International Transport Forum

Motorway Cost Estimation Review

The Case of Slovakia

Case-Specific Policy Analysis

OECD

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The International Transport Forum

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List of acronyms

AACE	Association for the Advancement of Cost Engineering
AASHTO	American Association of State Highway and Transportation Officials
BoQ	Bill of Quantities
DfT	Department for Transport
ER	Expert Review (*Štátna expertíza*)
FIDIC	Fédération Internationale des Ingénieurs-Conseils (*International Federation of Consulting Engineers*)
HOAI	Honorarordnung für Architekten und Ingenieure (*Architectural and Engineer Fee Regulation*)
NDS	Národná dialnicná spolocnost (*The Slovak Motorway Company*)
NOK	Norwegian Kroner
OB	Optimism bias
QA	Quality assessment
RIBA	Royal Institute of British Architects
UK	United Kingdom
VAT	Value Added Tax

Executive summary

What we did

This report reviews Slovakia's approach to motorway cost estimation in comparison with international practice. Motorways represent one of the best starting points for analysing infrastructure projects because data availability is generally better and international benchmarking has a better chance of being successful. The study is based on a worked case of cost estimation, interviews with local experts and an extensive ex post comparison of final project cost with the estimates made at various stages of the project. This analysis was carried out for all 28 motorway projects in Slovakia that commenced construction after the year 2005 and became operational by the end of the year 2016. The projects reviewed in this report represent a major part of overall public capital expenditures for transport infrastructure in Slovakia. The results of the ex post analysis were compared with international experiences.

Importantly, this assessment is not measuring whether projects are more expensive than they should be. Project cost estimates are not the only basis for measuring the efficiency of project delivery. Nevertheless, inaccurate cost estimates may lead to the selection and construction of sub-optimal projects, can cause problems with budget planning, and may mislead bidders in the procurement phase, as well as result in other negative outcomes.

What we found

The Slovak approach to project cost estimation departs from practices used internationally in advanced economies in several ways.

Firstly, the final cost of the Slovak projects was on average more than 20% below the Ministry of Transport Expert Review (Štátna expertíza, hereinafter ER) budget estimate, which is prepared early in the project development. Internationally, similar projects display a 20% cost overrun on average. The primary cause of the cost over-estimation in Slovakia appears to be the use of high unit prices in the estimates due to lack of a historic unit price data. Using inaccurate unit price estimates can negatively impact Cost-Benefit Analysis and project selection.

This systematic estimation error persists in the procurement estimate, used to announce project cost in public tenders. The cause appears to be overreliance on an early ER estimate. Several cases were identified where a higher, less accurate ER project cost estimate was used for procurement in place of a lower, more advanced cost estimate elaborated later in the project development process.

Empirical evidence suggests that reduction of uncertainty influences bid pricing in infrastructure procurement. A 2008 study for example found that the announcement of a credible cost estimate led to a sustained 9% reduction in average bid prices for complex works. From this perspective, using an inaccurate estimate is a lost opportunity to better inform the market and bid pricing.

There is no adequate dedicated database in Slovakia of historic unit prices for motorway projects that can be used to estimate costs for material and work. Such a database is a main tool for reliably estimating costs. Its absence also inhibits identification of collusion on pricing in the construction market. Instead, estimates in Slovakia are built from official statistics such as the general construction cost index, partial databases of the estimators (designers and ad hoc inquiries with suppliers of construction materials). These are unlikely to adequately reflect price movements for motorway projects or rebates for major infrastructure projects.

The current cost estimation process provides an assessment of project risks that is not fully in line with international practices. Ideally, risk assessment would identify the major risks to the project, their probabilities and potential impact through a structure process. Its outcomes would then be used to adjust the baseline estimate. In Slovakia, a contingency of 8 to 12% of estimated costs is attributed to baseline estimates on a nominal basis. The estimate is also applied inconsistently through the subsequent project development stages. Another contingency is included in the announced project value at tendering or in the contract, which creates no value.

There appears to be little systematic quality assurance and review of the investment programme. Projects tend to undergo significant changes prior to procurement. Consequently, large cost variations occur between early ER estimates and the last in-house estimates based on detailed design. In some projects this appears to happen due to growth, or trimming, of a project’s scope. Comprehensive quality assurance and programme review is good practice and would provide better information during project development.

Equally, no formal decision point for consent to build exists that requires a consistent level of design detail, cost and benefit certainty and other information to approve projects. Such a data set should be defined to support decision making at the point where the authorities formally approve a project and take responsibility for its execution. Its absence has implications on prioritisation, accountability, and ex post performance assessment. An ER is approved by the Transport Minister as part of the planning system; yet this happens too early in the project development process.

A systematic cost overrun of 9.3% was identified when comparing the winning bid with the end cost of the project. This comparison is distinct from the above comparison between earlier estimates (ER) and the end cost and serves to establish contract performance only. A cost overrun of 9.3% is comparable to available international experience, but nevertheless suggests room for improvement in procurement and contract management practices.

In terms of average on-time delivery, Slovak motorway construction on average does not stand out in international comparison. However, the trend for individual projects with regard to on-time completion is ground for concern. This is also the case for cost-estimation - the inaccuracy of both the ER and the procurement estimate is increasing over time.

What we recommend

Build the skills needed to assist cost estimation for motorway projects

Cost estimation in Slovakia is performed mostly by engineers. Broadening the skillsets available and introducing more specialised professions will help organisations to improve cost estimation and other related processes. These include quantity surveyors, programme planners and risk managers.

Create a public database of historical unit prices for motorways and other infrastructure

A freely accessible database of unit prices from past infrastructure projects, maintained by a public authority, should be created to inform future cost estimates. This data will also be useful to develop cost variation formulae, provide more robust pricing advice to contractors and help monitor price movements in anti-collusion investigations. The appraisal of projects by authorities and decision making will also benefit from this data.

Introduce comprehensive quality assurance throughout project development

The government's Expert Review (ER) should become part of a comprehensive quality assurance system for infrastructure projects and investment programmes. Such a system should encompass project identification and selection, change management, cost-benefit estimates, the procurement method, and contract management. It should follow international practice, with quality assurance performed by external experts. These experts need to be as independent as possible, for instance by selecting them through the finance ministry or the Court of Audit.

Make systematic risk assessment an integral part of cost estimation

Current cost estimation practices can be improved by incorporating a systematic risk assessment, enabling probabilistic or risk adjusted estimates. A manual with a detailed description of the process should be prepared by the state/national motorway company. Training support and technical assistance from foreign institutions with experience in risk management could be sought.

Improve the management process for infrastructure projects and programmes

Comprehensive assessment of this part of the planning system falls outside the scope of this report. However, our preliminary analysis suggests that some important foundations for it are missing. The authorities should define the level of design detail and cost estimation accuracy required at different stages of project development. The stages should be linked to the budget, programming and project decision-making process, with clear accountability. An official schedule of the programme should be defined and followed. This requires a system engineering approach, beginning with the end in mind and monitoring progress and direction throughout the project realisation process.

Extend the analysis in this report to determine whether the Slovak motorways represent value for money

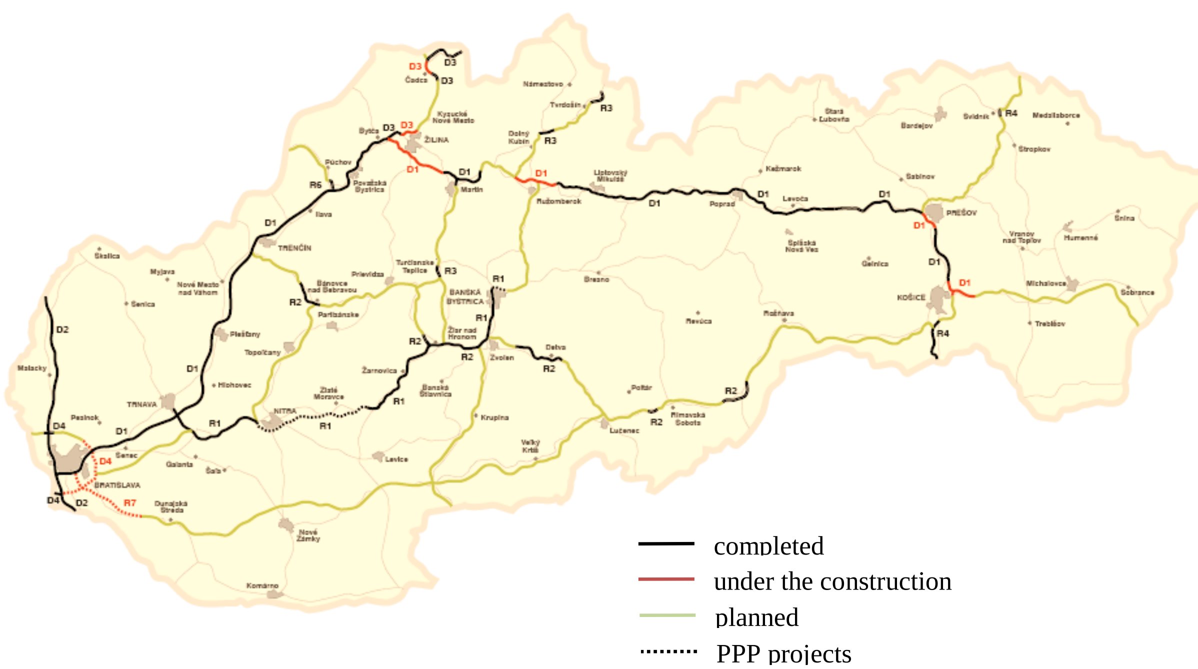
Factors outside the cost estimation process typically contribute to cost escalation if not managed appropriately. They also relate to the question, how the Slovak motorways stand in terms of value for money. These factors concern identifying and selecting options, change management and cost analysis. Also relevant is the procurement method, including the question of which activities, given the size of the Slovak market, should be tendered or brought in-house; arket engagement and visibility of forward workload; market competitiveness; and post contract management or other elements to monitor. Lastly the analysis should also encompass maintenance operations.

Slovakia started with an ambitious motorway plan

The Slovak motorway programme originated in plans created when Slovakia was still part of Czechoslovakia. After the declaration of independence by the Slovak Republic in 1993 the programme was repeatedly modified. The planned network has been extended from the initial 660 km to the current 1 865 km.

The original 660 km plan aimed at finishing the core motorway network – a link from Bratislava via Žilina and Košice towards the Ukrainian border (now known as the D1 motorway), a link from Žilina to Poland (D3), and a connection from Czechia via Bratislava to Hungary (D2). By 1993, 195 km of this plan was completed and by 2015 an additional 370 km was envisaged. In subsequent years the original plan was expanded several times, primarily by adding an additional 1 160 km of expressways (Slovenská správa cies [2009]). As of 2017 the Slovak motorway plan envisages a motorway and expressway network of approximately 1 865 km. If these connections were completed, Slovakia would have the highest number of motorway km per citizen across Europe. Despite ambitious planning up to 2017, Figure 1 illustrates that the majority of the network remains unfinished.

Figure 1. **The Slovak motorway network**



Source: The Slovak Motorway Company (NDS).

As per Table 1, the majority of what was initially considered as core network is also unfinished.

Table 1. **Slovak motorway and expressway plan and execution**

Strategy valid as of	Planed network		Completed		Unfinished	
	Total	Core Motorways	Total	Core Motorways	Total	Core Motorways
1993	659 km	659 km	195 km	195 km	465 km	465 km
2017	1 865 km	705 km	751 km	465 km	1 099 km	240 km

Source: Ministerstvo dopravy, pôšt a telekominikácií (2001), Slovenská správa ciest (2017).

The Slovak authorities are aware that the motorway programme faces challenges on multiple parts of the project life-cycle. For example national planning was subject to frequent and significant changes. The motorway (and expressway) planning was not accompanied by a feasible public or private financing plan. Project selection became subject to a cost-benefit analysis (CBA) only in recent years. Without such a tool there is a danger that the authorities will select and build the wrong sections or too many of them.

For cost-benefit analysis to be of value it needs to be conducted properly and the required key inputs (cost and benefit estimates) should be accurate to a level commensurate with the design. Efforts are already underway to improve the benefit estimates and Slovakia is in the process of deploying a national transport model. However, it is much less clear whether the cost estimation process for motorway is adequate. Moreover, the cost estimation system plays an essential role at different parts of the project life-cycle, not just project selection.

The Slovak Ministry of finance has approached the ITF at the OECD to review the cost estimation process in Slovakia. It has also asked that the system and its performance be compared with international practice.

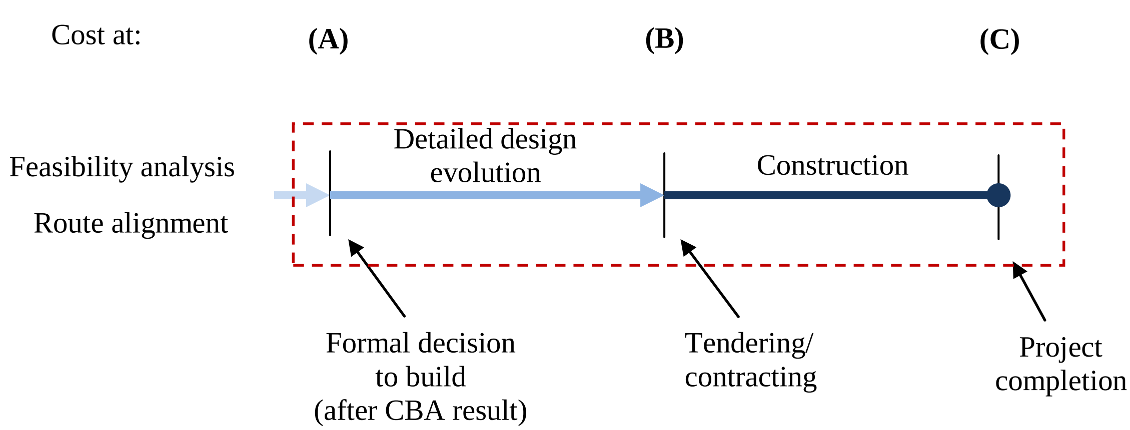
The scope of this review

The purpose of this analysis is to evaluate the performance of the motorway cost estimation process in Slovakia and its accuracy. If such a process/system is not set up properly, it can have multiple adverse effects. It can adversely affect the cost-benefit analysis (because the cost estimates will be inaccurate) misinforming the decision maker on which projects contribute more or less to social welfare. Inaccurate cost estimates at a later stage of project development can also lead to an inadequate project budget or create issues during procurement (e.g. inadequate classification of works/materials may lead to bidder confusion and higher prices). Delays also have important implications for project delivery as well as planning.

As a first step the current Slovak approach to cost estimation for motorway projects was reviewed and compared with international practice. This involves a review of cost estimation examples, review of supporting documentation (any manuals), and interviews with different experts involved in cost estimation.

The second is demonstrated in Figure 2, where the average (across the delivered projects) cost and time performance at two main reference points is investigated.

Figure 2. **Project development life-cycle**



The cost estimation accuracy determined through comparing points A and C is relevant for determining the accuracy of our estimates, when a decision to build the project was made (i.e. selected as the best alternative of the available ones). It can also signal whether significant cost growth (e.g. due to scope expansion) happened before the tendering phase was actually reached.

The cost performance through comparing points B and C can reveal how self-disciplined the procurement authority is in terms of not expanding the scope of the project under construction. Alternatively, significant cost growth in this part can also be due to poor contract management.

In addition the analysis will assess, whether there were significant differences between the last in-house estimate (which is also the basis for establishing the project budget) and the winning bid.

As a last step the cost performance at both stages is compared with available international evidence from other countries.

All the above steps will also be executed to assess on-time delivery performance (with the exception of the last in-house estimate and the winning bid).

Finally, it needs to be stressed that the scope of this analysis does not include a detailed investigation of other causes that may affect the motorway construction cost performance or delays, beyond those related to the cost/time estimation process. These could include such factors as scope creep, labour and materials price indices, procurement methods, changes in standards (including environmental obligations), political influence, cost of borrowing, commercial appetite etc.

Improving the Slovak motorway cost estimation process

In this section we first provide an overview of the cost estimating practice in Slovakia and compare it with international practice. We then reconcile the two perspectives, revealing a range of options to amend and upgrade the approach in Slovakia.

The prominent position of the Expert Review's

Our analysis of the Slovak estimating process is based on a series of interviews with a variety of stakeholders in Slovakia (Appendix 1). We also carried out a desktop review of example documents made available to the team and by reference to publically available documents, as well as a subsequent Bill of Quantities (translated into English). Details of each of these information sources are contained in R4 Kosice – Kechnec project documentation.

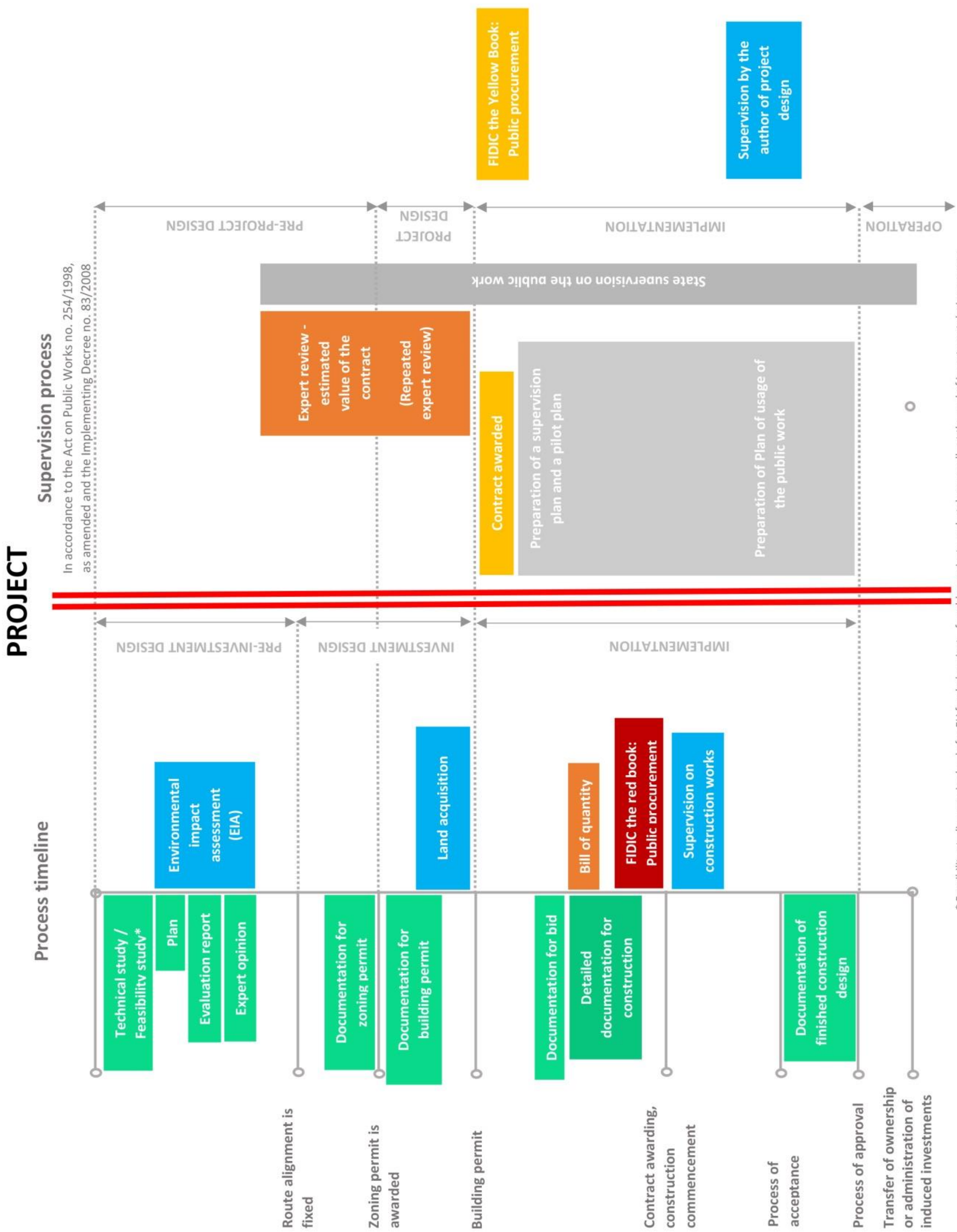
The complete project documentation development process for Slovak Highways is outlined in Figure 3. It is beyond the scope of this study to investigate the full details of the process as we only focus on cost estimation. It is marked on the figure itself, where different levels of the cost estimates are developed, which we describe in turn below.

The cost estimation process for motorway projects in Slovakia begins at the technical/feasibility stage where the engineer, hired by the motorway company, estimates the cost of a scheme. Whilst these estimates appear to address all of the usual components of a good estimate, estimating is nowadays a specialist activity and rarely an engineer's core skill set, so there may be a risk in their accuracy. These estimates are broadly developed in one of two ways: by using data gained from recent bids or by preparing a high-level estimate based on broad quantities. In both cases these are carried out at a very high level. The approach to capturing data did not appear to be consistent and as such could lead to varying degrees of accuracy as applied to these high-level estimates.

In the next step a slightly more detailed estimate is prepared for the zoning permit. At this point the engineer's estimate is reviewed and validated by the ER. This is done by a department within the Ministry of Transport and Construction. This is a requirement of the Slovak Act on Public Works for any schemes over EUR 6.6 m. Based on observations, there seemed to be little evidence of any challenge to the engineer's estimate. There was reference to data captured from other schemes but this didn't appear to be consistent and could therefore run the risk of inaccuracy if not used appropriately. On occasion external consultants are used to offer support but again there was little evidence of any challenge or subsequent amendment to the engineer's estimate.

Following the Expert Review (ER) stage a Bill of Quantities (BoQ) is prepared for the tender phase if a Design Bid Build contract (FIDIC the Red Book) was chosen to procure the infrastructure. A sample BoQ for one scheme was reviewed (though the drawings upon which it was based were not provided). It seemed very thorough and detailed with over 3 000 items. These were all priced in the estimate and gave confidence that there was a detailed understanding of the costs. The procurement estimate however is not based on the BoQ, but on the less detailed and accurate ER estimate. BoQ becomes an internal estimate without a clear role. In the case of Design and Build contracts (FIDIC the Yellow Book), a less-detailed BoQ is provided and the procurement estimate is based on ER as well.

Figure 3. **Project documentation development process for Slovak motorways**



Notes: (*) Feasibility studies required only for EU-funded projects, for older projects undertaken usually at the end of investment design process.
Source: Ministry of Finance of the SR and Ministry of Transport, Construction and Regional Development of the SR 2016.

The procurement estimate (but not the individual unit prices) is published with the tender announcement and provided to each (potential) bidder to inform them of the Slovak Motorway Company's (NDS) view of what a particular scheme may be worth. Although this approach can give bidders a reasonable indication of the scale and quality of work anticipated, it can undermine bidders' confidence in the client if the estimate is too low, or leave room for bidders to make a disproportionate profit if the estimate is too high.

The ER estimate can potentially determine or influence the procurement estimate. This appears to be an anomaly promoted by current Slovak legislation. The Slovak Act on Public Works states that "The price stated in the protocol of the ER is an estimated value according to the separate statute" (where "separate statute" refers to Act on Public Procurement). This imparts significant importance to the ER assessment.

The Slovak Act on Public works does not require the ER be updated before procurement. The update is actually not permitted if the building permit was already issued. The only case when repeating the ER is necessary is if the detailed design showed that it is not possible to reach the estimate set by the ER. If detailed outline sets a lower price than the ER, the ER update is not necessary and the procurement estimate is based on the less accurate ER estimate.

Throughout this process no structured analysis of risk and uncertainty is performed. A judgmental contingency of 8-12% is added on top of base estimates.

International cost estimation: Matching accuracy to design detail and accounting for uncertainty

The international experience generally follows three broad methods of pricing: top-down unit rates (cost per km), benchmarking (comparison with other similar scale projects), and bottom-up unit rates based on a detailed measure BoQ (cost per m^3 etc.). Each is briefly outlined below (AASHTO 2013):

- Conceptual or parametric estimating techniques (top-down unit rates) are primarily used to support the development of planning or early scoping phase estimates when minimal project definition is available. Statistical relationships or non-statistical ratios, or both, between historical data and other project parameters are used to calculate the cost of various items of work (i.e. centre lane miles or square foot of bridge deck area, cost per km of a motorway).

- Historical bid-based estimating (benchmarking) relies heavily on element or bid items, or both, with quantities and good historical bid data for determining item cost. The historical data normally is based on bids from recent projects. The estimator must adjust the historical data to fit the current project characteristics and location. The historical data must also be adjusted to reflect current prices.

- Cost-based estimating (BoQ) considers seven basic elements: time, plant and equipment, labour, subcontractor, material, overhead, and profit. Generally, a work statement and set of drawings or specifications are used to "take off" material quantities required for each discrete work task necessary to accomplish the project bid items. From these quantities, direct labour, materials and equipment costs are calculated based on calculated or assumed production rates.

All approaches, to various extents, draw on historical data, involving past bids or past unit prices. These can be collected by the procuring authority itself, or for past unit prices especially, public or commercial providers of unit price data and related indices for various construction subsectors may exist[1]. In Belgium for example, the Flemish government has created an online database of unit prices for all public works (roads, waterways, ports, coast and regional airports) to support the cost estimation and procurement processes[2].

Key amongst the approaches above is the balance of pricing with actual design knowledge. Most estimators take a very conservative approach at the early stage when the design is still quite immature. Simply speaking the more advanced the design, the more accurate the estimate. At feasibility, there are too many “unknown unknowns” to rely on a BoQ and quantified risk analysis alone. Top-down unit rates can assist in getting to an early estimate that is broadly correct and accommodates minor variations within the larger pricing tolerance. Benchmarking has its uses, though primarily as a sense check rather than a deterministic tool. In practice, the margins of error in the benchmarking process are likely to be bigger than those derived by top-down methods and so should be treated as a mechanism to “place” a project against its peers rather than identify what its price “should be”.

In some cases procurement authorities also rely on formal industry classifications to define at what project development stage a specific level of design detail and estimate accuracy is required. Examples involve RIBA[3], AACE[4] (in the UK and internationally), and HOAI[5] (in Germany). For the procurement authorities the most basic stages are the feasibility study (whether a solution is feasible), project selection (which solution is the best one), and procurement (of the chosen solution). Where statutory planning processes are necessary for the delivery of projects, there may be an additional stage for these deliverables.

In the last two decades the traditional approaches to cost estimation have been extended by paying greater attention to risk and uncertainty. The inputs and outcomes of the traditional approaches are now risk adjusted. This process generally involves an execution of a risk assessment workshop (with the risk factors determined subjectively by the participants), creation of a risk register, and the use of the Monte Carlo method to elicit a probability distribution of the possible outcome rather than a single “true” value.

When historical data is available on past project performance for similar projects, adjustments to the estimates can be applied. This approach is known as reference class forecasting and has been suggested for use in infrastructure cost estimation by Bent Flyvbjerg (2002). This approach is not without challenges (Infrastructure Risk Group, 2013; Makovsek, 2014) or critique (Eliasson and Fosegerau, 2013; Börjesson, Eliasson and Lundberg, 2014), but it does not undermine the relevance of performing a risk due diligence and consistent ex post analysis.

The UK Treasury, for example, goes some way towards recognising pricing uncertainty though the Green Book approach with Optimism Bias (OB), though this is often misunderstood by industry as an approximation to risk. The uplifts in use have been developed to achieve a high degree of confidence that the project is deliverable within the derived budget and is only to be used for the economic case rather than an assessment of contingency, but they are based on studies which are now quite old. For highways 44% is to be added at prefeasibility, 15% at project selectio, and 3% at detailed design (DfT 2017))[6]. Individual procuring authorities have the possibility to analyse their own specific historic performance and apply the resulting uplift, but there is no public overview available concerning how often that is actually the case. The performance of Highways England for example has improved to such an extent it no longer applies an OB uplift.

The notion of OB is a valuable element that recognises at the feasibility stage there are many aspects that are unknown such as ground conditions, land/property powers or political pressures that will only emerge as more investigation and stakeholder discussions are carried out. A risk analysis commensurate to the level of project development is clearly necessary to recognise the “known unknowns”. Aside from qualitative and quantitative risk assessment, quality assurance at earlier stages of project development has also established itself as an important part of in-house due diligence. The case of Norway is presented in Box 1. In the UK and elsewhere, there is a general reliance on ISO9001.

Box 1. **The quality assurance process for motorway project development in Norway**

Norway introduced its quality assurance (QA) procedure in 2000. At first, quality assurance was required before submitting the project for funding and approval from the parliament (formal decision to build). In 2005 the process was expanded to an earlier stage and was also required after the project selection phase (CBA), where one or no alternatives for further planning are selected. At the project selection phase the focus is on both costs and benefits.

All public projects above NOK 750 m (Slovakian Koruna) (EUR 80 m) must be subject to a quality assessment. This is approximately 11 times higher than the Slovak ER threshold. The appraisal is done by an external independent consultant chosen by the Ministry of Finance. The consultant´s cost estimate is based on documents prepared by the responsible ministry (agency) including an overall project management document, a complete baseline estimate and an assessment of at least two alternative contract strategies. The consultant reviews the documents, assesses success factors and pitfalls, quantifies uncertainties and gives recommendations regarding the project cost frame and contingencies as well as recommendations regarding project management to fulfil the proposed cost (Odeck et al., 2015). The policy in Norway was to ensure with an 85% probability that the end cost of the projects will not exceed the estimate.

Odeck et al. (2015) identified significant difference in cost overruns present between the period before and after the QA inauguration. Average cost overrun decreased from initial value 13% to -11%. However in the same period the Norwegian Public Roads Administration also executed an organisation and a procurement reform, introducing public tendering for project execution. The reform is likely to lead to increased efficiency and lower project cost causing temporary upward bias in the cost estimates, which necessarily build on historical figures. An example of such an interaction is available in Makovšek (2014). After these effects subside, future investigations will be able to more accurately assess the impact of quality assurance in Norway.

Slovak motorway cost estimation system performance

The Slovak authorities have expressed interest to investigate the cost/time performance of all the motorway projects that began construction after the year 2005 and became operational by the end of 2016. A total of 18 projects were identified as meeting these criteria, which were procured as 28 contracts.

According to the scope defined in the second section, the cost/time performance analysis requires that estimates on expected cost and time at different project development phases are collected and compared with project end cost. We describe below the data, the methodology and results.

The data

Data on cost/time estimates was sourced from the project documentation as well as the ER protocols, while data on the end cost was sourced from the general ledger of the NDS. The advantage of the general ledger data is the level of detail, which is generally not available in secondary sources/reports. For example project cost are recorded in multiple subcategories, such as how much was spent on land acquisition, design etc.).

During the process of data collection several issues were encountered, which to a smaller extent affected our approach to analysis. For example, due to historical reasons much of the detailed data was incomplete and could not be analysed (e.g. we could not assess the accuracy of land acquisition cost, which can be a very significant part of the total project cost). Issues were also encountered with regard to cost estimates due to inconsistent reporting/presentation in the project documentation. A summary of all the data gathered are in Appendix 1, Appendix 2, and Appendix 3. Details of the data collection and challenges encountered and necessary adjustments are summarized in Appendix 4.

The methodology

In view of the issues encountered with regard to data completeness our analysis was focussed on construction cost only. In line with the generally used approach in this type of analysis (a literature review is available in Makovšek and Moszoro, 2017) all the cost were adjusted to 2016 prices using a general construction sector cost index[7]. All cost is net of VAT.

The performance of all cost metrics below is expressed as a ratio between two reference points and in percent (sums of two quantities). For example:

$$\textit{Cost performance at decision to build} = \frac{\sum_i^n (Cost\ at\ project\ completion)}{\sum_i^n (Estimated\ cost\ at\ ER)} 100$$

The symbols i = 1,…, n merely represent that the calculation is an average based on all available observations (in this particular case 18 projects). The cost (or time) performance is then expressed as cost (or time) overrun in percentage points above 100% and underrun in percentage points below 100%.

For time-related metrics a different approach was used, where first a time difference needed to be calculated between two reference dates, after which average performance could be assessed. For example:

$$\begin{array}{l}\textit{Time performance} \\ \textit{at decision to build}\end{array} = \frac{\sum_i^n (\textit{Actual start of operations} - \textit{Estimated start of operations at ER})}{n} 100$$

The following performance measures were assessed:

- The cost and time estimate at the project decision to build (ER estimate) vs cost and time at completion. The process of investment preparation in Slovakia does not include an official point, where a formal decision to build is taken (i.e. a choice that a particular solution will be further developed and procured). Normally, this point generally follows the execution of the CBA (which was only recently introduced in Slovakia) and where the progress towards a detailed project design is about halfway (this is the case for example in the UK, US and other countries). In consultation with the Slovak authorities it was assumed that the closest comparable point to a decision to build in the Slovak context would be the estimate at the ER. As this estimate can be relevant for investment appraisal and be used for budgeting it is considered with the risk contingency, when one was used (such is also the practice in international literature, surveyed below).

- The winning bid (ex ante contract value and expected duration) vs contract cost and time at completion. The NDS generally follows a practice where a risk contingency is included in the contract. This ratio excludes the risk contingency from the comparison (this too is standard in international literature)[8].

With regard to on-time performance, the majority of the estimates were based on years (with the exception of the contract of course). When comparing with the outcome dates it was assumed that the estimate was always mid-year. Clearly, this only provides a very rough idea with regard to on-time performance.

In addition to the above performance indicators, we also assessed two more relationships to get a better view at the accuracy of in-house cost estimates just prior to tendering:

- The winning bid vs the procurement estimate: ER estimates are brought forward with the general construction cost index. Based on these estimates the tender value of the contract is announced, which represents a signal to the market of what (the investing authority thinks) the contract's value is. The contingency in the procurement estimate is included in the comparison. In almost all cases the contingency applied is 8-12 %, hence if cost estimation were accurate the result should exhibit a small cost underrun.

- The last in-house estimate prior the procurement vs the procurement estimate: This follows findings from the previous section, where it was determined that the Slovak legislation (§ 11 art. 9 of Act on Public Works) requires the ER be used to inform the tender value. Only if during later preparation of the detailed design the new estimates are higher than the one in the ER, the latter must be repeated/revised. This would be a natural result if the initial estimate is too low. In the opposite case, a too high estimate would be used to announce the tender, which could potentially adversely affect competition outcomes. Hence this measurement only controls, whether the initial ER was significantly amended prior the actual procurement.

In addition to calculating the ratios between different reference estimates and end cost/time performance we also performed a statistical testing of whether the ratios are meaningful. Each ratio is in essence a comparison of two distributions of observations (two estimates at different points of time or the estimates and end results). If the distributions are not normal (Gaussian) than any conclusion that a mean of the end cost is different (higher or lower) than the mean of the estimates could be misleading. A Wilcoxon signed-rank test was executed on all pairs to determine that any systematic differences are statistically significant.

The results

The basic statistics of the samples we are analysing are provided in Table 2. There is a large difference observable between the ex ante values of projects (ER estimates) and contracts (winning bids) although the substance represented by the two is the same.

Table 2. **Select descriptive statistics of the main two samples of projects and contracts**

Sample	Number	Length (km)	Value (EUR m)		Total ex ante value (EUR m)
			Min	Max	
Projects (ER estimates)	18	180	21.2	415.7	3 145
Contracts	28		9.7	189.5	2 104

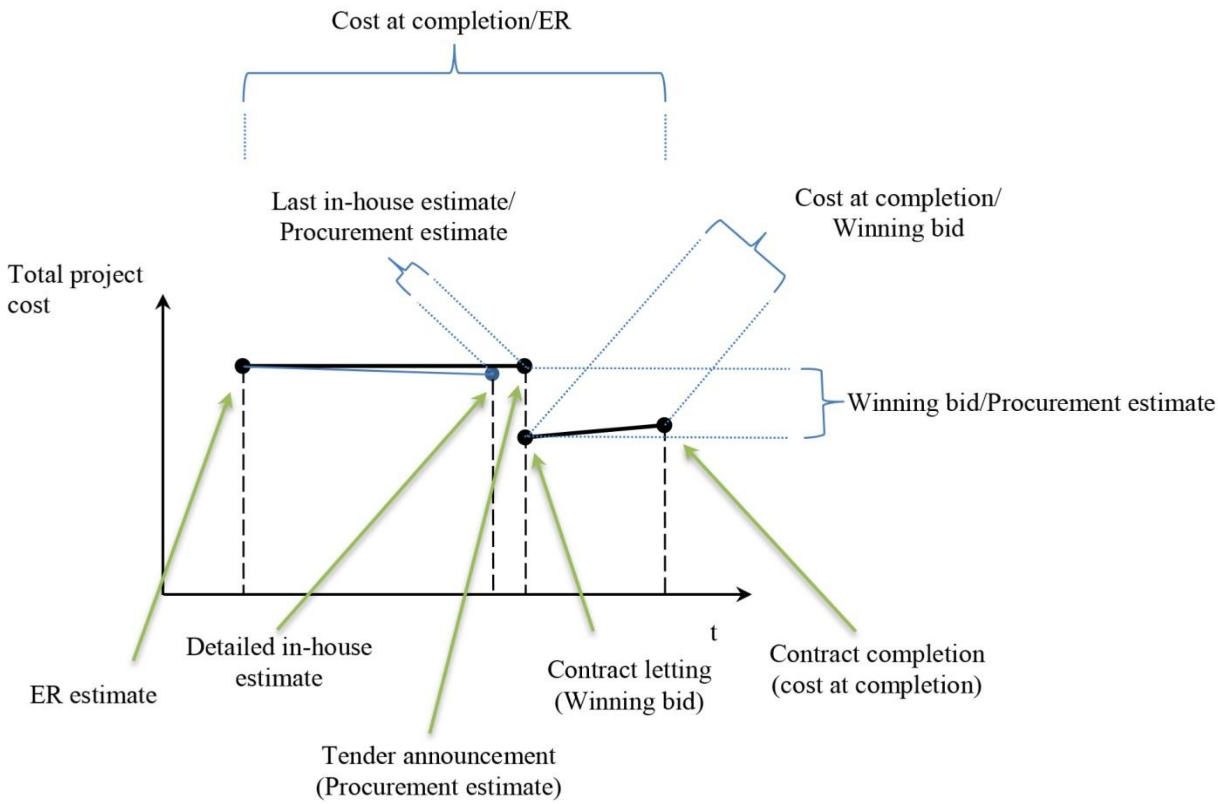
Table 3 shows the cost performance metrics explained in the previous section. For greater clarity, Figure 4 provides an illustration, to which part of the project development cycle particular metrics refer.

Table 3. **Cost performance results**

Systematic performance measure	Projects	Contracts
Cost at completion/ER	73.1%*	n/a
Winning bid/Procurement estimate	n/a	67.0%*
Last in-house estimate/Procurement estimate	n/a	99.3%
Cost at completion/Winning bid	n/a	109.3%*

Notes: (*) Statistically significant.

Figure 4. **An illustration of individual performance metrics on a project development timescale (fixed prices)**



The results in Table 3 suggest that the ER estimate is systematically too high. After the projects have been tendered the cost drops systematically. This could happen for two reasons. One reason might be that the scope of the projects was reduced. The ER estimate is made at an early phase of project development. Further development of the design normally means that as detail is added the costs generally increase. One explanation why systematic cost overestimation occurs could be that projects ultimately procured actually had a reduced scope compared to the initial ideas (i.e. the quantity to be built was smaller).

According to the information provided by the NDS[9] at least eight out of the 18 projects were subject to a significant scope alteration between the ER and public procurement. In at least six cases, scope significantly increased, and another two were subject to significant scope reduction (e.g. only two out of four lanes were built). A significant amount of required work made it difficult for the NDS to clarify, what exactly happened in distinct projects and what part of the scope growth was the result of a more detailed design and where the purpose of the project was actually extended.

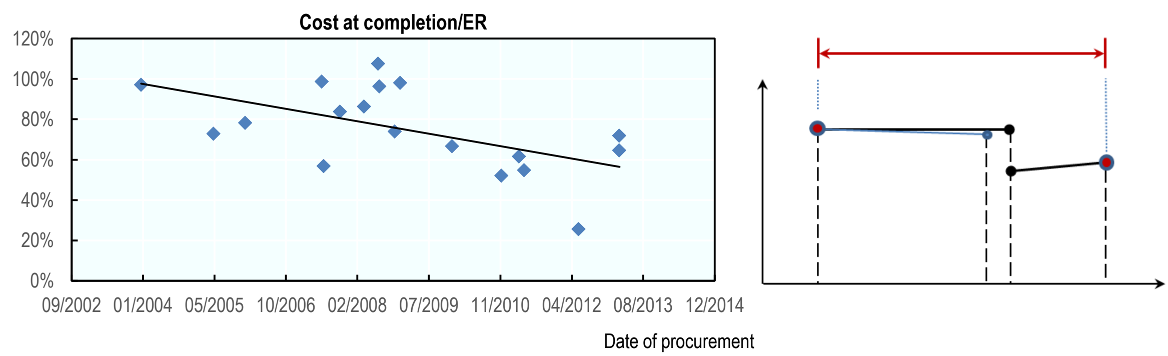
The second potential reason for the systematic cost overestimation could be that the unit prices in the estimates up to the tendering are too high (i.e. the prices are the cause, not the change in quantities).

The results in Table 3 show that later estimates (the last in-house estimate; procurement estimate) do not markedly improve upon the ER result. Since no significant changes in project scope can occur between tender announcement (which uses the procurement estimate) and contract award, we are led to the conclusion that the dominant source of the overestimation in all estimates are the unit prices. As similar data sources are used for price estimation throughout the project preparation process, it is likely that high unit prices are persistent in all phases of the estimates.

The next metric relates to contract performance. Cost at completion tends to be on average 9.3% above the initially contracted amount. The precise causes (e.g. scope creep, contract management, contract type) of this deviation are beyond the scope of this report.

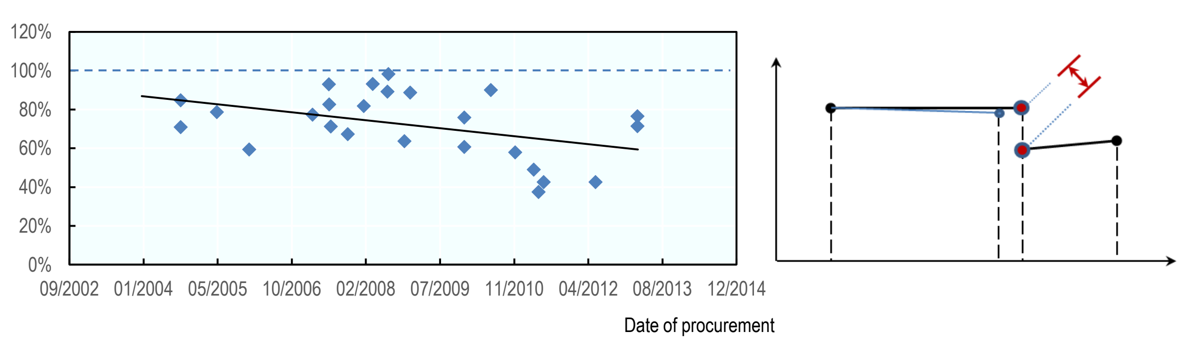
An analysis of the trends for each of the four performance measures is captured in separate figures below. To the right of each figure, there is a reduced illustration that shows which particular reference points in project development timescale are considered.

Figure 5. **Project and contract cost performance over time – Cost at completion/ER**



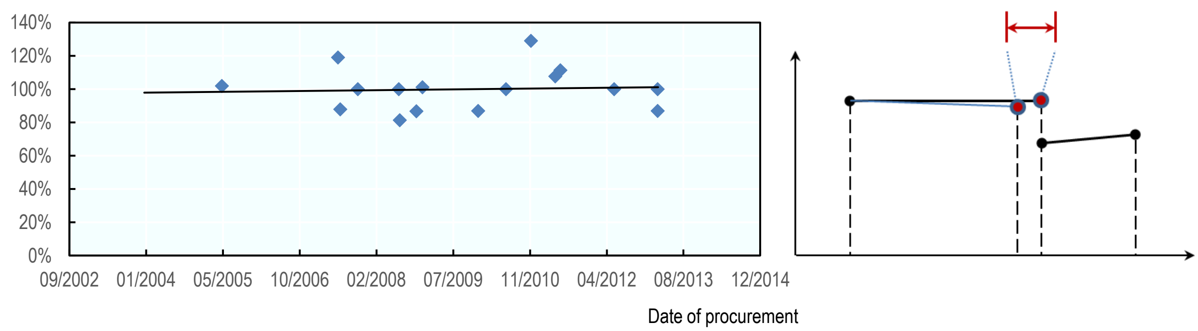
An immediate observation for Figures 5 and 6 appears to be that the error in cost estimates at different phases is increasing over time. The more recent projects have been estimated to cost substantially more than they actually did, compared to older projects. This cannot be due to construction market dynamics, where temporary effects are visible, whereas Figure 6 shows persistent cost overestimation.

Figure 6. **Project and contract cost performance over time – Winning bid/Procurement estimate**



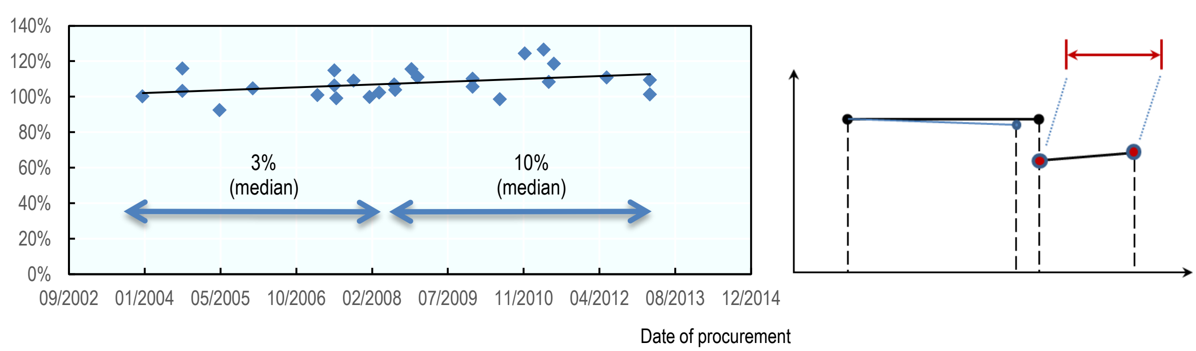
In Figure 7, significant changes in the value of individual projects are revealed between the last in-house estimate based on detailed design and the estimate used for procurement. As noted above, this appears to be the result of fitting some project estimates to a higher ER estimate, and scope growth and scope trimming in others.

Figure 7. **Project and contract cost performance over time – Procurement estimate/Last in-house estimate**



In Figure 8, the cost overruns vs the winning bid appear to be slightly increasing. Splitting the observations in two groups (the first 13 projects and the last 14) shows that the median cost overrun per contract in the first period was 3% and 10% in the second. This could be due to a variety of reasons[10] the investigation of which is beyond the scope of this report.

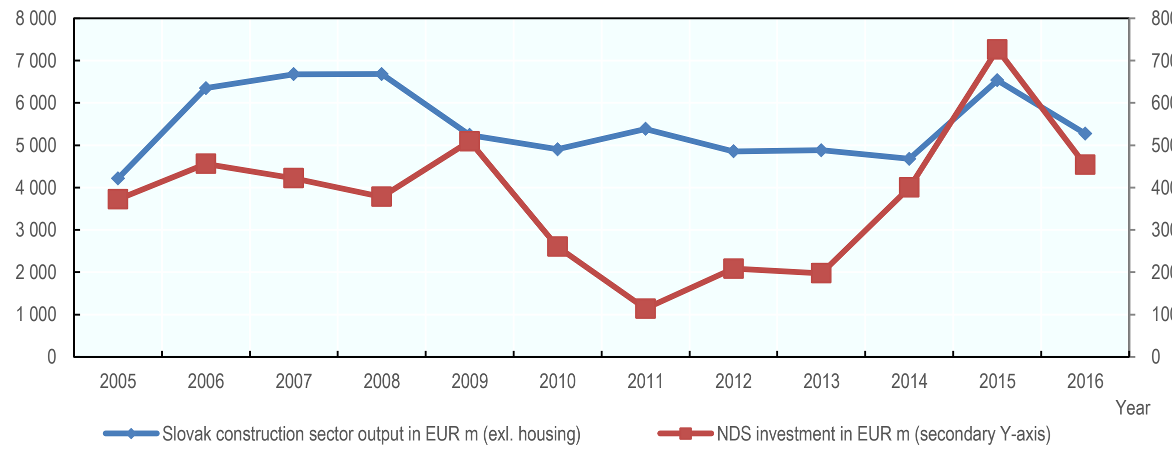
Figure 8. **Project and contract cost performance over time – Cost at completion/Winning bid**



None of the trends materially change if, as the reference date, the date of project completion was chosen.

That the trends above, especially in Figures 5 and 6, were under some influence by the price movements on the market (the cost estimation is always done on historical data) cannot be excluded (i.e. because the market prices dropped estimates based on historical prices would be too high). However, the ER and procurement estimates have been systematically too high even before the crisis and are getting progressively worse over time. They appear to have little relation with the construction market activity (captured in Figure 9).

Figure 9. **Slovak construction sector activity**



Note: For NDS only construction works are included (expenditures for studies, land acquisition etc. are excluded).
Source: Statistical Office of the Slovak Republic.

Fewer opportunities on the contract market may lead to more competition for those that are available. In terms of contractor strategies the consequence may be an increased presence of underbidding as a tactic, which leads to increased pressures on the investor to secure additional revenues beyond the initial (low) bid. Stricter contract management is one response to this development.

In an international comparison of cost performance with the limited data available from other international studies (Table 4), Slovakia is an outlier in terms of early cost estimates (i.e. when compared to the decision to build). In terms of cost growth after the contract has been tendered (Table 5) Slovakia's performance is comparable.

Table 4. **Slovak motorway cost performance and other studies (decision to build vs. cost at completion)**

Source	Reference estimate	Project type	Time period*	Observations	Average cost overrun (%)	Area
Cantarelli et al.2012b, Flyvbjerg et al., 2003	Decision to build	Roads	1927-2009	278	21.2	NW Europe
		Bridges, tunnels		39	25.3	
Cantarelli et al., 2012a	Decision to build	Roads	1980-2009	37	18.9	Netherlands
		Bridges, tunnels		15	21.7	
Makovšek et al., 2012	Decision to build	Roads	1995-2007	36	19.19	Slovenia
Lundberg et al., 2011	Decision to build	Roads	1997–2009	102	21.2	Sweden
Lee et al., 2008	Decision to build	Roads	1985-2005	138	11.0	South Korea
Odeck, 2014	Decision to build	Roads	1993 - 2007	1045	10.0	Norway
Locatelli, 2017**	Decision to build	Roads	2001-2014	15	103.0	Italy
This analysis	Decision to build	Roads, bridges, tunnels	2008-2016	18	-26.9	Slovakia

Notes: (*) The time period reflects the year of project completion. (**) Includes only mega projects, with average cost above EUR 1 billion. The comparability with other studies in this set is limited as mega projects face considerably larger complexities.

Table 5. **Slovak motorway cost performance and other studies (contract award vs. cost at completion)**

Source	Reference estimate	Project type	Time period*	Observations	Average cost overrun (%)	Area
Ellis et al., 2007	Contract value	Roads and bridges	1998–2006	1 908	9.36	USA, Florida
Bordat et al., 2004	Contract value	Roads	1996-2001	599	5.6	USA, Indiana
Bhargava et al., 2010	Contract value	Roads	1995-2001	1 862	4.1	USA, Indiana
Hintze and Selstead, 1991	Contract value	Roads	1985–1989	110	9.2	USA, Washington
Love et al., 2015; 2009 ; 2014b)	Contract value	Roads	N/A	44	12.5	Australia
Verweij 2015	Contract value	Roads	-2014	36	22.4	The Netherlands
This analysis	Contract value	Roads and bridges	2008-2016	28	9.3	Slovakia

Notes: (*) The time period reflects the year of project completion.

In addition to the cost performance, we also assessed the performance of on-time delivery. Given that in estimates at different levels, the estimated start of operations (there is no differentiation between the start of operations and the completion of works[11]) are very rough (in years), the on-time performance should be viewed with a wide margin of tolerance.

As the Table 6 suggests, on average projects started 2.4 years after the year expected in the ER but were on average delivered faster. On average the construction of the selected motorway projects took three years with the contracts lasting more than six months longer than initially stipulated.

Table 6. **Time performance results**

Systematic performance measure (delay in years)	Based on ER	Based on the winning bid (contract)
Construction start	2.4*	n/a
Start of operations*	n/a	n/a
Works completion*	1.8*	0.6*

Note: (*) Statistically significant.

The international literature on project time performance is limited and generally refers to data, which might be dated. Nevertheless, the review is represented in Table 7.

Table 7. **Slovak motorway time performance and other studies using the decision to build as reference point**

Source	Project type	Time period	Observations	Average delay in completion(%)**	Area
Love et al., 2014a	Roads	by 2009	44	9.0	Australia
Skamris, 1997	Bridges & Tunnels	1987-1994	7	46.0	Denmark
This analysis	Roads and bridges	2008-2016	18	32% or 1.8 years	Slovakia

Note: (**) All studies refer to the estimated construction duration (x% more than planned). The Australian study used the estimate at contract award as the reference point and the Danish and the Slovak as the formal decision to build.

On average it takes four years for projects to advance from the ER to the procurement. For three projects it took more than seven years. While we do not have an overview of studies to fall back to in this regard these numbers are not unusual in major infrastructure projects.

In terms of performance over time, Figure 10 exhibits that the estimates at the ER level, when projects will become operational, are becoming less accurate throughout time, i.e. it is taking progressively longer for projects to become operational given the expectations of the estimators. Figure 11 suggests a similar trend for delays in contract completion though that is less clear due to performance distribution.

Figure 10. **On-time delivery of motorway projects in Slovakia with regard to the ER estimate**

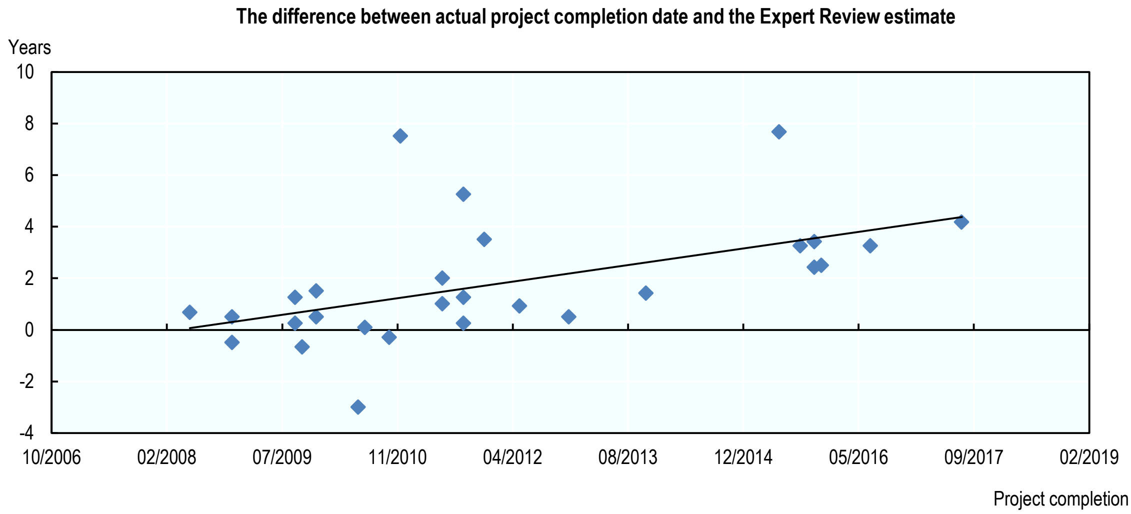
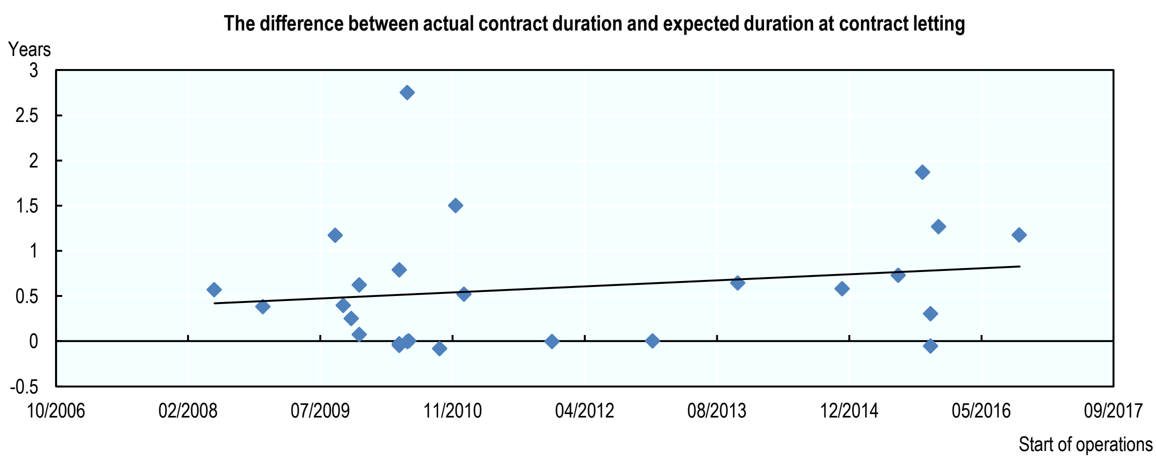


Figure 11. **Expected and actual contract duration for motorway projects in Slovakia**



Findings and recommendations

This report investigated the practice and performance of the Slovak motorway cost estimation system. A qualitative examination of the approach to cost estimation was performed together with an examination of the historic cost performance in Slovakia on 28 projects (essentially all completed major projects, constructed during the years 2005 and 2016).

The qualitative exercise revealed the following:

- The formal quality assurance element (the ER), which occurs early in the project process, merits improvement. Insofar pricing and risk assessment are concerned there was no evidence that the ER challenged the engineer’s estimate.

- Beyond the ER, at no stage in the process was it evident that a review of the programme/quality assurance to deliver the work was undertaken.

- Despite the fact that the ER is performed at a very early stage of project development, the Slovak legislation puts great weight on this document throughout the project preparation process. As more detailed documentation is developed, later estimates can often be higher than the earlier ones. Despite this there are several cases, where lower cost estimates based on more advanced design documentation were ignored and a higher cost estimate from the ER was relied on to procure projects. The ER estimate appears to act as an unchanging baseline, though the reason for this is not fully clear.

- There is no serious consideration of a systematic risk assessment in the cost estimation process. A contingency of 8-12% is attributed to baseline estimates on a judgemental/subjective experience basis.

- The estimators are missing one of the main tools to build reliable cost estimates. There is no database of historic unit prices for motorways available. Its absence also inhibits the identification of any collusion in the construction market.

- In relation to the cost estimation and project planning process, there is no formal decision to build, defining the level of the design detail, cost and benefit certainty and other conditions to approve a project. It is at this point where the Minister (Government) formally approves a project and takes responsibility for its execution. The lack of it has implications on project prioritisation, accountability and ex post performance assessment. The ER is signed by the Transport Minister but it is too early in the project development process, at a level when the estimates are too high of a level usefully support decision making.

- The NDS also includes a contingency in the contract with the contractor, which is unusual and unclear in purpose.

The quantitative assessment measured the relationship between various levels of estimates and the end cost of projects.

The analysis of on-budget delivery in Slovakia reflects many of the points above. The final cost of projects is on average 27% lower than the ER estimate (which was chosen as an equivalent to the decision to build in Slovakia). This is unusual in international experience, where on average cost overruns of 20% are recorded[12].

Our analysis suggests there are two related causes for this. The estimates in the ER and the unit prices applied on latter more detailed estimates/design appear to be excessively high. This observation is based on the large drop between the estimate announced at procurement and the subsequent winning bid, when essentially no scope changes can happen.

Given the risk pricing theory and empirical findings (Makovšek and Moszoro, 2017; De Silva et al., 2009; Kosmopoulou and Zhou, 2014), bidders bid more aggressively when uncertainty is reduced. In this particular case, the public side is providing the wrong signal to the market by consistently advertising procurement estimates that are too high. The market has no doubt recognised this. However, if the estimates were accurate and would be accepted as credible by the market, further significant savings in bids and project end cost could be potentially achieved (in the study of De Silva et al. [2008] up to 9% average bid reduction is cited on some types of works where additional information was released to the bidders as opposed to a case, where this information was unavailable[13]).

The cost development after contract letting did not reveal any surprises. The cost at completion for the 28 contracts is on average 9.3% above the winning bid. This is comparable to other available international experience.

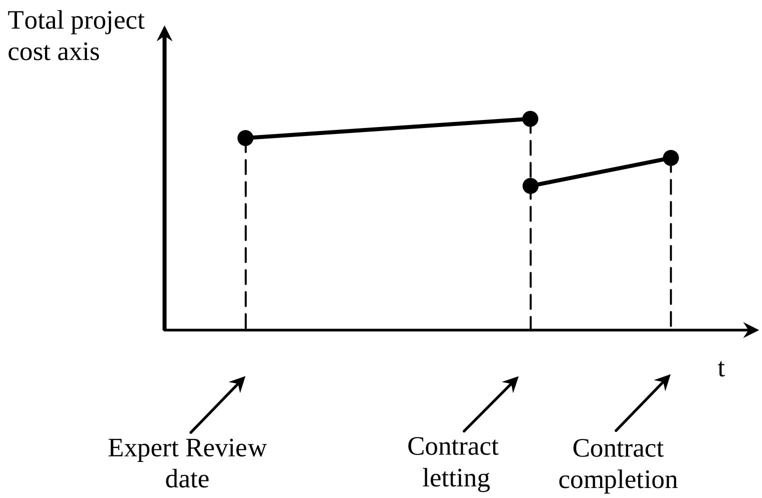
The general evolution of cost in estimates and contracts (in current prices) performance can be illustrated as shown in Figure 12. The total estimated cost of projects is on the left axis and the unit price level on the right one. We have determined that the initial ER estimate is overestimated. Scope changes later appear to play a role as well; nonetheless available details do not allow us to precisely determine the relative influence. The ER estimate is then brought forward with the general construction price index. Once the contract is let, the price level remains fixed (as is common in the FIDIC Red Book contract used in Slovakia) and all cost growth can only come from variation claims (errors and omissions in design, unexpected issues etc.).

Between the ER and the procurement estimate individual projects appear to be subject to considerable cost variability. There may be multiple causes (fitting to available budget, correcting estimates, political pressure, adjusting project scope to changed needs), which are beyond the scope of this report. However, this does suggest there is a lack of a robust project selection and budgeting framework, which makes manipulation with the project scope more and more difficult as the project matures through its development.

The Slovak experience of programme timescales does not seem unusual. About four years pass between the first ER and the start of procurement although in a few cases more than seven years were required. Against the same benchmark, operations start about one-and-a-half years later than expected. Contracts on average take more than six months longer than initially stipulated. From the international studies available, this performance does not seem to stand out.

The trend of the cost and time performance are grounds for concern. In particular the inaccuracy of the ER estimate and, in that relation, the procurement estimate through time is strongly increasing, while any trends for other categories appear to be less pronounced.

Figure 12. **Estimated cost levels in motorway project preparation and procurement in Slovakia (current prices)**



Several recommendations follow from our findings:

- After the challenges encountered regarding the current approach to cost estimation and quality assurance, it is worth considering whether the following skill set maybe sought within Slovakia in assisting the cost estimation process:

    - Quantity surveyors, programme planners and risk managers.

  These skills have to be built everywhere, where people are involved in cost estimation and/or project management (be it at the ministry level or in the executive bodies). Elements of these skillsets may, in part, already be included in formal education at the university level. In many instances, in other countries these profiles are subject to professional training and continuous training requirements after a formal university degree has been obtained[14].

- The state or the NDS should create a unit price database for motorway projects based on past bids. Technical assistance should be available from any advanced country where this process is well developed. The database should be used to inform future cost estimates, develop cost variation formulas (for materials such as oil, steel and others), to provide more robust pricing advice to contractors, help monitor price movements and thus inform anti collusion investigations.

- The ER should be amended to become part of a comprehensive quality assurance system for the projects and programmes alike. Such a system should encompass option identification and selection, change management, cost and benefit estimates, the procurement method, and contract management. Systematic ex post analysis should be an integral part of this process. It should follow international practice with assurance performed by external competent experts.

- The State should define what level of design detail and cost estimation accuracy is required at different stages of project development. These should be progressively more demanding and independent on any earlier estimate (as appears to be currently the case).

- Traditionally cost plans evolve through the life of the project, developing in detail and accuracy as more information becomes available during the design process as set out below:
    - Pre-project: business case and project budgets are established.
    - Options: elemental cost plan developed following concept design including outline proposals for structural design, building services systems and outline specifications.
    - Development: preliminary and initial estimates evolve from the elemental cost plan above as the design matures to a detailed design and tender.
    - Construction: post award and contract management, cost to completion estimates are undertaken to monitor final outturn cost
- The stages in the previous point should be linked to the budget, programme and project decision-making process, with clear accountability. A formal decision to build needs to be established at the point where the preferred solution is chosen and based on a more detailed project development phase. An example illustrating the Highways England cost estimating phases is shown below, and similar processes exist for other major UK transport infrastructure owner-maintainers.

Table 13. **The cost estimating process in Highways England**

Project development	**Scope**			**Cost estimating**	**Risk**	
Project stage	**Client scheme requirements**	**Client phase remit**	**Appraisal specification report**	**Costs**	**Risk Management Plan/Register**	**Quantitative risk assessment**
Strategy shaping and prioritisation	Produced	Produced	Produced	Order of magnitude estimate		
Option identification	Reviewed	Reviewed	Refined	Options estimate	Produced	Produced
Option selection	Reviewed	Produced	Refined	Options estimate	Updated	Updated
Preliminary design	Reviewed	Reviewed		Prelim/initial estimate	Updated	Updated
Statutory procedures and powers	Reviewed	Reviewed		Refined estimate	Updated	Updated
Construction preparation/ Detailed design	Reviewed	Produced		Final estimate	Updated	Update
Construction commissioning and handover	Reviewed	Reviewed		Cost to completion estimate	Updated	
Closeout				Cost to completion estimate	Updated	

Source: Authors, based on Highways England Project Control Framework[15].

- Current cost estimation practices should be upgraded by systematic risk assessment, enabling probabilistic or risk adjusted estimates. The State/NDS should prepare a manual with a detailed description of the process. Training or technical assistance from institutions with more experience in risk management should be sought.

There are other factors to consider outside of the cost estimation process which traditionally contribute to cost growth if not managed appropriately:

- Post contract management, change management and cost analysis could be reviewed. This is usually an area where significant cost growth can occur without appropriate controls in place.
- The procurement method appears to be somewhat inflexible and lagging behind best practice elsewhere. There is seemingly no other consideration than the "lowest bid wins" approach.
- True competition: the current commercial environment could be vulnerable to the development of collusion practices amongst the contractors which could lead to artificially inflated bids. Steps are needed to ensure that this risk is minimised.

The review of these factors is beyond the scope of this report and we can only recommend they be given due attention in the future.

Lastly, the cost estimation is a subset of a broader budgeting, programme and project management processes. While these were not the subject of our analysis we did encounter at least one anomaly, which may merit a more comprehensive review of the system. There appears to be no formal decision to build in the Slovak investment preparation process. In many developed countries (GRB, DNK, USA, NOR, SWE etc.) a point in the project's development process exists, where the relevant Minister needs to make a formal decision whether a particular project will be procured or not. Its absence makes it difficult to have a view on project prioritisation, reduces accountability, and makes any assessment of ex post performance even more challenging. The ER acceptance is signed by the Transport Minister but it is too early in the project development process as it is done at a level when the estimates are too high of a level to usefully support decision making.

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Appendix 1. List of interviews executed for this study

Monday 19 June, 2017	
Ministry of Finance 17:00	
Ján KOVALČÍK	INEKO – analyst
Tuesday 20 June, 2017	
Ministry of Finance 08:00	
František BRLIŤ	CEMOS
National Motorway Company (NDS) 09:15	
Tomáš POLLÁK	NDS - Investment dep.
Lýdia VALENTOVÁ	NDS – Financial dep.
Adrián SLUŠNÝ	NDS – Engineer/project manager
Viera SEMANČÍKOVÁ	NDS – Coordination unit
Rastislav DRUSKA	NDS – Coordination unit
Jiří HÁJEK	NDS – Investment dep.
Ladislava CENGELOVÁ	MoT
Tomáš PŠENKA	MoT – Road Transport Section
Juraj KOVÁŘ	MoT – Strategy dep.
Ivan LANTAI	MoT – Strategy dep.
Ministry of Finance 11:30	
Ivan VIŠŇOVSKÝ	MoT – Expert Review unit
Nikola MELEGOVÁ	MoT – Expert Review unit
Juraj KOVÁŘ	MoT – Strategy dep.
Ministry of Finance 13:30	
Pavol ABRHAN	Skanska – Head of Risk Analysis

Appendix 2. List of projects analysed and cost performance

MW EW	Project	Length (km)	Lanes	ER Estimate (SE)	Internal estimate (IE)	Procurement estimate (PE)	Winning bid (WB)	Cost at completion (CC)	CC/SE (%)	WB/PE (%)	CC/WB (%)
MW	Dubná Skala - Turany	16.490	2+2	261.6	381.4	354.4	132.6	143.5	54.9	37.4	108.2
MW	Fričovce - Svinia	11.220	2+2	226.8	N/A	226.0	110.4	139.6	61.6	48.9	126.4
EW	Pstruša - Kriváň	10.380	2+2	239.1	206.3	237.8	169.7	171.8	71.8	71.4	101.2
MW	Jablonov - Studenec, I. phase	5.210	2	90.5	54.1	53.5	47.4	52.6	58.1	88.5	111.0
MW	Jablonov - Studenec, II. phase		2		40.8	40.8	36.7	36.2		89.9	98.6
EW	Žarnovica - Šaš.Podrhadie I. phase	9.680	2+2	105.6	74.8	85.2	60.7	60.1	56.9	71.2	99.1
EW	Žarnovica - Šaš.Podrhadie II. phase	8.370	2+2	123.3	94.7	116.5	114.3	118.7	96.3	98.1	103.8
MW	Mengusovce - Jánovce, I. section	8.000	2+2	393.4	N/A	194.2	115.2	120.5	30.6	59.3	104.6
MW	(Mengusovce _Jánovce, I.section technologies		other		N/A	11.8	9.7	9.6		81.8	99.8
MW	Mengusovce - Jánovce, II. section	6.230	2+2		N/A	108.2	91.5	106.0		84.6	115.8
MW	(Mengusovce - Jánovce, II section, PP-KK feeder road part 1- addendum)		other		N/A	0.0	0.0	11.2			
MW	Mengusovce - Jánovce, III. section	11.620	2		N/A	112.5	79.6	82.1		69.8	104.6
MW	Mengusovce - Jánovce, III. section – 4 lanes road completion - addendum)		2		N/A	0.0	0.0	44.2			

Appendix 2. List of projects analysed and cost performance (continued)

MW EW	Project	Length (km)	Lanes	ER Estimate (SE)	Internal estimate (IE)	Procurement estimate (PE)	Winning bid (WB)	Cost at completion (CC)	CC/SE (%)	WB/PE (%)	CC/WB (%)
MW	Mengusovec - Jánovce, SSUD Mengusovce		other		N/A	15.7	12.1	12.2		77.2	100.8
EW	Žiar nad Hronom - bypass	5.760	2	108.7	59.0	59.0	25.0	27.7	25.5	42.4	110.8
EW	Košice - Milhosť	14.180	2+2	125.7	109.2	125.6	76.0	83.8	66.6	60.6	110.2
MW	Jánovce - Jablonov I. section	9.000	2+2	415.7	130.3	101.0	58.4	72.6	17.5	57.8	124.3
MW	Jánovce - Jablonov II. section	9.540	2+2		318.5	286.2	121.4	143.9		42.4	118.5
EW	Ruskovce - Pravotice (1/2 profile)	9.560	2	142.4	110.1	110.1	84.1	92.0	64.6	76.4	109.4
MW	Sverepec - Vrtižer, I. section	4.900	2+2	401.6	N/A	177.5	165.2	168.9	42.1	93.1	102.3
MW	Sverepec - Vrtižer, II. section	4.695	2+2		N/A	179.1	147.7	157.0		82.5	106.3
MW	Sverepec - Vrtižer, I. section, 2 phase	0.000	2+2		N/A	25.8	19.6	20.7		75.8	105.6
MW	Hričovské Podhradie - Žilina (Strážov)	9.148	2+2	240.4	245.6	241.0	189.5	175.0	72.8	78.6	92.4
EW	Trstená – bypass	7.200	2	58.7	67.3	67.3	45.2	49.3	83.9	67.2	109.0
EW	Horná Štubňa - bypass	4.321	2	21.2	24.0	24.0	21.4	22.8	107.5	89.1	106.9
EW	Svidník - road realignment	4.573	2	30.2	33.2	27.9	26.0	29.8	98.7	93.0	114.8
MW	Studenec – Beharovce	3.326	2+2	28.6	25.0	28.8	18.3	21.2	73.9	63.6	115.5
MW	Svinia - Prešov, západ	7.057	2+2	130.9	129.7	129.7	127.0	127.1	97.1	0.0	100.1
	Total	**180.460**		**3 144.6**	**2 103.9**	**3 139.8**	**2 104.7**	**2 300.1**	**73.1**	**67.0**	**109.3**

Appendix 3. List of projects analysed and time performance

MW EW	Project	Length (km)	Lanes	Delay in years (against ER estimates)			Delay in years (against the contract)
				Start of construction	Construction duration	Completion	
MW	Dubná Skala - Turany	16 490	2+2	4.5	-1.3	3.3	0.7
MW	Fričovce - Svinia	11 220	2+2	1.8	1.5	3.3	1.3
EW	Pstruša - Kriváň	10 380	2+2	3.6	-1.1	2.5	-0.1
MW	Jablonov - Studenec, I. phase	5 210	2	-0.3	0.5	0.3	0.0
MW	Jablonov - Studenec, II. phase		2	1.5	0.0	0.5	0.0
EW	Žarnovica - Šaš.Podrhadie I. phase	9 680	2+2	3.8	-2.7	-3.0	0.3
EW	Žarnovica - Šaš.Podrhadie II. phase	8 370	2+2	3.5	-2.5	1.0	0.5
MW	Mengusovce - Jánovce, I. section	8 000	2+2	1.9	-0.4	1.5	0.6
MW	(Mengusovce _Jánovce, I. section technologies		other	3.8	-3.3	0.5	0.1
MW	Mengusovce - Jánovce, II. section	6 230	2+2	-0.9	1.4	0.5	0.4
MW	(Mengusovce - Jánovce, II section, PP-KK feeder road part 1 (addendum)		other	N/A	N/A	N/A	0.0
MW	Mengusovce - Jánovce, III. section	11 620	2	1.1	0.2	1.3	1.2
MW	Mengusovce - Jánovce, III. section – 4 lanes road completion (addendum)		2	N/A	N/A	N/A	0.0
MW	Mengusovec - Jánovce, SSUD Mengusovce		other	1.5	-2.2	-0.7	0.4
EW	Žiar nad Hronom - bypass	5 760	2	7.0	0.7	7.7	0.6
EW	Košice - Milhosť	14 180	2+2	0.3	1.1	1.4	0.6
MW	Jánovce - Jablonov I. section	9 000	2+2	3.0	0.4	3.4	1.9
MW	Jánovce - Jablonov II. section	9 540	2+2	3.0	-0.6	2.4	0.3
EW	Ruskovce - Pravotice (1/2 profile)	9 560	2	3.7	0.5	4.2	1.2
MW	Sverepec - Vrtižer, I. section	4 900	2+2	2.1	-0.1	2.0	0.8
MW	Sverepec - Vrtižer, II. section	4 695	2+2	0.6	-0.5	0.1	0.0

Appendix 3. List of projects analysed and time performance (continued)

MW EW	Project	Length (km)	Lanes	Delay in years (against ER estimates)			Delay in years (against the contract)
MW	Sverepec - Vrtižer, I. section, 2 phase	0 000	2+2	2.0	-1.0	0.9	0.0
MW	Hričovské Podhradie - Žilina (Strážov)	9 148	2+2	0.6	0.1	0.7	0.6
EW	Trstená bypass	7 200	2	0.8	0.4	1.3	-0.1
EW	Horná Štubňa - bypass	4 321	2	3.5	0.0	3.5	0.0
EW	Svidník - road realignment	4 573	2	6.5	1.0	7.5	1.5
MW	Studenec Beharovce	3 326	2+2	0.6	-0.9	-0.3	0.0
MW	Svinia - Prešov, západ	7 057	2+2	2.5	2.8	5.3	2.8
	Total	**180 460**		2.4	-0.2	1.8	0.6

Appendix 4. Performance data caveats

NDS provided both access to primary and secondary (its own/synthetic reporting) data sources. Primary data were sought and acquired for the following categories:

- accounting system records (general ledger); grouping project expenditures into five main categories (design, construction, technology, construction site arrangement andenabling works) and a further subdivision of this totalling 43 sub categories)
- construction contracts (including all addendums and annexes and winning bid for the procurement), including the final invoice (if issued; which effectively completes the project)
- ER
- public procurement evaluation.

The following information was sought and acquired from secondary data sources: the winning bid total (procured price) with subdivisions; the total of all recorded expenditures for the construction works contract; and the total of all expenditures for the project (construction, land acquisition, project documentation preparation and supervision).

Due to missing information in the general ledger it was not possible to attribute a small part of the cost of individual projects to particular contracts (it was not clear to which project they belong). This was predominantly the case for land acquisition and design cost. The error on average amounted to 1.7%. We also encountered a difference between the sum of expenditures for individual contracts and the final invoice (0.6% on average with 3.4% maximum). Where such a difference arose, we corrected the expenditure sum to match the final invoice total.

The completeness of the land acquisition and design costs data also appears to have been affected by accounting operations. When NDS took over operations from its legal predecessor all assets were brought into the NDS ledger as a fair value (current market price), i.e. the historical cost of land acquisition was no longer available. All the projects that were selected for analysis were affected by this issue.

For six out of the 28 contracts, final cost needed to be estimated. For these projects final invoices have not yet been issued, which effectively means these contracts are not yet complete and will incur further cost. To accommodate for this the NDS provided estimates of expected remaining cost for each incomplete project.

The use of contingency as an explicit or implicit category was not consistent throughout the projects. According to the Slovak legislation the contingency must be a separate part of cost estimate in the ER (Edict of the Mistry of Transport, Construction and Regional Development of the Slovak republic no. 83/2008 implementing the Act on Public Works no. 254/1998). A contingency of 8 to 12% is normally added on top of the total value of construction works, enabling works, technology and construction site preparation. In one-third of cases analysed it is also included in the construction contract, which is unusual and of no consequence for our analysis. The legislation makes no provisions, how the contingency should be applied beyond the ER.

With regard to time performance the ER sets an estimated construction commencement and duration estimate based on years only.

Notes

1 An example in the US that also provides data for heavy construction is the R.S. means publication (www.rsmeans.com). In the UK for example, the RICS (Royal Institute of Chartered Surveyors) hosts the Building Cost Information Service (BICS) (available at: http://www.rics.org/uk/knowledge/bcis/)

2 The Media(a)n project within the Flemish department for mobility and public works.

3 https://www.ribaplanofwork.com

4 http://www.costengineering.eu/Downloads/articles/AACE_CLASSIFICATION_SYSTEM.pdf

5 http://www.hoai.de/online/HOAI_2013/HOAI_2013.php

6 Table 8, Transport Assessment Guidance by the UK Department for Transport - WebTAG: TAG unit A1-2 scheme costs, July 2017 (https://www.gov.uk/government/publications/webtag-tag-unit-a1-2-scheme-costs-july-2017)

7 As was explained in the previous section, Slovakia does not maintain a motorway specific unit cost database, which would allow the creation of a motorway specific price index.

8 In estimates prior to the project tendering, the contingency was part of the total cost on which decisions regarding the project were made. The contingency in the bid is defined by the NDS and is of no practical significance to the contractor. They must still make variation claims, which the NDS must approve and if those breach the contingency in the bid that cannot imply that the contractor's variation or other claims are capped. The contractor must build their own contingency and profit margin regardless of whether the NDS includes a contingency in the bid itself or not.

9 A detailed review of changes in scope between the different phases of the project and an assessment of how these changes alone affected the cost of the project would be a very time consuming process.

10 For example if the market is low the bidders may be more inclined to underbid to secure the contract during the tendering, placing the investor under increased pressure to allow additional revenues (e.g. through variation claims) above and beyond the initial contract. On the investor's side, a stricter approach to contract management or a different contracting regime altogether may be required.

11 In practice, road infrastructure can always become operational well before all works are completed. There are activities in the construction contract that can be completed after the road is already operational (e.g. revegetation/landscaping).

12 The point isn't, of course, that Slovakia should pursue as high cost overruns like other countries, but that any large deviations are not good – systematic cost overruns or underruns.

13 In this particular study, the effect of additional information made available to the bidders was analysed. The Oklahoma Department for Transport made additional information available that was compared with another road authority, where this was not the case. The information policy change involves the release of more than the state's overall estimate of the project cost. The state revealed its estimate for each component of the project by releasing a set of individual cost estimates for each quantity of material used and each important task involved. For example, in one case, the state can reveal the cost of excavation

which depends on soil conditions, and in another, the cost of a specific bridge repair which depends on the extent of the damage (De Silva et al., 2009).

14 Examples of international associations include The International Project Management Association (www.ipma.world/), the Project Management Institute (https://www.pmi.org/), and the standard Projects in Controlled Environments (PRINCE) (https://apmg-international.com/product/prince2).

15. See http://assets.highways.gov.uk/roads/road-projects/A12+Chelmsford+to+A120/The+Project+Control+Framework+Quick+Reference+Guide+v1+February+2017.pdf

Motorway Cost Estimation Review

The Case of Slovakia

The ongoing development of Slovakia's motorway network has prompted efforts to improve project selection and infrastructure governance more generally. This report reviews Slovakia's approach to estimating motorway construction costs in the light of international practices. The accuracy of cost estimates at different project development stages affects the selection of projects, budget planning, or the bidding for the project. This report offers a broad range of measures that can advance the accuracy of estimates.

This report is part of the International Transport Forum's Case-Specific Policy Analysis series. These are topical studies on specific issues carried out by the ITF in agreement with local institutions.

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