ASIAN DEVELOPMENT BANK **PPA: PRC 22246**

PROJECT PERFORMANCE AUDIT REPORT

ON THE

SHANGHAI-NANPU BRIDGE PROJECT
(Loan 1082-PRC)

IN

THE PEOPLE'S REPUBLIC OF CHINA

November 1999

CURRENCY EQUIVALENTS

Currency Unit – Yuan (Y)

		At Appraisal (February 1991)	At Project Completion (June 1997)	At Operations Evaluation (May 1999)
Y1.00	=	$0.1915	$0.1201	$0.1208
$1.00	=	Y5.2221	Y8.3259	Y8.2777

ABBREVIATIONS

ADB	?	Asian Development Bank
ADT	?	average daily traffic
CSC	?	construction supervisory committee
EIRR	?	economic internal rate of return
FIRR	?	financial internal rate of return
km	?	kilometer
m	?	meter
MOS	?	Municipality of Shanghai
OEM	?	Operations Evaluation Mission
O&M	?	operation and maintenance
PCR	?	project completion report
PPAR	?	project performance audit report
PRC	?	People's Republic of China
SHRBCC	?	Shanghai Huangpu River Bridge Construction Company
SJC	?	Shanghai Jiushi Corporation
SMEDI	?	Shanghai Municipal Engineering Design Institute
SNBAO	?	Shanghai-Nanpu Bridge Administrative Office
TA	?	technical assistance
VOC	?	vehicle operating cost

NOTES

(i) The fiscal year (FY) of the Government and the Municipality of Shanghai ends on 31 December.
(ii) In this report, "$" refers to US dollars.

Operations Evaluation Office, PE-529

BASIC DATA

Shanghai Nanpu Bridge Project (Loan 1082-PRC)

PROJECT PREPARATION/INSTITUTION BUILDING

TA No.	TA Name	Type	Amount ($)	Approval Date
1049-PRC	Huangpu Bridge[1]	PP	95,000	24 Oct 1988
1152-PRC	Design Review of the Nanpu Bridge	AO	100,000	26 Apr 1989
1517-PRC	Toll Bridge Operations and Management	AO	760,000	28 May 1991
1518-PRC	Formulation of Economic Reform Policies and Infrastructure Planning for the Development of Pudong	AO	920,000	28 May 1991

KEY PROJECT DATA ($ million)	As Per ADB Loan Documents	Actual
Total Project Cost	238.00	226.88
Foreign Exchange Cost	53.70	72.56
Local Cost	184.30	154.32
ADB Loan Amount/Utilization	70.00	69.75
Loan Amount Canceled		0.25

KEY DATES	Expected	Actual
Fact-Finding	23 Nov-11 Dec 1988	23 Nov-11 Dec 1988
Appraisal	2 Feb-18 Mar 1989	2 Feb-18 Mar 1989
Follow-Up Appraisal	12-24 Nov 1989	12-24 Nov 1989
Loan Negotiations	14-17 May 1990	14-17 May 1990
Board Approval	28 May 1991	28 May 1991
Loan Agreement		26 Jun 1991
Loan Effectiveness	27 Sep 1991	9 Aug 1991
First Disbursement		20 Aug 1991
Project Completion	31 Dec 1994	30 Nov 1992
Loan Closing	30 Jun 1995	15 Mar 1995
Months (effectiveness to completion)	39	16[2]

KEY PERFORMANCE INDICATORS (%)	Appraisal	PCR	PPAR
Economic Internal Rate of Return	12.2	15.6	16.4

ADB = Asian Development Bank, AO = advisory and operational, PCR = project completion report, PP = project preparatory, PPAR = project performance audit report, TA = technical assistance.

[1] Relates to project preparation for the Nanpu Bridge.

[2] Board approval on loan effectiveness was delayed following the disruption caused by civil protests at Tianamen Square in June 1989. ADB's lending activities to the People's Republic of China were resumed in 1991.

Financial Internal Rate of Return	7.3	8.6	8.4

BORROWER People's Republic of China

EXECUTING AGENCY Municipality of Shanghai

MISSION DATA

Type of Mission

	Missions (no.)	**Person-Days** (no.)
Fact-Finding	1	57
Appraisal	1	83
Follow-Up Appraisal	1	26
Technical Review	1	16
Technical Review Follow-Up	1	18
Inception	1	7
Review	7	67
Project Completion	1	68
Operations Evaluation	1	20

EXECUTIVE SUMMARY

The Project was formulated under the Government's Eighth Five-Year Plan (1991-1995), which included efforts to develop Shanghai City and particularly the Pudong New Area on the east bank. The project objective was to expand transport capacity across the Huangpu River and thereby facilitate the development of Pudong New Area on the east bank.[1] The project scope included (i) constructing an 846 meter cable-stayed toll bridge; (ii) constructing concrete road approaches on the east and west sides of the bridge; (iii) installing facilities for toll collection, traffic monitoring, and administration; (iv) procuring equipment for construction, maintenance, and operations; (v) improving access and connecting roads; (vi) relocating housing and business amenities; and (vii) providing engineering consulting services for implementation and training. Eighty-six person-months of consulting services were provided under technical assistance (TA) attached to the loan to (i) develop bridge management and operational procedures, and (ii) formulate economic reform policies for the ongoing development of the Pudong New Area.

The Appraisal Mission was completed in March 1989, and the Follow-Up Appraisal Mission was fielded in November 1989. Civil protests in Tianamen Square in June 1989 delayed the Project from going to the Board, and the Asian Development Bank (ADB) loan of $70 million equivalent and attached TAs were not approved until 28 May 1991. The appointed Executing Agency for the Project and TAs was the Municipality of Shanghai (MOS). The Borrower was the People's Republic of China.

The Project was implemented as appraised, helped by advance procurement action and ADB's agreement to retroactively finance about $49 million. By the time the loan was formally approved, only a small section of the bridge was unfinished. The bridge was opened for traffic in December 1991, and the overall Project completed in November 1992, two years ahead of schedule.

The final project cost of $227 million was 4.7 percent less than the appraisal estimate. Total disbursements under the ADB loan of $69.75 million were $0.25 million less than the approved loan amount. The ADB loan represented 31 percent of the total project cost. Commercial cofinancing represented 21 percent and financing by MOS represented 48 percent. TA to the Project amounted to $1.875 million.

The project rationale: to help restructure Shanghai's economic base by building the first bridge across the Huangpu River helped develop the Pudong New Area as a business and financial center. Without the Project, congestion and overcrowding on the west bank would have been accentuated and the pace of economic development for the Pudong New Area slowed.

Success of the Project is shown in the operational, economic, financial, and social performance. The quality of construction was high and within the appraised cost. Beneficiary satisfaction is also high in terms of aesthetics, use, and the Project's resettlement arrangements. Current traffic volumes exceed the appraised forecast volume by nearly 200

[1] The Huangpu River divides Shanghai into east and west banks and is a busy waterway and port area for oceangoing vessels. Pudong is the whole of the area within the Shanghai Municipality on the east side of the Huangpu River. The Pudong New Area is also known as Pudong.

percent. All residents and business owners interviewed by the Operations Evaluation Mission responded they were fully satisfied with the Project's resettlement arrangements and better off than before the Project.

The Project benefited from competent consultants and a strong management team. The economic internal rate of return of 16.4 percent attests to the economic viability of the Project, and the financial internal rate of return is a satisfactory 8.4 percent. Both estimates include an investment cost of about $91 million for the resettlement of displaced businesses and residents. The attached TA 1517-PRC[2] to strengthen the toll and bridge management operations strongly influenced the way bridge operations are managed. TA 1518-PRC,[3] which aimed to strengthen the economic development policies of the Pudong New Area contributed to the general debate on the east bank's development but was of lesser influence than TA 1517-PRC due to the (i) report's poor dissemination, (ii) absence of an effective follow-up mechanism, and (iii) overpowering progress toward development when the report was released. Although there are weaknesses in project planning and design that might have been improved with the benefit of hindsight, the economic viability, financial performance, overall effectiveness, and net achievements at each project stage exceed appraisal targets, and the Project is rated overall generally successful.

Key issues for the future are the needs to (i) enhance the quality of forecasting traffic volume; and (ii) anticipate and provide for pavement maintenance and other, rather than by reactive response.

The key project lessons learned are (i) the benefits of a comprehensive and participatory approach to project preparation, particularly for addressing resettlement issues; (ii) the need to strengthen follow-up reporting systems on attached TAs; (iii) the benefits of a planned and well-coordinated housing and business resettlement scheme with adequate prior consultation with affected parties and installation of all necessary public services before relocating residents and firms; (iv) the need for a more professional approach to preparing forecasts to avoid technical underdesign; and (v) the need to ensure traffic forecasts are integrated with engineering design requirements.

Apart from administration of the loan, no follow-up action is required by ADB. MOS is encouraged to address the question of bridge congestion, and air and noise pollution within the broader context of Shanghai's traffic control policy. The Shanghai Nanpu Bridge Administration Office is encouraged to implement measures within its own range of capabilities for easing the traffic flow, such as increasing the number of tollbooths or modifying toll charges. Periodic and rehabilitative maintenance of the bridge and approaches should also be planned.

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[2] TA 1517-PRC: *Toll Bridge Operations and Management*, for $760,000, approved on 28 May 1991.

[3] TA 1518-PRC: *Formulation of Economic Reform Policies and Infrastructure Planning for the Development of Pudong*, for $920,000, approved on 28 May 1991.

I. BACKGROUND

A. Rationale

1. The Project was included as a priority under the Government's Eighth Five-Year Plan (1991-1995). The strategy for developing Shanghai was to restructure the city's economic base by removing infrastructure constraints through increasing the number of bridges and tunnels across the Huangpu River (the Nanpu Bridge was the third of these crossings);[1] constructing a new port and airport; and facilitating the development of new business and housing centers.

B. Formulation

2. The Project was formulated as part of a master plan for developing Shanghai City. Independent feasibility studies for the Project were completed under the Japan International Cooperation Agency and the Shanghai Municipal Engineering Design Institute (SMEDI) in 1988. Technical design was developed from a prefeasibility study sanctioned by the Municipality of Shanghai (MOS) in 1979. The Asian Development Bank (ADB) approved a project preparatory technical assistance (TA) in October 1988[2] and commissioned an independent technical review of the detailed design in 1989.[3] The Appraisal Mission for the Project was completed in March 1989, and the Follow-Up Appraisal Mission was fielded in November 1989. Technical review missions were completed in December 1989 and September 1990. Civil protests at Tianamen Square in June 1989 delayed the Project from going to the Board for approval, and the ADB loan of $70 million equivalent and the attached TAs were not approved until 28 May 1991. MOS was appointed the Executing Agency for the Project and TAs. The Borrower was the People's Republic of China (PRC).

C. Objective and Scope at Appraisal

3. The project objective was to expand transport capacity across the Huangpu River to help accelerate development of the Pudong New Area on the east bank.[4] The project scope included (i) constructing an 846 meter (m) cable-stayed bridge with a 423 m center span; (ii) constructing concrete road approaches of 3,754 m for the west side of the bridge, and 3,746 m for the east side; (iii) installing facilities for toll collection, traffic monitoring, and administration; (iv) procuring equipment for construction, maintenance, and operations; (v) improving access and connecting roads; (vi) relocating housing and business amenities; and (vii) providing engineering consulting

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[1] Shanghai is a major port city on the coast of the People's Republic of China. The Huangpu River, which divides the city into east and west banks, is a busy waterway and port area for oceangoing and coastal vessels. Prior to the Project, two tunnels linked the east and west banks. One tunnel was completed in 1972 and the second in July 1990. Vehicular ferry crossings were also available and transferred some 19,000 vehicles per day.

[2] TA 1049-PRC: *Huang Pu Bridge*, for $95,000, approved on 24 October 1988.

[3] TA 1152-PRC: *Design Review of the Nanpu Bridge*, for $100,000, approved on 26 April 1989.

[4] Pudong is the whole of the area within the Shanghai Municipality on the east side of the Huangpu River. The Pudong New Area is also known as Pudong.

services for implementation and training. Eighty-six months of consulting services were provided under TA attached to the loan to (i) develop bridge management and operational procedures,[5] and (ii) formulate economic reform policies for the ongoing development of the Pudong New Area.[6]

4. The Project was expected to help address the population imbalance between the east and west banks, hasten traffic flow, and reduce travel times. The quantifiable economic benefits of constructing the Nanpu Bridge were vehicle and ferry operating cost savings, time savings, and avoided investments in housing construction and additional ferries. Nonquantifiable benefits that underline the project rationale were realizing the economic development potential of the Pudong New Area, and relieving the adverse social impacts of overcrowding on the west bank. Appendix 1 provides details of the project scope and targets.

5. The Project was not expected to face any major technical risk. Because of the advanced stage of construction and approval of advance payment action, the risk of implementation delay was considered minimal. No significant environmental risk was expected, and the overall project design was considered to have incorporated appropriate steps to minimize all risks.

D. Financing Arrangements

6. The estimated total project cost (Appendix 2) at appraisal was $238 million equivalent, with a foreign exchange component of $53.7 million. The ADB loan of $70 million equivalent was to be used to cover $45.2 million of the foreign exchange cost and $24.8 million equivalent of the local currency cost. The Shanghai Jiushi Corporation (SJC), an MOS agency, was to fund the remaining foreign exchange cost of $8.5 million. Of the remaining local cost ($159.5 million equivalent), SJC was to finance 69.9 percent, and four commercial cofinanciers under the ADB complementary financing scheme were to finance 30.1 percent.[7] The foreign exchange portion of the ADB loan was to cover the foreign exchange costs associated with construction, imported equipment, consulting services, and the service charge on the loan during construction.

7. The first ADB loan to the PRC was approved in October 1987. Prior to the loan for the Project, the PRC received approval for 8 loans totaling $506 million and 37 TA grants totaling $14.1 million, including 4 TAs for the transport sector totaling $0.8 million. The Project is the second loan for the transport sector.[8] Since the approval of the loan for the Project, the transport sector (excluding ports) has received 23 loans totaling $3.5 billion and 46 TA grants totaling $22.5 million. The project loan, drawn from ordinary capital resources, provides for a repayment period of 25 years, including a grace period of 5 years, and for interest to be paid at a variable rate.

E. Completion

8. The project completion date envisaged at appraisal was 31 December 1994, and the loan closing date in the Loan Agreement was 30 June 1995 (para. 19). The project completion report

[5] TA 1517-PRC: *Toll Bridge Operations and Management*, for $760,000, approved on 28 May 1991.
[6] TA 1518-PRC: *Formulation of Economic Reform Policies and Infrastructure Planning for the Development of Pudong*, for $920,000, approved on 28 May 1991.
[7] Under the complementary financing scheme, ADB provides a guarantee to commercial cofinanciers.
[8] The first was Loan 948-PRC: *Shanxi-Xiaoliu Railway*, for $37.7 million, approved on 31 January 1989.

(PCR) released by ADB's Infrastructure Department[9] in July 1997, discusses the Project's scope, implementation, operational aspects, and development impacts. The Project was viewed as a significant accomplishment of engineering and construction management, and financially and economically viable (para. 38). When the PCR was being prepared, the average daily traffic across the bridge was nearly 50 percent more than that forecast. The attached TAs (footnotes 5 and 6) for developing bridge management operations and economic policies for the development of the Pudong New Area were also considered satisfactory. Overall, the Project was considered very successful.

9. Based on PCR details, information in ADB files pertaining to project implementation, and consultants' reports, the PCR assessment of the Project was realistic. Recommendations for follow-up included (i) establishing a separate corporate entity for operation and maintenance (O&M) of the bridge, and (ii) monitoring air and noise pollution as a base for introducing mitigating measures as necessary.

F. Operations Evaluation

10. This project performance audit report (PPAR) reviews the findings of the PCR and assesses the appropriateness of formulation and design, quality of implementation, and achievement of objectives. The PPAR presents the findings of the Operations Evaluation Mission (OEM) that visited the Project from 16-27 May 1999. Special attention is given to assessing progress on the development of the Pudong New Area against the intended supporting developments cited at appraisal. The effectiveness of TA, environmental consequences of higher traffic flows, and policy issues surrounding the underlying project objective are also pursued. The report is based on the findings of the OEM after three years of operational data; a review of the PCR, the appraisal report, and material in ADB files; discussions with ADB staff, and senior MOS officials; and interviews with beneficiaries. Copies of the draft PPAR were provided to the Government, MOS, and ADB staff concerned for review, and their comments were considered in the preparation of this PPAR.

[9] Now called the Infrastructure, Energy, and Financial Sectors Department (West).

II. IMPLEMENTATION PERFORMANCE

A. Design

11. Following the technical design of the Nanpu Bridge in 1979 (para. 2), lengthy and exhaustive reviews ensured the engineering design was sufficient to meet traffic requirements while minimizing investment costs.[1] Resettlement was conducted only after affected residents and businesses were extensively consulted. The consultation process, and taking into account beneficiary needs, appears to have been an important factor in the success of this project component. During implementation, the project scope was expanded slightly to finance additional international engineering consulting services needed for project preparation of the Yangpu Bridge Project.[2] The appraised project scope was otherwise not modified.

B. Contracting, Construction, and Commissioning

12. Management and organization of the Project was carried out with stringent monitoring and supervision. International consultants (paras. 21 and 22) were recruited under the TAs (footnotes 5 and 6) and in accordance with ADB's *Guidelines on the Use of Consultants.* Domestic consultants were recruited using local procedures for detailed design and construction supervision. MOS valued highly the domestic consultants' contribution to technical and institutional development. Although the OEM had no alternative yardstick by which to evaluate the domestic consultants' inputs, they performed well based on OEM's discussions with senior MOS officials.

13. All civil works contracts were awarded following MOS's standard local competitive bidding procedures and were acceptable to ADB. ADB financed 17 contracts, of which 6 were for the main bridge and approaches, and 11 for housing relocation. Construction was completed within a tight schedule and to a high standard, and no contractual disputes were encountered. All civil works contracts were awarded before formal loan approval (para. 14).

14. Procurement of goods and services was carried out following ADB's *Guidelines for Procurement.* ADB financed 13 contracts for supplying construction materials and four contracts for supplying equipment. The procurements executed by the Shanghai International Trust and Investment Corporation, an agency authorized to enter into contracts with foreign suppliers and consultants on behalf of MOS, were approved by ADB under either advance procurement action or retroactive financing between October 1988 and January 1991. Approvals under advance

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[1] The prefeasibility study was completed in 1983 by SMEDI, and the design proposals prepared were reviewed as a feasibility study in 1986 in collaboration with the Japan International Cooperation Agency. Project preappraisal was commissioned in December 1987 to the Shanghai Investment and Consulting Corporation. Full appraisal was commissioned in January 1988 to the China International Engineering Consulting Corporation. SMEDI had designed four cable-stayed bridges and studied in 1984 the construction of the almost identically designed Annacis Bridge in Vancouver. Separate technical reviews were carried out by Japanese and Canadian consultants engaged by ADB under TA 1049-PRC (footnote 2) and TA 1152-PRC (footnote 3).

[2] Loan 1188-PRC: *Shanghai Yangpu Bridge Project,* for $86 million, approved on 17 November 1992.

procurement action and retroactive financing totaled $49 million of which $35 million was approved prior to the Tianamen Square protests in June 1989.[3] No significant difficulties were encountered with ADB's procurement procedures, equipment performance, or quality of materials supplied. Strict inspection tests were applied to all materials and equipment as they were supplied.

15. The bridge was built according to the appraised design and construction standards.

C. Organization and Management

16. The organization and management structure for the Project, as agreed by ADB, proved effective. MOS established a construction supervisory committee (CSC) comprising senior representatives from the Municipality's agencies. Under the guidance of CSC, the Shanghai Huangpu River Bridge Construction Company (SHRBCC) was responsible for administering the Project and liaising with MOS, ADB, and consultants.[4] As of February 1999, the SHRBCC had a staff of 191 people. SHRBCC's working relationship with ADB was satisfactory. Between August 1988 and March 1997, ADB fielded 7 review missions, 1 reconnaissance mission, 1 fact-finding mission, 1 appraisal mission, 1 follow-up appraisal mission, 1 technical review mission, 1 follow-up technical review mission, and 1 project completion mission.

17. When the Project was completed, an operating agency called the Shanghai Nanpu Bridge Administrative Office (SNBAO) was established under SJC's administration with responsibility for managing bridge operations including maintenance, toll collections, and administration (para. 31).

D. Actual Costs and Financing

18. The project cost of $226.88 million was financed by MOS ($109.13 million), ADB ($69.75 million), and commercial cofinancing ($48 million). Table 1 summarizes the estimated and actual project costs. Overall project costs represent an underrun of 4.7 percent ($11.12 million) on the appraisal estimate, mainly due to savings on contingency provisions. The ADB loan represented 31 percent of the total project cost; commercial cofinancing, 21 percent; and MOS's contribution, 48 percent. ADB's attached TAs to cover consultants' fees and expenses amounted to $1.68 million. Appendix 2 provides details of project costs and financing.

Table 1: Summary of Estimated and Actual Project Costs[a]
($ million)

Item	Appraisal	Actual
Foreign Exchange Cost	53.7	31.7
Local Currency Cost	184.3	195.2

[3] More than 50 percent of the $35 million was approved for the purpose of advancing construction on residential housing for the relocation of displaced residents from where the bridge approaches were to be built. The balance was approved for the procurement of construction materials on road related civil works to ensure project construction on the bridge was not disrupted.

[4] SHRBCC was established in 1988 with an initial staff of 69, mainly from MOS's Engineering Bureau.

Total	**238.0**	**226.9**

[a] Of the total project cost, $91 million was invested in the resettlement of businesses and residents.

E. Implementation Schedule

19. The bridge opened for traffic in December 1991, one year ahead of schedule. A one-year maintenance period followed and the overall Project was completed in November 1992. Total project completion, involving improvements to access roads and relocation of housing, was planned for 31 December 1994. Early completion was a result of (i) MOS's commitment to the Project, and (ii) early completion of the approach roads and housing relocation. Appendix 3 provides details of the appraised versus actual schedules for principal activities.

F. Technical Assistance

20. Feasibility studies completed in 1983 and 1986 and technical reviews by international consultants provided the basis of ADB's appraisal. The technical reviews, including those carried out under TAs 1049-PRC (footnote 2) and 1152-PRC (footnote 3), examined the engineering designs and concluded the bridge design was technically sound. MOS experts in engineering design, construction, finance, and project management prepared project details, including those for housing relocation. Independent experts and representatives of affected businesses and families reviewed the details before ADB appraisal.[5]

21. The prime tasks of TA 1517-PRC (footnote 5), to develop appropriate management and operational procedures for traffic control, toll settings and collection, and bridge maintenance, were successfully implemented. In addition to seminars explaining recommendations, follow-up tours were arranged for key staff members to study the management systems of toll bridges in Japan, Singapore, and Thailand, and for toll machine engineering in Hong Kong, China and the Republic of Korea.[6] The engineers and staff members of SNBAO who attended the study tours and training courses have largely been retained. Their feedback to OEM on the effectiveness of the study tours and training courses was positive. The TA recommendations and operational manuals were adopted. The study tour participants found seeing the management systems for maintaining staff performance of particular benefit. Taking into account the general achievement of TA objectives, the utilization and effectiveness of operation recommendations, and the positive feedback from participants on the study tours and training courses, TA 1517-PRC is rated generally successful. The recommendations and technology transfer gained were usefully applied, and the study tours were reported to be very useful. Feedback from engineers and staff members of SNBAO who attended the training courses attests to the generally successful rating for this TA.

22. The effectiveness of TA 1518-PRC (footnote 6), completed in November 1992, was limited. MOS was unable to answer the OEM's questionnaire covering this TA, and little corporate memory of the TA remains. The study report's observations and recommendations were general,

[5] Independent reviews were obtained, among others, from the China International Engineering Consulting Corporation and the State Planning Commission.

[6] The TA study report and study tours were completed during 1991.

and without supporting proposals for attaining them. Several useful recommendations were made, some of which were implemented, but most recommendations would probably have been adopted without the TA. A State Planning Commission representative considered the report to concentrate too heavily on general strategies rather than practical proposals. The representative surmised that while the study could claim little credit for specific measures or investments, the study had generally contributed to the debate on the development of the Pudong New Area. No formal arrangements were made for distributing the report, or for discussing or following up on its recommendations. In view of the $926,000 cost of the TA and the lack of tangible impact, this TA is rated at best partly successful. Strengthening the follow-up mechanism for TA studies would help enhance their effectiveness.

G. Compliance with Loan Covenants

23. MOS's compliance with loan covenants was satisfactory apart from delays in submitting project accounts, operational reports, and completion reports. Important operational covenants relating to setting tolls were complied with.

III. PROJECT RESULTS

A. Operational Performance

24. Operational performance of the Project is assessed in terms of the volume of traffic on the bridge, time and vehicle operating cost (VOC) savings, and bridge O&M. The Project achieved all the standards and targets envisaged at appraisal.

25. The average daily traffic (ADT) on the bridge was more than 62,700 vehicles in 1997. The ADT declined to 58,900 in 1998 (because the Xupu Bridge opened)[1] but is expected to exceed 60,000 vehicles again in 1999. The ADT is 2.9 times (199 percent) the appraisal forecast of 20,930 for 1999 and represents an annual growth rate of 32 percent since 1991.[2] Daily traffic flows as high as 68,000 have been recorded.[3]

26. Passenger cars are increasingly dominating the bridge traffic, exceeding 44 percent of all traffic in 1998 compared with 16 percent in 1991. This rising share reflects an upsurge in passenger car traffic associated with increased private vehicle ownership.[4]

27. The time and VOC savings to bridge traffic in 1998 are estimated at $63 million compared with about $26 million forecast at appraisal, with both estimates valued in 1999 prices. The bridge eliminated queuing for and reduced the average crossing time by vehicular ferry from 10-15 minutes to less than 5 minutes. Before the Nanpu Bridge was opened, queuing up to 1.5 hours was common. The average distance saved per vehicle trip is about 0.6 kilometers (km).[5]

28. Bridge O&M has been satisfactory. There has been satisfactory deployment of O&M equipment, and transfer of skills and experience from domestic and international specialists. While maintenance is satisfactory to date, it has been reactive, with no planning for longer term requirements (para. 54). Traffic control and toll collections are carried out effectively.

B. Institutional Development

29. MOS, as Executing Agency, exercised its responsibility for financing the bridge and its general coordination of the development of Shanghai and the Pudong New Area through its investment arm, SJC.[6] Beyond establishing SHRBCC (the construction unit) and the SNBAO (administration unit) and providing supporting TA, the Project did not see a need for institutional strengthening of SJC or other MOS agencies associated with the Project.

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[1] The third bridge crossing after Nangpu and Yangpu (see map).
[2] Actual traffic volumes using the bridge were less than forecast for the first three years of operation.
[3] Discussion concerning design capacity and forecasts are provided in paras. 51 and 53.
[4] The rising share was anticipated at appraisal, though less dramatically.
[5] This was the appraised estimate based on an origin-destination survey undertaken in 1987.
[6] SJC operations include investments in infrastructure, banking and insurance, industrial engineering and construction, tertiary industry, and property development.

30. SJC is a well-staffed government agency with an established record of investment financing and coordination. Experience gained through the Project was reported useful for subsequent investments in the Yangpu and Xupu bridges. The technical personnel of SHRBCC gained valuable experience prior to constructing the bridge through liaison with design institutes, notably the SMEDI which was primarily responsible for the bridge design, and through supervision and quality control during construction. As the Nanpu Bridge was a new engineering concept for Shanghai, the independent designers and contractors involved in its implementation absorbed new skills.

31. SNBAO, which was set up for bridge O&M, learned largely from experience and conducts its responsibilities satisfactorily. SNBAO has introduced comprehensive training and incentive schemes and installed an adequately equipped maintenance unit. Operational targets are set to improve efficiencies and to lessen average delays for toll collection, and accident clearance. The historical charts show these operational indicators are improving. The experience and knowledge gained on day-to-day operations has also proved useful in operating other bridges.

32. Several other institutions were involved with project implementation. The Shanghai Housing Construction Bureau provided new housing for displaced residents, while the Nanmatou (Pudong) branch of the Municipal Housing Management Bureau was responsible for resettling the displaced households and maintains the properties and collects the rents. The Price Control Bureau determines both housing rents and bridge tolls subject to the approval of the Shanghai People's Congress. MOS's environmental protection unit was closely involved with the environmental aspects of design and construction and continues to finance and oversee the decorative features of the bridge and its immediate surroundings. The Planning Commission and Foreign Investment Administration were associated with the Project's attached TA (footnote 6) for formulating the economic development strategy for the Pudong New Area. The Mission was unable to interview staff members of these institutions independently (although several sent representatives to plenary meetings with the OEM), and the extent to which these institutions benefited through their association with the Project could not be reliably assessed. However, based on the overall success toward developing the Pudong, and satisfactory construction and operation of the second and third Huangpu bridges, the OEM concludes that the involvement of these institutions was effective.

C. Financial Performance

33. Appendix 4 summarizes the 1994-1998 financial statements for SJC. The project assets and operations form only part of the overall financial performance of SJC but are relevant to the Nanpu Bridge's operations. Significantly, the Nanpu Bridge assets represent less than 7 percent of SJC's total assets but about 26 percent of gross profits.[7]

34. The financial performance trend for SJC shows a growth in total assets of 18.1 percent per annum, lower growth in income revenues, and variable to static growth in gross profits.[8] Associated with these trends, short-term investments tripled from Y1.1 billion to Y3.9 billion, long-term investments increased from Y7.9 billion to Y10.8 billion, and shareholders' equity as a proportion of total assets increased from 32.2 percent to 35.4 percent. Total operating and

[7] Gross profits are defined to equal total operating and investment revenues less operating and nonoperating expenditures.

[8] Associated with variances in operating and nonoperating revenues.

investment profits before income tax as a proportion of owners' equity was a moderate 3.5 percent in 1998.

35. By way of contrast, the Nanpu Bridge assets reflect a highly profitable investment. Associated with stronger than forecast traffic growth (para. 25), toll revenues increased from Y16.3 million in 1992 to Y175.1 million in 1998, while gross operating profits increased from Y9.9 million to Y163.8 million (Table 2). Gross operating profit (before depreciation and financial charges) as a proportion of total revenues was 93 percent in 1998. Financial charges reduce this proportion to about 22 percent. Without an increase in toll rates, operating profits will continue to increase until about 2003, when maximum carrying capacity is reached. However, the future increase may be less significant in dollar values (Table 2).

Table 2: Comparison Projected versus Actual Financial Performance

Year Ending	**Projected** (Y million) Toll Revenues	**Projected** (Y million) Operating Profit[a]	**Actual** (Y million) Toll Revenues	**Actual** (Y million) Operating Profit[a]	**Actual** Operating Profit ($ million)
1992	0.0	0.0	16.3	9.9	1.8
1993	80.8	72.8	37.5	28.2	5.0
1994	84.7	75.7	77.3	62.0	7.2
1995	88.1	78.4	138.1	123.0	14.7
1996	82.9	72.4	170.6	152.0	18.3
1997	87.2	75.9	188.3	175.8	21.2
1998	91.0	78.8	175.1[b]	163.8	19.2

[a] Toll revenues minus operating expenses, excluding depreciation and financial charges.
[b] Toll revenues reduced with the Xupu Bridge's opening.

36. Toll charges per vehicle are the same to cross the Huangpu River via all bridges, tunnels, and ferries. Between December 1992 and February 1999, tolls were adjusted four times and the average toll per vehicle trip across the Nanpu Bridge increased by 7.6 percent per annum. This annual rate compares with an average annual increase in the retail price index of 11 percent per annum.[9] Although toll adjustments have not matched inflation, financial performance has been good and helped by higher than expected growth in traffic.

D. Financial and Economic Reevaluation

37. Estimates at appraisal for the Project's financial internal rate of return (FIRR) include anticipated investment costs, O&M costs for the bridge, expected toll charges (which were planned to be uniform across all crossing modes), and forecasts for the volume of traffic. For calculating the economic internal rate of return (EIRR), the appraisal adjusted the investment costs net of taxes and O&M costs to their economic equivalence. The economic benefits at appraisal were calculated considering the forecast volume of traffic; VOC savings arising from crossing the Huangpu River at higher average vehicle speeds; time savings arising from reduced queuing times and a reduced average travel distance of 0.6 km; and avoidance of housing costs, investment costs in additional ferries, and costs due to fog delays. The traffic forecasts were estimated as a function of the expected economic growth of Shanghai, trends in

[9] PRC inflation slowed considerably from 1994, and was about 8.3 percent in 1996, 2.8 percent (1997), -0.8 percent (1998) and forecast to equal -2.0 percent for 1999.

vehicle ownership, and the results of a vehicle origin-destination survey in 1987. Table 3 compares the FIRR and EIRR appraisal estimates with the PCR and PPAR reestimates.

Table 3: Overall Project FIRR and EIRR Estimates
(percent)

Item	Appraisal	PCR	PPAR
FIRR	7.3	8.6	8.4
EIRR	12.2	15.6	16.4

EIRR = economic internal rate of return, FIRR = financial internal rate of return,
PCR = project completion report, PPAR = project performance audit report.

38. The PCR repeated the approach that was adopted at appraisal and considers actual investment costs, year of disbursement, and date of bridge opening; and actual traffic volumes, and O&M costs to FY1995. The PCR's FIRR of 8.6 percent and EIRR of 15.6 percent reflect the increased traffic volumes compared with those forecast at appraisal. The OEM reestimated the FIRR and EIRR generally following the appraisal and PCR methodologies, and based on additional data covering operations during 1995-1999. The EIRR reestimate of 16.4 percent confirms the Project's economic viability. The FIRR of 8.4 percent is higher than the weighted average cost of capital[10] and confirms the Project's financial viability. Both reestimates are understated because rental returns and sales of project housing to relocated residents are not considered. Appendix 5 provides a detailed account of the methodological assumptions and workings underlying the FIRR and EIRR estimates for the appraisal, PCR, and PPAR. The insensitivity of the FIRR reestimates despite the higher than projected growth in traffic is attributed to the (i) delayed increase in traffic until after 1994 (footnote 17), (ii) faster than expected change in traffic mix,[11] and (iii) impact of lower toll charges for car traffic.[12] The change in traffic mix and the lower difference in VOC savings for cars compared with trucks also affects the EIRR reestimates.

39. Without the investment cost in resettlement, OEM's reestimate of the FIRR would have improved to 12.4 percent and the EIRR to 22.4 percent. The FIRR and EIRR are insensitive to changes in the forecast volume of traffic after 1999.[13] Without any increase in traffic, the FIRR decreases to 8.2 percent and the EIRR remains almost the same. Appendix 5, Table A5.4 provides the FIRR and EIRR sensitivities to other changes.

E. Socioeconomic and Sociocultural Results

40. By facilitating the transfer of motor vehicle traffic across the Huangpu River, the Nanpu Bridge was intended to support MOS's policies and projects for the economic and social

[10] Estimated in real terms to be about 6 percent.
[11] At appraisal, the vehicle composition of traffic crossing the river was 15.7 percent passenger cars, 66.5 percent medium and heavy trucks, 10.8 percent buses, 7 percent other, and no significant change was projected. Based on trends since and the present traffic mix (para. 26), by 2003 cars are expected to comprise 65 percent; medium and heavy trucks, 18.8 percent; buses, 12.1 percent; and other, 4.1 percent.
[12] In May 1999, the toll was Y15 for passenger cars and Y60 for medium trucks.
[13] Because the maximum vehicle carrying capacity of the bridge is reached around 2003.

development of the east bank. In addition to the Nanpu Bridge, plans included providing for more river crossings, including the Yangpu and Xupu bridges, Yananlu tunnel, and a pedestrian underpass; developing a port in Waigaoqiao; constructing a new airport; constructing a metro line linking the east and west banks; improving the trunk road network; providing a new water supply system; installing telecommunications and power facilities; and creating a resettlement program to rehouse 283,000 residents, mostly from overcrowded areas of the west bank, by 1992. The program also envisaged opening key development zones (free trade, financial, export processing, industrial, and high tech zones) locating within them foreign and domestic investment attracted by enhanced financial and tax incentives.

41. Most of these objectives have been achieved ahead of schedule. The Yananlu tunnel was opened in July 1990, the Yangpu Bridge in December 1993, the Xupu Bridge in June 1997, and the pedestrian underpass (near Nanpu) is scheduled for completion in November 1999. Major public infrastructure projects envisaged have also been completed or are near completion, most of them ahead of schedule. Started in October 1997, the first phase of the Pudong International Airport (with one runway in operation) is scheduled to be opened at the end of 1999. Road linkages between the airport and Outer Ring Road were completed in 1997 as were the improvements of the Yanggao expressway. To meet the expanded needs of residents and industry for water, the capacity of the water supply system was expanded in 1994 by 400,000 tons per day. Actual annual sales of water increased from 100 million tons in 1991 to 251 million tons in 1997. Telecommunication, power distribution, and public mass transport systems were also significantly expanded, and the Pudong metro line is being extended. The second phase of the Waigaoqiao Port was completed in 1998, raising the annual container capacity of the port to 600,000 twenty-foot equivalent unit. The new development zones (notably the free trade, financial, and export processing zones) and a high tech industrial park have also been completed or are near completion,[14] with many foreign and PRC companies, including international banks, located within.

42. Coinciding with the achievement of objectives, the gross output value of the Pudong New Area's industry increased from Y18.7 billion in 1991 to Y134.6 billion in 1997, expanding from 21 to 25 percent of Shanghai's total. The average value added per capita for the Pudong New Area increased by 12 times from Y5,274 to Y60,172. New foreign investment contracts increased from 92 to 615, rising from 18 percent to 34 percent of the total new contracts in Shanghai. By the end of 1997, more than 1,300 major industrial enterprises were operating and exports reached Y21 billion, nearly 50 percent higher than that of the previous year. Between 1991 and 1997, the population increased from 1.34 billion to 1.53 billion, a rate less than that expected at appraisal. However, retail sales of consumer goods increased from Y1.8 billion to Y16.2 billion between 1991 and 1997, increasing from 5 to 12 percent of Shanghai's total. Investment in urban infrastructure rose from Y0.8 billion to Y11.9 billion, increasing from 12 to 29 percent of Shanghai's total. Pudong New Area is now regarded as Shanghai's commercial center. More than 4,000 industrial and commercial enterprises employ about 400,000 workers. The local labor force is enjoying a steadily rising level of prosperity and plentiful employment opportunities in managerial, semiskilled, and manual occupations.

43. Immediate social effects from the Project arose from the displacement of 4,200 households and 130 businesses by the bridge construction works. The resettlement of residents was efficiently carried out. Apartment blocks were completed and equipped, and the full range of public services, such as schools, clinics, and on-site maintenance, were in place before

[14] These include the Shanghai Waigaoqiao Free Trade Zone, the Shanghai Lujiazui Financial and Trade Zone, the Shanghai Jinqiao Export-Processing Zone, the Shanghai Zhangjiang High Tech Industrial Park, and the Shanghai Wangqio Industrial Zone. In 1997, export-import trade reached $2.77 billion.

occupancy.[15] The OEM visited a resettlement site and found all residents interviewed to be totally satisfied with their relocation arrangements under the Project. Accommodation and facilities were reported to be of a much higher quality than those of the original residences, and spacious landscaped recreational areas contrast with the high density of the former residential area. When relocating, residents were offered leased accommodations of a standard determined by that of their original residences, without the alternative of cash compensation. Now that people are permitted to purchase their homes, more than half the relocated households are estimated to be taking advantage of this option. Most residents work close to home due to the ample employment opportunities in the Pudong New Area. Those that work on the west bank reported that distance or travel requirements did not inconvenience them. Resettlement is consistent with ADB's current policies and procedures for resettlement (which had not been formulated at appraisal).

44. In addition to resettling the households and businesses displaced by the bridge's construction, the Project had the broader objective of contributing to the transfer of some 230,000 people to the east bank. Statistics on progress toward this objective were not monitored and could not be reliably gauged from population statistics. The goal of reducing urban congestion on the west bank appears to have been achieved, but with faster than expected development of residential accommodations in the new west bank suburbs.

45. Businesses were also satisfactorily relocated. Compensation was paid for loss of premises and business, and enterprises searched for and leased alternative sites on favorable terms. Many relocated firms took advantage of the move to expand operations and reinvest in modern equipment. Apart from this immediate advantage, the displaced firms benefited from the improved business conditions made possible by the Nanpu Bridge. In particular, transport transit times from the Pudong New Area's industrial and export zones to Shanghai Port have been greatly reduced.

F. Women in Development

46. The Nanpu Bridge was a gender-neutral project, yielding no particular social or economic benefit to women through its implementation. Engineering institutions in Shanghai, including those directly concerned with the Project, employ a relatively high proportion of women, including women in senior positions, who benefited from the transfer of skills and experience through the Project.

G. Environmental Impacts and Control

47. Constructing the bridge had no hydraulic influence on the river. A three-year air pollution monitoring program undertaken for MOS, with regular reports to ADB, shows that pollution from vehicle emissions is above the recommended national level. Sound levels have also exceeded standard limits at some bridge measurement sites,[16] particularly at night.

48. The vehicle emission pollution is being dealt with on a municipality-wide scale. Motor vehicles must now use unleaded fuel and be fitted with clean exhaust systems. The maximum permitted vehicle life is 10-14 years according to type. These and other controls are enforced

[15] Resettlement design was conducted after consultation with affected householders.
[16] Measurements are taken at five sites on or adjacent to the bridge.

through annual vehicle tests and spot checks. MOS has also adopted a policy of reducing the current high level of annual increase in vehicle journeys to 8 percent, but this conflicts with the interests of automobile owners. Little evidence exists that this policy of vehicle restraint is being seriously implemented. Reducing noise pollution at the bridge depends on MOS initiatives.

49. Considerable expense is incurred on aesthetics. MOS takes pride in the Nanpu Bridge as a leading Shanghai landmark, and more than $0.6 million is spent annually on flower boxes, decorative lighting, and other bridge features, excluding the cost of maintaining the surrounding public gardens. Additional decoration, such as illuminating the cable stays, is planned. MOS is proposing to transfer part of this cost to the Bridge Administration Office.

H. Sustainability

50. Revenues are more than adequate to cover operating expenses (para. 35) and capital outlay for periodic maintenance and rehabilitation, such as pavement resealing and cable replacement. Without an increase in toll rates, revenues and operating profits will continue to increase until around 2003, when the maximum carrying capacity of the Nanpu Bridge is reached. The bridge is adequately managed with trained and motivated staff, and bridge O&M is considered sustainable. Traffic volume will increase with the opening of the Pudong International Airport in late 1999. Congestion is currently not a major problem, but the bridge has reached its theoretical design capacity of 60,000 vehicles per day, and increased congestion at peak hours is expected in the future.[17]

51. Operational improvement measures involving additional tollbooths, speedier toll collection procedures, and a discriminatory pricing policy attracting traffic to less heavily trafficked river crossings are measures being considered to relieve congestion. The design of the bridge and its approaches do not allow for additional capacity increases. The only long-term solution to cope with the rapidly growing traffic is additional Huangpu bridges or tunnels.[18]

52. The resettlement aspects of the Project have been concluded. Both householders and businesses are satisfied that they have been adequately provided for and no sustainability questions arise.

[17] Design capacity of the bridge is measured in engineering terms according to the load bearing tonnage. Subsequent derived estimates of vehicle carrying capacity vary from 45,000 to 60,000 vehicles per day. Based on the OEM's inspection, the practical limit is 60,000 vehicles. Without excessive queuing, SNBAO engineers currently assess the maximum carrying capacity to be 83,000 vehicles per day.

[18] An additional bridge or tunnel is planned as part of the Outer Ring Road.

IV. KEY ISSUES FOR THE FUTURE

53. **Excessive Conservatism in Design.** The Project's aesthetics, use, and extremely high beneficiary satisfaction capture important measures of the Project's success. Success is also reinforced by the deeper evaluation results for operational, financial, and economic performance. It is surprising in retrospect that proving the feasibility and economic viability of the Project (EIRR of 12.2 percent at appraisal) proved so difficult. The elements of skepticism enforced conservatism at project preparation to the point that major capacity underdesign occurred. Traffic volume exceeded the design capacity's lower limit of 45,000 only four years after opening and in 1999 is nearly 200 percent more than that appraised. The circle approaches and on-off ramps at the bridge ends restrict vehicle speeds and flow rates at peak hours, and serious bottlenecking occurs with vehicle breakdowns, and the absence of curb space. Although reliable forecasts of traffic volumes are difficult to achieve, more realistic forecasts could have helped planners anticipate the design limitations to meet traffic volumes, and the economic viability indicators would have reinforced this conclusion.[1] As the economic costs of underdesign can be significant, more professional expertise should be applied to preparing forecasts and ensuring they are integrated with engineering design requirements (and consistent with meeting least-cost development plans for further expanding traffic carrying capacity).

54. **Periodic Bridge Maintenance.** SNBAO carries out maintenance on a day-to-day reactive basis as required. These efforts have been adequate because virtually all maintenance since 1991 has been recurrent and easily financed from toll revenues. However, periodic maintenance and rehabilitation will become necessary for pavement resealing, and no formal provision has been made for this. In the interests of ensuring availability, sufficiency of funding, and correct timing of operations to minimize traffic disruption, requirements for periodic maintenance should be reviewed and scheduled appropriately.

[1] High, low, and medium scenarios could have been developed, as is generally favored when forecasting urban traffic volumes. The different scenarios would normally be used to predict the implications on design, including flow rates and capacity.

V. CONCLUSIONS

A. Overall Assessment

55. The Project benefited from competent consultants and a strong project management team. The Project's underlying rationale of removing transport constraints across the Huangpu River to stimulate the commercial and economic development of the Pudong New Area and to relieve urban overcrowding in Shanghai proved sound. However, the degree to which the Project stimulated the development of the Pudong New Area cannot be separated from the impact generated by other development programs. Regardless, the bridge has served a demand that was substantially underestimated.

56. The Project's success is captured in the high satisfaction derived by Shanghai's citizens, vehicle owners, passengers and relocated businesses; and from the evaluation results for implementation, operational, economic, social, and environment performance. Bridge construction was completed a year ahead of schedule and overall implementation two years ahead of schedule, with a saving of some $12 million (4.7 percent) on the appraised project cost. The quality of construction for the bridge, road access improvements, and new housing is high. In terms of project outcomes, vehicle use of the Nanpu Bridge currently exceeds the appraised forecast by nearly 200 percent. The relocation of affected residents and businesses was conducted satisfactorily, and all of the respondents met by the OEM felt they were better off than before the relocation. ADB's attached TA 1517-PRC (footnote 5) to strengthen the toll and bridge management operations was effective, and had a strong influence on the way in which bridge operations are managed. TA 1518-PRC (footnote 6) which aimed to strengthen the economic development policies of the Pudong New Area, contributed to the general debate on development, but was of limited influence due to (i) the report's weak dissemination, (ii) absence of an effective follow-up mechanism, and (iii) the overpowering development occurring when the report was released. Although there are weaknesses in project planning and design that might have been improved with the benefit of hindsight—considering the economic viability, financial performance, overall effectiveness, and net achievements at each stage of the project cycle measured against appraisal targets—the Project is rated overall generally successful.

57. Key issues for the future are the need to (i) enhance the quality of forecasting traffic volume so engineering underdesign does not occur, and (ii) anticipate and plan for pavement maintenance requirements, rather than by reactive response.

B. Lessons Learned

58. The key lessons learned from the Project are (i) the benefits of a comprehensive and participatory approach to project preparation (para. 11); (ii) the need to strengthen follow-up reporting systems on advisory TAs (para. 22); (iii) the benefits of a planned and well-coordinated housing and business resettlement scheme with adequate prior consultation with affected parties and installation of all necessary public services before relocation of residents and firms (paras. 11 and 43); and (iv) the need for a more professional approach to forecasting

traffic volume and understanding of the implications forecasting has on the engineering design of infrastructure projects (para. 53).

C. Follow-Up Actions

59. Apart from administration of the loan, no follow-up action is required by ADB.

60. MOS should address the question of bridge congestion, and air and noise pollution within the broader context of its traffic control policy for Shanghai. SNBAO should implement measures within its own range of capabilities for easing the traffic flow, such as increasing the number of tollbooths or modifying toll charges. Steps should also be taken to plan for periodic and rehabilitative maintenance of the bridge and approaches.

APPENDIXES

GOALS, TARGETS, INPUTS, AND RESULTS[a]

Goals/Inputs	Targets	Expected Outcomes and Impacts	Actual Outcomes and Impacts
1. Sector/Area Goal			
?? Improve transport access to Shanghai's east bank to (i) stimulate the commercial and economic development of the Pudong New Area, and (ii) relieve residential overcrowding of Shanghai's west bank	?? Reduce cost of location in and transit to the Pudong New Area to encourage relocation of businesses from the west bank, increase industrial output, and attract new foreign investment ?? Encourage resettlement of 283,000 people from overcrowded west bank ?? Open key development zones ?? Construct a new international airport with a connecting road to the Nanpu Bridge ?? Construct a second subway linking the east and west banks ?? Construct a port in Waigaoqiao ?? Construct 35 kilometers of railway connecting Waigaoqiao and Cachejing ?? Construct Yanggao Road (expressway) and Pudong Road (primary trunk road) ?? Augment water supply system, telecommunications, and power systems	?? Accelerated growth of gross industrial output, number of industrial and commercial enterprises, and new foreign investment ?? Social and cultural development resulting from relocation of residents from the bridge site and west bank in improved housing with modern amenities and ample employment opportunities	?? Visible and measurable increases in commercial activity in the Pudong New Area ?? Relocation of households and businesses from the bridge site in improved conditions ?? Resettlement of new residents to the east bank and new development in west bank suburbs ?? Envisaged new development zones completed or near completion ?? Opening of Pudong International Airport in December 1999 (ahead of schedule) ?? Other planned infrastructure, including Yanggao Road Expressway and road linkages to the Outer Ring Road completed in 1997 ?? Telecommunications, utilities, and water supply all expanded as envisaged
2. Project Goals			
?? Construct an 846 meter toll bridge across the Huangpu River, including approach roads and improvements to access roads ?? Relocate households and businesses displaced by the bridge construction ?? Attract households from overcrowded west bank areas	?? Reduce vehicle operating costs and travel times from the west bank to the Pudong New Area ?? Achieve a traffic volume on the bridge of 20,900 vehicles per day by 1999 ?? Demolish 4,200 households and 130 businesses at the bridge site and construct new apartments in the Pudong New Area ?? Support the Shanghai Master Plan of accommodating 283,000 additional people on the east bank	?? Traffic flows increased ?? Cost recovery through toll revenues ?? Provision of new housing with modern amenities ?? Resettlement of household and businesses in the Pudong New Area ?? EIRR: 12.2 percent ?? FIRR: 7.3. percent	?? Traffic volume in excess of 60,000 by 1999 ?? Toll revenues covering bridge operating expenses 15 times over ?? Achievement of business and residential relocation from bridge site to clear satisfaction of business owners and householders ?? EIRR:16.4 percent ?? FIRR: 8.4 percent
3. Project Inputs			
?? Procurement ?? Civil works (bridge construction, access road improvement) ?? Supervision ?? Demolition of premises, land acquisition, and construction of new housing ?? Technical assistance (TA) for (i) bridge operation and management, and (ii) development of an economic strategy for the Pudong New Area	?? Project costs - Bridge const. $88.69 million - Land acquisition and Relocation $98.90 million - Others (including contingencies) $50.41 million - Total $238.00 million ?? Project financing plan - ADB $70.00 million - Cofinancing $48.00 million - Borrower $120.00 million ?? Provide about 86 months of TA ?? TA financing $1.68 million	?? Project completion by 31 December 1994	?? Project completion by 30 November 1992 ?? Project costs - Bridge const. $109.82 million - Land acquisition and relocation $91.14 million - Others $25.92 million - Total $226.88 million ?? Project financing - ADB $69.75 million - Cofinancing $48.00 million - Borrower $109.13 million ?? TA financing $1.48 million

ADB = Asian Development Bank.

[a] Although some similarity in format exists, this comparison is not intended to represent a logical framework. A logical framework was not prepared for this Project at appraisal.

ACTUAL VERSUS APPRAISAL COSTS FOR THE SHANGHAI-NANPU BRIDGE PROJECT

($ million)

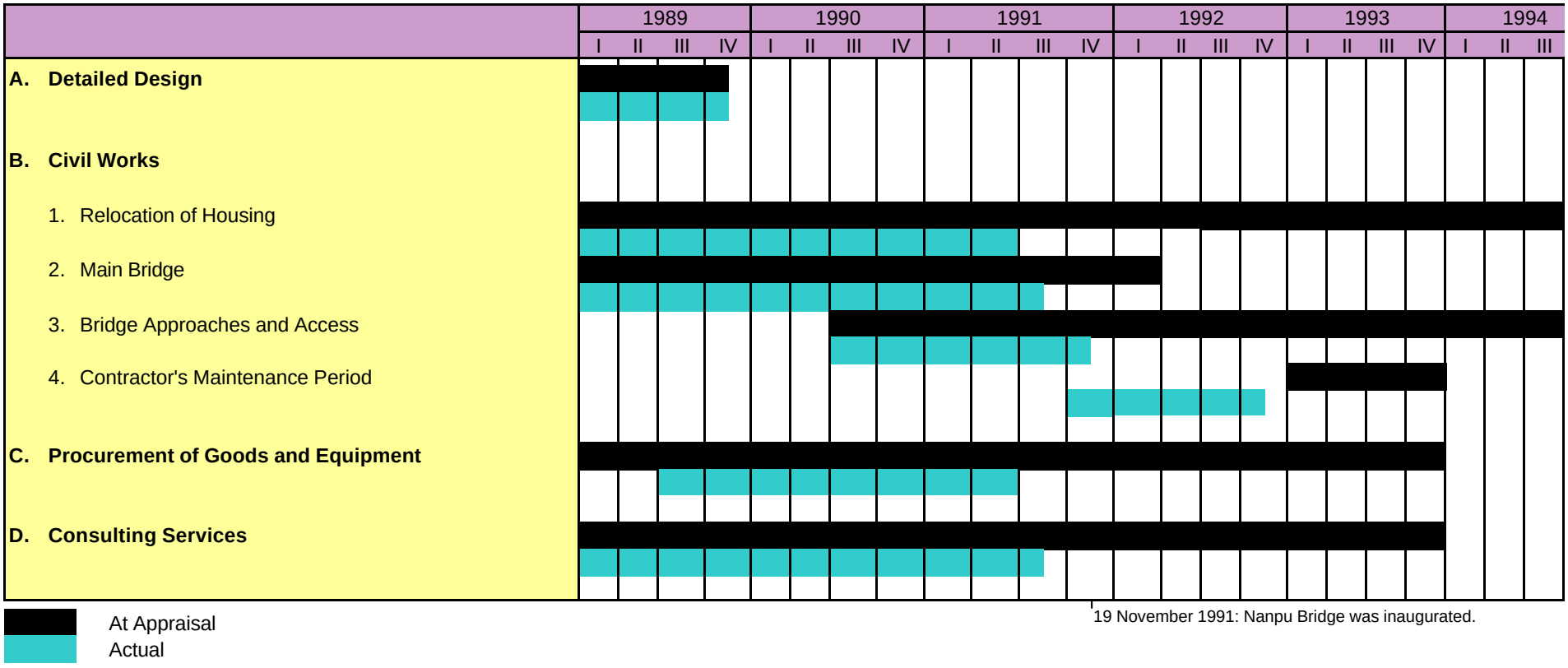
Item	Appraisal[a]			Actual		
	Foreign Cost	Local Cost	Total Cost	Foreign Cost	Local Cost	Total Cost
Implementation Costs						
Borrower-Financed	8.51	111.49	120.00	8.51	93.33	101.84
ADB-Financed	31.13	24.77	55.90	6.51	49.39	55.90
Cofinanced	0.00	48.00	48.00	0.00	48.00	48.00
Subtotal	**39.64**	**184.26**	**223.90**	**15.02**	**190.72**	**205.74**
Interest During Construction						
Borrower-Financed	0.00	0.00	0.00	2.81	4.48	7.29
ADB-Financed	14.10	0.00	14.10	13.85	0.00	13.85
Cofinanced	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal	**14.10**	**0.00**	**14.10**	**16.66**	**4.48**	**21.14**
Total Project Costs						
Borrower-Financed	8.51	111.49	120.00	11.32	97.81	109.13
ADB-Financed	45.23	24.77	70.00	20.36	49.39	69.75
Cofinanced	0.00	48.00	48.00	0.00	48.00	48.00
Total	**53.74**	**184.26**	**238.00**	**31.68**	**195.20**	**226.88**
TA 1517-PRC ($'000)						
ADB-Financed	704.00	56.00	760.00	624.00	56.00	680.00
Borrower-Financed	0.00	45.00	45.00	0.00	45.00 [a]	45.00
Subtotal	**704.00**	**101.00**	**805.00**	**624.00**	**101.00**	**725.00**
TA 1518-PRC ($'000)						
ADB-Financed	797.00	123.00	920.00	680.20	123.00	803.20
Borrower-Financed	0.00	45.00	45.00	0.00	45.00 [a]	45.00
Subtotal	**797.00**	**168.00**	**965.00**	**680.20**	**168.00**	**848.20**

ADB = Asian Development Bank.

[a] Estimates at appraisal for assistance provided in kind to meet consultant office requirements and local transport.

Source: ADB documents and mission estimates.

APPRAISAL AND ACTUAL IMPLEMENTATION SCHEDULES




IV

FINANCIAL STATEMENTS

Table A4.1: Income Statement for Shanghai Jiushi Corporation

(Y million)

Item	1994	1995	1996	1997	1998
Operating Income	879.2	1,364.8 [a]	1,258.5 [a]	934.8	993.5
Less:				549.7	682.2
Operating Cost	138.8	584.8	437.9	2.6	2.7
Business Tax	4.1	6.5	7.8	21.0	21.4
General Administrative Expenses	21.1	22.2	55.5	15.3	12.3
Financial Expenses	5.4	45.2	9.8	346.2	274.9
Gross Profit	709.8	705.4	747.6	346.2	274.9
Add:					
Nonoperating Income	0.9	[b]	0.0	307.7	363.8
Less:					
Nonoperating Expenses	0.7	1.1	0.9	0.5	1.1
Total Profit	709.6	704.3	746.6	653.4	637.6
Performance Indicators (%)					
Gross Profit/Operating Income	80.7	51.7	59.4	37.0	27.7
Total Profit/Owner's Equity	19.2	18.3	16.2	12.9	9.9
Total Profit/Total Assets	6.2	5.8	4.9	4.0	3.5

[a] Associated with liquidating property assets.

[b] Less than $0.05 million.

Table A4.2: Balance Sheet Statement for Shanghai Jiushi Corporation[a]
(Y billion)

Item	1994	1995	1996	1997	1998
Fixed Assets					
At Cost				1.16	1.33
Depreciation				0.11	0.14
Net Fixed Assets	1.55	1.41	1.31	1.05	1.19
Construction in Progress	—	—	—	—	0.54
Deferred Assets	[b]	0.00	0.00	0.00	0.08
Long-Term Net Investment	7.94	9.21	9.96	10.53	10.78
	9.49	10.62	11.27	10.53	11.40
Current Assets					
Cash	0.22	0.51	1.96	0.57	1.61
Short-Term Investments	1.09	0.84	1.73	3.35	3.86
Accounts Receivable	0.64	0.22	0.22	0.17	0.13
	1.95	1.57	3.91	4.09	5.60
Total Assets	**11.44**	**12.19**	**15.18**	**15.67**	**18.19**
Current Liabilities					
Short-Term Loans	0.09	0.30	0.50	0.00	0.00
Advances	[b]	[b]	[b]	1.87	2.28
Accounts Payable	0.80	1.30	1.82	1.77	1.67
	0.89	1.60	2.32	3.64	3.95
Long-Term Liabilities					
Loans	6.70	6.23	5.60	4.76	4.62
Accounts Payable	0.00	0.53	2.66	2.81	2.90
Other	0.16	[b]	[b]	0.21	0.26
	6.86	6.76	8.26	7.78	7.78
Owner's Equity					
Paid in Capital	2.00	2.00	2.00	2.00	3.80
Retained Earnings	0.99	1.14	1.85	3.05	2.64
Capital Surplus	[b]	[b]	[b]	[b]	[b]
Undistributed Profits	0.71	0.70	0.75	0.00	0.00
	3.70	3.84	4.60	5.05	6.44
Total Liabilities	**11.45**	**12.20**	**15.18**	**16.47**	**18.17**
Performance Indicators					
Owner's Equity/Total Assets (%)	32.3	31.5	30.3	30.7	35.4
Current Assets/Current Liabilities (ratio)	0.07	0.05	0.13	0.14	0.19
Long-Term Loans/Total Liabilities (%)	0.98	0.92	0.68	0.61	0.59
Total Profit/Total Assets (%)	6.20	5.77	4.92	3.97	3.51

— = not separated into accounts for year concerned.

[a] At 31 December.

[b] Less than Y5,000.

FINANCIAL AND ECONOMIC EVALUATION

A. Background

1. Before the Shanghai-Nanpu Bridge was opened to traffic on 1 December 1991, vehicle traffic could cross the Huangpu River at five points. Two of these were tunnels and three were ferry crossings. The Tapulu and Yananlu tunnels were about 4 kilometers (km) apart on opposite sides of the Nanpu Bridge site (see map). The Tapulu Tunnel had been in existence since 1972, and the Yananlu Tunnel was opened in July 1989. The three ferry crossings, plus a fourth at the site of the Nanpu Bridge, had been operating for many years.[1] Two of the ferry crossings were about 7 km and 16 km downriver from the Nanpu Bridge site. The third ferry crossing was about 10 km upstream from the Nanpu Bridge site. The Nanpu Bridge was opened on 1 December 1991, the Yangpu Bridge (about 12 km downstream from the Nanpu) in December 1993, and the Xupu Bridge in June 1997.

2. Before the Yananlu Tunnel was opened, waiting times of 60-90 minutes were common at the ferry crossings, and 60 minutes at the Tapulu Tunnel during peak traffic hours. After the opening of the Yananlu, congestion was less. In July 1990, the Yananlu Tunnel was reported to be operating at 83 percent of capacity. However, as average annual daily traffic volumes using all crossing facilities were increasing by about 10 percent, congestion and queuing would again become a major problem within two years. The opening of the Nanpu Bridge on 1 December 1991 provided timely relief from this problem.

B. Appraisal Methodology

3. The appraisal team considered the total volume of vehicle traffic crossing the Huangpu River, and projected the future total volume as a function of the (i) expected economic growth of Shanghai, (ii) trends in vehicle ownership, and (iii) spatial distribution growth in Shanghai. From these totals, the proportion that would use the Nanpu Bridge was calculated based on a vehicle origin-destination survey in 1987. Traffic on the Nanpu Bridge was forecast to increase from 18,424 vehicles per day in 1995 to 22,137 vehicles per day in 2000, and thereafter at 5.6 percent per year reaching 38,335 vehicles per day in 2010, and 46,074 vehicles per day in 2020.

4. For the purposes of calculating the economic internal rate of return (EIRR), the appraisal calculated benefits from the Project as the sum of the savings in ferry and vehicle operating costs (VOCs), time savings, avoidance of housing costs, avoidance of investment costs in additional ferries and associated infrastructure, and avoidance of costs due to fog delays. Savings in VOCs were calculated as a function of the average distance savings (0.6 km). Time savings were calculated in terms of saved vehicle hours per day to the economy (20 minutes per vehicle), and valued for truck and bus passenger costs based on the average number of persons travelling for business purposes, and the average wage. The ferry savings, VOC savings, and time savings were more than 95 percent of the overall benefits.

C. Project Completion Report Methodology

5. The project completion report (PCR) followed the methodology used at appraisal. Considerable differences were reported for actual traffic volumes and traffic mix.[2] Total traffic volumes across the Huangpu River were in line with historical growth increases. However, actual

[1] The fourth crossing at Nanan was closed in November 1989 following the opening in July 1989 of the Yananlu Tunnel.

[2] Actual traffic volumes using the Nanpu Bridge were higher (by 24 percent in 1995 and 60 percent in 1996) than those forecast at appraisal. The actual number of vehicles crossing the Huangpu River using the Nanpu Bridge was 56,456 in 1996 and in 1999 is in excess of 60,000.

traffic growth across the Nanpu Bridge was 35 percent per annum compared with the appraisal forecast of 3.7 percent per annum. The EIRR reestimate of 15.6 percent, compared with 12.2 percent at appraisal, reflects similar investment costs and commissioning one year earlier. The PCR also calculated an alternative EIRR of 22.4 percent, which accounted for the impact of the bridge on overall economic development (para. 17).

D. Project Performance Audit Report Approach

6. Evaluation for the Asian Development Bank's project performance audit report (PPAR) follows the general evaluation approach at appraisal but has the advantage that the actual volume and mix of traffic is known for every year since the Nanpu Bridge was opened to traffic in December 1991. The PPAR benefit-cost streams associated with the Project's actual investment are based on actual amounts for the first seven years while projections beyond 1998 are imputed with more certainty (Table A5.1). Differences between the appraisal, PCR, and PPAR are largely attributed to the volume of traffic using the bridge and the change in traffic mix. Less significant differences follow from exclusion of minor benefits such as avoided investment in ferries and housing.

(i) least cost option: is that development option where the sum of the discounted present values for capital investment, construction, operation and maintenance costs of the various alternative development options for meeting the expected growth in volume of traffic across the river is the minimum;

(ii) with-project option: is that development option which proposes to construct the Nanpu Bridge; and

(iii) without-project option: is that development option which maintains the existing means for crossing the river by ferry and tunnel and without any further investment expansion.

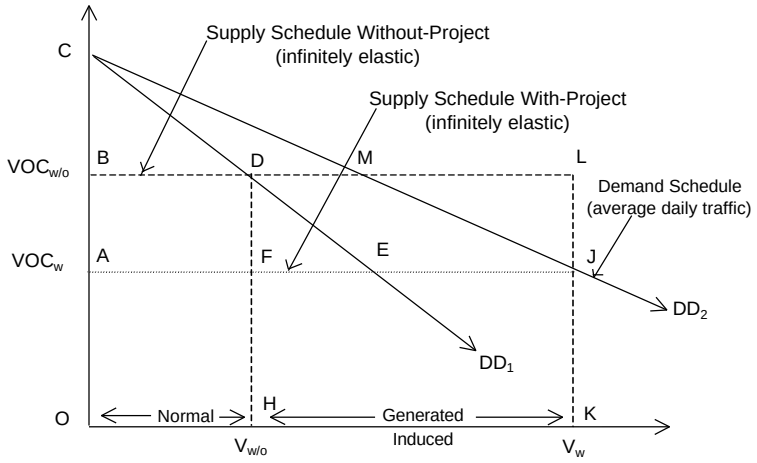
7. In relation to these assumptions, some 7,000 vehicles switched to using the Nanpu Bridge in the first year of opening.[3] This is considered the level of "normal" traffic (Figure A5.1) for which it was more beneficial to use the Nanpu Bridge on the grounds of VOC and time savings. All traffic on the Nanpu Bridge after 1991 in excess of this normal traffic volume is assumed to be generated or induced.[4] The level of 7,000 vehicles is also assumed the upper limit for the number of vehicles that could have continued to cross the Huangpu River by ferry without an increased investment capacity in ferries.

8. Traffic volumes reflect actual volumes and vehicle mixes using the Nanpu Bridge for 1992-1998. Thereafter, traffic volumes are projected to grow at an average annual rate of 7.4 percent per annum up to year 2003, when the maximum capacity of the bridge is reached.

[3] That is apart from interested vehicle operators who crossed the Nanpu Bridge as a novelty, but who would not normally use the bridge.

[4] Traffic generated may occur on account of lower VOC and time savings and other development incentives.

Figure A5.1: Economic Vehicle Operating Cost Savings for the Nanpu Bridge



Economic $Surplus_{w/o}$ = Consumer Surplus = BCD

Economic $Surplus_{w}$ = Consumer Surplus = ACJ

Net Gain in Economic Surplus = ?ACJ – ?BCD

= [ABDF] + [FDMJ + CDM]

= [gain for normal traffic] + [gain for generated traffic]

$= V_{w/o} [VOC_{w/o} - VOC_w] + R * \frac{1}{2} [VOC_{w/o} - VOC_w][V_w – V_{w/o}]$

Notes

a See para. 16 for computation formula and definitions of symbols.
b The tolls payable on ferries and for using the Nanpu Bridge are, for this approach, computed into VOCs. Tolls are a price determinant of demand, and VOCs are a price determinant of supply. Since the bridge and ferry toll is less than the VOC for each respective crossing, the VOC can also be considered a determinant of willingness-to-pay on the demand schedule.
c The VOC dimensions represent VOC per average trip. In practice, VOC per vehicle per kilometer is calculated and multiplied by the assumed average origin-destination trip length. If the average trip length differs from the with- and without-Project cases, the computation must also take this saving in VOC into account.
d The higher the level of generated traffic, the smaller MLJ is relative to CDM.
e The more parallel the shift in demand from DD_1 to DD_2 and the higher the level of generated traffic, the smaller MLJ is relative to CDM.
f Over time, the demand schedule swings out with economic growth and further induced development. Tending to counter the induced increase in demand is the limited capacity of Nanpu Bridge, leading to congestion and slower operating speeds so that VOC_w tends to increase.

9. The traffic mix for the without-Project case is represented by motorbikes 1.8 percent by volume, cars 15.7 percent, light buses 10.5 percent, heavy buses 2.3 percent, light trucks 5.2 percent, medium trucks 56.4 percent, and heavy trucks 8.1 percent. After opening the Nanpu Bridge, the traffic mix changed significantly with the increased availability of cars (Table A5.2).

Table A5.2: Vehicle Traffic and Mix

Year	Total Traffic (vehicles per day)	Vehicle Mix (%)						
		Motorbikes	Cars	Light Buses	Heavy Buses	Light Trucks	Medium Trucks	Heavy Trucks
1991 (without)	7,040	1.8	15.7	10.5	2.3	5.2	56.4	8.1
1992	8,540	8.1	18.4	10.0	2.3	5.0	48.9	7.3
1993	20,080	7.2	21.5	9.6	2.2	4.7	48.1	6.7
1995	57,930	4.8	29.4	8.8	2.1	4.3	45.0	5.6
1999	66,551	3.8	50.8	7.4	1.9	3.6	28.6	3.9
2001	79,210	3.8	62.3	6.8	1.9	3.6	18.1	3.5
2003	84,000	3.8	65.2	6.7	1.9	3.6	15.5	3.3

10. Capital costs represent a revaluation of the PCR estimates from 1995 prices to 1999, and include the cost of the main bridge, approach and access roads, equipment, operations facilities, resettlement of businesses and housing, and consulting services. The adjustment to 1999 prices is made based on (i) the change in the World Bank's manufacturer's unit value index applied to the foreign expenditure portion; and (ii) the gross domestic price deflator for the PRC applied to the local expenditure portion. For the PCR, aggregate financial investment costs (net of taxes) were disaggregated into tradables and nontradable items. Tradable items were converted to economic values using a world price numeraire for construction, skilled and unskilled labor, and nontradable items converted to economic values using a standard conversion factor of 0.926.[5]

11. Operation and maintenance (O&M) costs largely reflect labor costs. Other costs covering power and capital maintenance on vehicles and equipment are less than 20 percent of the total O&M expenditures. O&M economic expenditures are obtained after applying a composite conversion factor of 0.985 for the shadow wage rate (1.0) and conversion factor of 0.926 on nonlabor items.

12. VOC savings for normal traffic are evaluated as the VOC savings derived as a result of traveling at a faster average speed plus the savings on traveling 0.6 km less per crossing. VOC savings for generated traffic are derived as a result of traveling at faster speeds for the with-Project case. As volumes across the Nanpu Bridge increase, slower average operating speeds apply for the with-Project case (Table A5.3). Items accounted for in VOCs include fuel and oil costs, tire costs, repairs, and other for a given level of road surface improvement and terrain.[6] Toll charges are imputed under other. Base data sources are derived from surveys in 1997 for the World Bank's Highways Development Model for urban traffic conditions. The level of improvement for the with- and without-Project cases are assumed to be the same. VOCs in economic values are expressed in constant 1999 prices in yuan at the domestic price level using a shadow

[5] This resulted in project costs being higher than their financial equivalent. Table A5.2 provides the sensitivities of the EIRR to possible capital cost variations.

[6] The road surface improvement level corresponds to an internal roughness index of 2-3.

exchange rate of 1.08 for tradable cost components (fuel, oil, and tire costs). Table A5.3 provides indicators of the financial and economic base data for VOCs at different operating speeds in 1999.

Table A5.3: Financial Vehicle Operating Costs/100 km at 1999 Prices[a]

Average Operating Speed (km/h)	Motorbike	Car and Utility Vehicles	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck
20	42.8	125.3	157.1	154.9	195.6	213.1	227.8
30	32.7	94.9	118.8	133.5	145.8	151.4	190.1
50	23.9	69.1	88.8	121.4	105.1	121.3	168.6
70	23.3	67.0	85.6	124.1	94.8	120.4	167.6
90	27.8	78.2	97.0	156.7	101.8	144.0	205.2

[a] Internal Roughness Index = 2.5

13. Time savings reflect money values placed on their time by drivers and passengers when making choices between routes and modes. Time savings arise from (i) reduced queuing at the ferry and tunnel approaches, (ii) reduced average travel distance per crossing, and (iii) increased average travel speeds. Components (i) and (ii) apply to normal traffic and (iii) to normal and generated traffic. For evaluation purposes, no time savings are assumed to apply to generated traffic, the value of which compared with the alternative crossing, is assumed to be accounted for in terms of VOC savings.

14. Prior to the opening of the Nanpu Bridge, vehicles using the two tunnels took an average 20 minutes longer. For normal traffic, 70 percent of car traffic and 90 percent of other vehicle traffic are assumed for business purposes. The saving in time for drivers and passengers is valued at the average hourly wage rate for drivers, and applied to the average number of persons per vehicle. Based on statistical records for numbers of vehicles and persons (passengers) crossing the Huangpu River in 1990,[7] the numbers of passengers (including the driver) assumed crossing for commercial purposes were 1.7 for motorbikes, 4 for cars, and 11 for other vehicles.

15. For economic valuation, time savings are evaluated by assuming that the saved travel time of 20 minutes per vehicle is used for productive purposes.[8] All drivers and passengers in business cars and trucks are considered to be “paid for travel” in the course of their work based on the average annual wage of staff and workers in 1997 equal to 11,425 yuan.

16. The computational formulas applied for evaluating the project EIRR with reference to Figure A5.1 and notes a and f are as follows:

[7] Which in aggregate averaged 22 persons per vehicle.
[8] In conventional terms, this would require understanding the proportion of persons traveling and being paid in the course of work.

VOC^{i} = (normal savings) + (generated savings)

= $V_{w/o}\left[(VOC^{i}_{w/o} - VOC^{i}_{w}) + (0.6 \times VOC^{i}_{w/o})\right] + R\left[(VOC^{i}_{w/o} - VOC^{i}_{w}) + (V^{i}_{w} - V_{w/o})\right]$

TS_i = $V_{w/o} * ts_i * Vt$

where

VOC^{i} = vehicle operating cost savings in year i;
$V^{i}_{w/o}$ = volume of normal traffic without-Project in year i;
$VOC^{i}_{w/o}$ = average vehicle operating costs per kilometer without-Project in year i;
VOC^{i}_{w} = average vehicle operating costs per kilometer with-Project in year i;
$V_{w/o}$ = volume of traffic without-Project that uses the Nanpu Bridge on opening;
V^{i}_{w} = volume of traffic using the Nanpu Bridge in year i;
R = $0.5 < R$[9];
TS_i = value of time savings in year i arising from delays, ferry stoppages, and queues;
ts_i = average time savings per vehicle trip in year i; and
Vt = value of time per minute.

17. The underlying objective to facilitate development of the Pudong New Area by constructing the Nanpu Bridge prompted (in the PCR, case II), an evaluation of benefits in addition to those accounted for in terms of VOC and time savings for normal traffic. Based on studies for the correlation between infrastructure and economic growth in the PRC,[10] 27.5 percent of the growth in Pudong's share of the gross national product in 1991 (which will decline to 0.3 percent of the gross national product by 2015), was apportioned to the impact of the bridge. While this approach is conceptually valid, the added value of development benefits may not be valid given the Government's other special incentives for developing the Pudong New Area.[11] Because of the difficulties of differentiating development benefits associated with construction of the Nanpu Bridge from those already captured by the measure of VOCs, the OEM has not imputed development benefits attributed to the Project.

18. Sensitivity tests reveal that without the investment cost in resettlement, the FIRR would have improved from 8.4 percent to 12.4 percent, and the EIRR from 16.4 percent to 22.4 percent. The FIRR and EIRR sensitivity to changes in other underlying assumptions is shown in Table A5.4.

[9] For computation purposes, R is assumed equal to 0.8.
[10] Liu, Deshun. 1991. *A Comparative Analysis of Regions of China in Infrastructure and Economic Growth,* Research Institute, China People's University.
[11] These include a number of complementary development projects including resettlement, business relocations, urban development, new port and airport developments, and special foreign investment incentives.

Table A5.4: FIRR and EIRR Sensitivity to Parameter Changes
(percent)

Item		FIRR	EIRR
A.	**Base Case**	**8.4**	**16.4**
B.	**With the Following Changes:**		
	10 percent decrease in VOC (for without-Project)	—	15.9
	10 percent decrease in vehicle traffic crossing after 1999	7.7	16.3
	Increase in the conversion factor from 0.926 to 0.97	—	16.2
	Decrease in the average time savings per trip from 20 minutes to 15 minutes	—	15.0
	10 percent decrease in the assumed unit value of time	—	15.9
	10 percent decrease in toll revenues	7.7	—
	Overall Effect with all Changes	**7.1**	**13.8**

— = not applicable, EIRR = economic internal rate of return, FIRR = financial internal rate of return, VOC = vehicle operating cost.