRC strategies involving major investments such as "upgrade to a paved road" and reconstruction had the largest reductions in all three indices. Also noted is the strategy with reseal and fog seal that showed substantial reductions both in the number of feasible road sections and NPV/km. This reflects the fact that these strategies are marginal even in Case A rather than indicating the nature of these treatments regarding the sensitivity to ED.

TABLE 11 : PERCENT REDUCTION FROM CASE A TO CASE B BY ALTERNATIVE TYPE (BOTSWANA)

Predominant Work Activity	No. of Feasible Subproject		NPV/km		ERR		% Reduction from Case A to Case B		
	Case A	Case B	Case A	Case B	Case A	Case B	No. of Feasible Subproject	NPV/km	ERR
1. Overlay & Reseal	5	2	0.107	0.002	27.1%	12.3%	60%	98%	55%
2. Reseal & Overlay	2	1	0.005	0.000	44.7%	12.7%	50%	100%	72%
3. Reseal & Fog Seal	5	0	0.033	-0.015	19.1%	7.9%	100%	147%	59%
4. Fog Seal & Reseal	3	3	0.103	0.041	45.7%	27.0%	0%	60%	41%
5. Fog Seal & Overlay	1	1	0.024	0.004	82.6%	33.1%	0%	82%	60%
6. Reconstruction & Reseal	1	0	0.060	-0.002	34.8%	11.1%	100%	104%	68%
7. Overlay & Overlay	1	1	0.054	0.015	64.9%	29.3%	0%	72%	55%
8. Regravelling & Regravelling	4	1	0.021	-0.006	21.6%	9.9%	75%	131%	54%
9. Regravelling & Upgrade to Pave	1	0	0.017	-0.027	22.1%	2.9%	100%	257%	87%
Total/ Overall	23	9	0.424	0.011	30.9%	12.5%	61%	97%	60%

FIGURE 9 : EFFECTS OF ECONOMIC DOWNTURN BY ALTERNATIVE TYPE (BOTSWANA)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

2.3 COUNTRY ANALYSIS: INDIA

2.3.1 SUMMARY OF PAD ANALYSIS

The HDM-4 economic analysis of Karnataka State Highway Improvement Project 2 covered twenty five road sections identified as stage one high priority links by a preceding feasibility study. All links are of flexible pavements with varying condition and strength characteristics, homogeneous in terms of traffic, pavement width and condition, totaling 831 km. The HDM-4 analysis examined the economic feasibility of the upgrading (widening) of these links to two lane 7.0m carriageway roads with geometric improvements and paved or earth shoulders. This project alternative was compared with a without-project-alternative, consisting of routine maintenance and periodic maintenance of 20 mm Premix Carpet applied every 4 years, at each link. These links were grouped in two sets and analyzed separately as Run-1 and Run-2. The analysis period was twenty years for both runs with 2008 and 2009 as the start years, respectively. The discount rate was 12%. The results of the analysis are presented in Table 12 under Case A for India. The analysis indicates that the project alternatives are economically feasible at all links. The NPV and ERR of the overall project were US$ 927 million and 37%, respectively.

TABLE 12 : RESULTS OF HDM-4 ANALYSIS WITH CASE A AND CASE B DATA (INDIA)

Road section	Section length (km)	Work description	Case A			Case B		
			Base Cost (M US$)	NPV (M US$)	EIRR (%)	Base Cost (M US$)	NPV (M US$)	EIRR (%)
67A	23.5	Upgrading to 2L w/paved shoulder	11.7	9.8	22%	16.7	7.4	18%
67B	28.9	Upgrading to 2L w/paved shoulder	14.6	13.3	22%	20.7	12.4	19%
T8	31.8	Upgrading to 2L w/paved shoulder	16.1	1.7	14%	22.8	-0.7	12%
M7D	43.5	Upgrading to 2L w/paved shoulder	19.1	77.7	52%	27.2	82.9	43%
21B	38.5	Upgrading to 2L w/paved shoulder	21.8	18.9	23%	31.0	16.0	19%
13A	32.5	Upgrading to 2L w/paved shoulder	19.3	89.3	61%	27.5	107.4	52%
13B	41.4	Upgrading to 2L w/paved shoulder	21.7	122.4	66%	30.9	152.5	58%
6C	28.6	Upgrading to 2L w/paved shoulder	16.7	32.9	34%	23.6	42.9	32%
63A	22.8	Upgrading to 2L w/paved shoulder	14.0	20.4	28%	20.0	16.6	22%
63B	27.5	Upgrading to 2L w/paved shoulder	13.3	0.6	13%	18.9	-3.2	9%
63C	21.1	Upgrading to 2L w/paved shoulder	9.2	7.7	23%	13.1	7.1	20%
63D	35.2	Upgrading to 2L w/paved shoulder	17.5	54.7	40%	24.8	60.9	36%
63E	27.9	Upgrading to 2L w/paved shoulder	15.8	15.3	22%	22.4	10.1	17%
64F	20.0	Upgrading to 2L w/paved shoulder	10.6	9.7	24%	15.1	11.9	22%
64G	35.8	Upgrading to 2L w/paved shoulder	17.6	9.9	20%	25.0	12.4	19%
19A	19.2	Upgrading to 2L w/earth shoulder	10.8	4.8	19%	15.3	5.6	18%
19B	42.3	Upgrading to 2L w/earth shoulder	20.8	31.9	35%	29.5	39.1	32%
19C	18.4	Upgrading to 2L w/earth shoulder	9.3	16.5	36%	13.2	18.4	33%
19D	28.0	Upgrading to 2L w/earth shoulder	16.3	0.9	13%	23.1	-1.0	11%
T21	32.2	Upgrading to 2L w/paved shoulder	15.4	25.4	34%	21.8	30.8	31%
M7B	45.4	Upgrading to 2L w/earth shoulder	22.3	167.5	90%	31.7	195.7	73%
M7C	26.2	Upgrading to 2L w/earth shoulder	20.0	-3.0	9%	28.4	-7.6	7%
M7A	49.8	Upgrading to 2L w/earth shoulder	11.5	51.8	54%	16.3	48.1	43%
10A	61.3	Upgrading to 2L w/earth shoulder	23.1	52.2	39%	32.8	63.3	36%
10B	48.7	Upgrading to 2L w/paved shoulder	21.7	96.5	56%	30.8	115.8	50%
Project total	830.5		410.2	926.7	37%	582.5	1044.9	32%

2.3.2 Modeling the Effects of Economic Downturn

The traffic growth rates assumed in Case A Data and the actual and predicted GDP growth rates given in WEO are as shown in the Fig. 10. In the HDM-4 analysis of the subject project in Indian different traffic growth rates were assumed for different vehicle types in Case A Data. Fig. 10 shows the weighted averages of such traffic growth rates for Run-1 and Run-2. In Case B Data, the weighted average traffic growth rates were modified to coincide with the actual and predicted GDP growth rates for the period 2008-2015 for Run-1 and 2009-2015 for Run-2, respectively. The traffic growth rates of each vehicle type were then modified by "prorating" these modifications[4]. Fig. 10 indicates that the extent of the traffic demand reduction due to ED is not very big especially with Run 2. This is because India is one of the least affected countries with a rapid recovery from ED and modest traffic growth rates assumed in Case A Data..

Figure 10 : Traffic Growth rate of Case A Data and GDP growth rate of WEO (India)

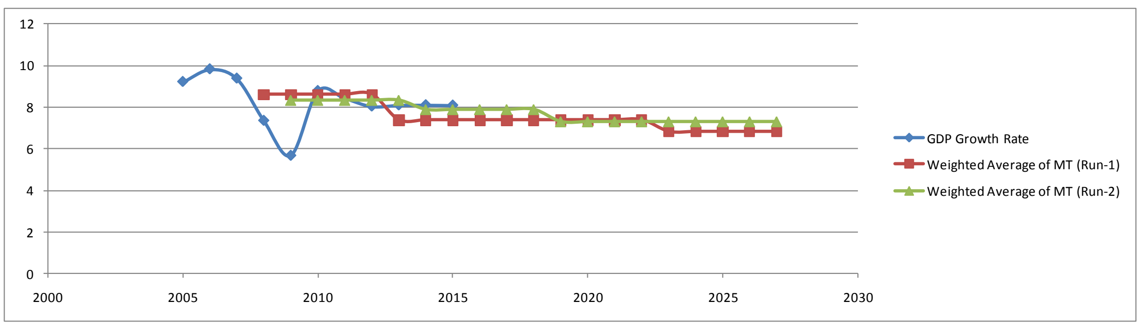
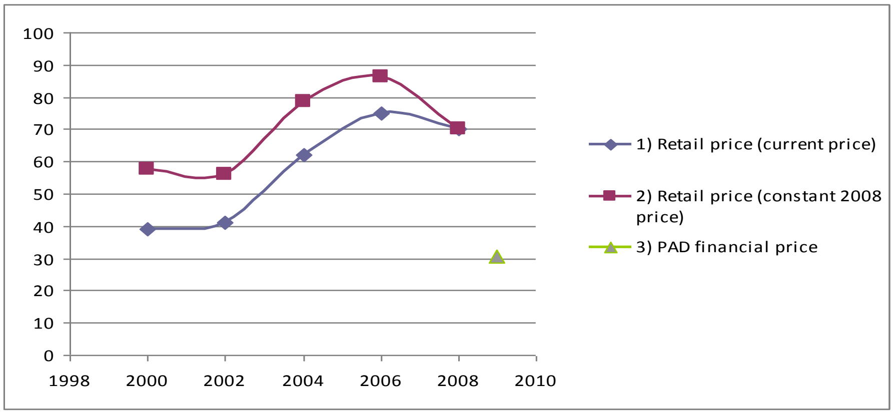


Table 7 shows that the fuel price adjustment factor for India is very high compared with other countries. This is because of the fact that the recent hike in fuel price was very rapid in India while relatively low price was assumed in Case A Data as depicted in Fig. 11. Coupled with the fact that the GDP related price adjustment factors are not very different from unity, the analysis with Case B Data is deemed to reveal the effect of ED through the relative change in factor prices.

[4] See Annex B for a detailed description of the procedure used to modify the traffic growth rates of different vehicle types

FIGURE 11 ;HISTORICAL FUEL PRICES AND ASSUMED FUEL PRICE IN CASE A DATA (INDIA)



2.3.3 COMPARISON OF THE RESULTS OF CASES A AND B

The result of the HDM-4 analysis with Case B Data are summarized in Table 12 der Case B. It shows that the number of feasible subprojects decreased from 24 to 21. Effects of ED on individual subprojects are illustrated in Fig. 12. These figures indicate that while the NPVs of most subprojects increased (by about 17%), the ERRs decreased (by about 14%). This can happen if the NPV curve, representing a function of the discount rate, for Case B, is steeper than that for Case A, and the two curves intersect at a discount rate between 12% and the ERR value of Case A. As the traffic growth rates are not very different between Cases A and B in India, this appears to be mainly due to the relative change in factor prices. The total NPV of all subprojects increased to 1,045 million US dollars, which is 13% higher than that of the Case A value. However, as the investment cost increased more than NPV (by 42%), ERR decreased by 14%.

FIGURE 12 : EFFECTS OF ECONOMIC DOWNTURN ON INDIVIDUAL SUBPROJECTS (INDIA)

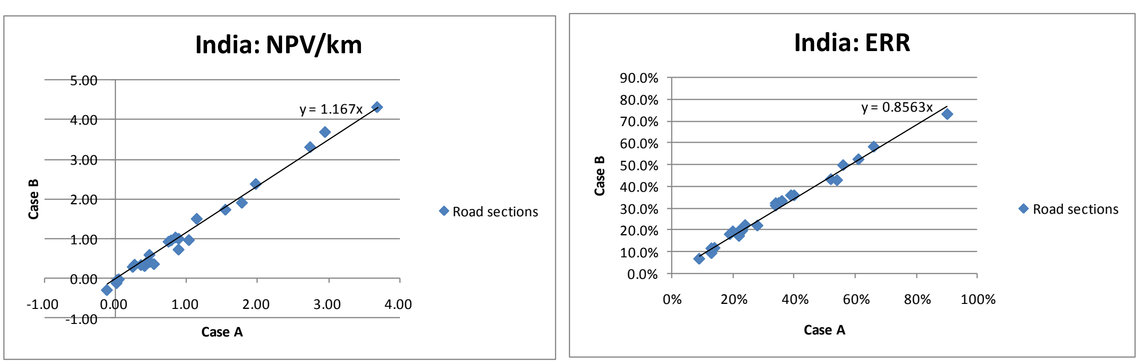
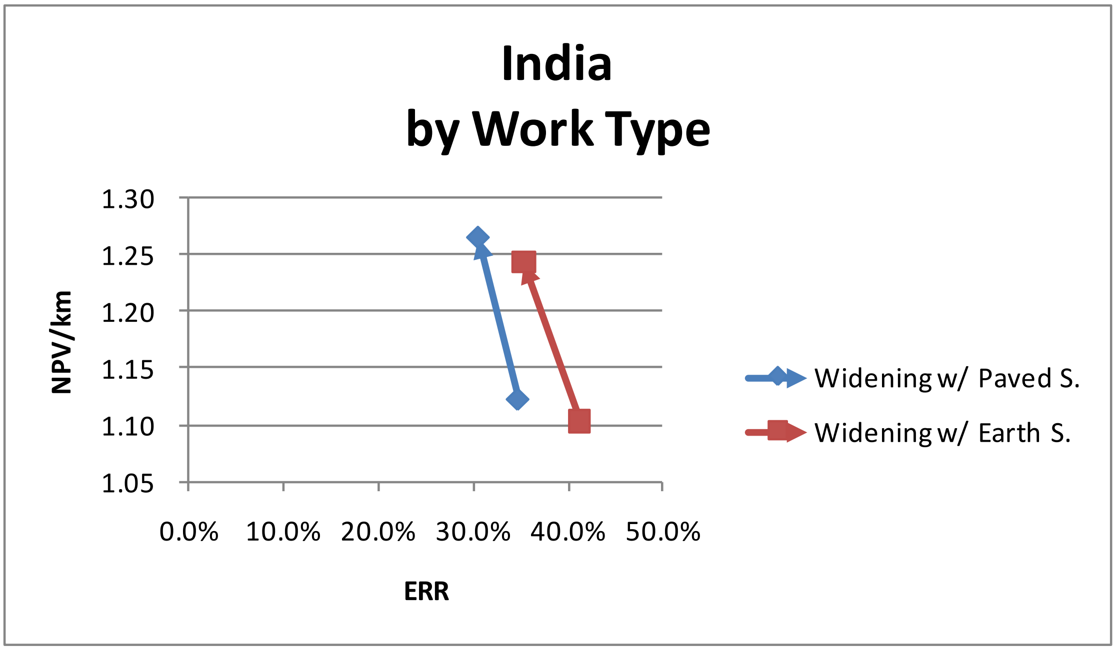


Fig. 13 illustrates the effects of ED by the type of project alternatives. There are only two types, widening with paved shoulder and widening with earth shoulder, and the figure shows that the effects of ED are similar with both types in that while NPV/km increased, ERR decreased from Case A to Case B. This is a very different pattern from Pattern "A". Table 13 presents the reductions in the number of feasible subprojects, NPV/km and ERR from Case A to B, in percentages, for each alternative type, which confirms the absence of difference between the two.

FIGURE 13 : EFFECTS OF ECONOMIC DOWNTURN BY ALTERNATIVE TYPE (INDIA)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

TABLE 13: PERCENT REDUCTION FROM CASE A TO CASE B BY ALTERNATIVE TYPE (INDIA)

Predominant Work Activity	No. of Feasible Subproject		NPV/km		ERR		% Reduction from Case A to Case B		
	Case A	Case B	Case A	Case B	Case A	Case B	No. of Feasible Subproject	NPV/km	ERR
Widening with Paved Shoulders	17	15	1.12	1.27	34.6%	30.5%	12%	-13%	12%
Widening with Earth Shoulders	7	6	1.10	1.24	41.2%	35.3%	14%	-13%	14%
Total/ Overall	24	21	1.12	1.26	36.5%	31.9%	13%	-13%	13%

2.4 COUNTRY ANALYSIS: KENYA

2.4.1 SUMMARY OF PAD ANALYSIS

The HDM-4 economic evaluation of Additional Financing Credit for Northern Corridor Transport Improvement Project covered three homogeneous road sections totaling 158 km. It examined the economic feasibility of a proposed project alternative against a without project case at these road sections. The road sections were in very bad condition with average speeds in the range of 40-50 km/hour. To improve the road sections, a project alternative consisting of routine maintenance and patching, rehabilitation or widening of the roadway in the first year of the analysis period, followed by a 50 mm overlay when the road roughness reaches 4.5 IRI, m/km, was considered. The without-project case consisted of routine maintenance and patching and road rehabilitation (without widening) when road roughness reaches 12 IRI, m/km. The analysis was conducted with the evaluation period of 20 years, with 2008 as the start year, and a 12% discount rate. The results of the analysis are presented in Table 14 under Case A. The analysis found that the project alternatives are economically feasible with positive NPVs for all three sections. The overall NPV and ERR are 65.7 million US dollars and 19%, respectively.

TABLE 14 : RESULTS OF HDM-4 ANALYSIS WITH CASE A AND CASE B DATA (KENYA)

Road section	Section length (km)	Work description	Case A			Case B		
			Base Cost (M US$)	NPV (M US$)	EIRR (%)	Base Cost (M US$)	NPV (M US$)	EIRR (%)
1. Mau Summit – Kericho	55	Rehabilitation	86.4	14.4	17%	90.8	6.7	14%
2. Kericho – Nyamasaria	81	Rehabilitation	101.7	39.7	24%	106.7	29.2	20%
3. Nyamasaria – Kisum a/p	24	Rehabilitation and widening to 4L	66.9	11.6	16%	70.2	4.5	14%
Project total	160		255.0	65.7	19%	267.7	40.3	16%

2.4.2 MODELING THE EFFECTS OF ECONOMIC DOWNTURN

The traffic growth rates assumed in Case A Data and the actual and predicted GDP growth rates given in WEO are as shown in Fig. 14. The same traffic growth rates were assumed for all six vehicle types considered in the HDM-4 analysis. Generated traffic was assumed as 22% of normal traffic. In Case B Data, the traffic growth rates of normal traffic were modified to coincide with the actual and predicted GDP growth rates for the period of 2008-2015, with no change in the ratio of generated traffic to normal traffic. The effect of ED on GDP growth rates was modest in Kenya, and the traffic growth rates assumed in Case A Data approximately coincided with the average GDP growth rates of the 2008-2015 period. However, as the traffic growth rates were reduced for the first part of the 2008-2015 period in Case B Data, net effect, after accounting for discounting factor, is a moderate decrease in overall traffic demand.

FIGURE 14 TRAFFIC GROWTH RATE OF CASE A DATA AND GDP GROWTH RATE OF WEO (KENYA)

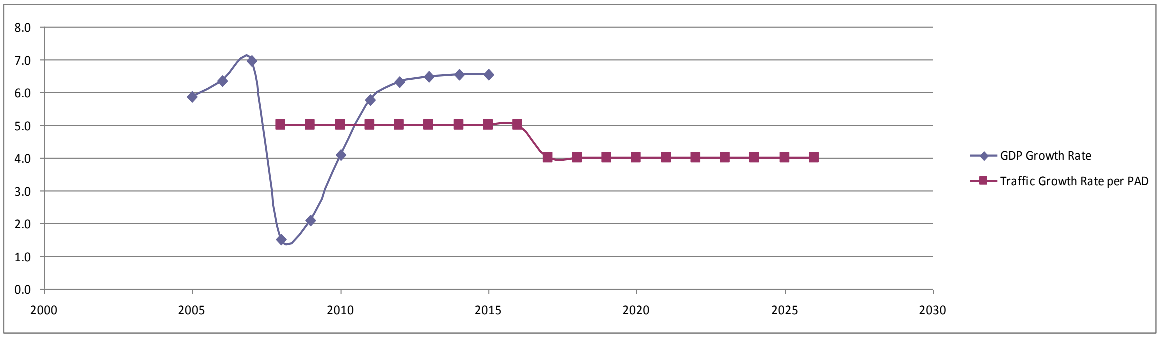
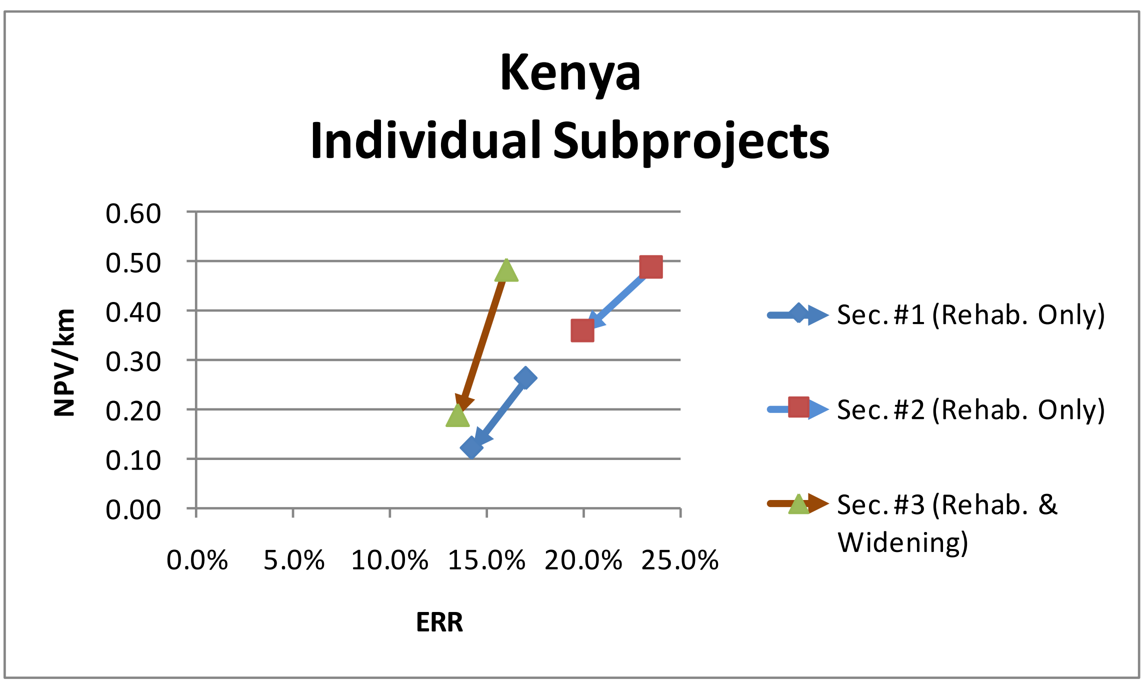


Table 7 shows that the GDP adjustment factor and wage adjustment factor for Kenya are almost negligible (equal to unity), while the fuel price adjustment factor is 12 to 15 percent higher than these values. Consequently, a moderate effect is expected by the change in factor prices.

2.4.3 COMPARISON OF THE RESULTS OF CASES A AND B

The result of the HDM-4 analysis with Case B Data are summarized in Table 14 under Case B. It shows that the project alternatives are still feasible for all sections (subprojects) with Case B Data. Effects of ED on individual subprojects are illustrated in Fig. 15. It indicates that both NPV/km and ERR decreased with all cases, displaying Pattern "A". The overall NPV decreased by 61% to 40.3 million US dollars, and ERR decreased by 16% to 16%.

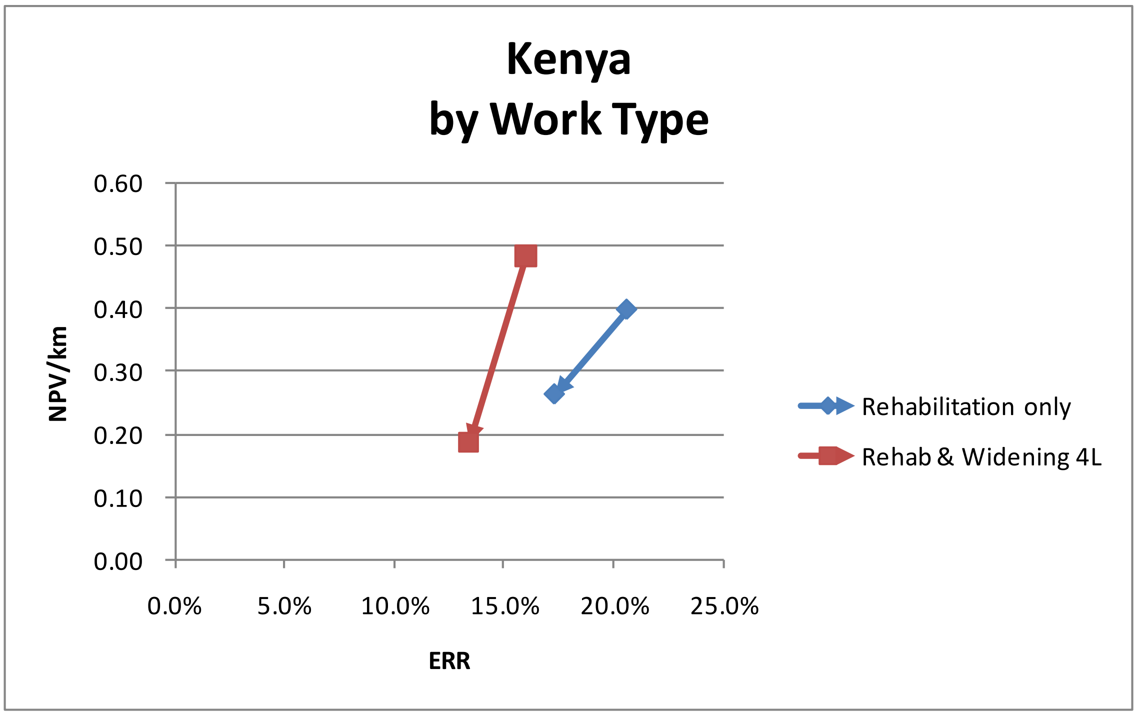
FIGURE 15 : EFFECTS OF ECONOMIC DOWNTURN ON INDIVIDUAL SUBPROJECTS (KENYA)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

Fig. 16 illustrates the effects of ED by the type of project alternatives. There are only two types, rehabilitation only, and rehabilitation and widening to a 4 lane road. There is only one subproject belonging to the latter. They show the same tendency of reducing both NPV/km and ERR values from Case A to Case B. Due to the smallness of the samples, it is difficult to note any systematic difference between the two. Table 15 presents the reductions in the number of feasible subprojects, NPV/km and ERR from Case A to B, in percentages, for each subproject type. As in Botswana study, it shows that the reductions in percentages are larger with the alternative type involving more expensive works, i.e, widening.

FIGURE 16 : EFFECTS OF ECONOMIC DOWNTURN BY ALTERNATIVE TYPE (KENYA)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

TABLE 15: PERCENT REDUCTION FROM CASE A TO CASE B BY ALTERNATIVE TYPE (KENYA)

Predominant Work Activity	No. of Feasible Subproject		NPV/km		ERR		% Reduction from Case A to Case B		
	Case A	Case B	Case A	Case B	Case A	Case B	No. of Feasible Subproject	NPV/km	ERR
1. Rehabilitation	2	2	0.40	0.26	20.6%	17.3%	0%	34%	16%
2. Rehabilitation & Widening to 4L	1	1	0.48	0.19	16.0%	13.4%	0%	61%	16%
Total/ Overall	3	3	0.41	0.25	19.2%	16.2%	0%	39%	16%

2.5 Country Analysis: Lao PDR

2.5.1 Summary of PAD Analysis

The HDM-4 economic evaluation of Road Sector Project examined the economic feasibility of the project alternative proposed for twenty unpaved roads, totaling 455.5 km, by comparing them with a without-project alternative. The without-project alternative was defined as one grading per year or do-nothing. The project alternative consisted of condition responsive regravelling and routine maintenance of one grading per year. The analysis period was 20 years starting from 2010, and the discount rate was 12%. The results of the analysis are presented in Table 16 under Case A. The analysis found that the project alternative is feasible with positive NPVs for all roads, and the overall NPV and ERR are 1.92 million US dollars and 23%, respectively.

Table 16 Results of HDM-4 Analysis with Case A and Case B Data (Lao PDR)

Road section	Section length (km)	Work description	Case A			Case B		
			Base Cost (M US$)	NPV (M US$)	EIRR (%)	Base Cost (M US$)	NPV (M US$)	EIRR (%)
1	20	Regrav./Spot Rehab.	0.20	0.03	16%	0.20	0.00	12%
2	19	Regravelling	0.17	0.06	16%	0.17	0.03	15%
3	22	Regravelling	0.13	0.18	44%	0.13	0.14	38%
4	20	Regravelling	0.13	0.09	21%	0.13	0.06	19%
5	17	Regravelling	0.10	0.11	37%	0.10	0.08	32%
6	20	Regravelling	0.13	0.05	17%	0.13	-0.03	9%
7	24	Regravelling	0.16	0.12	28%	0.16	0.09	24%
8	30	Regravelling	0.21	0.15	28%	0.21	0.11	24%
9	30	Regravelling	0.24	0.16	27%	0.24	0.11	22%
10	29	Regrav./Spot Rehab.	0.27	0.09	19%	0.27	0.04	15%
11	21.5	Regravelling	0.15	0.12	24%	0.15	0.09	21%
12	20	Regrav./Spot Rehab.	0.17	0.02	14%	0.17	0.00	11%
13	30	Regravelling	0.27	0.03	15%	0.27	-0.05	No IRR
14	20	Regravelling	0.10	0.16	70%	0.10	0.08	38%
15	30	Regravelling	0.14	0.24	70%	0.14	0.12	38%
16	30	Regravelling	0.29	0.05	16%	0.29	0.02	13%
17	24	Regravelling	0.17	0.06	21%	0.17	0.03	16%
18	23	Regravelling	0.16	0.14	39%	0.16	0.07	25%
19	12	Regravelling	0.11	0.02	15%	0.11	0.01	13%
20	14	Regravelling	0.10	0.04	19%	0.10	0.02	16%
Project total	455.5		3.37	1.92	23%	3.37	1.02	9%

2.5.2 Modeling the Effects of Economic Downturn

The traffic growth rates assumed in Case A Data and the actual and predicted GDP growth rates given in WEO are compared in Fig. 17. In the HDM-4 analysis of the subject project in Lao PDR six traffic growth patterns were assumed for seven vehicle types. The figure only shows the weighted average of these growth patterns. Lao PDR is one of the least affected countries by ED with inconspicuous dents in the GDP growth rate history. However, the assumed traffic growth rates in Case A Data were higher than GDP growth rates by more than 2% for most of the time before 2015. In Case B Data the weighted average traffic growth rates are modified to coincide with the actual and predicted GDP growth rates for the period of 2010-2015, representing a sizable reduction in traffic demand. The weighted averages were then used as the basis for modifying the traffic growth rates of all vehicle types during the same period[5].

FIGURE 17: TRAFFIC GROWTH RATE OF CASE A DATA AND GDP GROWTH RATE OF WEO (LAO PDR)

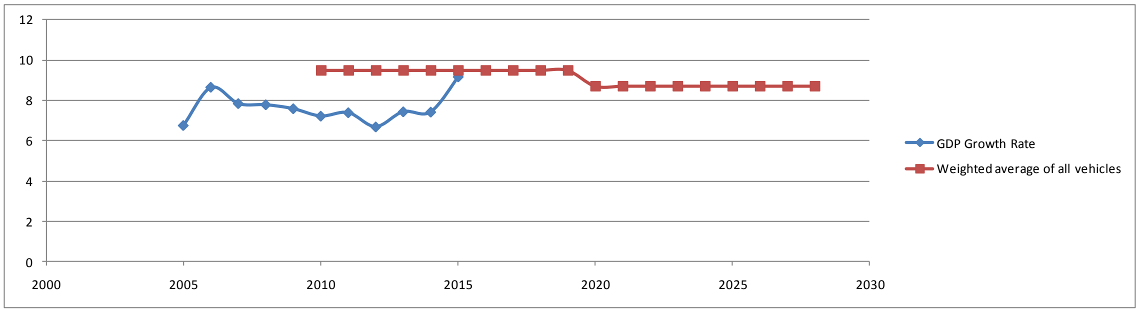


Table 7 shows that all adustment factors are almost unity indicating that the effect of ED through the relative change in factor prices is almost negligible. This is due to the fact that the original HDM-4 analysis for the PAD was conducted in 2008, and factor prices did not substantially change since then.

2.5.3 COMPARISON OF THE RESULTS OF CASES A AND B

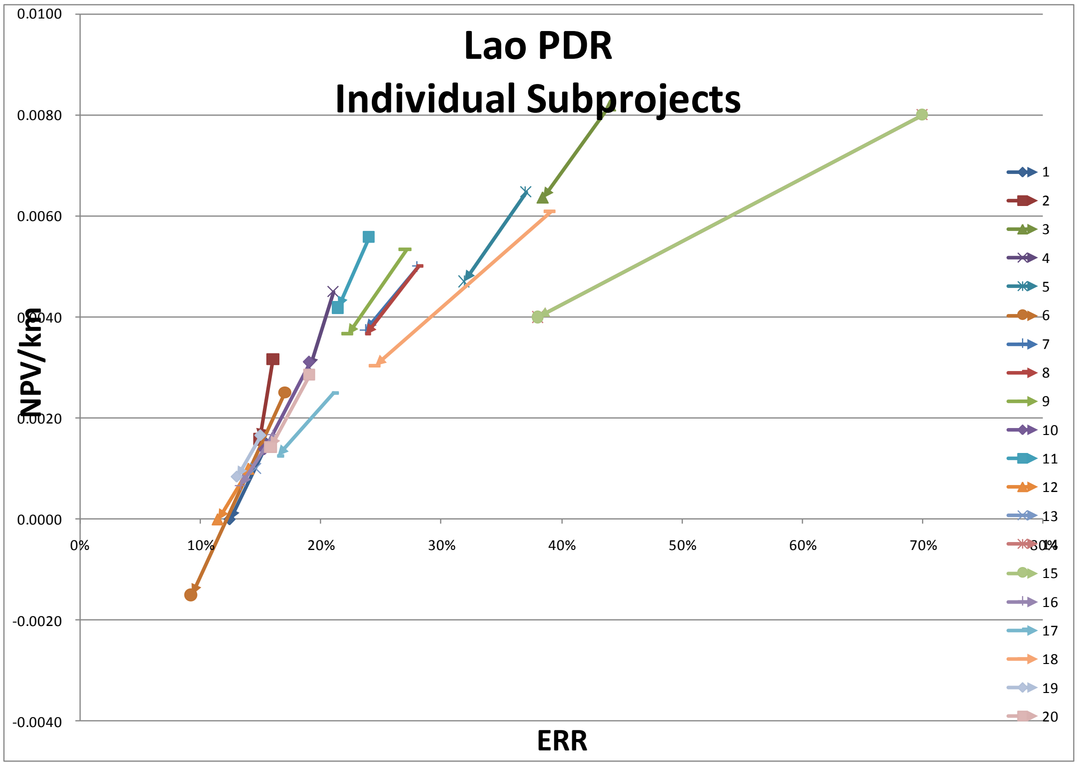
The result of the HDM-4 analysis with Case B Data are summarized in Table 16 under Case B. It shows that all but three subprojects are feasible with Case B Data. The effects of ED on individual subprojects are illustrated in Fig. 18. It shows that the arrow pattern is "A", similar to the patterns of Argentina, Botswana and Kenya. Table 17 presents the reductions in the number of feasible subprojects, NPV/km and ERR from Case A to B, in percentages, for the whole project. As all subprojects are of the same type, no breakdown by project type is shown in the Table. The overall NPV reduced to 1.02 million US dollars, which represents 47% reduction from Case A. The ERR reduced to 8.6%, which is 63% reduction from Case A.

TABLE 17 : PERCENT REDUCTION FROM CASE A TO CASE B (LAO PDR)

Predominant Work Activity	No. of Feasible Subproject		NPV/km		ERR		% Reduction from Case A to Case B		
	Case A	Case B	Case A	Case B	Case A	Case B	No. of Feasible Subproject	NPV/km	ERR
Total/ Overall	20	17	0.0042	0.0022	23%	8.6%	15%	47%	63%

[5] See Annex B for a detailed description of the procedure used to modify the traffic growth rates of different vehicle types.

FIGURE 18 : EFFECTS OF ECONOMIC DOWNTURN ON INDIVIDUAL SUBPROJECTS (LAO PDR)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

2.6 COUNTRY ANALYSIS: PARAGUAY

2.6.1 SUMMARY OF PAD ANALYSIS

The HDM-4 economic evaluation of Road Maintenance Project covered 826 km of paved roads with the aim of identifying road sections that receive only routine maintenance over the 2007-2010 period and sections in which some kind of periodic maintenance, rehabilitation or improvement is economically justified. The road network was subdivided into 60 homogeneous sections. Multiple road maintenance alternatives were compared for each road section, and it was also the aim of the analysis to identify the most economically efficient alternative for the latter sections. The without-project alternative considered in the analysis consisted of routine maintenance and rehabilitation with a 200 mm overlay when road roughness reaches 5.5 IRI, m/km. The project alternatives evaluated include micro surfacing, overlay and mill and replace road works. The analysis period was 15 years stating from 2006, and the discount rate was 12%. The results of the analysis are summarized in Table 18 under Case A. The analysis found that 18 sections should receive routine maintenance only while some kind of periodic maintenance, rehabilitation or improvement was economically justified at 42 sections. The total NPV of all feasible and efficient alternatives is US$ 30.5 million and the overall ERR is 39.6%.

TABLE 18 : RESULTS OF HDM-4 ANALYSIS WITH CASE A AND CASE B DATA (PARAGUAY)

Road section	Section length (km)	Work description	Case A			Case B		
			Base Cost (M US$)	NPV (M US$)	EIRR (%)	Base Cost (M US$)	NPV (M US$)	EIRR (%)
1-1	0.9	OL 50	0.05	0.2	48%	0.06	0.2	48%
1-3	4.9	OL 50	0.21	0.8	50%	0.25	1.0	51%
1-5	10.2	Micro Surf. & OL	0.29	2.2	83%	0.36	2.6	85%
1-6	10.2	Micro Surf. 12	0.02	1.7	>100%	0.02	2.2	>100%
1-7	5.9	Micro Surf. & OL	0.25	0.6	41%	0.29	0.7	42%
1-8	5.9	Micro Surf. 12	0.02	0.5	68%	0.03	0.6	71%
1-9	2.6	Micro Surf. 12	0.06	0.2	33%	0.07	0.2	33%
1-10	2.6	Micro Surf. 12	0.06	0.2	37%	0.07	0.3	37%
1-11	1.7	Micro Surf. 12	0.04	0.1	36%	0.05	0.2	38%
1-12	1.7	Micro Surf. 12	0.03	0.1	31%	0.04	0.2	34%
1-13	5.5	Micro Surf. 12	0.11	0.5	41%	0.14	0.6	42%
1-14	2.5	Micro Surf. 12	0.06	0.2	37%	0.07	0.3	37%
1-15	2.5	Micro Surf. 12	0.05	0.2	35%	0.06	0.3	37%
1-16	1.7	Micro Surf. 12	0.03	0.2	56%	0.04	0.3	58%
1-18	2.7	Micro Surf. 12	0.06	0.3	42%	0.07	0.3	42%
1-19	2.2	Micro Surf. 12	0.05	0.2	36%	0.06	0.3	36%
1-20	0.5	Micro Surf. 12	0.01	0.1	56%	0.01	0.1	57%
1-21	7.4	Micro Surf. 12	0.17	1.8	74%	0.20	1.7	74%
1-22	7.4	Micro Surf. 12	0.17	1.5	68%	0.20	1.9	69%
1-23	5.6	Micro Surf. 12	0.12	0.8	48%	0.14	1.0	49%
1-24	5.6	Micro Surf. 12	0.11	0.7	47%	0.13	0.9	48%
1-25	3.7	Micro Surf. 12	0.08	1.0	96%	0.09	1.2	97%
1-26	5.5	Micro Surf. 12	0.11	0.4	39%	0.14	0.6	41%
2-1	16.1	Micro Surf. 12	0.30	1.1	57%	0.36	1.3	57%
2-2	15.9	Micro Surf. & Shoulder	0.96	0.8	22%	1.14	1.0	22%
2-3	7.5	Micro Surf. & Shoulder	0.45	0.4	23%	0.54	0.4	21%
2-4	7.6	Micro Surf. & Shoulder	0.22	0.5	31%	0.26	0.5	30%
2-5	29.4	Micro Surf. & Shoulder	1.35	2.8	32%	1.36	3.0	32%
2-6	46.3	Micro Surf. & Shoulder	0.26	2.2	42%	0.32	2.9	44%
2-7	4.8	Micro Surf. & Shoulder	0.03	0.3	45%	0.03	0.3	46%
2-11	31.6	Micro Surf. 12				1.38	0.1	15%
2-16	26.4	Micro Surf. 12	0.13	0.3	29%	0.15	0.4	30%
2-17	31.1	Micro Surf. 12	0.47	0.2	17%	0.56	1.1	24%
3-1	12.2	Micro Surf. 12	0.00	1.1	>100%	0.01	1.4	>100%
3-2	8.6	Micro Surf. 12	0.15	0.8	43%	0.18	0.8	40%
3-3	14.8	Micro Surf. 12	0.29	1.8	55%	0.35	2.0	56%
3-4	20.3	OL 50	0.19	1.0	36%	0.22	1.2	37%
3-5	13.6	Micro Surf. & Shoulder	0.13	0.3	24%	0.16	0.7	31%
3-6	12.4	Micro Surf. & Shoulder	0.19	0.1	17%	0.22	0.5	24%
3-7	31.9	Micro Surf. & Shoulder	0.29	0.5	24%	0.35	1.6	31%
3-8	20.6	Micro Surf. & Shoulder	0.41	1.0	27%	0.49	1.2	29%
3-9	25.4	Micro Surf. & Shoulder	0.89	0.5	21%	1.07	0.5	21%
3-10	9.8	Micro Surf. 12	0.11	0.1	26%	0.13	0.1	26%
Project total	485.7		9.00	30.5	40%	11.85	38.5	40%

2.6.2 MODELING THE EFFECTS OF ECONOMIC DOWNTURN

The traffic growth rates assumed in Case A Data and the actual and predicted GDP growth rates from WEO are compared in Fig. 19. In the HDM-4 analysis of the subject project in Paraguay, a same traffic growth rate and no generated traffic are assumed for all vehicle types throughout the analysis period. To mimic the situation where the effects of ED were known at the time of the HDM-4 analysis, the traffic growth rates for the period of 2006-2015 were replaced with the actual and predicted GDP growth rates in Case B Data. Paraguay is one of the least affected countries by ED with a quick recovery. Coupled with the fact that the PAD analysis assumed a modest traffic growth rate compared with GDP growth rates, traffic volume assumed in Case B Data represents a moderate increase rather than decrease from Case A Data.

FIGURE 19 : TRAFFIC GROWTH RATE OF CASE A DATA AND GDP GROWTH RATE OF WEO (PARAGUAY)

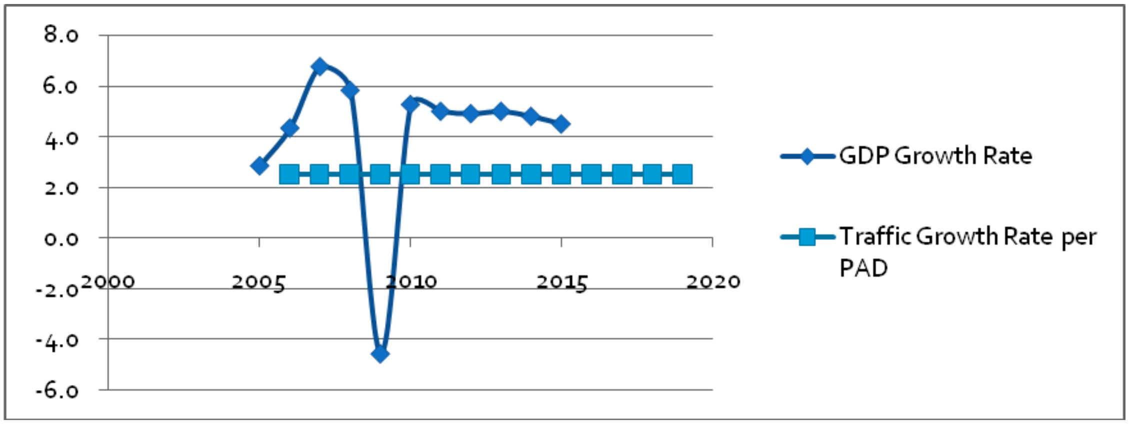
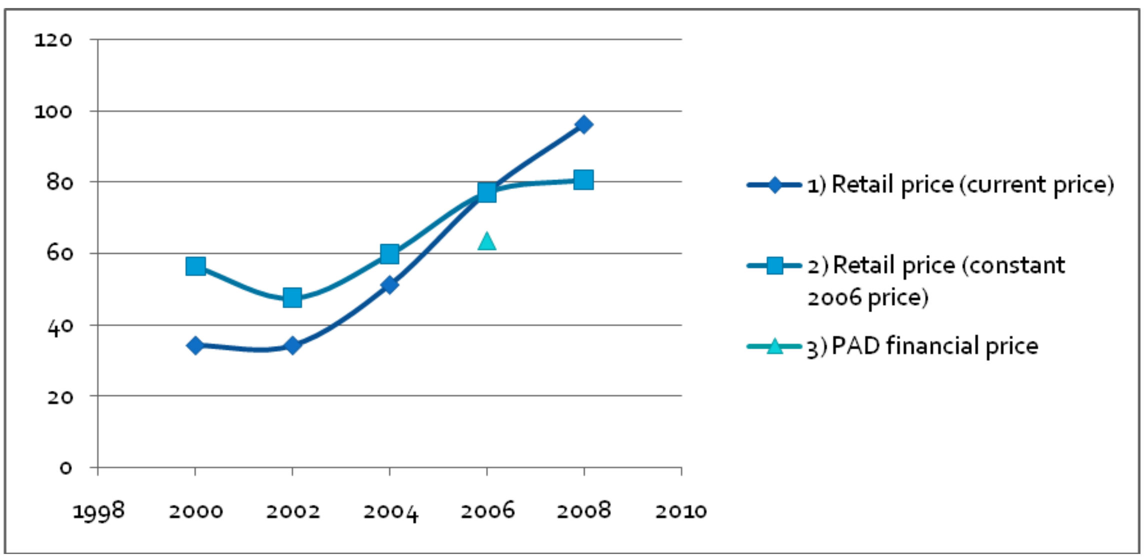


Table 7 shows that the fuel price adjustment factor for Paraguay is modest compared to other countries. This is due to the fact that the assumed fuel price in Case A Data was not so different from the actual price in 2006 as indicated in Fig. 20. Also, the fuel price adjustment factor is only slightly different from other price adjustment factors, implying little effect of ED through the relative change in factor prices.

FIGURE 20 : HISTORICAL FUEL PRICES AND ASSUMED FUEL PRICE IN CASE A DATA (PARAGUAY)



2.6.3 COMPARISON OF THE RESULTS OF CASES A AND B

The result of the HDM-4 analysis with Case B Data are summarized in Table 18 under Case. Fig. 21 illustrates the changs in NPV/km and ERR of individual subprojects from Case A to Case B. These figures indicate that both values increased with most subprojects due to the increase in traffic demand, the major effect of ED in Paraguay. The NPV and ERR of all feasible and efficient subprojects increased to 38.5 million US dollars and 40.3%, respectively. There was no change in the most efficient project alternative for each subproject except for one case, for which it changed from routine maintenance to microsurfacing as the project alternative became feasible with Case B Data.

FIGURE 21 : EFFECTS OF ECONOMIC DOWNTURN ON INDIVIDUAL SUBPROJECTS (PARAGUAY)

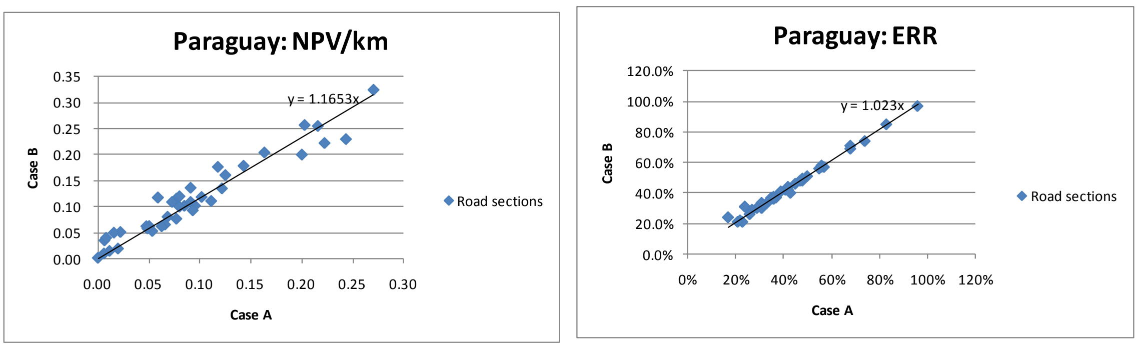
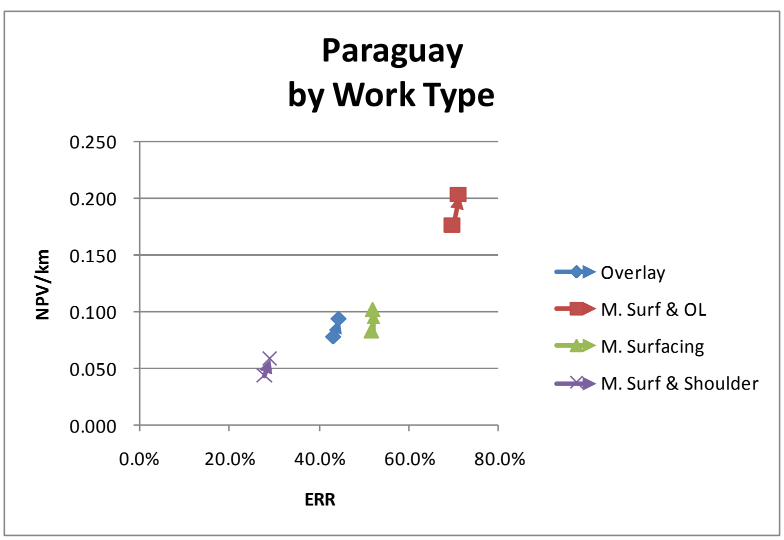


Fig. 22 illustrates the effects of ED by the type of project alternatives. There are four types in the Paraguay project, overlay, microsurfacing followed by overlay, microsurfacing with shoulder repair and microsurfacing only. It is noted that the direction of the arrows is north east, opposite to that of all other countries but India. This is due to the increased traffic.

FIGURE 22 : EFFECTS OF ECONOMIC DOWNTURN BY ALTERNATIVE TYPE (PARAGUAY)



Note: Arrows indicate the change in the values of ERR and NPV/km from Case A to Case B.

Table 19 presents the reductions in the number of feasible subprojects, NPV and ERR from Case A to B, in percentages, for each subproject type. Negative values of these percentages imply increases. The table shows that the types which do not involve expensive overlays had slightly larger increases in NPV/km.

TABLE 19 : PERCENT REDUCTION FROM CASE A TO CASE B BY ALTERNATIVE TYPE (PARAGUAY)

Predominant Work Activity	No. of Feasible Subproject		NPV/km		ERR		% Reduction from Case A to Case B		
	Case A	Case B	Case A	Case B	Case A	Case B	No. of Feasible Subproject	NPV/km	ERR
1. Overlay 50 mm	3	3	0.077	0.093	43.2%	44.3%	0%	-21%	-3%
2. M. Surf. & Overlay	2	2	0.177	0.203	69.7%	71.0%	0%	-15%	-2%
3. Micro Surfacing 12 mm	26	27	0.083	0.102	51.6%	51.9%	-4%	-23%	-1%
4. M Surf. & Shoulder	11	11	0.044	0.059	27.8%	29.0%	0%	-35%	-4%
Total/ Overall	42	43	0.067	0.085	39.6%	40.3%	-2%	-26%	-2%

2.7 SUMMARY OF COUNTRY ANALYSIS

If ED were anticipated and its effects known when the HDM-4 economic analyses for the preparation of PADs were conducted, different values of Focal Parameters would have been used as inputs to HDM-4. To analyze the effects of ED, Case B Data were created by modifying Case A Data with GDP growth rates and price adjustment factors of the countries. Depending on the discrepancy between the assumed traffic growth rates in Case A Data and the GDP growth rates, the traffic volumes were decreased or increased in Case B Data for each country. The country analyses revealed that the extent of the decrease was the largest with Botswana, Lao PDR and Argentina, followed by Kenya; the traffic was increased with Paraguay. It also revealed that the magnitude of the variance in price adjustment factors was different by country. The major contributor to the magnitude of variance is the fuel price adjustment factor which is the largest with Botswana and India followed by Paraguay and Kenya. Table 20 summarizes the magnitudes of these indices for each country under the caption of "Input".

The effects of ED thus modeled in the modification of HDM-4 inputs resulted in the changes in outputs of all subprojects analyzed. The changes were discussed in terms of the arrow pattern, i.e., the pattern of (ΔERR, ΔNPV/km) arrows in ERR-NPV/km plane, and percent reductions in the number of feasible subprojects, NPV/km and ERR. Under the heading of "Output," Table 20 also summarizes the results in these respects. The fourth column lists the average of the percentage reductions in the number of feasible subprojects, NPV/km and ERR of each country. The rightmost column lists the type of arrow pattern, "A" through "C". "A" is the pattern in which all arrows point to south-west. "B" is the unique pattern of India where arrows point to north-west. "C" is the pattern of Paraguay where arrows point to north-east.

The relationship between the indicators in the second column and the fourth column clearly shows the positive relationship between the decrease in traffic and the decrease in economic viability of projects, the effect of ED in terms of the output of HDM-4 analysis. It is interesting to note, however, that the magnitude of the decrease in the value of the indicator in the fourth column is different for Argentina and Lao PDR which had the same magnitude of the "values" in the indicators in the second and third columns, indicating the existence of the third factor or the limitation of this kind of qualitative analysis.

Regarding the relationship between the inputs and the arrow pattern, regardless of the magnitude of variance in price adjustment factors, decrease in traffic appears to bring about Pattern "A". As Paraguay had increased traffic, its pattern resulted in "C, which is similar to "A" but with opposite arrow directions. India displayed a very different arrow pattern from all other countries due to the fact that the variance in price adjustment factors played the greater role than the change in traffic volume.

TABLE 20 : EFFECTS OF ED ON HDM-4 INPUTS AND OUTPUTS

	Input		Output	
	Magnitude of Traffic Volume Adjustment*	Magnitude of Variance in Price Adjustment Factors**	Average Reduction in No. of Feasible Subprojects, NPV and ERR (%)	Pattern of Reductions in NPV/km and ERR***
Argentina	∆∆	~	17	A
Botswana	∆∆∆	++	73	A
India	~	++	4	B
Kenya	∆	+	18	A
Lao PDR	∆∆	~	42	A
Paraguay	++	+	-10	C

Note:* "∆", "+" and "~" indicate decrease, increase and neutral, respectively. The number of marks represents the degree of decrease or increase.

** The number of "+" signs indicate the degree of variance. "~" implies little or no variance.

*** Patterns are defined in the main text.

It is of interest to see if the effects of ED were different by the type of project alternatives. Two questions may be asked regarding this point. One is regarding the robustness of the choice of most economical project alternative amongst multiple alternatives. Does ED cause the change in this choice? Argentina and Paraguay studies are the only ones which have multiple project alternatives included in constituent subprojects and may be analyzed to answer this question. The analyses of these cases indicate that there was no change in this choice except for one of the Paraguay subprojects which changed its most economical alternative from routine maintenance to micro-surfacing as it became feasible under Case B Data.

Another question to be posed is regarding the impact on the feasibility of individual subprojects. Are there any systematic difference in the degree of decrease or increase, as a result of ED, in NPV/km or ERR by the type of project alternatives? In this respect, two cases revealed that alternative types which are more expensive had larger decreases than other types. In Botswana analysis, maintenance strategies involving "upgrading to a paved road" and "reconstruction" had larger decreases than seven other types. In Kenya analysis, "rehabilitation and widening" had larger decreases than "rehabilitation only." However, although not very strong, converse was the case in Paraguay analysis where the alternative types which do not involve expensive overlays had larger increases with increased traffic.

Thus, the outcome of the country analyses was not very decisive regarding the differential effects of ED by the type of project alternatives. This is mainly due to the lack of the variety in alternative types included in respective studies. To overcome this shortcoming, all results with Case A Data and Case B Data will be pooled and analyzed together in the next section.

3 ANALYSIS OF POOLED DATA

3.1 INTRODUCTION

In the previous chapter, the effects of ED, both in terms of the inputs and outputs of HDM-4, have been discussed for the six case countries/projects separately. It has been shown that the extent of the effects was different from country to country, which led to the identification of some qualitative relationships between the inputs and outputs. However, as the number of project alternatives is limited in each case, it was not possible to examine these relationships quantitatively. Also, the limited variety of project alternatives in each case did not allow in-depth study of the difference, if any, in these relationships by type of project alternatives. The objective of this chapter is, by pooling the data together from all these cases and conducting quantitative analyses, to gain more insight in these relationships. The quantitative relationships obtained through the analysis will facilitate quick scenario analyses on the effect of ED without resorting to elaborate HDM-4 studies.

3.2 VARIABLES OF THE QUANTITATIVE MODELS

The quantitative models which are pursued in this chapter are of the following form:

$$\mathbf{y} = f(\mathbf{x}_1, \mathbf{x}_2, \dots)$$

where y is a summary indicator of an economic analysis of an individual subproject, such as NPV, NPV/km or ERR; and $\mathbf{x}_1, \mathbf{x}_2, \dots$ are the explanatory variables representing the extent of the traffic reduction and the change in relative prices due to ED of the country where the subproject is situated, and the characteristics of the subproject. Variables representing other characteristics of the country than effects of ED, and the characteristics of subprojects including the type of predominant works may be included as explanatory variables, if necessary. Without these variables, however, the present study chose the following set of variables:

$$(\mathbf{NPV/km})_{\mathbf{B}} = f((\mathbf{NPV/km})_{\mathbf{A}}, \mathbf{TAF}, \mathbf{VPA}) \qquad (1)$$

$$\mathbf{ERR}_{\mathbf{B}} = f(\mathbf{ERR}_{\mathbf{A}}, \mathbf{TAF}, \mathbf{VPA}) \qquad (2)$$

The subscripts A and B denote that the variables are from Case A and B Data, respectively. TAF and VPA are the indices representing the extent of the change in traffic demand and relative factor prices from Case A to B, which are described in detail in the next section.

Given the values of
$(\mathbf{NPV/km})_A$,
and $\mathbf{ERR_A}$ of a subproject and the values of TAF and VPA
of the country, models in Eq. (1) and (2) will predict the values of $(\mathbf{NPV/km})_B$ and $\mathbf{ERR_B}$ of the subproject without resorting to HDM-4 analyses including time consuming preparation of input data. As no variables are included in the explanatory variables representing the specific characteristics of subprojects and the country, the effects of such variables may be analyzed by examining the bias in the predictions with these models. Such bias, if any, may be considered as being caused by such variables.

3.3 Aggregate Input Indices of the Effects of Economic Downturn

Traffic adjustment factor (TAF, hereinafter) which is defined by the following equation, is an aggregate index representing the extent of the discrepancy between the two traffic volumes, that of Case A and Case B:

$$\mathbf{TAF} = \frac{\sum_{n=1}^{T} \frac{V_n^A - V_n^B}{(1+r)^{n-1}}}{\sum_{n=1}^{T} \frac{V_n^A}{(1+r)^{n-1}}} \quad (3)$$

where T is the length of the predefined analysis period; $\mathbf{V_n^X}$ (X=A or B) is the traffic volume of the n-th analysis year of Case X; and r is the discount rate of the analysis.

Note that both denominator and numerator are adjusted by the discounting factor of each year in the above definition. The traffic volume of the n-th analysis year of Case X, $\mathbf{V_n^X}$ (X=A or B), is given by the equation below:.

$$\mathbf{V_n^X} = V_0 \prod_{i=1}^{n} (1 + g_i^X) \quad (4)$$

where $\mathbf{V_0}$ is the traffic volume of year zero (one year before the start of the analysis period), which is common for both cases, and $\mathbf{g_i^X}$ (X=A or B; i=1,2,….,T) the traffic growth rate of the i-th analysis year of Case X.

Given $\mathbf{g_i^X}$ (X=A or B; i=1,2,….,T), TAF can be computed for each country using Eq. (3) and (4). Note that the value of $\mathbf{V_0}$ is not necessary in this computation. A numerical example with a step by step explanation of the computational procedure is provided in Annex E. Table 21 shows the values of TAF of the six case countries computed by using the modification method of traffic growth rates discussed above. Note that the values of TAF may be computed without creating a whole HDM-4 input data, once the modification method has been determined.

Variance of price adjustment factors (VPA, hereinafter) is an aggregate index representing the extent of the relative change in factor prices, which is defined as the variance of the three price adjustment factors, i.e. GDP, wage and fuel price adjustment factors. Table 21 also shows the values of VPA of the six case countries computed with the values given in Table 7. Note that the value of VPA can be computed without creating a whole HDM-4 input data, once the values of the three price adjustment factors have been given.

TABLE 21 : TRAFFIC ADJUSTMENT FACTOR AND VARIANCE OF PRICE ADJUSTMENT FACTORS

	TAF	VPA
Argentina	7.39	0.0023
Botswana	23.42	0.44
India	2.44	0.36
Kenya	2.85	0.0042
Lao PDR	8.42	0.0000
Paraguay	-8.15	0.0038

3.4 REGRESSION MODELS

Various functional specifications of the models in Eq. (1) and (2) were tested with the data given in Tables 8, 10, 12, 14, 16, 18 and 21, which resulted in the selection of the models in Eq. (3) and (4) as the best. The figure in the parentheses below each the parameter is the t-statistic of the parameter. The value of $\mathbf{R}^2$ is also indicated for each model. These statistics and the signs of the parameters indicate the "goodness" of these models. The first parameter of each model should take the value of one, as they imply the extent of the change (which is no change) in the event of no changes in traffic volume and factor prices between the two cases (i.e., TAF=0 and VPA=0). As the values of these parameters were not restricted to unity in the estimation, they are not exactly unity, but reasonably close to it[6].

[6] The hypothesis of the value being equal to unity cannot be rejected with 5% confidence level for Eq. (3), but it can be rejected at infinitesimal confidence level for Eq. (4).

$$\widetilde{(NPV/km)}_B = (1.1554 - 0.03362 * TAF + 0.2497 * VPA)(NPV/km)_A \qquad (3)$$

(27.788) (-7.264) (2.420) $(R^2 = 0.9939)$

$$\widetilde{ERR}_B = (0.8678 - 0.01912 * TAF + 0.09542 * VPA)\,ERR_A \qquad (4)$$

(77.699) (-19.132) (1.577) $(R^2 = 0.9957)$

3.5 Comparison of Regression Predictions and HDM-4 Outputs

3.5.1 Coefficients of $(NPV/km)_A$ and ERR_A and Arrow Pattern of Countries

Table 22 compares the values of $(1.1554 - 0.03362 * TAF + 0.2497 * VPA)$ and $(0.8678 - 0.01912 * TAF + 0.09542 * VPA)$, the coefficient terms of $(NPV/km)_A$ and ERR_A of Eq. (3) and (4), respectively, computed with the values of TAF and VPA of the six countries given in Table 21, and the arrow patterns given in Table 20. The value of these coefficients larger than one implies that $(NPV/km)_B$ or ERR_B is larger than $(NPV/km)_A$ or ERR_A, respectively. The table shows that Pattern "A" appears in the countries where both coefficients are smaller than unity, except for Kenya. Pattern B of India coincides with the coefficient of $(NPV/km)_A$ larger than one and the coefficient of ERR_A smaller than one. Pattern "C" of Paraguay coincides with both values larger than one. Thus, Eq. (3) and (4) "explain" the arrow patterns reasonably well. The fact that Kenya does not follow this rule seems to be attributable to statistic errors.

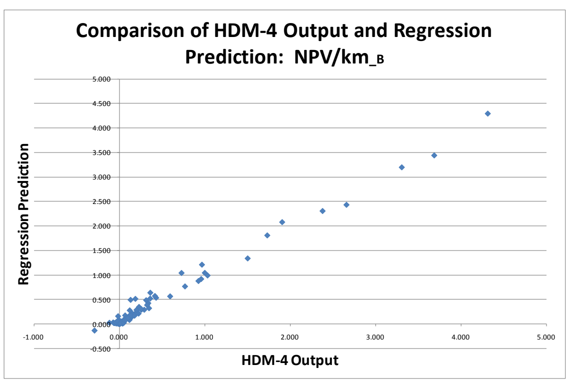
TABLE 22 : COMPARISON OF REGRESSION MODEL PREDICTION AND ARROW PATTERN

	Prediction with Regression Models		HDM-4 Output
	NPV/km Factor*	ERR Factor**	Arrow Pattern***
Argentina	0.91	0.73	A
Botswana	0.48	0.46	A
India	1.16	0.86	B
Kenya	1.06	0.81	A
Lao PDR	0.87	0.71	A
Paraguay	1.43	1.02	C
Note)	* The value of (1.1554−0.03362*TAF+0.2497*VPA) appearing in Eq. (3)		
	** The value of (0.8678−0.01912*TAF+0.09542*VPA) appearing in Eq. (4)		
	*** Copied from Table 20.		

3.5.2 REGRESSION PREDICTIONS AND HDM-4 OUTPUTS OF $(NPV/km)_B$ AND ERR_B OF SUBPROJECTS

The values of all right hand side variables of Eq. (3) and (4) are available from Tables 8, 10, 12, 14, 16, 18 and 21 for all subprojects under study. Using these values, the values of $(NPV/km)_B$ and ERR_B were predicted with these regression models. Fig. 23 compares these predictions with those obtained by running HDM-4 with Case B Data, which are also listed in Tables 8, 10, 12, 14, 16 and 18. Fig. 23 shows that the predicted values generally agree with the HDM-4 outputs, confirming the goodness of fit of the regression models.

FIGURE 23 : COMPARISON OF HDM-4 OUTPUT AND REGRESSION PREDICTION



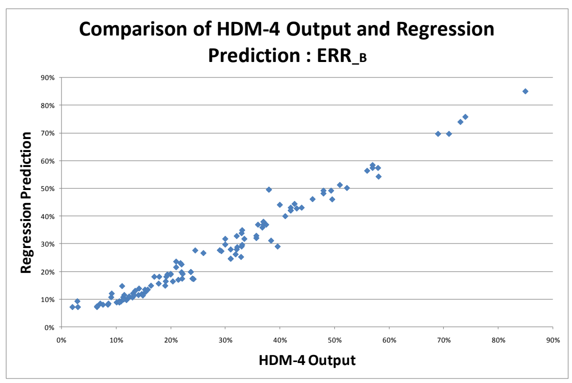


Fig. 24 and 25 show the breakdown of the plots of Fig. 23 by country. From these figures, no substantial difference is observed among the countries in the relationship between the predicted values and the HDM-4 outputs, indicating that the regression relationships are general enough to be applicable for the six case countries without any country specific variables as the explanatory variables.

FIGURE 24 : COMPARISON OF HDM-4 OUTPUT AND REGRESSION PREDICTION BY COUNTRY

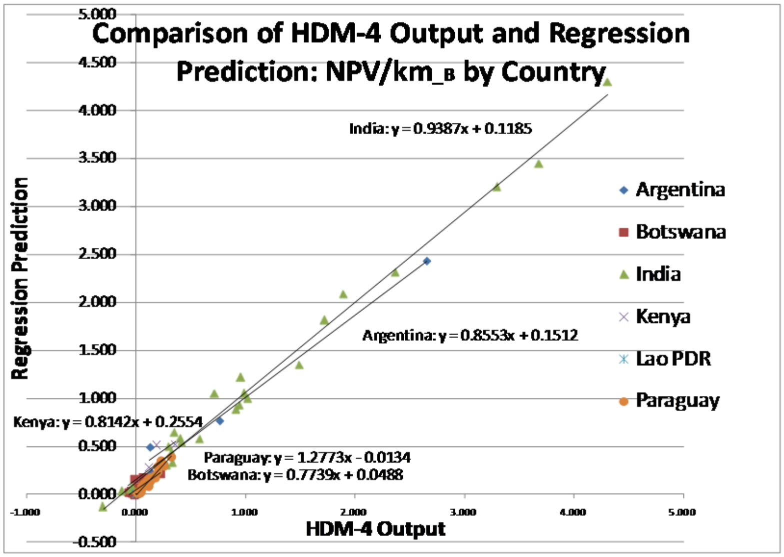


FIGURE 25 : COMPARISON OF HDM-4 OUTPUT AND REGRESSION PREDICTION BY COUNTRY

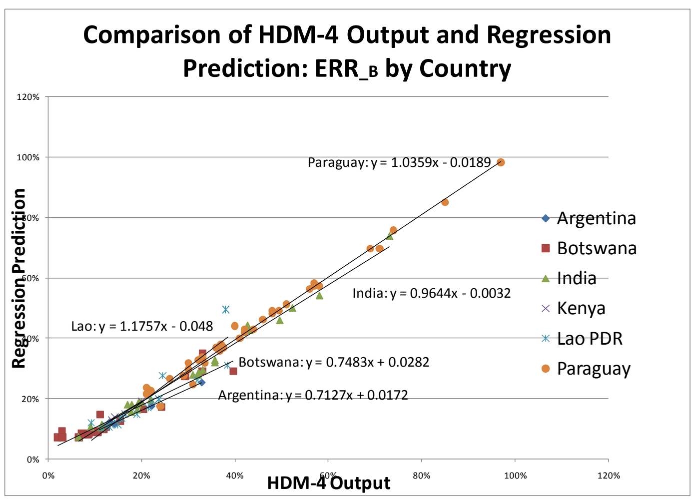


Fig. 26 and 27 show the breakdown of the plots of Fig. 23 by the type of predominant works included in project alternatives. Predominant works are classified in four types: "improvement", "overlay", "resealing" and "regravelling". Fig. 26 shows that many "improvement" works are far more expensive than other works and the range of the data is dominated by this work type. Therefore, although Fig. 26 appears to indicate that "regravelling" is different from all other work types, caution must be used in interpreting the result. As the data are more evenly dispersed in Fig. 27 for all work types, what is suggested by this figure, that is there is not much difference in the applicability of the regression models by work type, may be a more convincing conclusion.

FIGURE 26 : COMPARISON OF HDM-4 OUTPUT AND REGRESSION PREDICTION BY WORK TYPE

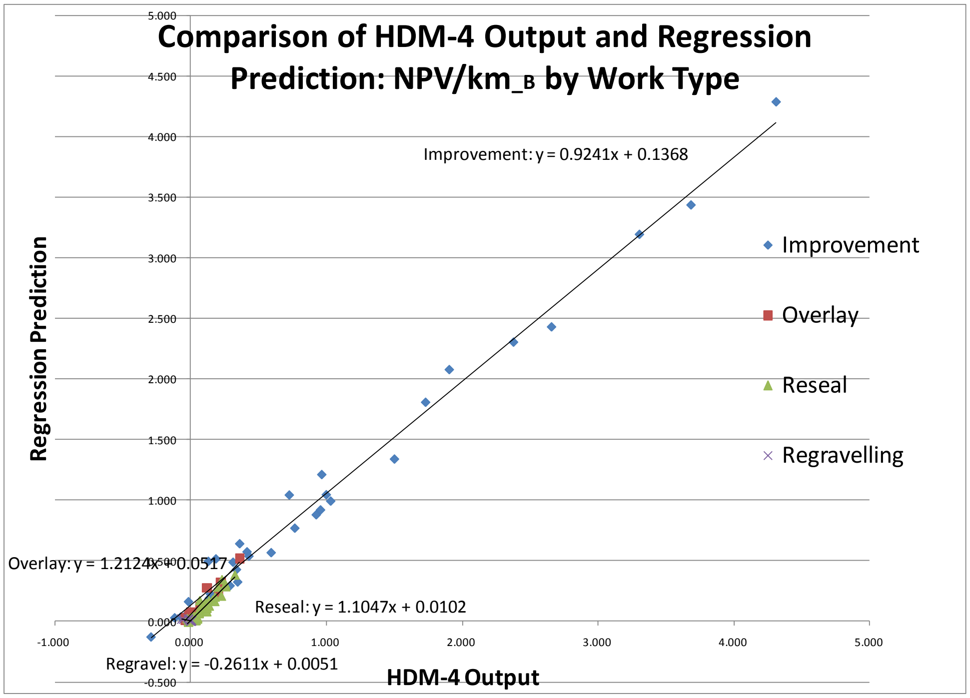
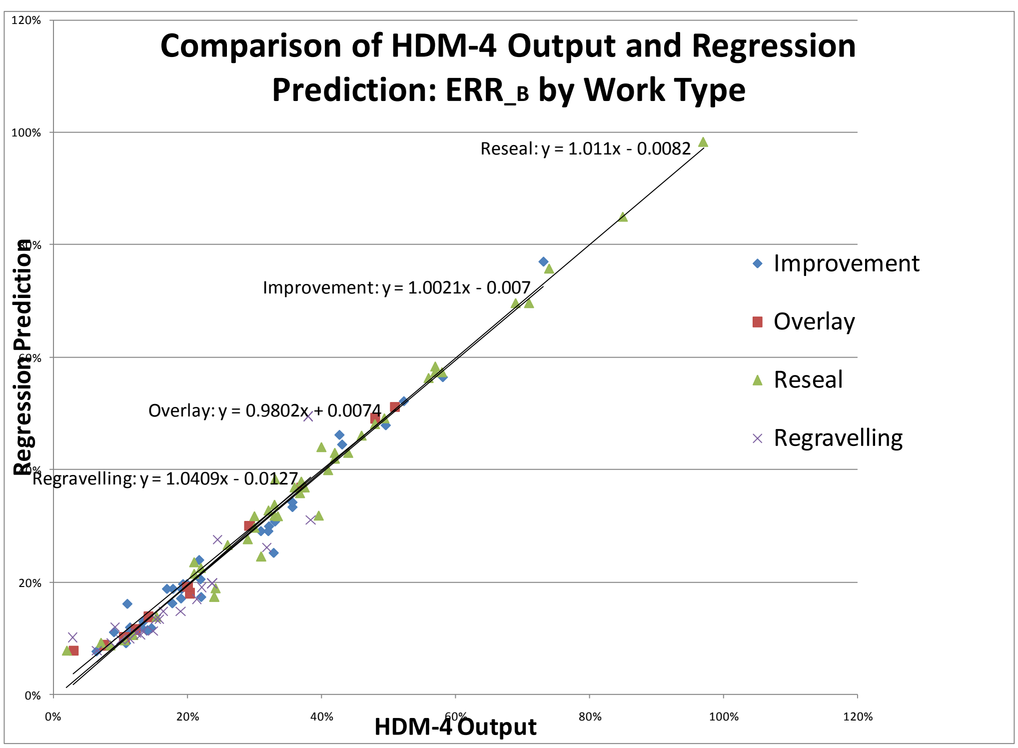
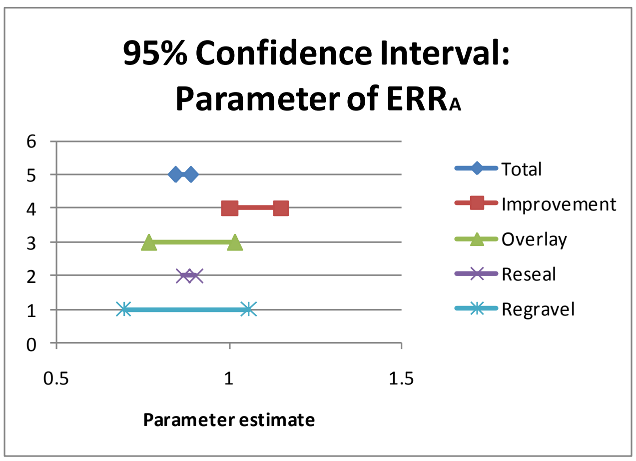


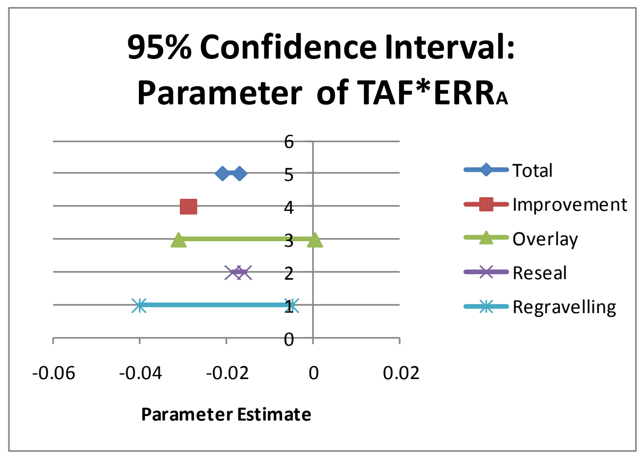
FIGURE 27 : COMPARISON OF HDM-4 OUTPUT AND REGRESSION PREDICTION BY WORK TYPE

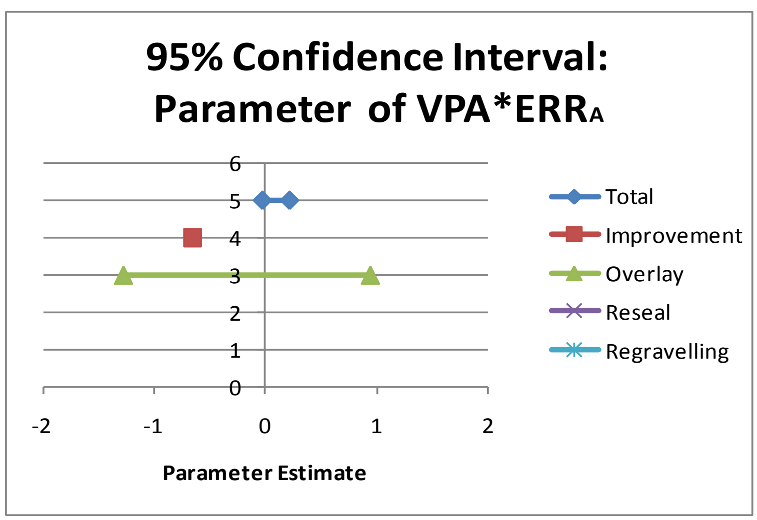


To examine this point more closely, the pooled data was split into four data sets by work type, and the regression model with the same functional specification as Eq. (4) was estimated separately with each set. Fig. 28 shows the 95% confidence intervals of the estimated parameters for the three coefficients of $\mathbf{ERR_A}$, TAF*$\mathbf{ERR_A}$ and VPA*$\mathbf{ERR_A}$. Note that due to the lack of the variability of the third variable, VPA*$\mathbf{ERR_A}$, in the separated data sets for "reseal" and "regravelling", the coefficient of this variable was not estimated for these work types, and no confidence intervals are shown in the third figure in Fig. 28. The figures indicate that the parameter estimates for "improvement" are slightly different from those of other work types or the pooled data, indicating different sensitivities to the explanatory variables. To be more specific, the absolute values of the estimated parameters for "improvement" are all larger than those of the pooled data, indicating a stronger sensitivity to the change in explanatory variables.

FIGURE 28 : 95% CONFIDENCE INTERVAL OF THE ESTIMATED PARAMETERS OF REGRESSION (4)







3.6 Summary of Pooled Data Analysis

Without including variables representing specific characteristics of countries and/or project alternatives as explanatory variables, good regression models were estimated that predict the values of NPV/km and ERR of a project after a change in traffic demand and factor prices as a function of the values of the indicators representing these changes and the values of NPV/km and ERR before the change. The effect of ED involves much uncertainty, and the magnitude of the change in these indicators is different by country. The regression models allow conducting quick sensitivity analyses of project viability under the effect of ED for a variety of countries and different project alternatives.

Although the regression models were estimated with very high degree of fitness to data without the variables that are specific to alternative types, a close statistic analysis revealed that there is certain evidence indicating that the viability of project alternatives that involve "improvement" is more sensitive to the change in traffic demand and relative change in factor prices. This is consistent with the finding discussed49Voltaire

in section 2.7 regarding the cases in Botswana and Kenya. This may be due to the high cost nature of this project type, and demand a special caution when applying the regression models.\

4 CONCLUSION

To assess the effects of increased uncertainty with inputs of Cost Benefit Analysis on the economic viability of road projects, this study first investigated the range of variability of the inputs for the six selected projects/countries. It was found that the variability ranges differ by country reflecting the degree of decrease in transport demand and relative change in factor prices due to economic downturn. Using published data, these ranges were quantified for the case projects/countries for most inputs, although some inputs such as social discount rate were not quantified due to the lack of reliable data. Using the Highway Development and Management Model (HDM-4), the variability of inputs was then translated into the variability of the economic viability of projects.

The methodology adopted in this study for identifying the effect of economic downturn on projects viability is to compare the results of the economic analyses of the two cases: one of original cost benefit analyses that were conducted without the knowledge of economic downturn, and another of a hypothetical case where all relevant effects of economic downturn on the inputs of the analyses were assumed to be known at the time the analyses. The effect of economic downturn on the viability of projects were identified as the difference in the outputs of these analyses in terms of economic summary indices such as net present values (NPV), NPV per unit length of road (NPV/km), economic internal rate of return (ERR), etc.

The comparison of the HDM-4 outputs was conducted in two different ways. One is the comparison by country/project and another by means of cross sectional statistic analyses with pooled data. Since the number and the variety of subprojects included in each project/country are limited, studies in country analyses were limited to qualitative analyses. A general relationship between the extent of the effect of economic downturn and the degree of change in NVP, NVP/km and ERR was observed in the country analyses. More specifically, the pattern of arrows representing the changes in ERR and NPV/km of subprojects between the two cases was closely linked with the changes in input variables. Also, although not very decisively, it was found that the viability of project alternatives that involve high investments tends to be more affected by economic downturn than alternatives of other types.

The regression analysis of pooled data revealed that indicators representing the economic viability of subprojects after economic downturn, $(\mathbf{NPV/km})_B$ $\mathbf{and}$ $\mathbf{ERR}_B$, can be estimated with high precisions given the values of these indicators before (or without) the economic downturn, $(\mathbf{NPV/km})_A$ $\mathbf{and}$ $\mathbf{ERR}_A$, and the values of the indicators representing the extent of the effect of economic downturn on traffic demand and relative change in factor prices. Two indicators were found to be significant in representing these effects: traffic adjustment factor (TAF) and variance of price adjustment factors (VPA). These models may be used in conducting quick sensitivity analyses of the economic viability of projects without resorting to elaborate HDM-4 analyses.

The fact that the regression models fit the pooled data very well with very high R^2 values without including country specific or project specific variables indicate that the relationships obtained are general enough to be used with wide range of countries and projects. However, an elaborate statistical analysis revealed that "improvement" type project alternatives are more sensitive to changes in the values of TAF and VPA. This is consistent with one of the findings in country analyses, and indicates that the use of the regression models in the analysis of projects with project alternatives of improvement type merits a caution.

The insights regarding the effects of varying inputs and parameters on the viability of road projects thus obtained are deemed to facilitate the formulation and implementation of road projects that increase the welfare of the society under the environment of increased uncertainty in an economic downturn. To formulate and implement relevant road projects, impacts for different segments of society, especially on the poor, also need to be understood. Although this study was unable to analyze the effect of economic downturn by social segments, it may be achieved in a similar manner if cases are available that include subprojects specifically formulated to address the poverty.

ANNEXES

The annexe tables are also available on the Transport website: www.worldbank.org/Transport

Annex A. HDM-4 Inputs: Case A Data

HDM-4 Inputs (all data).xlsx

Annex B. Traffic Growth Rate Adjustment

Traffic growth rate adjustment.xlsx

Annex C. Fuel Price Adjustment

Fuel price adjustment.xlsx

Annex D. HDM-4 Inputs: Case B Data

Modified HDM-4 Inputs (all data)_ver

Annex E. Numerical Example of TAF Computation

Annex E.docx

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INTERNET LINKS

Global Economic Prospects, The World Bank	http://web.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTDECPROSPECTS/GEPEXT/EXTGEP2010/0,,menuPK:6665259~pagePK:64167702~piPK:64167676~theSitePK:6665253,00.html
International Fuel Prices, GTZ	HTTP://WWW.GTZ.DE/EN/THEMEN/29957.HTM
Minimum Wage Database, ILO	HTTP://WWW.ILO.ORG/TRAVAILDATABASE/SERVLET/MINIMUMWAGES?COMINGFROMMENU=TRUE&PAGECLASS=ORG.ILO.LEGISLATION.WORK.WEB.CATEGORYSEARCHPAGE
Short-Term Energy Outlook – Real Petroleum Prices, U.S. Energy Information Administration	HTTP://WWW.EIA.DOE.GOV/EMEU/STEO/PUB/FSHEETS/REAL_PRICES.HTML
World Development Indicators, The World Bank	http://data.worldbank.org/indicator
World Economic Outlook, International Monetary Fund	http://www.imf.org/external/pubs/ft/weo/2010/01/weodata/weoselco.aspx?g=2505&sg=All+countries+%2f+Emerging+and+developing+economies+%2f+Developing+Asia

LIST OF ABBREVIATIONS

HDM-4	Highway Development and Management Model
ED	Economic Downturn
PAD	World Bank Project Appraisal Document, its draft or the like
WEO	World Economic Outlook April 2010, IMF
PAF	Price Adjustment Factor
NPV	Net Present Value
ERR	Economic Internal Rate of Return
NPV/km	NPV divided by the length of the road section
OPRC	Output and Performance Based Road Contracting
TAF	Traffic Adjustment Factor
VPA	Variance of Price Adjustment Factors

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