EXPERIENCE WITH EVALUATION OF ECONOMIC EFFECTIVENESS OF MOTORWAY AND ROAD PROJEKCTS BY HDM – 4 METHOD SYSTEM IN THE CZECH REPUBLIC

V. Škvor, PRAGOPROJEKT, a.s., Prague, e-mail :skvorv@pragoprojekt.cz

ABSTRACT

Evaluation of economic effectiveness of road construction and maintenance in the Czech Republic has been made for over 30 years by simpler methods of Czech origin, based also on the investors working costs flow and road users economy.

The HDM – 4 system has been in use in the Czech Republic since the beginning of its distribution in 2000. The national systems were abandoned, because the has a broader approach to economic effectiveness evaluation and does not required any explanations when negotiating project financing with banks and government institutions (with was necessary when using a national system). Due to the density of road network and the financial requirements of its completion and rehabilitation the priority of individual projects cannot be determined seriously without economic evaluation.

In the first phase we made the necessary calibration of input data. Subsequently, until the present, we have evaluated 35 motorway and road projects financed mostly from the state budget in co-operation with the European Investment Bank EIB. The calibration was made in accordance with programme instructions for the determination of long-term inputs i.e. the discount rate, vehicle fleet, time value, accident rate and maintenance. Other inputs are determined individually for individually for every individual project.

The discount rate was determined with regard to the general financial environment in the Czech Republic, it was based on the interest of long-term debentures issued in the Czech Republic at 7%. The vehicle fleet consists of a number of vehicle types. Every selected type represents a vehicle class in the traffic stream. The ascertainment and selection of vehicle fleet representatives was based on statistical files of vehicle register kept by Police of the Czech Republic. The representatives were selected form 16 types of the most widely used and sold vehicles. Five categories of vehicle representatives were selected for the model – passenger cars, trucks (up to 3,5 t and 18 t), trucks with trailers and buses.

Time value was determined in accordance with HDM – 4 methodology. A comparison of the results with the time value based and average wages achieved in the CR did not show any substantial differences. At present the time value derived from average wage in the CR is updated annually and compared with HDM – 4 methodology.

Accidents and accident valuation are based on accident statistics, continuously kept and updated by the Police of the CR. These statistics cover all accidents the damage of which exceeds CZK 20 000. Minor accidents not investigated by the police are reported to insurance companies. The accident valuation is based on the data ascertained by the Police estimates, insurance companies and service organization, consequences of injuries, lost earnings and permanent consequences of injuries.

The climatic conditions of the CR have been determined on the basis of national long-term statistical measurements. The required climate characteristics are determined for individual regions of the CR.

The traffic data are based on national traffic counts in the road network on the basis of which the traffic stream characteristics for evaluation needs have been determined.

Apart from the afore mentioned inputs further date are supplemented for every individual project, such as:

- technical studies incl. maps
- traffic data, incl. predictions

local traffic surveys (traffic stream structure, occupancy, quota of foreign vehicles)

- accident data
- data on road defects, road passports, progress of maintenance
- surveys of existing state of road network influenced by the project, incl. photographic documentation
- investment costs and construction period

In conclusion the paper presents the results of two evaluations by way of example.

1. INTRODUCTION

Evaluation of economic effectiveness of road projects and their maintenance , though very costly, have been performed in the Czech Republic for over 30 years. In the past this evaluation was made by simpler, either domestic or foreign, methods (Ekotra, HDM-3).

Like the present HDM-4 method also the previously used methods were based on the investor's working costs flow and the economy of road users, but the scope of computations was smaller.

2. GENERAL

When the distribution of the new HDM-4 system and its software started in 2000, we bought four licenses which we have been using since. The reasons for the purchase of this system and abandoning of the previously used national system consisted in that the HDM-4 system evaluated economic effectiveness on a broader scale. Another advantage was that in the discussions of project finances with banks, and government institutions (Ministry of Finance, Ministry of Transport) it was not necessary to give a detailed explanation of the system (which is necessary in case of a national system).

The HDM-4 model is used all over the world – in highly as well as less highly developed countries – for the planning of road network construction and renovation. It is used also in the Czech Republic, particularly because of the density of road network and the financial needs of its completion and renovation.

3. HDM-4 MODEL IN THE CONDITIONS OF THE CZECH REPUBLIC

Before the start of HDM-4 application we have made the necessary detailed calibration of input data. Since then we have evaluated 35 motorway and road projects, mostly financed from the state budget with the co-operation of the European Investment Bank (EIB).

The most difficult part of the implementation of the system in national environment is the calibration of input data which we have made in accordance with the programme instructions as shown in the following table.

	SW HDM 4		
Vehicle fleet	**Time value**	**Accidents**	**Road maintenance**
– provision and evaluation of vehicle register	– working time	– accidents with deaths	– road databank (data on pavement defects)
– statistical file of insured vehicles (third party insurance)	– free time	– accidents with injuries	– calibration, defect development, history

– statistical file of sales		– accidents with material damage	– repair types
– evaluation and assessment of individual files		– file pricing	– pricing
– vehicle price data			
– selection of representatives			

4. SETTING OF HDM-4 WORKING ENVIRONMENT FOR CZECH CONDITIONS

4.1 Discount Rate

The discount rate was examined with the purpose to assure a reasonable yield of the capital invested in roads to be interesting for investors, i.e. as a minimum compensation for assumed investment hazards. The general financial environment of the Czech Republic was assessed with regard to this factor.

The applied discount rate was based on the rate of interest of debentures of long-term maturity (15 years) issued in the Czech Republic and fluctuates about 7 %.

4.2 Vehicle Fleet

The Manager offers the functions for the storage and processing of vehicle parameters required for the computation of their velocities, operating costs and other effects. The file includes also the data on single-track vehicles and other than motor vehicle traffic. The vehicle fleet consists of a number of vehicle types. Every vehicle type represents a vehicle class in the traffic stream (such as small car, big truck, etc).

4.2.1 Vehicle Register

The definition and selection of vehicle fleet representatives is based on the vehicle register statistical files previously kept by the Police of the Czech Republic and transferred to local government in accordance with the present legislation, and the files of third party insurance of insurance companies. Apart from statistical files we have made our own investigations of vehicle sales (types, trade marks), their prices, prices of spare parts, prices of work in service centres and frequency of their use. On the basis of these data we have come to the following conclusions:

The principal files were assessed as of 1 January 2000. In the years to follow until the present we have been making minor corrections with reference to vehicle sales. According to our information they are undergoing mild stagnation with a mild tendency to higher purchases of smaller passenger cars. Table No. .... gives the numbers of vehicles by type and category as of 1 January 1999 and 1 January 2000. On 1 January 2000 the total number of vehicles was 5 497 354 pcs – a slight reduction of 3.2 %. At present the number of vehicles has attained the previous value again.

The number of passenger cars was 3 431 412, which is a reduction by 1.5 % (exclusion of old vehicles, etc.). On the other hand the number of trucks increased (144 277 pcs, i.e. 112.5 % of initial state) and trailers (45 607 pcs, i.e. 123%). The increase of the number of trucks with trailers manifests itself negatively in higher pavement wear.

With reference to the above figures the average motorization rate is::

total – 10 500/5 497 354 = 1.91

passenger cars – 10 500/3 431 412 = 3.06 %

Detailed vehicle register was subjected to an analysis by make and type of vehicles used on our roads. From the number of passenger cars approx. 52.77 % are SKODA cars of various types, with the maximum of SKODA 120 type. Due to the very fast vehicle fleet renovation the S 120 was replaced with Felicia and Octavia types of the same make. The rest are passenger cars of foreign make of analogous parameters and categories.

The situation of trucks is slightly different. In case of small and medium category trucks almost 50 % of most widely used vehicles are of domestic make, in the higher category vehicles of foreign make prevail. The majority of buses is of domestic make.

In the course of the years to follow the situation has changed mildly, but not to the extent necessitating a change of representative vehicles (A detailed analysis of vehicle register is illustrated by detailed tables available from the author).

All other sources of vehicle registration and/or use give analogous data, but are not complete with reference to number. A revision will be made after the completion of vehicle registration check proceeding in the Czech Republic at present which will be completed in 2004. Our definite selection of representative vehicles was confirmed also by an informative survey of traffic stream structure with reference to the frequency of individual vehicle types. The selection of representative vehicles is shown in the following chapter.

4.2.2 Selected Representative Vehicle Types

The selection was made from 16 types of the most widely used and sold vehicles. For model input data 5 representative vehicle types have been selected – passenger cars, trucks (up to 3.5. t and up to 18 t), trucks with trailers and buses. These vehicle types correspond also with the method of regular national traffic counts taking place every 5 years.

In every category one vehicle, most widely used, sold or supplied with spare parts at present was selected. The selected types represent their respective category by their technical parameters and unit prices of repairs, spare parts, fuels, etc. All input parameters were checked by surveys in servicing and selling organizations.

Vehicle type	
Vehicle category	**Representative vehicle**
Passenger car	Skoda Octavia 1.6 GLX
Small truck (up to 3.5 t)	Lublin 3584 3.5 t
Medium truck (up to 18 t)	Skoda Liaz 18.23 PB
Truck with trailer (40 t)	Man 18.410 FLT + Kögel SNCO 24 P 170
Bus	Karosa bus B 941

4.3 Time Value

The time value as one of the most significant economic inputs of HDM-4 model was determined in co-operation with City Plan Ltd. which prepared a study concerning various approaches to and methods of time value determination and submitted also a specific computation respecting HDM-4 methodology. A comparison of the results with the time value based on average wage in the Czech Republic did not discover any significant difference. At present the time value derived from the average wage in the Czech Republic is updated annually and compared with the HDM-4 methodology.

Time spent by travelling has an economic value corresponding with the value of time use for another activity. For working time this value corresponds with the average wage of the individual monitored also for individual working activities (e.g. professional drivers, etc.). According to general practice also the free time value is equivalent to individual wages, usually varying between 20 and 25 % of these wages. It is assumed that the quota of travel time in working hours represents 20 % of total travel time. A weighted average yields the final time value.

In case of projects in border regions the time value is modified with reference to the quota of foreign vehicles in the traffic stream (according to national traffic count supplemented with local counts) and the time value of the neighbour state. We have some experience with the studies in FRG border regions, where we use the time value of foreign roads users intended directly for use in economic analyses.

The time value is a significant input element in the decision-making process concerning the amount of toll and predetermines the drivers´ willingness to pay for motorway use.

Time Value Computation

Nationality	Working time value [CZK]	Non-working time value [CZK]	Quota of working time [%]	Quota of non-working time [%]	Weighted travel time costs	Quota of foreign and domestic vehicles [%]
Czechs	75	19	20	80	26.8	59
Germans	695	191	20	80	294.8	41
Average	329	90				100

Source: Data on average wages, Ministry of Transport of FRG (2001)
Time Value Study by City Plan (2000)

4.4 Accident Rate

4.4.1 General

Accident statistics are kept and updated continuously by the Police of the Czech Republic on the basis of investigated accidents. New data are introduced into the file by Accident Investigation Protocols. The statistics include all accidents the damage of which exceeds 20 000 CZK. Minor accidents, not investigated by the Police, are reported to insurance companies.

The Accident Protocol includes the accident site, time, injury (heavy, light, mortal) and the amount of damage. These data are introduced, apart from the statistics, also to the Road Databank where they form part of the description of road quality and its dangerous parts. The principal calibration of this input was based on the above mentioned data bases. The relative accident rate was determined on the basis of actual accidents on the road network influenced by the evaluated project. The relative accident rate for new roads is determined on the basis of a scientific study elaborated by Technical University, Prague (Professor Ing. František Lehovec CSc., Assoc. Professor Karlický).

4.4.2 Accident Classification

Accidents with material damage only - without injuries, with only minor vehicle damage not preventing further drive.

Accidents with injuries - light and serious injuries, vehicle damage of major extent; the damage involves medical attendance, emergency transport and haulage service.

Accidents with resulting death - mortal injuries, total damage to destruction of vehicles. First aid service, fire brigade and haulage service attendance is required.

4.4.3 Accident Valuation

Accident valuation has been made on the basis of comparisons of prices ascertained by the police (estimates), insurance companies and service centres, valuation of injury consequences, lost earnings, permanent injury consequences.

Unit Costs of Losses due to Accidents	
Type of loss	**Evaluation (thous. CZK)**
Mortal injury	7 297
Serious injury	2 620
Light injury	272

Source: Bulletin of the Ministry of Interior (updated to 2002 values)

Accident with material damage has been priced at 59 thous. CZK

4.4 Climatic Conditions of the Czech Republic

On the basis of long-term national statistical measurements of climatic conditions the required values for climate characteristics have been determined for the individual areas of the Czech Republic.

4.5 Traffic Data

National traffic counts on the road network have been made for a number of years. On the basis of their results the traffic stream characteristics to suit the HDM-4 requirements have been determined. On the basis of long-term traffic development monitoring the necessary traffic development predictions are made for every individual project.

5. INPUT DATA DETERMINATION AND COLLECTION

The input data include:
- technical studies incl. maps,
- traffic data of traffic predictions,
- local traffic surveys (traffic stream structure, vehicle occupancy, quota of foreign vehicles),
- accident data,
- road defects data, road passport, maintenance frequency,
- survey of existing state of road network, influenced by the project incl. photographic documentation,
- capital construction costs incl. construction period.

5.1 Road Maintenance and Repairs

5.1.1 Road Maintenance and Traffic Assurance

is based on the costs of these works expended in 2000 - 2003. The maintenance includes primarily the following works:

- Winter maintenance

  varies between 28 and 130 thous. CZK/km according to road type and location and includes snow ploughing, spreading of inert materials, de-icing salts, remedy of heavy snowfall consequences (snowbreaks, snowdrifts, avalanches, etc.)
- Other maintenance
  - remedy of local post-winter defects (potholes, subsidence, etc.), vegetation maintenance - cutting, road clearing, etc.
  - road repairs concern major repairs depending on the number of defects. With reference to the type and seriousness of defects the repair types included in the programme have been supplemented with the repairs currently made in the Czech Republic.

    The individual defects were priced in 2000 and valorized continuously in the years to follow. The pricing of standard repairs is given in the following table.

Item	Unit	Price

Repair of potholes	CZK/sq.m	250
Repair of cracks	CZK/sq.m	500
Road surface reconstruction (milling and wearing course renovation 40 mm)	CZK/sq.m	245
Road surface reconstruction (milling and wearing and base courses renovation 100 mm)	CZK/sq.m	610

In case of continuous repair, i.e. wearing and base course replacement, we proceed on the basis of a detailed design and diagnostics of the road incl. a detailed defect description. Investment costs are determined on the basis of these documents.

The above mentioned data are used as input data to the programme.

6. EXAMPLES EVALUATION

6.1 General

The evaluations were made to the orders of the Roads and Motorways Directorate of the Czech Republic, an organization directly subordinated to the Ministry of Transport of the Czech Republic. All evaluations concerned specific projects on the basis of prepared designs and were made for the purpose of variant selection or decision, whether the project should be incorporated into construction programme immediately or in the future. Strategic (long-term) and medium-term (programme) evaluations were not made, because the reconstruction of roads and motorways proceeds on the basis of the government decision for the period terminating 2010. At present the application of further HDM-4 modules (programme and strategic analyses) is envisaged to refine and determine the priorities of construction and reconstruction on economic basis.

The existing road and motorway network was shown on the map in the introduction.

6.2 Economic Assessments – Survey of Results

Economic assessments are shown in the annexed table concentrating on the most significant indicators we use. The results show that the investment adequacy depends on traffic load and investment costs, which are proportionate with the road or motorway category required. Unreasonable category requirements (two-lane, four-lane) or exacting design requirements result in high construction costs and in case of lower traffic load the roads or motorways are unprofitable. Also further induced costs related to road construction are important.

A comparison of individual projects is shown in the annexed table and can contribute to explicit decisions and priorities.

6.3 Project I/7 Křímov - Hora Sv. Šebestiana

The resulting figures of this project were not most adequate in terms of a simple traffic load and investment costs comparison. The project forms part of road connection between Chomutov and Chemnitz.

The reconstruction of the whole connection proceeds successively and has been included into the programme of PHARE projects. However, the assessment concerned only the part, where the existing road traverses the protection zone of a source of potable water for Chomutov, a town with a population 50 000, and its environs. To assure population protection and due to inadequate technical road parameters this section is closed for heavy truck traffic at present.

The assessment compares the ”zero variant”, i.e. the variant without relocation, with the ”proposed variant”, i.e. the relocation of existing road outside the protection zone. The assessment

yielded very low internal revenue rate (IRR) and a negative net present value (NPV). The result was influenced chiefly by the fact that the new alignment is longer to maintain distance from the protection zone of the water source supplying potable water to the whole area. The final assessment included a benefit (generated revenue) of a vehicle breakdown which could contaminate the water source for a long period. After its review by the PHARE representatives the project was accepted for implementation.

6.4 Project R4 Čimelice - Mirotice

The project concerns the construction of a four lane expresway assessed as an autonomous part of the whole R4 expressway alignment of international importance (Prague - Milín - Nová Hospoda - Strakonice - Vimperk - Strážný - FRG state border). In this case two proposed variants were assessed, one shorter, the other longer. With regard to the conclusions of an EIA study and in the interest of a significant landscape element preservation the route longer that the existing road was recommended for construction. The project implementation will improve transport connection with the Budějovice Region, reduce the negative impact of transport on municipalities and generate profit as an economic benefit to environment and preservation of the landscape character of the area concerned. Due to the economic results achieved the project was recommended for construction in the proposed period.

7. CONCLUSION

The results of economic assessments of prepared investments carried out so far make it possible to conclude that the HDM-4 method is suitable and applicable to the assessment of economic effectiveness of investments in Czech conditions, as it yields results which have their logic in spite of possible dispersal of values and provides sufficient arguments for public authorities to justify the investments. However, it requires a profound knowledge of the assessed problems and particularly a time-consuming and high-quality input data preparation.

Vratislav Škvor, MSc.
Pragoprojekt