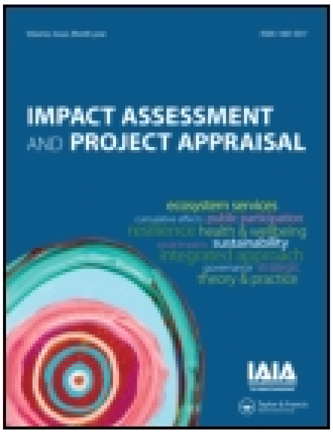

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Overestimated benefits and underestimated costs: the case of the Paraguay—Paraná navigation study

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Navigation projects

Overestimated benefits and underestimated costs: the case of the Paraguay–Paraná navigation study

Paul C Huszar

A major river navigation project, the Paraguay–Paraná Hidrovia, is being considered by the governments of Argentina, Bolivia, Brazil, Paraguay and Uruguay. The recently completed feasibility study for this project is seriously flawed and the errors systematically contribute to overestimating benefits and underestimating costs. The errors include overestimating the probability of a collapse in navigation, ignoring alternative forms of transportation, overestimating growth in regional shipments, omitting relevant construction costs, and perhaps most importantly, ignoring significant negative impacts to the environment. Correcting these errors, either individually or in concert, leads to the project not being economically feasible. Also provided is a method for including unspecified costs, such as those to the environment, in the analysis without further expensive and time-consuming studies.

Keywords: navigation; environmental impact; economic evaluation

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STIMULATED BY THE FORMATION of the Southern Cone Common Market (MERCOSUR) in 1991, the Plata Basin countries of Argentina, Bolivia, Brazil, Paraguay and Uruguay are considering ways to improve transportation within and between their countries. A number of transportation projects are either currently underway or in the planning stages. Perhaps the most ambitious and controversial of these is a plan to improve barge and ship navigation known as the Paraguay–Paraná Hidrovia[1] (HPP). Currently, a feasibility study for this project is being considered for approval by the five countries. This paper provides a review and critique of this feasibility study .

Figure 1 shows the study area. The initial plan for HPP was conceived by the Brazilian engineering firm of Internave Engenharia in 1992 and would have made the 3,440 km length of the Paraguay–Paraná river system from Nueva Palmira, Uruguay to Cáceres, Brazil navigable year-round (Internave Engenharia, 1992). At present, vessels of up to 100 meters in length can navigate only the first 453 km up to Corrientes, Argentina and then smaller vessels must be used to reach Asunción, Paraguay.

Further upriver passage becomes more difficult as shallow barges must be used to get past rapids and narrow straits. Navigation upstream of Corrientes is sometimes suspended because of low flows during the dry season. Dredging and course changes have been proposed all the way to Cáceres to allow navigation by convoys of barges of at least 500 tons (Jelen, 1995).

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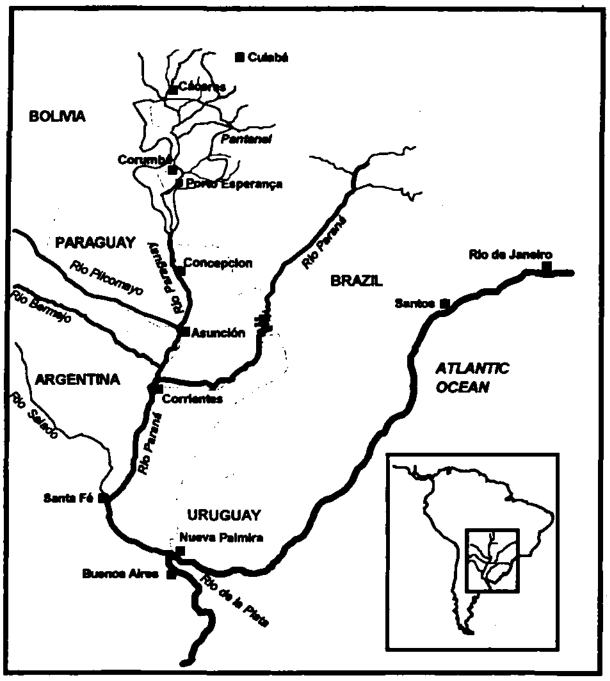

Figure 1. Map of Paraná-Paraguay Hidrovia

This initial plan would have had construction costs exceeding US$1 billion and maintenance costs would have been another US$3 billion over the next 25 years (Internave Engenharia, 1992). Funding for the project was to come from the Inter-American Development Bank (IDB) and the MERCOSUR countries. The initial feasibility study by Internave Engenharia concluded that the project was both physically and economically feasible.

A year after the Internave Engenharia (1992) study, Wetlands for the Americas commissioned an analysis of the potential environmental costs and benefits of HPP (Bucher *et al*, 1993). A multidisciplinary group of scientists conducted the analysis. It found that the project evaluation was flawed by both calculation errors and the omission of environmental costs; the project was not likely to be economically feasible when environmental costs were included. Moreover, it outlined numerous potential environmental costs that should be evaluated in a complete assessment of the project.

In response to the Wetlands for the Americas study, as well as pressure from environmental organizations such as the World Wildlife Fund, IDB rejected the findings of Internave Engenharia (1992) and called for a more complete and accurate study of the project. The IDB provided approximately US$11 million for an engineering/economic feasibility study and an environmental impact study (EIS). The studies were administered through the United Nations Development Program (UNDP) and managed by the Comité Intergubernamental de la Hidrovia Paraguay–Paraná (CIH). The CIH is supported by the governments of Argentina, Bolivia, Brazil, Paraguay and Uruguay.

In 1995, the CIH commissioned two one-year long studies of the proposed Paraguay–Paraná Hidrovia, one to analyze the engineering and economic feasibility of the proposed project and one to analyze its environmental impacts. The engineering–economic study was conducted by a consortium of consulting firms consisting of Hidroservice, Louis Berger and EIH (HLBE), and the environmental study was undertaken by a similar consortium consisting of Taylor, Golder, Consular and Consul (TGCC). The two studies were supposed to be linked, especially in the identification and measurement of environmental costs, in order to provide a complete analysis of the benefits and costs of the project and, therefore, of its social desirability.

The general conclusions of these studies are that the environmental consequences are negligible and that the project is feasible from both an engineering and an economic standpoint. These studies were accepted by the CIH in December, 1996 and have now been sent to the participating countries of Argentina, Bolivia, Brazil, Paraguay and Uruguay for their approval and commitment to constructing the project. Even before formal approval of the report by the participating countries, Argentina, Bolivia and Paraguay have begun dredging activities as part of the project. With approval of the project, large-scale construction will begin.

In January, 1997, the World Wildlife Fund (WWF) determined that it should become involved in assessing the validity of the HLBE and TGCC studies. The author of this paper was part of the WWF assessment group and was responsible for the review of the economic feasibility study. The purpose of this paper is to present the economic feasibility portion of that review.

The presentation is divided into three main sections. First, it summarizes the economic conclusions of the HLBE report, which is both long and confusing. By summarizing the results, it is possible to reveal both what is being concluded and how these conclusions are arrived at. Secondly, the basis for these conclusions is analyzed. Numerous errors are found in the HLBE analysis which make its conclusions highly questionable. Finally, the conclusions of this paper are summarized.

HLBE's conclusions

The HLBE report identifies the primary benefits of the Hidrovia project to be:

- reduced risk of interruptions to transportation due to low river flows; and
- reduced transportation costs due to both economies of scale from the use of larger barge trains and time savings because of round-the-clock navigation.

The primary costs of the project are the initial dredging and the annual maintenance of the channel. In

By considering construction to eliminate the risk of transportation interruptions due to low river flows as independent of other navigation improvements, HLBE introduces errors

addition, there are costs of signing to mark the channel.

The HLBE report first analyses what is called a "base case" which would eliminate what is described as the risk of transportation interruptions due to low river flows. The base case is analyzed for two reaches of the river: Asunción to Corumbá and Santa Fé to Asunción.

HLBE then analyzes a number of alternative scenarios that incrementally increase the size of the project beyond the base case. As will be noted later, this is a peculiar approach which unnecessarily introduces error into the calculations.

HLBE's base case

HLBE calculates that guaranteeing navigation would yield a benefit–cost ratio (B/C) of 2.30 and a net present value (NPV) of US$92.405 million with a 12% discount rate. The internal rate of return (IRR) is calculated to be 55%. While not explicitly saying so, HLBE uses a 12% discount rate because this is the minimum rate of return acceptable for IDB loans. HLBE concludes that the base case of guaranteeing navigation is economically feasible and acceptable to the IDB.

In evaluating the base case, HLBE considered two sub-reaches of the Paraguay River: from Asunción to Corumbá and from Santa Fé to Asunción. Given HLBE's estimates of benefits and costs, the strongest economic case for guaranteeing navigation is in the Santa Fé to Asuncion reach (IRR=115%). Guaranteeing navigation in the Asunción to Corumbá reach has considerably smaller economic returns (IRR=39%). Thus, the economic feasibility of guaranteeing navigation on the Asunción to Corumbá reach of the Paraguay River will be considerably more sensitive to errors in the measured benefits and costs.

HLBE's scenario evaluations

HLBE analyzes a total of 21 scenarios or alternative project configurations, the most important of which are discussed here. Which option is recommended by HLBE is not clear. HLBE says that it prefers one scenario for the Santa Fé to Corumbá reach, but that the CIH selected another. Then, in a separate analysis at the end of the report, an evaluation of scenarios for the Corumbá–Cáceres reach of the river (through an area called the Pantanal) is added and HLBE concludes that a scenario called B2 is preferred. However, HLBE selects scenario B2 subject to numerous qualifiers which seem to indicate a lack of enthusiasm for this option.

Preferred scenario

Of the 13 scenarios evaluated for the reach from Santa Fé to Corumbá, HLBE concludes that the scenario it calls E2E1 is preferred. This scenario would accommodate 4×4 barge trains (four barges across and four long connected together) on the Santa Fé–Asunción reach of the Paraguay River with a 3.0 meter deep channel and on the Asunción-Corumbá reach with a 2.6 meter deep channel. While HLBE calculates greater economic returns for other scenarios, E2E1 is selected because it allows barge trains of the same size to travel all the way from Santa Fé to Corumbá, thus avoiding the reconfiguring of barge trains at Asunción necessitated by other scenarios.

Selected scenario

While E2E1 is HLBE's preferred scenario, the CIH selected one called F2E1. This would accommodate 4×5 barge trains on the Santa Fé–Asunción reach with a 3.0 meter deep channel and 4×4 barge trains on the Asunción–Corumbá reach with a 2.6 meter deep channel.

The reason for CIH's selection is that it has very similar costs to E2E1, but has what they consider to be the additional advantage of allowing for larger barge trains in the Santa Fé–Asunción reach. This does not show up in terms of greater estimated benefits in the HLBE calculations.

Corumbá–Cáceres scenario

Finally, as what seems to be an afterthought, HLBE evaluates eight additional scenarios for navigational improvements in the Corumbá–Cáceres reach of the river. These are all evaluated in conjunction with the F2E1 scenario for the Santa Fé–Corumbá reach. These scenarios would accommodate 4×5 barge trains on the Santa Fé–Asunción reach with a 3.0 meter deep channel, 4×4 barge trains on the Asunción–Corumbá reach with a 2.6 meter deep channel, and 1×2 barge trains on the Corumbá–Cáceres reach with a 1.8 meter deep channel.

HLBE concludes that, if the Ferronorte railroad connecting Cuiaba to the port of Santos in Brazil is not completed before the year 2021, the scenario it calls B2 between Corumbá and Cáceres is the preferred alternative. If Ferronorte is completed prior to 2005, however, HLBE concludes that scenario B2 is not economically feasible.

Errors in HLBE's analysis

There are a number of conceptual, procedural, measurement and calculation errors in the HLBE analysis,

Table 1. Summary HLBE evaluation with basic corrections

Benefits and costs	Base case	E2E1	F2E1	B2+F2E1
Convey design				
Santa Fé–Asunción	4×4	4×4	4×5	4×5
Asunción–Corumbá	3×4	4×4	4×4	4×4
Corumbá–Cáceres	–	–	–	1×2
Channel depth				
Santa Fé–Asunción	2.0	3.0	3.0	3.0
Asunción–Corumbá	2.0	2.6	2.6	2.6
Corumbá–Cáceres	–	–	–	1.8
Navigation hours per day	18	22	22	22
	(millions US$)	(millions US$)	(millions US$)	(millions US$)
Benefits of improved navigation				
Annual 1997	0	0	0	0
Annual 1998	21.15	31.74	31.74	40.52
Annual 2016	32.69	55.78	61.12	83.11
Other benefits to development				
Annual 1997	0	0	0	0
Annual 1998	0	3.05	3.05	3.05
Annual 2016	0	8.00	8.00	12.89
Dredging and signals				
Initial	29.94	86.49	87.78	102.25
Annual	6.62	18.18	18.92	21.86
Environmental costs				
Initial	0.76	0.76	0.76	0.95
Annual 1998	0.23	0.23	0.23	0.35
Annual 2016	0.38	0.38	0.43	0.50
Net present value (NPV)	92.41	91.33	85.36	148.65
Internal rate of return (IRR)	50.62%	25.21%	21.18%	28.45%

which, when corrected significantly, alter the conclusions. The following analysis first identifies and corrects the conceptual and procedural errors and then addresses the measurement and calculation errors.

Conceptual and procedural errors

First, the HLBE analysis is conducted using its base case as the 'without project' condition. This is clearly not the case. The base case represents significant alterations to the river system and is part of the project proposed by HLBE to reduce interruptions to navigation and reduce transportation costs. By treating the base case as an issue separate from the alternative scenarios, HLBE unnecessarily confuses the analysis and, ultimately, causes errors. By subtracting the costs of the base case from the costs of the alternative scenarios, HLBE makes the scenarios look less costly than they actually are.

Second, HLBE's alternative projects or scenarios are not mere additions to the base case, but require the construction of the base case. That is, these scenarios should be evaluated in terms of all their costs and benefits. Indeed, the scenarios and the base case are interdependent projects and the correct analysis is to evaluate the NPV of each project and select the one with the greatest NPV (Sassone and Schaffer, 1978).

Third, HLBE's initial construction and annual maintenance costs for the base case scenârio differ between evaluation of the base case by itself and evaluation of the alternative scenarios. Lower costs are used by HLBE to evaluate the base case by itself, which makes it look economically more feasible. Then higher costs are used for the base case when the scenarios are evaluated, which makes the scenarios look more economically feasible.

Fourth, HLBE's calculations implicitly assume that benefits resulting from the navigational improvements will be realized while the project is under construction. Obviously, this is not the case. Benefits will be realized only after the improvements are made.

Finally, HLBE analyzes the base case for the 20-year period from 1997 to 2016, which is conventional for this type of project. However, the alternative scenarios are evaluated for the 24-year period from 1997 to 2020. The effect on the NPVs of the alternatives is not large, but this type of carelessness is indicative of much of the HLBE analysis.

Values in Table 1 are calculated from those used by HLBE, but are corrected for the errors identified so far. It can be seen that, given the values from the HLBE study, the alternative with the greatest NPV is scenario B2 in the Corumbá–Cáceres reach of the river along with scenario F2E1 in the Santa

The only environmental costs identified by HLBE are losses to fishing: the environmental scientists involved in the WWF assessment identify a range of likely environmental costs

Fé–Corumbá reach. The B2/F2E1 scenario has a NPV of US$148.65 million and an IRR of 28.45%, when the HLBE data are correctly calculated.

The alternative with the next most preferred scenario is E2E1, with a NPV of US$91.33 million and IRR of 25.21%. The third highest ranked alternative is the base case with a NPV of US$90.96 and IRR of 50.62%. The least preferred alternative should be scenario F2E1 with a NPV of US$85.36 and IRR of 24.18%. However, as will be seen in the next section, the benefit and cost values used by HLBE are often highly questionable and, when corrected, lead to very different conclusions.

Measurement and calculation errors

There are also a number of measurement and calculation errors in HLBE's benefit–cost analysis. These fall into roughly the following categories:

- probability of a collapse in navigation;
- benefits of guaranteeing navigation;
- environmental costs;
- alternative transportation of regional production; and
- growth of regional production.

Each of these will be addressed in turn.

Probability of a collapse in navigation

HLBE defines a "collapse in navigation" as occurring with river flows below two meters for three months per year (HLBE, 1996). HLBE estimates that there is currently a 40% probability of a collapse in navigation on the Paraguay River between Corumbá and Asunción and a 20% probability of a collapse on the reach from Asunción to Santa Fé. The differences in the annual transportation costs over these reaches with and without river navigation is multiplied by these probabilities to estimate the benefits of guaranteeing navigation.

The mathematics of HLBE's calculations are flawed. Moreover, the hydrological basis for HLBE's calculations is highly questionable.[2] Indeed, barge operators estimated that shipments are interrupted currently (before implementation of HPP) for a maximum of three months no more than one in five years (that is, 20% of the time) in the Asunción–Corumbá reach of the river and are never interrupted in the Asunción–Santa Fé reach (dos Santos, 1997).

Correcting HLBE's calculations using the probabilities supplied by the barge owners results in a negative net return for each of the scenarios, except for B2. With the corrected values for a probability of a collapse, scenario B2 has a NPV of US$32.74 million and IRR of 15.62%.

Benefits of guaranteeing navigation

Next is the problem of what value is lost if there is a collapse. As calculated by HLBE, the annual savings of shipping by water are lost with a collapse. This does not seem likely. For cargoes that are shipped every month of the year, the loss is confined to the months when shipping by water is not possible and the costs are simply the storage costs and any associated loss in value of the product while waiting to be shipped.

Even if, as HLBE implicitly assumes, these cargoes cannot be stored and must be shipped by alternative modes, the lost benefits are simply for the time period when alternative transportation must be used (for instance, three months), not for the entire year. Moreover, soybean production, one of the most important cargoes, requires transportation only seven months per year and this corresponds with the high water season, so that low flows are not likely to affect soybean shipments.

Correcting HLBE's calculations using a collapse period of three months results in negative net returns for all of the scenarios except for the base case. Using a three-month period for a collapse, the base case has a NPV of US$20.46 million and IRR of 17.59%, but the other scenarios have negative NPVs and IRRs below 12%.

Environmental costs

There are several problems with HLBE's estimation of environmental costs. First, the only environmental costs associated with the initial and annual dredging of the waterway identified by HLBE are losses to fishing. This seems inadequate. The environmental scientists involved in the WWF assessment, as well as earlier reports (for instance, Bucher *et al*, 1993), identify a range of likely environmental costs, which are ignored by HLBE.

Second, HLBE estimates the value of fish losses as simply the reduced value of commercial fishing. Besides the 'use' value of fish, there are other values, including the role of fish in the food chain for other wildlife, that should be considered. Even if the analysis is confined to the direct usage of fish by humans, commercial fishing is not the only use. Indeed, HLBE identifies both commercial and sport fishing values earlier in the report, but when it comes to measuring environmental costs, it only considers losses to commercial fishing. According to HLBE's own data, neglecting sport fishing has the effect of reducing the possible losses to fishing by approximately 50%.

Third, HLBE only considers the direct impacts on commercial fishing of reduced fish populations. Reduced commercial fishing catches will affect other sectors of the economy, such as restaurants and sellers of fishing equipment. Moreover, reduced incomes by commercial fishermen will reduce incomes to others from whom they buy. That is, HLBE does not account for the systemic or multiplier effects of commercial fishing on the local and regional economies. These indirect impacts are likely to be three to four times the direct impacts.

Fourth, HLBE calculates losses to commercial fishing as a linear function of the proportion of the river affected by the 'plume' (the cloud of silt in the river formed below dredging activities) from dredging. Moreover, HLBE's calculations imply that the impact of dredging has a duration of only one year. Both of these assumptions seem highly questionable and require examination by qualified scientists.

Fifth, HLBE estimates the annual value of commercial fishing to be US$34 million, but the loss to commercial fishing to be only US$0.76 million due to initial dredging and only US$0.23 million annually due to maintenance dredging. That is, the environmental losses are estimated to be only 2% of total commercial fishing value and annual losses to be less than 1% of total commercial fishing value. How this is determined is not clear from the report, but it is so small as to be practically insignificant.

Finally, HLBE assumes that the commercial fishing losses of scenarios E2E1 and F2E1 are the same as for the base case and that they are only slightly greater for scenario B2 in the Corumbá–Cáceres reach, even though these scenarios entail much more dredging than the base case. The initial dredging cost of the base case is US$25.96 million and the annual maintenance dredging cost is US$6.62 million. The initial dredging cost for scenario E2E1 of US$79.23 million is 3.05 times greater and the annual maintenance dredging cost of US$14.30 million is 2.16 times greater than for the base case. Similarly, the initial dredging cost for scenario F2E1 of US$80.52 million is 3.10 times greater and the annual maintenance dredging cost of US$15.03 is 2.27 times greater than for the base case.

The initial dredging cost for scenario B2 of US$94.83 million is 3.65 times greater than the base case, yet the commercial fishing losses estimated by HLBE are only US$0.95 million or 1.25 times greater than for the base case. The annual dredging cost for B2 is US$17.65 million or 2.67 times greater than for the base case, but annual commercial fishing losses are estimated to be only US$0.35 million or 1.52 times greater.

Moreover, HLBE's nominal value of the environmental cost for B2 is in spite of the fact that the Pantanal is broadly acknowledged to be the most environmentally sensitive and significant reach of the river. That is, dredging in the Pantanal would have broad ranging environmental costs and earlier led the Brazilian government to conclude that they would not sanction dredging in this area.

It should also be noted that the reports produced by HLBE and TGCC do not agree on the impact the project will have on fisheries. HLBE assumes very small impact, while TGCC estimates that the impact could be very serious in some reaches.

In general, HLBE's method of measuring environmental cost has the effect of minimizing its significance. While it is beyond the scope of this study to measure the dollar value of the environmental cost associated with the alternative projects, it does determine what critical value of environmental cost would make the projects unfeasible. That is, this study determines how great environmental cost has to be to judge that alternative scenarios are not economically feasible.

Using the assumptions of the HLBE study (that is, a 40% probability of a collapse on the Asunción–Corumbá reach of the river, a 20% probability of a collapse on the Santa Fé–Asunción reach and that the value of avoiding a collapse is equal to the annual cost savings of the waterway) yields a critical environmental cost of US$93.4 million for the base case, US$93.9 million for scenario E2E1, US$88.8 million for scenario F2E1 and US$152.6 million for scenario B2. That is, environmental cost would have to be 133% of dredging cost for the base case, 57% of dredging cost for scenario E2E1, 52% of dredging cost for scenario F2E1 and 76% of dredging cost for scenario B2 to judge these projects economically unfeasible.

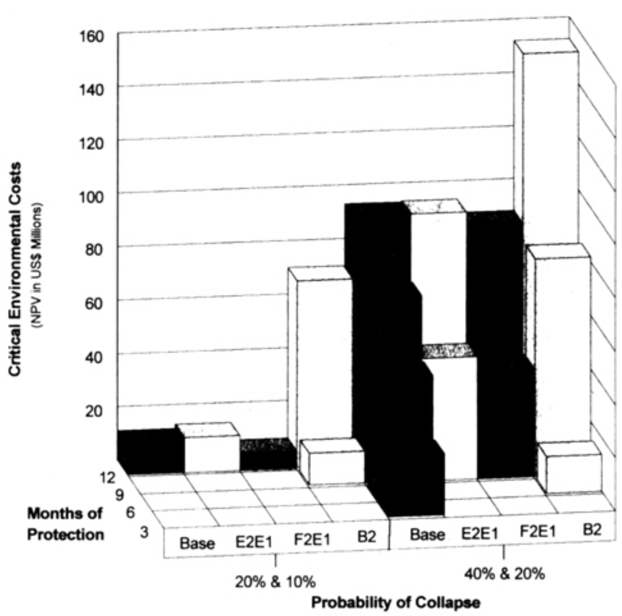

Figure 2. Critical environmental costs for project to be unfeasible with different months of protection and probability of collapse

Note: The critical environmental cost is the cost to the environment that, if included in the benefit–cost calculations, would make the NPV negative, when the discount rate used is 12%, or equivalently make the IRR less than 12%

Table 2. Critical environmental cost for project to be unfeasible with different months of protection and probability of and probability of collapse (NPV in US$ millions and % of dredging cost)

Months protected	Probability of collapse (Asuncion–Corumbá and Santa Fé–Asuncion)		
	20% & 0%	20% & 10%	40% & 20%
Base case			
3	0	0	23.2 (33%)
6	0	0	46.7 (67%)
9	0	0	69.9 (100%)
12	0	11.9 (17%)	93.4 (133%)
E2E1			
3	0	0	0
6	0	0	0
9	0	0	46.1 (28%)
12	0	13.2 (8%)	93.9 (57%)
F2E1			
3	0	0	0
6	0	0	0
9	0	0	41.0 (24%)
12	0	6.8 (4%)	88.8 (52%)
B2			
3	0	0	0
6	0	0	14.0 (7%)
9	0	12.0 (6%)	82.3 (41%)
12	0	70.3 (35%)	152.6 (76%)

However, as already seen, the assumptions used by HLBE are questionable. If the probability of a three-month collapse is 20% on the Asunción–Corumbá reach of the river and zero on the Santa Fé–Asunción reach, as estimated by barge operators, none of the scenarios is economically feasible, even if it is assumed that the value of avoiding a collapse is equal to the annual cost savings of the waterway.

Alternatively, if the value of avoiding a collapse is equal to the cost saving of the waterway for three months (that is, the duration of the collapse), then, even with HLBE's assumed probabilities of a collapse, only the base case is economically feasible. In this case, if environmental cost has a present value over the 20-year life of the project of only US$23.2 million or 33% of the dredging cost, then the base case is not economically feasible either.

Table 2 and Figure 2 summarize the critical environmental cost for different combinations of probabilities of a collapse and months of protection. Table 2 also shows the critical environmental cost as a percentage of dredging cost in order to judge the relative size of these costs in comparison with the direct project cost. The critical environmental cost is the value of losses to the environment that would make the various scenarios economically unfeasible. The critical environmental cost is in terms of its net present value (NPV) for the 20-year life of the project.

In calculating the NPV of the critical environmental cost, it is assumed that the environmental cost will be proportional to the extent of dredging and, therefore, the amount of the dredging cost.

Alternative transportation

HLBE assumes that practically all production from the region will be shipped by the waterway under the base case and scenarios E2E1 and F2E1. Specifically, it assumes that 42% of the soybean production and 100% of the iron, manganese, clinquer, pulp, and wheat production will be shipped on the waterway, as well as all imports of petroleum. There are, however, competing forms and routes of transportation that either exist currently or are likely to in the near future.

Indeed, HLBE recognizes this possibility when discussing the B2 scenario for the Corumbá–Cáceres reach. According to HLBE, completion of the Ferronorte railroad from Cuiaba to the port of Santos on the Atlantic Ocean prior to the year 2021 would result in shipments on the waterway being too small to justify the expense of dredging between Corumbá and Cáceres. The construction of this railroad was nearly completed before being temporarily stopped because of financial problems. It is this interruption in the railroad's construction that leads HLBE to speculate on the possible financial feasibility of scenario B2 through the Pantanal.

However, the Noel Company from the United States has recently purchased the São Paulo to Campo Grande portion of the railroad, has been granted a concession for the Corumbá to Bauru portion and will operate the railroad. Also, needed bridge work over the Paraná River is being completed by the Brazilian Government. Finally, ample financial backing for the project has been obtained from PREVI, the pension fund of the Banco do Brasil, so that all indications are that the railroad will soon be completed (Galinkin, 1997). That is, even in terms of HLBE's own analysis, scenario B2 is clearly not economically feasible.

Two other waterway projects will also compete with the Paraguay–Paraná Hidrovia for cargo. The Madeira–Amazon Hidrovia, which will carry cargo to the northeast, is capable of carrying 70% of the soybean production and 35.6% of the milo production from the region. The Araguaia–Tocantins Hidrovia,

HLBE's failure to consider the effects of improved alternative transportation means that comparisons are to existing not improved alternatives, and it is assumed that nearly all regional production will be captured by the waterway

Table 3. Growth of regional exports and imports

Product	Total regional exports (1,000 tons/yr)		
	1997	2020	Percent increase
Soybean	5,885	11,888	102
Iron	1,400	4,300	207
Manganese	121	121	0
Clinquer	555	1,212	118
Pulp	267	600	125
Petroleum	1,216	2,614	115
Wheat	227	616	171
Total	9,671	21,351	127

Source: HLBE (1996, Table 9.1)

which will also ship to the north, could ship 17.7% of the soybean, 7.4% of the milo and 14.6% of the other cargo from the region (Galinkin, 1997).

Improved trucking routes are also being constructed in the region. The Cuiabá–Santarém highway and the Saída para o Pacífico highway are nearly complete and will reduce both the time and cost of shipping by truck.

HLBE's failure to consider the effects of improved alternative transportation results in at least two errors. First, when calculating the transportation cost savings of the waterway, improved water transportation is compared with existing alternative road and rail transportation, even though these alternative modes of transportation are being improved too. The savings and, therefore, the benefits of the waterway will be much less than estimated by HLBE. Second, when calculating the cargo loads for the waterway, HLBE assumes that nearly all regional production will be captured by the waterway, but, with good alternatives, this is obviously not the case. Again, this leads to an overestimation of benefits by HLBE.

As seen in the previous analysis, the HLBE calculations are very sensitive to the estimates of benefits. Reducing the cargo loads captured by the waterway would have the same effect on the NPV of the project as reducing the number of months protected. Referring to Table 2 and Figure 2, a 25% reduction in cargo loads would be equivalent to the values for 9 months of protection, a 50% reduction would be equivalent to 6 months and a 75% reduction would be equivalent to 3 months.

A 50% loss of cargo loads due to competition from alternative modes of transportation would make scenarios E2E1 and F2E1 unfeasible, even without the other problems already discussed. In conjunction with the other problems, competition from the alternative transportation routes currently being completed will drastically reduce the feasibility of all of HLBE's alternative projects and probably render them unfeasible.

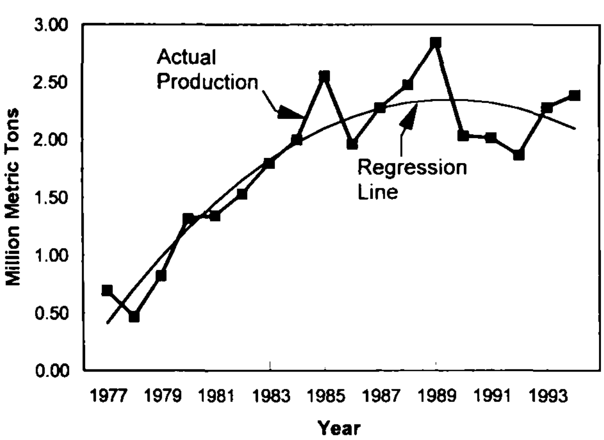

Figure 3. Soybean production in State of Mato Grosso, Brazil

Source: EMBRAPA (1998)

Growth of cargo loads

HLBE calculates the benefits of the base case and the scenarios as the savings in transportation costs they would provide over alternative transportation for a growing level of regional exports and imports. Table 3 shows HLBE's estimates of regional shipments. During the period from 1997 to 2020, HLBE predicts that regional shipments (in terms of cargo weight) will more than double from 9,671,000 metric tons to 21,351,000 metric tons, an increase of 127%. It predicts that soybean exports will increase 102%, iron ore exports 207%, clinquer exports 118%, pulp exports 125%, petroleum imports 115% and wheat exports 171%. With approximately 60% of the total, soybean shipments dominate this growth.

The high rates of growth of regional production estimated by HLBE, however, maybe more indicative of past trends than of the future. Indeed, there is increasing evidence that such rates may not be sustainable. Figure 3 is a graph of soybean production in Mato Grosso, the Brazilian state north of the Pantanal, over the 1979–94 period. After increasing rapidly during the late 1970s and early 1980s, it appears that soybean production has leveled off and may even be falling in the 1990s. The regression line in Figure 3 accounts for over 84% of the variation in the observed production levels.

Indeed, there is evidence to suggest that declining land fertility associated with the extended exploitation of tropical soils and nematode infestations are severely curtailing increases of soybean production (Galinkin, 1997). Moreover, HLBE concludes that most of the suitable areas for soybean production have already been developed, making further expansion of production unlikely.

HLBE's projection of a 3.25% annual growth rate in soybean production seems to rest on assumed increases in productivity (in output per hectare) that are not likely, given declining soil fertility and increasing pest infestations. HLBE's projections seem to correspond more with the trend in the early 1980s, but are clearly not the case for the late 1980s and the first part of the 1990s.

If HLBE's estimates of increases in regional production are incorrect, then so too must be its estimates of cargo loads and, therefore, the estimates of benefits that would accrue to the alternative projects. Again, there is reason to believe that the economic feasibilities of the alternative navigation projects identified by HLBE are questionable.

Conclusions

The consortium of consulting firms consisting of Hidroservice, Louis Berger and EIH (HLBE) conducted an economic evaluation for a total of 21 scenarios for improving navigation on the Paraguay–Paraná Hidrovia (HPP).

HLBE concluded that several scenarios are economically feasible, and from these the Comité Intergubernamental de la Hidrovia Paraguay–Paraná (CIH) selected a scenario which would accommodate 4×5 barge trains on the Santa Fé-Asunción reach with a 3.0 meter deep channel and 4×4 barge trains on the Asunción-Corumbá reach with a 2.6 meter deep channel.

HLBE also evaluated alternative scenarios for the Corumbá-Cáceres reach of the river and concluded that a scenario which would accommodate 1×2 barge trains with a 1.8 meter deep channel would be economically feasible, if the Ferronorte railroad from Cuiaba to Santos is not completed.

However, regardless of which scenario is being recommended, the analysis of this paper indicates that the economic feasibilities of all of HLBE's scenarios are highly doubtful. There are numerous errors in HLBE's evaluation, which when corrected indicate that none of the scenarios meets the minimum economic requirements of the IDB. More importantly, when HLBE's errors are corrected, the scenarios do not even produce positive net economic returns to society.

HLBE's errors systematically contribute to overestimating benefits of the project while underestimating costs. Among the most important errors in the HLBE evaluation are:

1. HLBE exaggerates the probability of a collapse in navigation and, as a result, the benefits that would be produced by avoiding such a collapse. HLBE's method of calculating the probability of a collapse is disputed by experts in hydrologic engineering. Furthermore, HLBE's predictions are contrary to accepted estimates of risk by barge operators on the river.
2. HLBE ignores competition from alternative forms of transportation, with the exception of Ferronorte. It seems to assume that the world will stand still while HPP is constructed. However, other modes of transportation are also being improved and constructed in the region. For example, it now seems clear that the Ferronorte railroad will be completed and that construction on the Corumbá–Cáceres reach of the river is not economically feasible. While HLBE recognized this possibility, it completely ignores improvements to and construction of other transportation routes in the region.
3. HLBE probably overstates the growth in shipments from the region, particularly soybean. It assumes past growth trends will continue into the future, when evidence from research groups such as CEBRAC (Fundacao Centro Brasileiro de Referencia e Apoio Cultural) indicates that past trends are not likely to continue. As a consequence, HLBE estimates cargo loads that are not likely to be possible, nor sustainable.
4. HLBE's analysis erroneously omits relevant construction costs. It assumes that a large portion of the basic cost of the project for what it calls the base case is not attributable to the project at all. In the analysis, however, the base case is an integral part of the project, and ignoring these costs is pure nonsense.
5. The HLBE analysis assumes that there will be no significant impacts to the environment, even in the Pantanal. The only environmental cost included in the economic analysis is to commercial fishing. Even the values used for commercial fishing losses are so small as to be insignificant.

   HLBE fails to include economic values for the broad range of environmental impacts identified by previous studies (Bucher *et al*, 1993). HLBE's identification and measurement of the environmental cost of the project are unacceptable by any professional standard.

The analysis of this paper shows that correcting these errors, either singly or in concert with one another, leads to an economic evaluation which does not support the HPP as proposed by HLBE. A corrected evaluation of the scenarios identified by HLBE shows negative net economic returns.

As a development project, the HPP should contribute to improving the general welfare of the population of the region. Indeed, the IDB recognizes this as one of its objectives for providing funds. Nevertheless, HLBE totally ignores the issue of the distribution of benefits and costs from the project.

While not the topic of this paper, evidence exists that the HPP will not produce a fair distribution of benefits and costs. The benefits will largely accrue to a relatively small number of already wealthy interests, while the costs will be spread more thinly over a relatively poor population. In particular, big companies involved in the construction of the project and major shippers such as large-scale soybean producers are likely to be the major gainers, while small landholders and indigenous people are likely to be made worse-off.

The HLBE economic evaluation is seriously flawed and should not be used as a basis for judging the economic feasibility of the HPP. HLBE takes such a narrow view of the project that it fails to identify and measure the relevant benefits and costs of the project correctly. Even within this narrow perspective, it makes so many mistakes that the results are not credible.

Notes

1. Hidrovia is Spanish for waterway.
2. Details of these errors are provided in the forthcoming WWF report entitled *Hydrovia Paraguay–Paraná: Facts and Fiction*.

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