

Economic Corridor Development for Inclusive Asian Regional Integration

Modeling Approach to Economic Corridors





Asian Development Bank



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6 ADB Avenue, Mandaluyong City 1550 Metro Manila, Philippines Tel +63 2 632 4444 Fax +63 2 636 2444 www.adb.org

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Foreword

or 2 decades, the Asian Development Bank (ADB) has assisted its developing member countries (DMCs) in reaping the benefits and lowering the costs of globalization by promoting regional cooperation and integration (RCl). ADB has also created, consolidated, and spread knowledge about RCl in Asia. Asian DMCs have strongly benefited from globalization, however in unequal measure. Within and across Asian regions, countries and areas with strong knowledge and productive capacities have experienced strong economic growth and rising prosperity, whereas their neighbors have languished. Worsening Gini coefficients in many countries are a clear indication for ADB to further spread the benefits from RCl, by improving the effectiveness of its RCl and knowledge support, as mandated in its 2006 *RCl Strategy*.

This publication records the perspectives on "Economic Corridor Development for Inclusive Asian Regional Integration" of expert speakers from different parts of the world, as they met on 16 and 17 May 2013 at ADB's Thailand Resident Mission. DMCs have been requesting ADB to conduct such "knowledge dialogues" between experts and decision makers to advise them on approaches that lead to more even, inclusive distributions of economic benefits and costs from RCI. The question underlying the entirety of this document is, "How can viable economic corridors be called into existence by dint of government and multilateral support?" The authors go about answering this question by examining the experience of economic corridor development of different regions from across continents. The resulting "action plan" highlights an evidence-based framework for the analysis of economic corridor development, which contains four "views" or elements: a policy, model, data, and organizational process view. These views constitute a hierarchy where the DMC's policy questions drive the analysis, and hence the models for successful economic corridor development. The models in turn drive data requirements, and considerations for building an appropriately rich data source drive organizational processes.

ADB's long-term strategic framework, *Strategy 2020*, mandates us to develop, mobilize, and apply "knowledge solutions" as a driver of change for stimulating inclusive economic growth across Asian regions. Going forward, such "signature knowledge" must be a clear response to priority development challenges facing DMCs, individually and collectively. This publication's focus on implementing high-quality knowledge and information systems solutions for the successful and cohesive development of regional economic corridors can strengthen ADB's reputation as a provider of signature knowledge. The application of the key findings contained in this publication can significantly enhance ADB's and the DMC's ongoing and future knowledge and investment operations.

Iwan Azis Head, Office of Regional Economic Integration Asian Development Bank

Executive Summary

On 16 and 17 May 2013, experts from around the world met in Bangkok, Thailand to present their work on economic corridors for regional economic cooperation.¹ The meeting agenda and the expert list are included in this publication. The discussions during the meeting focused on conceptual frameworks for thinking about the development of economic corridors in Asia's regions through application of economic modeling approaches. All theoretical and case study contributions written by the experts for the expert meeting are included in this publication.

Chapter 1 presents the action plan, a key output of the expert meeting in 2013. The action plan provides ADB and its clients with options for successful economic corridor investment in Asia's regions in three ways:

- 1. It outlines progress made in the expert community on a framework for evaluating alternative investments for economic corridor development. Under Strategy 2020, ADB has a mandate to identify new knowledge solutions and pilot-test them with the permission and participation of ADB's DMCs. It is increasingly clear to development practitioners that a new approach is needed to make effective use of economic geography toward the confluence of regional economic integration and inclusive growth. Large cumulative benefits not previously known by decisionmakers can become apparent when potential growth-inducing investments that raise the production potential of integrated economic and geographic areas are modeled along economic corridors. The end product from the execution of the action plan would be an interactive, evidence-based decision tool, which enables policy makers to trace the regional distribution of desired impacts from economic corridor development over the appropriate space and time.
- It establishes suitable organizational processes to meet data requirements and develop and maintain an optimal data resource management system. A comprehensive assessment of economic corridor performance over time for investment and policy decisions requires data along three parameters:

 the geographic-location-bound availability of economic resources, including human resources, natural resources, capital and financial resources, and physical resources such as infrastructure; (ii) movements over time of people, including their

¹ The ADB Charter gives "priority to those regional, subregional, and national projects and programs which contribute effectively to the harmonious growth of the region as a whole." In 2006, ADB formalized a Regional Cooperation and Integration (RCI) Strategy with four priorities: (i) improve cross-border physical connectivity, (ii) increase international trade and investment with regional and nonregional economies, (iii) contribute to regional macroeconomic and financial stability and financial market development, and (iv) improve regional environments and social conditions. "Regional integration here refers to a process through which economies in a region become more interconnected. Such economic interconnection can result from market-led and private-sector-driven actions, and/or government led policies and collective initiatives in a region. The latter—collective policies and initiatives by the governments which, in turn, could be either formally embodied in an intergovernmental treaty or informally agreed upon by the participating countries— is regional cooperation." From 2008 to 2010, ADB financing for such RCI activities amounted to over \$1.5 billion, and this figure has grown to well over \$2 billion since 2011.

services and goods (mobility of resources), since these movements have a time and economic cost dimension; and (iii) the evolving relationships of economic resources over time and through space, and the changing density of their interactions, interaction reliability, and quality. Chapter 2 will discuss issues and options surrounding data resources management. Projects as those discussed here will both use and generate extensive data, which needs to be arranged in a data catalogue to build models that will help make policy decisions and to evaluate results. A data catalogue has to be accessible. It would be best to implement the catalogue through a data portal that serves as a single point of reference. The portal set-up would be flexible enough to include data from diverse types of organizations, for instance client ministries and others. To be maintainable, the data catalogue has to provide good data descriptions (metadata). A data catalogue will be of greatest use if it avails of geospatial metadata. While openness of access is a virtue, there will be confidential data that needs to be either made anonymous or restricted to access. Long-term maintenance requires not only an institutional set-up, but also a user community that values the data.

3. It builds on the lessons learned (European Union [EU] and South Asia Subregional Economic Cooperation [SASEC]).

There are important lessons to be learned for successful corridor development from the experiences of the EU and SASEC regions. In each case, detailed models were constructed to assess the economic impact of corridor investments. The regions of Europe and eastern South Asia were split up into subregions for which data was collected and models built. Both regions also maintained detailed data on the transportation network, and of the effect of new infrastructure investment on the network. The commonalities of these two models suggest the specifications of a core data infrastructure that could support a variety of models that address the central question of corridor investment impact. The important point is that the appropriate model must be at the scale and level of detail of the EU and SASEC models.

The EU (Baltics) case in **Chapter 3** is a good example of an institutionalized process (spanning decades) for collecting data and building models to evaluate investments and support policy. The SASEC model (**Chapter 4**) was also used to prioritize investments, and additionally was at a scale that highlighted the regionally inequitable impact of corridor projects. The model was then used for the design of optimal policy, viz. to examine the possibility of using alternative transit fees for cargo that crosses through a country (to spread the benefits of the project widely).

What emerged from a consideration of these two cases (as well as broader discussions) was a framework for evidence-based policy analysis. This framework is summarized in Figure 1. We foresee a decision tool with a "policy view" that takes inputs and provides outputs at a policy-level using standard indicators and a user-friendly interface. Policy makers would, in particular, be able to specify the relevant scale (regional, national, local) and the model would be able to adjust impact assessments to this choice. The "model view" is the level at which the inner workings of the decision tool are specified (i.e. it contains the equations of the economic model). This is the logical framework within which the effects of changes in policies, whether ex ante or ex post, are calculated. The "data view" makes transparent the data resource management system underlying the model. Clearly, every model will have a corresponding set of data requirements, and the system must satisfy them. Additionally, we specify later a number of additional desirable conditions that would need to be satisfied. Finally, the data resource management system is supported by organizational processes that

institutionalize data collection, maintenance, and publishing. These different views constitute a hierarchy where policy questions drive analysis, and hence the models. The models in turn drive data requirements, and considerations for building an appropriately rich data resource drive organizational processes.





A short **Chapter 5** will bring into play global value chains as an important phenomenon of regional economic integration along economic corridors in Asia. A key strength of the model developed for the SASEC study was the incorporation of non-trivial value chains into a rigorous model of production and transportation. In principle, we can start with raw materials, end with finished products, and have intermediate stages of production spread out geographically. The final delivery of goods can be to "international markets," and inputs can be sourced from "international markets" as well. In the framework of this publication, international markets are distinct square tiles demarcated on the model-map with fixed prices and defined transportation costs from ports and other transportation hubs. In other words, we can trace the entire value chain—from raw materials to export—and clearly identify how final prices (hence competitiveness) depend upon infrastructure investments.

Such a framework can be very useful for studying a single good for which we can examine exactly the type of intervention (e.g. reducing the cost of exporting to international markets, or removing a significant transportation hurdle) that would make it more competitive in the global economy. In the SASEC study, this took the shape of conducting detailed studies of individual goods (existing or potential) in which a country could become competitive given the appropriate investments in infrastructure. The value chains were mapped out, and significant bottlenecks identified. We determined what investments were necessary to ensure that this good reaches international markets at competitive prices. We were also able to prioritize investments on the basis of the competitive advantage they would create.

A key part of the data gathering effort has to be to identify the goods in which the region has demonstrated some competitive advantage, as well as goods for which it could be competitive *given the appropriate infrastructure investments*. Under reasonable assumptions about the effect of investments on cost functions, we can simulate the outcome for the

Source: authors' own compilation.

region. We can also examine the effects of incremental stages of investments using multiple scenarios—with costs and benefits quantified by simulation.

When key policy makers and stakeholders pursue measurable outcomes for the development of regional economic corridors, the model and data framework (at a standard economic scale of relevance) allows for an investment-relevant development of scenarios, which will be monitored within an effective organizational process. Such a process, with all the elements of an evidence-based policy in place, is highly likely to generate successful economic corridor development, which would realize envisaged opportunities within the regions. Two priority regions in Asia, the Greater Mekong Subregion (GMS) and the Central Asia Regional Economic Cooperation (CAREC), face different opportunities.

The GMS (**Chapter 6**) is covered by very good spatial planning data, at numerous sector layers (for instance agriculture, energy, environment, population, tourism, transport, and urban, among others) at a very fine-grained scale. A combination with as yet missing traffic flow and trade data at a very fine-grained level opens up the exploration of opportunities to widen the existing transport corridors into economic-sector-embedded corridors. One opportunity is to invest in ecotourism corridors, which leverage the agglomeration of cultural heritage sites in the region. This could leverage several other, globally networked service-sector opportunities in turn. With such opportunity, or any other one for economic corridor development, the principle to follow is to augment the capacity in the inland poorer areas of GMS by linking them to the markets and agglomerations that support sufficient demand. These markets and agglomerations exist along coastal areas within GMS, and of course further abroad.

CAREC (**Chapter 7**) has high potential as a natural located bridge and transit region between the east of Asia and the European end of the Eurasian continent. The Russian Federation has historically been the main trading partner for Central Asian economies. Trade connections between the Russian Federation and the European Union are being strengthened and trade is intensified. Xinjiang province of the People's Republic of China (PRC) accounts now for the bulk of trade with the PRC. With the growing integration of PRC's western provinces with the east coast, the importance of PRC extending production networks into Central Asia is rising, along with opportunities to do so. Furthermore, low economic density² suggests opportunities for hub-and-spoke economic corridor development approaches.

² Defined as economic mass per unit of land area (World Bank, 2009. *Reshaping Economic Geography*. World Development Report).

Abbreviations

ADB	_	Asian Development Bank
AfT	_	Aid for Trade
ASEAN	_	Association of Southeast Asian Nations
CADGAT	_	Central Asia Data-Gathering and Analysis Team
CAREC	_	Central Asia Regional Economic Cooperation
CEP-BCI	_	Core Environment Program and Biodiversity Conservation Initiative
CFCFA	_	CAREC Federation of Carrier and Forwarder Associations
CKAN	_	Comprehensive Knowledge Archive Network
DMC	_	developing member country
EU	_	European Union
GIS	_	geographic information system
GMS	_	Greater Mekong Subregion
GVC	_	global value chain
GDP	_	gross domestic product
OREI	_	Office of Regional Economic Integration
PRC	_	People's Republic of China
SASEC	_	South Asia Subregional Economic Cooperation
SASI	_	Spatial and Socio-economic Impacts
SMEs	_	small and medium-sized enterprises
SMCA	-	Spatial Multi-Criteria Assessment
TEN-T	_	Transport- European Network Transport

Program

Dinner Reception, 19:00, 15 May 2013

Thursday, 16 May 2013		
8:45 a.m.–9:15 a.m.	Registration	
9:15 a.m.–10:00 a.m.	 Opening and introduction This session will clarify the understanding among participants of what economic corridors are and what they can and should achieve. It will outline a conceptual frame for thinking about economic corridors, and it will outline how this workshop will conceptualize a corridor development business plan through the application of a modeling approach, which prioritizes a set of corridor investments and policies—those that, in combination, yield the highest economic benefits in geographically balanced distribution. Welcome and opening addresses Craig Steffensen, Country Director Thailand Resident Mission, 8 minutes Wang Hong, Officer-in-Charge Kazakhstan Resident Mission, 5 minutes Myo Thant, Office of Regional Economic Integration (OREI), 5 minutes Participants' introductions, 12 minutes Introduction: context, objective, expected outputs, economic corridor development and monitoring framework, and meeting agenda details (H.P. Brunner, OREI, 18 minutes) 	
10:00 a.m.–10:15 a.m.	Coffee and Group Photo	
10:15 a.m.–12:15 p.m.	 Stocktaking I: Asian success, and emerging gaps. Issues: the need for economic corridors and expected success (user perspective). What can or could economic corridor development achieve? (Session Chair: Kislaya Prasad, University of Maryland and Brookings Institute) This session will take stock of approaches to economic corridor development in the GMS. It will present how the economic corridors were designed, how outcomes have been monitored, which methods are now envisaged to develop economic corridors and prioritize investments, and the advantages and disadvantages of methods. Presentation will be about variables of an economic model, the data available and needed for the measurement of outcomes, the expectation of stakeholders in terms of outcomes are and/or will be met. 	

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Program

program continued

Thursday, 16 May 2013		
	 Case Study 1: GMS corridors; Developing and widening regional backbones on land (expert presentation). Resource person: Lothar Linde. (45 minutes) Panel discussion on issues. Five priorities and how to achieve in GMS. Led and moderated by Vichelle Roaring, Thailand Resident Mission: Sumitra Pooltong, National Economic and Social Development Board (10 Minutes) Poon Thengburanathum, Chiang Mai University (8 minutes) Ruth Banomyong, Thammasat University (8 minutes) James Gilbert, Australian Government Overseas Aid Program, and Declan Magee, the United Kingdom's Department for International Development, on stakeholder expectations, multilateral, bilateral support and perspective (7 minutes each). General discussion (30 minutes) 	
12:15 p.m.–1:30 p.m.	Lunch	
1:30 p.m.–3:30 p.m.	 Good practices and lessons learned from relevant regional and international initiatives This session will detail the experience of opening the European market to the Baltic economies through economic corridor development. 'The Socioeconomic and Spacial Impacts (SASI) Model' will be presented in detail—how it has projected geographically fine-grained results from subnational investment programs (how it works, what it does). With the model, an ex post evaluation of outcomes from the investment program will be presented. Discussion will follow on the weaknesses and strengths of the model approach, and the relevance of such approach for the CAREC situation will be outlined. What are the time, data, and resource implications of using this kind of approach for the CAREC situation? Case Study 2: The Baltics in the EU—Structural investment within regional cohesion (Wim Spit, Ecorys, 45 minutes) Transit model in the EU (10 minutes—ADB) Discussion, Moderator Kislaya Prasad (45 minutes) 	
3:30 p.m.–3:45 p.m.	Coffee	

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program continued		
3:45 p.m.–6:15 p.m.	Data and scenario developer perspective	
	(Session Chair: Giuseppe Maggiore, ADB)	
	This session will set out the data framework and standard needed to apply the preferred modeling method and approach to economic corridor development. The SASEC experience will describe in detail the hybrid economic geography model employed, and what results this approach can yield over and above more traditional computable general equilibrium approaches (especially with respect to the geographic distribution of income, trade, and productivity benefits and/or costs; and nonlinear calculations of spillover, scale, and agglomeration effects for a region). What economic corridor development scenarios could be envisaged with this method in CAREC?	
	 Case Study 2: The EU data framework and model scenarios—reality check (Wim Spit, 25 minutes) Case Study 3: The SASEC experience, data protocol and model scenarios (expert consultant, Kislaya Prasad, 45 minutes) Open Discussion I: Scoping of scenarios from modelers' perspective (discussion co-chaired by international expert, Wang Hong, ADB CAREC, and Sabrina Varma, Australian Government Overseas Aid Program, 45 minutes) 	
	Dinner hosted by ADB	
Friday, 17 May 2013		
9:00 a.m.–10:30 p.m.	Stocktaking II: CAREC	
	(Session Chair: Craig Steffensen, ADB)	
	This session and following will present the plan for the application of a regional model, based on the key findings from the workshop interaction with experts. Most important is to determine the specific modeling approach to adopt, the resource inputs and data required, and how to explore possible investment scenarios to build up economic corridors in CAREC on a detailed geographic scale, in terms of finding the combination of investments yielding the highest combined benefits in a regionally balanced geographic distribution. What is the economic corridor development story for CAREC that is likely to best fulfill key stakeholder expectations?	
	CAREC model phase I (D. Roland-Holst and G. Sugiyarto, ADB Economics and Research Department presentation on what will come from it, 30 minutes) Case Study 4: CAREC economic corridors—Bringing the economic corridors in from the cold? (Roman Vakulchuk) (30 minutes) Discussion, moderated by Hans-Peter Brunner, OREI (30 minutes) Presentation by Mark Goh, National University of Singapore, on logistics.	

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program continued

Friday, 17 May 2013		
10:45 a.m.–12:15 p.m.	 Open discussion II: Implementation plans (chaired by Kislaya Prasad); breakout groups. Moderated by Mark Goh (focus on production chains, flow of resources and logistics) Vichelle Roaring (focus on economic resources and geographic distribution) Lothar Linde (focus on dynamics in geography, simulation scenarios) Giuseppe Maggiore, ADB Office of Information Systems and Technology (OIST) on knowledge tools 	
12:15 p.m.–1:30 p.m.	Lunch	
1:30 p.m.– 2:00 p.m.	Summary of open discussion I and II (Mark Goh, Vichelle Roaring, Lothar Linde, Giuseppe Maggiore, 5 minutes each).	
2:00 p.m.– 3:00 p.m.	Data collaborative forum: Data protocol implementation and maintenance (chaired by Giuseppe Maggiore, ADB) Presenter: Velichka Dimitrova and Mark Wainwright, Open Knowledge Foundation.	
3:00 p.m.–3:15 p.m.	Coffee	
3:15 p.m.–4:15 p.m.	Conclusion and follow-up plans (chaired by H. P. Brunner, OREI) (from workshop discussions, what is the outcome, including objectives and activities, technical approaches, respective roles of experts and/or partners, institutional arrangements, and timeline of activities)	
4:15 p.m4:30 p.m.	Meeting closure (Craig Steffensen, Country Director ADB Thailand Resident Mission, Wang Hong, Officer-in-Charge, ADB Kazakhstan Resident Mission, Guntur Sugiyarto, ADB Economics and Research Department, Myo Thant, ADB OREI, about 3 minutes each)	

Profiles

Willem Jacob Spit is a senior partner at Ecorys Netherlands. He has Master of Arts degree in Economics from the State University Groningen in the Netherlands. His key qualifications are: i) broad management expertise, in companies and projects; ii) team leadership experience as senior transport economist in studies on the transport policy, transport sector, and infrastructure development, covering freight and passenger transport, by inland waterways, roads, railways, coastal shipping and maritime shipping and seaports; iii) specialty in policy assessment, demand analysis, financial analysis, and economic appraisal of investment projects; advice on transport sector policies, including charging, market regulation, transport infrastructure planning; monitoring and evaluation, including ex ante and ex post evaluation; and iv) participation in multidisciplinary teams for intermodal transport feasibility studies.

Farrukh Irnazarov is country director and researcher at Central Asian Development Institute in Tashkent, Uzbekistan. He is in charge of several research projects on economic development, labor migration, regional trade, and transport issues in Central Asia. He is also completing his Ph.D. in Institutional Economics at University of Groningen, the Netherlands and serves as Affiliate Fellow at the Centre for Economic Research and Graduate Education, Czech Republic. In 2012 he was visiting scholar at Johns Hopkins University, School of Advanced International Studies, Washington, D.C., United States.

Roman Vakulchuk is country director for Kazakhstan, Cofounder of the Central Asian Development Institute in Almaty, Kazakhstan and Bishkek, Kyrgyz Republic. He is also guest researcher at the Norwegian Institute of International Affairs in Oslo, Norway. His interests are in trade competitiveness and the transport sectors in Kazakhstan and Uzbekistan, among others. He is currently pursuing a Doctor of Philosophy Degree in Economics at Jacobs University in Bremen, Germany.

Mark Goh is associate professor of the National University of Singapore and director of industry research at the Logistics Institute–Asia Pacific. He focuses on supply chain management and modeling, and developing logistics hubs, among others. He obtained his Ph.D. in 1987 from the University of Adelaide and his Masters of Business Administration in 1993 from Deakin University.

Lothar Linde is spatial planning and geographic information systems specialist in the Greater Mekong Subregion Environment Operations Center in the project office of Core Environment Program and Biodiversity Conservation Corridors Initiative (CEP-BCI) at ADB. He is task leader of the spatial planning and knowledge management subcomponents of the CEP-BCI, including program development and activity design, supervision of international and national consultants, design and implementation of analytical models and web-based knowledge tools. He earned his Master of Science in Geography at the University of Leipzig.

David Roland-Holst is computable general equilibrium economist at the University of California, Berkeley. He undertakes economic analysis of climate change impact and adaptation policies using multiregional computable general equilibrium framework covering participating countries. He obtained his doctorate and his Master of Science degree from the University of California, Berkeley.

Velichka Dimitrova is project manager for the Open Economics, Open Knowledge Foundation in London. She manages the Alfred P. Sloan Foundation-funded project about advancing collaborative and interoperable research in the economics profession. She has a Master in Philosophy in Environmental Policy from the University of Cambridge, UK.

Mark Wainwright is community coordinator of the Comprehensive Knowledge Archive Network (CKAN) software application at the Open Knowledge Foundation. He obtained his Bachelor of Arts in Mathematics, as well as a Masters of Philosophy at Trinity College, Cambridge.

Kislaya Prasad is director of the Center for International Business Education and Research, and research professor at the Robert H. Smith School of Business at the University of Maryland, College Park. He is also guest scholar at the Brookings Institution in Washington, D.C. He works on game theory, the complexity of choice under uncertainty, and the innovation and diffusion of technology. For ADB he has led a team of experts from Applied Agents, LLC and the Johns Hopkins Advanced Computing Center working on 'agent-based' economic geography models used to compare integrated regional investment scenarios. He has a Doctor of Philosophy degree in Economics, and Master of Science degree in Computer Science from Syracuse University.

Hans-Peter Brunner is senior economist at the Office of Regional Economic Integration (OREI) at ADB. He obtained his doctorate in 1990 in Political Economy from the University of Maryland, College Park, and he has a Master of Arts in International Relations from Johns Hopkins and a Masters of Business Administration from the Free University of Berlin. He has worked in South Asia and Southeast Asia investment operations with ADB. Prior to ADB, he worked with the Government of Germany on reunification strategies. His current work focuses on trade facilitation; the development of intermodal transport and logistics facilities for regional and global production chains; and the application of an economic geography and network modeling approach to regional economic integration investment strategies.

1

How to Make Economic Corridors Work in Asia's Regions?

Action Plan

Investments in developing economic corridors are increasingly thought to play a key role in the balanced economic development of lagging regions.¹ The focus of the workshop was to outline a conceptual frame for thinking about economic corridors and conceptualizing a corridor development business plan through the application of a modeling approach and data framework, which helps prioritize a set of economic corridor investments and policies—those that, in combination, yield the highest economic benefits in geographically balanced distribution. The Asian Development Bank (ADB), under Strategy 2020, its long-term strategic framework, has a mandate to identify new knowledge solutions and pilot-test them with the permission and participation of developing member countries (DMCs).² Further, ADB's *Knowledge Management Directions and Action Plan (2013–2015)* encourages the integration of information assets in ADB into a "data library" and initially makes them easily accessible to ADB staff and member countries and later to the public. Following this mandate, this paper will summarize the output of the workshop, and outline a follow-up action plan to:

- 1. build on lessons learned from the European Union (EU) and South Asia Subregional Economic Cooperation (SASEC);
- 2. progress on a framework for evaluating alternative investments for economic corridor development investments; and
- 3. establish suitable organizational processes to meet data requirements and develop and maintain an optimal data resource management system.

With this frame in line, it is opportune to explore opportunities for applying investments to pilot economic corridors (Greater Mekong Subregion (GMS), Central Asia Regional Economic Cooperation (CAREC), and elsewhere). Such a frame is urgently needed in light of two important themes that emerged at the workshop:

1. Several criteria are used to justify the funding of corridor projects (such as positive effects on incomes and employment, reductions in poverty and regional disparities,

¹ For a detailed explanation of economic corridors, see the following working paper by ADB's Office of Regional Economic Integration (OREI): ADB. 2013. *What Is Economic Corridor Development and What Can It Achieve in Asian Regions?* Manila.

² ADB. 2013. Knowledge Management Directions and Action Plan (2013–2015). Manila.

etc.). Subsequently, there is a need to determine if these benefits have materialized and if things are going according to plan. For this, the data needs to permit calculation of indicators that allow us to assess whether the potential and actual impact of corridors are being realized (i.e., in terms of the criteria used to justify the projects).

2. The models and data need to be at scales that permit a detailed assessment of the geographic distribution of project benefits and/or costs. The concern about a balanced distribution of benefits is especially pertinent in circumstances where benefits and costs are unevenly spread across borders (whereby some countries find themselves "transit countries," providing benefits for others but not realizing gains themselves). In the latter situation, the models can be a critical input in devising policies that spread benefits as widely as possible, and so in obtaining buy-in from all countries that are party to an economic corridor.

Lessons Learned (European Union and South Asia Subregional Economic Cooperation)

There are important lessons for successful corridor development to be learned from the experiences of the EU and SASEC regions. In each case, detailed models were constructed to assess the economic impact of corridor investments. The larger regions benefiting from the projects were split up into relatively small subregions for which data was collected and models built. Both also maintained detailed data on the transportation network, and on the effect of new infrastructure investment on the network. The commonalities of these two models suggest the specifications of a core data infrastructure that could support a variety of models that address the central question of corridor investment impact. Such a data infrastructure could support multiple models—the important point is that the appropriate model must be at the scale and level of detail of the EU and SASEC models.

The EU case is a good example of an institutionalized process (spanning decades) for collecting data and building models to evaluate investments and support policy. The SASEC model was also used to prioritize investments, and was at a scale that highlighted the regionally inequitable impact of corridor projects. The model was then used for the design of optimal policy, viz. to examine the possibility of using alternative transit fees for cargo that crosses through a country, to spread the benefits of the project widely.

What emerged from a consideration of these two cases (as well as broader discussions) was a framework for evidence-based policy analysis. This framework is summarized in Figure 1.1. We foresee a decision tool with a "policy view" that takes inputs and provides outputs at a policy-relevant level, using standard indicators and a user-friendly interface. Policy makers would, in particular, be able to specify the scale (regional, national, local) and the model would be able to adjust impact assessments to this choice. The "model view" is the level at which the inner workings of the decision tool are specified (i.e. it contains the equations of the economic model). This is the logical framework within which the effects of changes in policies, whether ex ante or ex post, are calculated. The "data view" makes transparent the data resource management system underlying the model. Clearly, every model will have a corresponding set of data requirements, and the system must satisfy them. Additionally, we specify later a number of additional desirable conditions that would need to be satisfied. Finally, the data resource management system is supported by organizational processes that institutionalize data collection, maintenance, and publishing. These different views constitute a hierarchy where the policy questions drive the analysis, and hence the models. The models.

in turn, drive the data requirements, and considerations for building an appropriately rich data resource drive organizational processes.



Figure 1 A Framework for Evidence-Based Policy Analysis

Evidence-Based Policy

For successful economic corridor development, implementation of an evidence-based policy framework is needed in a step-by-step plan spanning the next 6 to 18 months. Evidence-based policy requires an ex ante and ex post evaluation of opportunities. To make economic corridors work, four aspects, or views, of evidence-based policy must be implemented together to complement each other for success; policy, modeling, data, and organizational process. The proposed *framework* has sound theoretical and empirical foundations, yet is focused on the practical task of deciding among alternative projects—and so can provide key input to policy makers. The simulation of investment scenarios can point policy makers to options for balancing a benefit-pay-off matrix across administrative and/or political units of an economic corridor bottlenecks and hurdles for the region's economic development.

Policy View

There could be multiple indicators and measures of value for public projects (growth rates, outputs of specific industries, incomes in the region, impacts on vulnerable populations, etc.) and of cost (dollar cost of a project, environmental impact, etc.). Policy is implemented on varying scales: there are local, national, and regional policy views. Policy makers represent competing views and interests at these levels. The scale of the policy can dictate its policy view, and policy makers can disagree with each other. Especially at a supranational, regional level, the importance of regional integration in reconciling conflicting policy views is paramount for the success of regional economic integration and economic corridor development. The collective action problem tends to increase with scale.

As an example, let's take the transport sector in isolation. The value of transportation infrastructure investment lies in its enabling the faster and cheaper movement of goods and people. The first order effect of this is on the delivered prices of goods—goods produced in remote regions can be brought into world markets at more competitive prices

Source: Authors' own compilation.

(but equally, regions "protected" from competition by bad transportation infrastructure are opened up). The acceleration in transportation is also likely to affect the decisions of people in the region—for instance, in the location of economic activity. Consumption could become further removed in distance from the sources of production, and resources could be repurposed to produce goods for trade.

There are also very important secondary effects that need the attention of policy makers. The most significant secondary effects are likely to arise from the better integration of previously remote locations to economic centers (and hence into the regional and world economy). It is anticipated, in particular, that transport infrastructure investments are complementary to the development of clusters of excellence that can effectively take advantage of agglomeration and scale economies. Negative effects can however, overwhelm positive externalities like agglomeration and scale effects, if a remote region is opened up while it has little if any economic capacity to compete in markets. Then a region can be dominated by 'transit,' which depletes its resources and allows emigration of talent. It is desirable that we capture all of these effects, and the framework discussed at the workshop will enable us to do so.

Model View

Models are decision tools for policy makers. To be effective they have to reflect the geographic scale of the decision impact. Decisions can be made based on ex ante simulations of impact scenarios, and on ex post evaluations of previous interventions. To capture change over time, models are dynamic, i.e. they include a time dimension. They are modular and can be extended when demands for new indicators of success emerge.

For instance, the way that production, consumption, and trade patterns are affected by the transport infrastructure will eventually need to be answered using a simulation model in which economic decision-makers (principally producers, consumers, workers, entrepreneurs, and traders) make choices that take into account the costs and benefits of transportation alternatives. The choices include (a) what goods to produce, (b) what goods to consume, (c) what inputs to source and from whom, (d) where to locate production, and (e) what markets to participate in. As mentioned above, the economy would be spatially disaggregated and located in the real geography of the region in question. So we can imagine the local economy of a small subregion, connected via a transportation network with other such subregions, larger economic centers, the region, and the world economy. Details at the level of small administrative areas would allow us to specify how the local economies function, and how they interact with the rest of the world (before and after the intervention). The final fully-calibrated simulation model will capture both spatial and dynamic patterns of economic activity.

Once such a model is developed, we will have a tool that can be used to compare the regional economy before and after the infrastructure investment, and to measure the value of the project. Weighing the costs and benefits, we would be in a position to compare alternative projects to make reasoned recommendations.

Data View

Any project in this area will use and generate extensive data, both to build models to help make policy decisions, and to evaluate the results. For example, data will be needed on population, economic activity, poverty rates, transport accessibility and cost, etc. This data will need to come from a wide range of sources, including national governments, international agencies, and ADB's own research.

Much of this data is already collected, but is hard to find. Even data collected by existing ADB projects is not held or indexed in a central place, and so can be hard to track down—

particularly if one does not know beforehand whether the data exists. There are also cases where data collected for a project or report has later gone missing. Such cases highlight the need for a centralized data catalogue. A pilot for such a registry could be immediately useful if implemented as part of the present data-heavy project.

A data catalogue also presents the opportunity to open currently hard-to-find data for use and scrutiny by other bodies, projects, businesses, and the wider public. Data is a resource, the value of which increases when it is open: it becomes like public infrastructure such as roads that allow a vibrant business environment to function. Data is increasingly becoming a critical input in the founding of new businesses of the information age. By leading the transition to an open data standard (a standard that is already well under way internationally outside Asia) ADB would be making a valuable contribution to the business and governance environment of Asia.

Such a catalogue could collect and make open data from other willing organizations as well as ADB, including national governments, international agencies, etc. In particular governments, to do their work, must collect a large volume of data. In the past this data has been tightly guarded, but in recent years, governments around the world have made more data more openly available. A key element in the process has been the development of open data portals, where national and local governments, as well as other organizations, have implemented their own data hubs giving access to thousands of datasets.³ The drivers for this process have been diverse. One is the obvious potential for greater transparency⁴ to deliver more open, effective, and accountable government. However, demand for open data has also come from research, business and the third sector—all of which can make use of governments' incomparably rich sources of data. Data is vital in measuring progress in development, for example toward the Millennium Development Goals, and hence evaluating and guiding policy. Of course, not all governments have equal capacity to produce high-quality data, so there is also a need to build capacity and infrastructure to enable better and more reliable statistics to be produced and disseminated openly.⁵

To extract maximum utility from data, a data catalogue must include adequate metadata. For example, a dataset must come with enough metadata to understand what it refers to, which time period it covers, who has published it, etc. Particularly for a fundamentally spatial activity like the building of a corridor, it is essential to have good geospatial data and metadata: what is the geometry of the region covered by the data? This is all the more important considering that data is collected for different and overlapping areas. Geospatial metadata allows data from different sources to be integrated area by area (using suitable methodological choices where areas overlap), and enables different datasets to be immediately visually related by presenting them in layers on a map view. We can imagine multiple layers that identify the key production centers of industry and agriculture, the distribution of resources, tourist sites, vulnerable ecologies, existing transportation

³ E.g. data.gov.uk (United Kingdom), dados.gov.br (Brazil), data.gov (United States), open-data.europe.eu (European Union), iatiregistry.org (International Aid Transparency Initiative). See more examples at ckan.org/ instances/ and datacatalogs.org. The Economist, 18 May 2013 carried a feature about the given examples.

⁴ Open Government Partnership's concrete commitment on transparency: "Information on government activities and decisions is open, comprehensive, timely, freely available to the public and meets basic open data standards (e.g. raw data, machine readability)." A new executive order by the White House makes open and machine readable data the default for US government information: <htps://www.whitehouse.gov/the-pressoffice/2013/05/09/executive-order-making-open-and-machine-readable-new-default-government->.

⁵ See Shaida Badiee, 2013: 'Joining forces for better statistics'.

structures, etc. A time series of such geocoded inputs would be used by the models to compute impacts (which would also be geocoded). The good news is that for some of the regions of interest for the workshop (e.g. GMS), the necessary data collection effort is well under way.

In a similar way, a data catalogue will also be of greatest use if it can capitalize on geospatial metadata, for example enabling researchers to easily search for datasets of interest by area covered.

Organizational Process View

The building of a data resource of the kind outlined above requires organizational commitment at the highest levels. Data collection, maintenance, and publishing could not be sustained over any appreciable period of time if the activities are not integrated into the workflow of the collecting agencies. ADB collects vast amounts of data, and much of this is lost for further study and analysis at the conclusion of projects. A very valuable first step would be to make all of this data—the byproduct of completed projects—publicly available via a common portal. The appropriate budgeting of time and effort for this, together with the right rewards and penalties, should achieve this objective at relatively low cost. There are certainly well established precedents for this (data.gov.uk in the United Kingdom, data.gov in the United States, etc.), and a variety of mechanisms

are used to ensure compliance. Some unit in ADB, and/or in region-focused institutions, would need to take ownership of building the data resource management system and monitoring compliance.

The second level of commitment is required from country governments. Data collected by governments (censuses, national and provincial income accounts, surveys of poverty and nutrition, health surveys, etc.) also needs to be made accessible via a common portal to the general public. Once again, the experience of the European Union, the United States, and others could be a valuable guide in accomplishing this. The bigger challenge is likely to be to ensure that the data is (a) supranationally harmonized—i.e. a common set of indicators are used across a region, (b) is available as a time series at similar frequencies, and (c) is available at the level of detail (for states, districts, oblasts, localities) required for the models discussed above. While these are substantial challenges, there is no reason to wait until the data are perfect. It would still be a valuable enterprise if available data were made public right away, and improvements made gradually.

Opportunities (Greater Mekong Subregion and Central Asia Regional Economic Cooperation)

When key policy makers and stakeholders pursue measurable outcomes for the development of regional economic corridors, the model and data framework at a standard economic scale of relevance allows for an investment-relevant development of scenarios, which will be monitored within an effective organizational process. Such a process—with all the elements of an evidence-based policy in place—is highly likely to generate successful economic corridor development, which realizes envisaged opportunities within the regions. Two priority regions in Asia—GMS and CAREC—face different opportunities.

The GMS is covered by very good spatial planning data, at numerous sector layers (for instance environment, energy, transport, agriculture, tourism, urban, and population) at a very fine-grained scale. A combination with as yet missing traffic flow and trade data

at a very fine-grained level (see attachment on the good practice data frame) opens up exploration of opportunities to widen the existing transport corridors into economic-sectorembedded corridors. One opportunity is to invest in ecotourism corridors, which leverage the agglomeration of cultural heritage sites in the region. This could leverage several other, globally networked service-sector opportunities in turn. With such an opportunity, or any other one for economic corridor development, the principle to follow is to augment the capacity in the inland poorer areas of GMS by linking them to the markets and agglomerations that support sufficient demand. These markets and agglomerations exist along coastal areas within GMS, and of course further abroad.

CAREC has high potential as a transit region between the east of Asia and the European end of the Eurasian continent. The Russian Federation has historically been the main trading partner for Central Asian economies. Trade connections between the Russian Federation and the European Union are being strengthened and trade is intensified. Xinjiang province of the People's Republic of China (PRC) now accounts for the bulk of trade with the PRC, and with growing integration in the PRC of its western provinces with the east coast, the importance and opportunities of extending production networks into Central Asia is rising. Furthermore, low economic density suggests opportunities for hub-and-spoke economic corridor development approaches.⁶

The key agglomeration and other growth benefits in Central Asia could come from hub development around key urban centers, and maybe in newer secondary centers, whereas the transportation network links are completed in specific segments, and the quality characteristics of these network links is improved in critical locations along the way. Available numbers on the traffic density of road and rail along the CAREC corridors indicate that road transport serves trade among the CAREC economies over shorter distances, and that railway links carry the very small longer-distance traffic, fed by some extent from the more localized road traffic. Given the potential of the region as a bridge between East and West, this long-distance intermediary function of the region might be enhanced further.

Conclusion and Action Plan

The expert working group proposed the following action plan for this:

- 1. Gradual establishment of an *evidence-based policy* framework:
 - a. Development and dissemination of a set of standardized development indicators related to corridors and infrastructure generally. Modeled on the Millennium Development Goals (and any successor goals), these indicators should have sufficient scope to capture the many important services provided by transport and economic corridor infrastructure, yet be focused enough to be integrated into project evaluation and policy dialog. They should be user-friendly, easily understandable, and at scales appropriate for stakeholder consultations. To be most effective, such a suite of economic corridor development goals should be developed and agreed to by ADB and country policy makers.

⁶ Defined as economic mass per unit of land area (World Bank, 2009. *Reshaping Economic Geography*. World Development Report).

- b. Development of decision tools that make effective use of standardized data platforms and portals, promoting evidence-based policy research and dialog within and between ADB and regional members in their dealings with other development partners and private stakeholders. These tools should include, but not be limited to, modular and extensible economic models and descriptive results tools to more completely evaluate the development characteristics of infrastructure projects and to incorporate these into the policy dialog. A corridor-rating tool could be added.
- c. Hosting an online portal for data related to regional and global trade, infrastructure, demographics, and related economic activity. This would include, but not be limited to:
 - (i) digitized data from ADB sources, including historical project evaluation data and data generated for other ADB projects in several sectors.
 - (ii) contributed data from member countries, e.g. trade and transport statistics, census and Living Standards Measurement Study data, project evaluation data, etc.
 - (iii) data resources commissioned by ADB to fill gaps in the previous two categories (esp. for DMCs).

There are many examples of data commons like this now, and the architecture of such an ADB portal can be developed from these models.⁷ The primary service of this data commons is to centralize and facilitate access to economic evidence on activities related to ADB's primary development goals, supporting more effective regional dialog and development assistance.

- (iv) Dissemination of these data, indicators, and decision tools across the policy community with special emphasis on capacity building in DMCs. This would include development and implementation of online or in-person training programs, in-country seminars, and regional workshops to promote policy research and dialog based on a new generation of evaluation methods. Data frames and decision tools are only effective for policy and project evaluations, if they are well-administered and maintained through an effective organizational process.
- 2. Identification and establishment of suitable organizational processes to meet standardized data requirements and to develop and maintain an optimal data resource management system:

In a dialogue with senior officials in select pilot regions, a policy seminar for policy makers will be conceptualized. The main purpose of the seminar will be to present to policy makers with alternative economic corridor development indicators from which they can choose. The second purpose of the seminar will be to help policy makers decide on possible organizational mechanisms to meet standardized data requirements and develop and maintain an optimal data resource management system. Any effective organizational mechanism would need to complement and support ongoing institutionalized efforts. Its objective would be to promote

⁷ For an example, see ckan.org

synergies, identify and address data standards and gaps, build institutional capacity, and accelerate the evolution of economic corridor development for regional economic integration toward greater consistency and coherence. A chosen organizational process should be informal (workshops, conferences, capacity building efforts), advisory, and inclusive. We propose that at a policy seminar, an initial organizational structure and process be established, and that this be revised, as necessary, as its value and contribution are demonstrated.

The following features may be considered:

The organizational process would be an initiative sponsored and managed initially by ADB (secretariat). ADB would host a pilot publishing platform to make existing data discoverable for pilot regions. For instance, it would be under the GMS and/or CAREC ministerial process. A policy advisory group, supported by a working group, will put forward proposals for the gradual implementation of an evidence-based policy framework, and will be evolved in regular annual meetings. Recommendations for a work program and activities for an initial period of 12 months will be discussed and decided on during policy and working group meetings, which will include high level officials. Initial activities to be funded under cofinancing will be solicited as appropriate.

- 3. Deploy knowledge and decision tools to explore opportunities for applying investments to pilot economic corridors (GMS, CAREC, elsewhere):
 - a. A regional pilot initiative will be initiated on the basis of the draft action plan, through discussions with respective regional departments at ADB, and with support of one sector-focused community of practice.
 - b. Conceptualization of a policy seminar for policy makers of a pilot region (to be decided, could be GMS and/or SASEC), around the end of 2013. The concept will receive early endorsement of regional senior officials at a forum, before the seminar is organized.
 - c. In preparation of the policy seminar, development of a study proposal, which will contain suggested regional development indicators with alternatives to help policy makers judge the success of economic corridor development. The policy seminar will include focus groups through which seminar leaders will elicit the priority of various development indicators (including desired scale) for policy makers at the seminar. To the extent that there is any conflict in priorities between policy makers (for instance from different sectors, or different countries) the focus groups would explore mechanisms to resolve this conflict.
 - d. The study proposal will further specify the elements of a decision tool, which could be funded and developed under technical assistance. The proposal will specify a rating tool for specific economic corridors and even subcorridor segments. The elements to be specified are, among others, the scale(s) and the broad specifications of the simulation model, the data frame requirements needed to fill gaps based on an assessment of available data, the determinants of an ADB-sponsored publishing platform to make existing and upcoming data discoverable for stakeholders, and the details of possible investment scenarios that would fulfill the aspirations of decision makers in a pilot region. The seminar will present the opportunity to modify the set of indicators that are part

of the decision tool, as well as to make modifications to the specifications of the decision tool.

e. At the policy seminar, a pilot demonstration for a cross-country, regional data publishing platform and portal will be made, and a funding and resources plan will be proposed to begin a pilot project. This would harvest available institutional and national data systems into a regional platform. A proposal will be presented to stakeholders for the organization frame under which the publishing platform can be sustained.

At the policy seminar, or soon after its conclusion, it should be possible to specify in detail what the inputs and outputs of the decision tool will be, and what the implied requirements of the data infrastructure will be. We would hope to learn what the specific concerns of policy makers of the pilot economic regions are, and adapt the framework accordingly. The guiding principle in preparing for the seminar would be to preserve maximum flexibility until input from key stakeholders has been obtained.

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The Economist. (18 May 2013). "Open Data, A New Goldmine." London.

World Bank. 2009. Reshaping Economic Geography. World Development Report.

The following websites provided examples for this chapter.

National

dados.gov.br (Brazil) open-data.europe.eu (European Union) data.gov.uk (United Kingdom) data.gov (United States)

Other

iatiregistry.org (International Aid Transparency Initiative) ckan.org/instances/ datacatalogs.org.

Attachment

Data Framework for a Fine-Grained Simulation of Economic Corridor Development Data Representation

Reality is much more complicated than the simple illustration earlier. The first complication involves the real geography of a region. We need to split this into regions between which transportation occurs. Each subregion should be small enough so that transportation costs are negligible within a region. Then the cost and value functions can focus on transportation between regions. The problem that arises is that economic data—incomes, population, land use, etc.—are available only for much larger subregions (e.g. districts and other administrative boundaries).

Geography

In the SASEC study, we divided the region into 50 kilometer (km) by 50km subregions called tiles. The following map illustrates this:



Figure A1 South Asia Subregional Economic Cooperation Region Subdivided into Tiles



Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

In this instance, we see the map for the area covered by the SASEC study with a grid of tiles overlaid. We can then number the tiles (say there are N), and define the N \times N matrix where entries are distances between two tiles as in the illustration above. Multiple definitions of distance are possible. For instance, imagine a matrix whose entries are ones and zeros with an entry of one exactly when two tiles are adjacent to one another. (E.g. suppose the tile in the extreme northwest corner is tile 1, and the tile in the extreme southeast corner is tile N. These two tiles are not adjacent to one another, so the entry for (1, N) is 0. If 2 is the second tile in the first row, the entry for (1, 2) is 1.). Alternatively, the entries could be distance by current roads from one tile to another. In this latter case, the problem is that there could be

multiple routes for getting from one point to another. With this in mind, we can construct a matrix that only has shortest distances to the adjacent tiles. The distances to more remote tiles can then be computed as the minimum distance using the matrix (with only adjacent distance entries). The same procedure can be used for rail transport: tiles that are one train stop away are defined to be adjacent, and the distance entries for these adjacent stops can be used to compute distances between more remote locations. The same procedure can be followed for waterway transport as well. Finally, it is possible to combine modes of transport to get from one tile to another. Costs and delays at transit points (or at borders) are easily accounted for.

The case for time matrices is exactly analogous.

In the region above, there were international boundaries. These can be accounted for by imposing a larger cost for crossing an international boundary.

A more complicated problem arises at the boundaries of the entire region. In the SASEC case, the relatively quiet Myanmar boundary, the Himalayas, and the Bay of Bengal make the region relatively self-contained. We modeled connections with the external world via the ports, but India (which is only partially included in the region) was problematic.

Local Economic Data

There is a need for basic demographic information for the tiles and other pertinent information to model the region's economy. A minimal list of variables would include: population, wages, rents, income distribution, land-use patterns, goods produced, goods consumed, etc. Additionally, some data will be used for calibration of the model—principally, prices of final and intermediate goods. Much of this data is available from government sources and from international organizations.

The central difficulty here is that administrative regions for which data are available do not necessarily correspond to the tiles. This requires some method for allocating numbers from the administrative regions to tiles and vice versa. In essence, these are ad hoc approximations. One way around this problem is to use administrative regions instead of tiles. The downside is that these may be large, so that within region transportation costs are not negligible.

Transportation Infrastructure

Clear understanding of the transportation infrastructure is required. This information is then captured in the distance and time matrices described above. The simplifying assumption used above is that there is a single road route between two adjacent tiles. In practice, there may be more than one route (e.g. by highway or local routes). It is often the case that some routes are longer (or more expensive) but faster, while others are shorter (or cheaper) but take more time. Roughly, the time differences are compensated with cost differences. So, the assumption of a single road route is acceptable if we are collecting information along multiple dimensions (particularly, cost and time). The aggregated cost of different travel methods should be similar.

So, to summarize, we would have matrices (spreadsheets) with rail travel times, rail travel costs, road travel times, and road travel costs between adjacent locations. If waterways or air cargo are relevant, similar matrices can be constructed for them as well. Appropriate algorithms compute distances between nonadjacent locations. This can be done using multiple modes of transportation.

How are proposed improvements in the transportation infrastructure to be accounted for? These could take the form of new or improved roads, new rail lines, improved transit facilities, refrigerated storage or transport facilities, shortened times and costs at national borders, bridges, etc. For this, based on design and engineering specifications, we need to forecast reductions in time taken to travel (or to transport goods) between two locations. Where relevant, we would also modify the distance matrix (e.g. a new road connecting two locations).

In essence, "before" and "after" distance and time matrices are used to account for infrastructure investments. Demand for specific modes of transportation depends only upon time and distance of the alternatives. (Transportation infrastructure is a public good, and not priced in markets).

The parameters of the "value remaining" functions present additional options. The rate of depreciation of goods can also be changed (for instance, because of refrigeration facilities, better law and order, etc.).

Application to Value Chains

As goods proceed through the value chain they are transported, and processing can change the transportation costs (by changing the characteristics of the good). Consequently, different cost formulae need to be applied for goods at different levels of processing. In particular, there would need to be separate cost functions (depreciation rates) for intermediate and final goods. For instance, fruit pulp may be perishable, but once processed into jam, it may not perish in the time it takes to transport it to final consumers. In this case, the time depreciation rate for fruit pulp would be different from that of jam. This point is critical for understanding the geographical distribution of production. The time, distance, and other costs of transportation will determine the optimal geographical organization of production. For instance, if these costs are high for a key raw material, but low for the finished good, then production will occur near the source of the raw material. To summarize:

Differences in cost functions for intermediate and final goods will influence the geographical distribution of production—i.e. where raw materials are processed, where intermediate goods are produced, and where final goods are produced.

A key strength of the model developed for the SASEC study was the incorporation of nontrivial value chains into a rigorous model of production and transportation. In principle, we can start with raw materials, end with finished products, and have intermediate stages of production spread out geographically. The final delivery of goods can be in international markets, which, in the framework of this note, refer to distinct tiles with fixed prices, and defined transportation costs from ports and other transportation hubs. Inputs can be sourced from international markets as well. In other words, we can trace the entire value chain—from raw materials to export—and clearly identify how final prices (hence competitiveness) depend upon infrastructure investments.

Such a framework can be very useful for studying a single good for which we can examine exactly the type of intervention (e.g. reducing the cost of exporting to international markets, or removing a significant transportation hurdle) that would make it more competitive in the global economy. In the SASEC study, this took the shape of conducting detailed studies of individual goods (existing or potential) in which a country could become competitive given the appropriate investments in infrastructure. The value chains were mapped out, and significant bottlenecks identified. We determined which investments were necessary to

ensure that this good reaches international markets at competitive prices. We would also be able to prioritize investments on the basis of the competitive advantage they would create.

A key part of the data gathering effort has to be to identify the goods in which the region has demonstrated competitive advantage, as well as goods for which it could be competitive given appropriate infrastructure investments. Under reasonable assumptions about the effect of investments on cost functions, we can simulate the outcome for the region. We can also examine the effects of incremental stages of investments using multiple scenarios, with costs and benefits quantified by simulation.

2

Economic Corridors Data Case

Mark Wainwright and Velichka Dimitrova, Open Knowledge Foundation

Summary

his paper will outline some of the benefits for the Asian Development Bank (ADB) and clients of making openly available data relating to the analysis of economic corridors, and will give recommendations about the aspects that need to be considered when doing so. It will draw upon examples from transparency initiatives of governments and research communities. The recommendations refer to the publishing both of the baseline data, and also of scenario data and code resulting from the modeling of economic corridor development. Two case studies from government data portals will be also examined, to illustrate some of the possibilities in the use of geospatial data.

Background

Governments, to do their work, must collect a large volume of data. In the past this data has been tightly guarded, but in recent years, governments around the world have made more and more data openly available. A key element in the process has been the development of open data portals, where national and local governments, as well as other organizations, have implemented their own data hubs giving access to thousands of datasets.⁸ The drivers for this process have been diverse. One is the obvious potential for greater transparency⁹ to deliver more open, effective, and accountable government. However, demand for open data has also come from research, business and the third sector—all of which can make use of governments' incomparably rich source of data. Data is vital in measuring progress in development, for example towards the Millennium Development Goals, and hence evaluating and guiding policy. Of course, not all governments have equal capacity to produce high-quality data, so there is also a need to build capacity and infrastructure to enable better and more reliable statistics to be produced and disseminated openly.¹⁰

⁸ E.g. dados.gov.br (Brazil), open-data.europe.eu (European Union), data.gov.uk (United Kingdom), data.gov (United States), iatiregistry.org (International Aid Transparency Initiative). See more examples at ckan.org/ instances/ and datacatalogs.org.

⁹ Open Government Partnership's concrete commitment on transparency: "Information on government activities and decisions is open, comprehensive, timely, freely available to the public and meets basic open data standards (e.g. raw data, machine readability)." A new executive order by the White House makes open and machine readable data the default for United States government information: Office of the President of the United States. Executive Order. "Making Open and Machine Readable the New Default for Government Information" (09 May 2013)

¹⁰ See Shaida Badiee. (18 April 2013). "Joining forces for better statistics." World Bank Website. London.

In the field of research, there has been a similar growth in the recognition of the importance of open data. The need to implement better knowledge exchange and data sharing was reaffirmed with the launch of the Research Data Alliance¹¹—an international organization to facilitate the sharing, exchange, and reuse of research data. The benefits are obvious, enabling researchers to confirm and build on each others' results. Individual researchers also benefit from publishing their data. Reuse by other researchers will help reproduce their results, find collaborators, increase their numbers of citations, and direct new readers to their work.¹²

Nevertheless, progress has been gradual. Some journals in economics¹³ and other disciplines have implemented data availability policies, and funders have also emphasized the need to make research data openly available. In the United States, the government announced that it would give specific funding to make the results of federally-funded research freely available to the public, requiring researchers to better account for and manage the digital data resulting from federally funded scientific research.¹⁴ Similarly, the European Union (EU) also requires open access to publications and data funded through the EU's 7th Framework Programme for Research.¹⁵

Open Data Portals

As hinted above, it is increasingly recognized that there are many benefits to society from making government data open, and these are widely discussed elsewhere. To summarize a few:

- a. **Transparency:** Open data (for example, on budgeting and spending) makes government more transparent and accountable and can help expose or reduce corruption.
- b. **Many eyes:** Data can be used by researchers and citizens outside government to provide analyses that may help guide and improve policy.
- c. **Economic reuse:** Reliably available data creates opportunities for enterprise, leading to new services and economic growth. Geocoded data is particularly useful here, as it can be remixed with other data to provide personalized location-based services via apps on smart phones enabled with global positioning system receivers, for example, data about the location of public amenities, transport timetables, or real-time transport data.

The same or similar points apply to other types of data, including research data, such as data from modeling scenarios. The research process is transparent and reproducible, errors are found more easily, and results can be reused by other researchers who, for example, want to vary the parameters or use the same modeling data in a different study.

¹¹ rd-alliance.org

¹² For more on the benefits of publishing your own research data, see UK Data Archive. 2011. Managing and Sharing Research Data. Best Practice for Researchers. University of Essex. Colchester. and Royal Society. 2012. Science as an Open Enterprise. The Royal Society Science Policy Centre report. (Feb 12). London.

¹³ E.g. American Economic Review, Econometrica, the Review of Economic Studies, the Journals of Political Economy, etc.

¹⁴ Office of the President of the United States Office of Science and Technology Policy. Memorandum. Subject. "Increasing Access to the Results of Federally Funded Scientific Research," 22 Feb 2013.

¹⁵ European Commission (website). Research in Innovation, Science in Society, Policy Initiatives (page). Last Updated: 14 Nov 2012.

However, how well these benefits are realized depends on how the data is made open. The growth of open data portals reflects a number of ways in which these make the benefits more accessible.

In the first place, data cannot be called "open" unless it is listed and, if at all practicable, downloadable online. If data can only be accessed by contacting the data holder, this is at least a significant inefficiency. In practice, potential users will often not find the data or even know it exists. A data portal provides the functionality for data-holders to put their data online in a range of different ways, to fit in with existing systems and procedures.

Second, a data portal is a single, central point of reference for data from a particular source (or group of sources), or on a particular subject. A government-wide data portal, for example, makes it easy to search for data across everything published by different departments, at different times, and on different subjects. Again, without a central portal, even though all this data may be published, potential users are likely not to find it.

Third, a well-designed data portal will also guide data publishers toward providing consistent metadata. Users need to know a certain minimum about the data they are using, e.g. what year it refers to, how often it is updated, which organization collects it and who to contact for queries. A particularly important piece of metadata is the license under which the data is released. To fully realize the benefits of open data, an open license (permitting any kind of reuse) must be applied. But in any event, users need clarity about the types of reuse that are permitted.

Fourth, in addition to helping users find data stored elsewhere, the portal can store the data directly, providing an easy way for organizations to give their data a permanent home.

Fifth, a single data portal can bring together data from different sources. Publishing organizations can have access to and publish data according to their own requirements and workflow, making it far easier to ensure that data is up-to-date. Data and metadata can be handled in bulk—for example, imported from existing information systems. Data can also be harvested from sources elsewhere.¹⁶ Again, this ensures that the portal always has the latest version of the data.

Sixth, an open data portal serves not only outsiders but members of the publishing organizations themselves, helping them to more easily find and make use of their own data. When the Canadian province of British Columbia looked at site usage statistics, half the users of their open data portal were civil servants, i.e. the province's own employees.

Finally, note that an open data portal does not require an institutional open data policy. It is a valuable tool even if only a modest amount of data is being published, and more can be published later. For example, in the case of the United Kingdom's open data portal (data. gov.uk), the portal played a role in driving forward the open data and transparency agenda and the interest from data users helped galvanize further policy developments.

¹⁶ For instance, publidata.eu enables users to search for data from across nearly 20 official data portals within the EU, by harvesting records from these portals.
Evidence-Based Policy Analysis—Data View

Any project in this area of modeling economic corridors will both use and generate extensive data, to build models to help make policy decisions, and to evaluate the results. For example, data will be needed on population, economic activity, poverty rates, transport accessibility, and cost, etc. This data will need to come from a wide range of sources, including national governments, international agencies, and ADB's own research.

Much of this data is already collected, but is hard to find. Even data collected by existing ADB projects is not held or indexed in a central place, and so can be hard to track down—particularly if one does not know beforehand whether the data exists. There are also cases where data collected for a project or report has later gone missing. Such cases highlight the need for a centralized data catalogue. A pilot for such a registry could be immediately useful if implemented as part of the present data-heavy project.

A data catalogue also presents the opportunity to open currently hard-to-find data for use and scrutiny by other bodies, projects, businesses, and the wider public. Data is a resource the value of which increases when it is open: it becomes like public infrastructure such as roads that allow a vibrant business environment to function. Data is increasingly becoming a critical input in the founding of new businesses of the information age. By leading the transition to an open data standard (a standard that is already well under way internationally outside Asia) the ADB would be making a valuable contribution to the business and governance environment of Asia.

To extract maximum utility from data, a data catalogue must include adequate metadata. For example, a dataset must come with enough metadata to understand what it refers to, which time period it covers, who has published it, etc. Particularly for a fundamentally spatial activity like the building of a corridor, it is essential to have good geospatial data and metadata: what is the geography of the region covered by the data? This is all the more important considering that different data is collected for different and overlapping areas. Geospatial metadata allows data from different sources to be integrated area by area (using suitable methodological choices where areas overlap), and enables different datasets to be immediately visually related by presenting them in layers on a map view. We can imagine multiple layers that identify the key production centers of industry and agriculture, the distribution of resources, tourist sites, vulnerable ecologies, existing transportation structures, etc. A time series of such geocoded inputs would be used by the models to compute economic impacts (which would also be geocoded). The good news is that for some of the regions of interest for the workshop (e.g. GMS), the necessary data collection effort is well under way.

In a similar way, a data catalogue will also be of greatest use if it can capitalize on geospatial metadata, for example enabling researchers to easily search for datasets of interest by geographic area covered.

Recommendations

- 1. **Implement** a data portal as a single point of reference for data on economic corridors, including baseline data and modeling data.
- 2. **Enable independent publishing by various sources.** The portal is likely to include data from diverse types of organization. To keep the site manageable and for maximum flexibility, each organization should be able to access their own areas and publish data according to their own structures and procedures.
- 3. **Provide good metadata.** Good quality data, context, and documentation are needed to make optimal use of the data, i.e. to make it usable by other researchers.
- 4. Use an open license and open, machine-readable formats where possible. The value of open data is vastly greater where it can be reused as widely as possible, as input to calculations or web and mobile applications, remixed with other data, etc. This requires data formats that can be easily machine-processed,¹⁷ and a license that allows maximum reuse of data.¹⁸ However, there is no need to wait to publish data until it is in a particular format. You can always publish it now, and release it in another format later.
- 5. Ensure that confidential data, in particular personal data, is made fully anonymous or removed before publication.
- 6. **Start small and simple. Publish what you have.** If some publishers, or datasets, are ready, they do not need to wait until others are on board.
- 7. **Harvest from existing sources.** If relevant data is already published elsewhere it may be useful to harvest into the portal.
- 8. **Build community.** Ensure that potential reusers of the data know about the existence of the portal, and engage with data users, e.g. getting feedback on further data they would like to see released. Provide training to organizations holding data in uploading to the portal and providing good metadata.

¹⁷ For example, an Excel spreadsheet is vastly preferable to a PDF (portable document format), from which data cannot be easily extracted; and a spreadsheet in open CSV (comma-separated values) format is preferable to Excel, a proprietary format.

See Open Knowledge Foundation. 2012. Open Data Handbook. Cambridge. (http://opendatahandbook.org/ en/how-to-open-up-data/apply-an-open-license.html). For example, the Government of the United Kingdom has a standard license for open data, the Open Government Data license, which permits reuse of the data for any purpose, including commercial purposes. For examples of similar licenses, see http://opendatacommons. org/licenses/. In practice, for a cross-agency portal such as we are considering, as each publisher may have their own requirements, it is likely that different licenses will be in use. In any event, the license for each dataset should be clearly recorded in its metadata.

Case Studies

data.gov.uk

data.gov.uk is the Government of the United Kingdom's official open data portal. The site provides a centralized portal to "the wealth of government data," bringing together data from a variety of publishers: e.g. the Office for National Statistics, government departments, the National Health Service Information Centre, etc. It aims to make that data "easy to find, easy to license, and easy to reuse." data.gov.uk was launched in closed beta at the start of October 2009 and made public in January 2010. It now has over 9,000 datasets from hundreds of publishing departments and bodies.

data.gov.uk has been built on a combination of *CKAN*, the open-source data portal software developed by the Open Knowledge Foundation, and Drupal, the open-source content management system. Initial requirements were data catalogue capabilities (entering, editing, listing, and searching datasets) combined with basic content management features (site content, blog, theming etc). The use of open-source software and of existing components, to allow for rapid development, were also required (the initial prototype was developed in less than a month). Over time, a variety of new requirements have arisen, notably for data storage and previewing.

data.gov.uk also acts as the UK's hub for geospatial metadata aggregation in line with the *EU's INSPIRE* directive,¹⁹ and harvests information on geospatial datasets from a large number of other data catalogues and hubs. The site includes a *map-based search*²⁰ where data can be searched by location, and map-based previews, including Web Map Service (WMS) previews allowing individual layers to be switched on or off.

Responses have been very positive. The government continues to develop the site, which has a global reputation as an exemplar of a government data portal. The system has successfully handled growth from a few dozen to many thousands of datasets and a corresponding growth in site traffic, and has played a significant enabling role in the UK government's development of its transparency and open data agenda.

data.gov

The United States government's General Services Administration is planning to relaunch its data catalogue at the end of May 2013. Currently data is held on a number of different catalogues; in particular geospatial data at geo.data.gov is separate from the main portal at data.gov. They will be replaced with a single catalogue running the open-source data portal, *CKAN*.

Getting very large amounts of data in from a variety of federal and non-federal sources has made this a complex project, and the General Services Administration has been working on it with the Open Knowledge Foundation since October 2012. It uses CKAN's powerful harvesting functionality, which gathers metadata and validates, parses, and normalizes it to display in a consistent, browsable web user interface. Robust support has been added for harvesting documents in Federal Geographic Data Committee (FGDC) and International Organisation for Standards' ISO 19139 format from Web Accessible Folders (WAF), single

¹⁹ http://inspire.jrc.ec.europa.eu/

²⁰ http://data.gov.uk/data/map-based-search

spatial documents, Catalog Service for the Web (CSW) endpoints, ArcGIS portals, Z39:50 sources (a client–server protocol for searching and retrieving information from remote computer databases), as well as other CKAN instances.

Datasets and data links get their own unique persistent uniform resource locator (URL), which can be linked to and can be found using any mix of keywords, faceted by publisher (organization), tags, and formats, as well as location. A pilot of the site demonstrates the geospatial search. The Open Knowledge Foundation has added the ability to preview WMS and Keyhole Markup Language (KML) files on a map layer widget.

The General Services Administration has written more about the reasons for the migration in a recent post.²¹ Among others, the ability to harvest from data catalogues in other parts of government will save time for many people, and the new system provides a full application programming interface, which has been much-requested. CKAN's (and also Drupal's) open source model makes it possible for them to invite keen coders to contribute features to the site.

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²¹ http://www.data.gov/blog/under-hood-open-data-engine

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The following websites provided examples for this chapter.

Government websites dados.gov.br (Brazil) Inspire.jrc.ec.europa.eu (European Commission) open-data.europe.eu (European Union) data.gov.uk (United Kingdom) data.gov (United States)

Other

ckan.org/instances datacatalogs.org iatiregistry.org (International Aid Transparency Initiative) publidata.eu (European Union) rd-alliance.org

3

Case Study on European Union Experience

Willem Spit, Ecorys Netherlands

General Setting: European Union Policy on Infrastructure and Regional Development

Network Development and Cohesion are Central Themes in European Union Policy Within European Union (EU) policy, with respect to infrastructure, two main themes can be seen over the past decades.

The first theme is the translation of the common European market objective in transport infrastructure. From the early nineties onward, the development of the Trans-European Transport Network (TEN-T) has been a central element in the European strategy to integrate markets and remove barriers to trade. The TEN-T network consists of a set of priority corridors for road and rail that connect different parts of Europe and that have priority with respect to transport infrastructure investments, in particular when European cofinancing is involved. Such cofinancing can come from EU funds or from the European Investment Bank.

A second main theme in European policy relates to regional cohesion, or the policy to bring regions with lagging (economic) development toward the European average. The regional cohesion policy is behind a financing instrument like the Cohesion Fund, by which billions of Euros are invested in infrastructure works like roads, railways, water supply and sanitation, environmental projects, etc.

For both the TEN-T program and the Cohesion Fund, strategic choices need to be made regarding priority fields of investment. These are generally made at intervals of 7 years, in line with the European budget cycle. Every start of a new budget cycle gives the opportunity to redefine investment priorities between sectors, regions, and types of projects.

Instruments Have Been Developed to Assess Impacts

To have a sound basis for such strategic decisions, the European Commission usually assigns consultants to carry out studies in which various policy options are analyzed in terms of their impacts. Such impacts may be broadly defined, including financial, economic, social, environmental impact on various groups of stakeholders. The studies may alternatively focus on the welfare economic effects, including socioeconomic costs and benefits.

To enable such analyses, the Commission, over the years, has financed modeling work. One of these models is the Socioeconomic and Spacial Impacts (SASI) model that is central to this paper. The SASI model has been used on occasion to carry out analyses on the effects

of investment scenarios. This paper concentrates on two of such studies, one for the TEN-T programming and another for the Cohesion Fund policies. In both cases, the effects of investments scenarios relating to transport infrastructure have been analysed.

Transport Corridors As Basis for Economic Development

The concept of transport corridors is central to European infrastructure policy. Such corridors include not only main arteries, among which people and goods move within Europe, but also transfer points (sea ports, airports) and other arteries. The basic idea behind the policy is to enable the movement of goods and people at low costs to society, stimulating economic activity. Such economic activity may develop close to the infrastructure or further away from the main corridor, depending on various other factors, such as the need for and proximity to raw materials, the role of transport costs in total product price, the time sensitivity of products, the proximity to markets, the availability of labor, etc. In particular, in densely populated areas, the necessity to develop activity close to the infrastructure may be less urgent.

In other cases, however, the transport corridor may have as a specific goal to stimulate development of the areas that are close to the end points of the corridor. For instance, various European corridors start and/or end in port areas, some of which have substantial development potential.

Introduction of Socioeconomic and Spatial Impacts Model

General

The SASI model is one of the instruments that have been used in the past by the Commission to provide information for the strategic choices regarding investments in the (European) transport network. This section gives more detail on the SASI model, its structure, the level of detail used (regions, sectors), and the working of the model. This section is largely taken from the working document on SASI that is available on the Intranet.²²

The regional, economic, SASI model was originally developed to study European policy issues, such as European transport and cohesion policy. SASI has been developed at the Institute of Spatial Planning of the University of Dortmund since 1996, in cooperation with the Technical University of Vienna, in the EU project SASI (Spatial and Socioeconomic Impacts of Transport Investments and Transport System Improvements).

The SASI model is a recursive simulation model of socioeconomic development of regions in Europe, subject to exogenous assumptions about the economic and demographic development of the European Union as a whole, and transport infrastructure investments and transport system improvements in particular of the trans-European transport network. The SASI model differs from other approaches to model the impacts of transport on regional development by modeling not only production (the demand side of regional labor markets), but also population (the supply side of regional labor markets).

A second distinct feature of the model is its dynamic network database, maintained by RRG Spatial Planning and Geoinformation (a German consulting company) based on a

²² Michael Wegener (2008). SASI Model Description. Working Paper 08/01. http://spiekermann-wegener.de/mod/ pdf/AP_0801.pdf

strategic subset of highly detailed pan-European road, rail, and air networks, including major historical network changes as far back as 1981. The database also forecasts expected network changes according to the most recent EU documents on the future evolution of the trans-European transport networks.²³

Structure of the Model

The spatial dimension of the model is established by the subdivision of the European Union, Norway, and Switzerland and the Western Balkan countries into 1,330 regions²⁴ and by connecting these by road, rail, and air networks. For each region, the model forecasts the development of accessibility and GDP per capita. In addition, cohesion indicators expressing the impact of transport infrastructure investments and transport system improvements on the convergence (or divergence) of socioeconomic development in the regions of the European Union are calculated. Figure 3.1 visualizes the structure of the SASI model.



Figure 3.1 The Structure of the Socioeconomic and Spacial Impact Model

GDP = gross domestic product

Source: Michael Wegener, SASI Model Description, Working Paper 08/01, August 2008, p. 7.

²³ From the website of RRG, it is possible that no updates have been carried out since 2008. See http://www. brrg.de/index.php?language=en

²⁴ In addition, the model has 41 external regions covering Belarus, Iceland, Liechtenstein, Moldova, the Russian Federation, Turkey, and Ukraine.

The temporal dimension of the model is established by dividing time into periods of 1 year. By modeling relatively short time periods, both short- and long-term lagged impacts can be taken into account. In each simulation year, the seven submodels of the SASI model are processed in a recursive way, i.e. sequentially, one after another. This implies that within one simulation period, no equilibrium between model variables is established; in other words, all endogenous effects in the model are lagged by 1 or more years.

The SASI model has six forecasting submodels: European developments, regional accessibility, regional GDP, regional employment, regional population and regional labor force. A seventh submodel calculates socioeconomic indicators with respect to efficiency and equity. Figure 3.2 shows the sequence of the seven submodels.



Figure 3.2 The Sequence of Submodels

..... nothing to do in base year

GDP = gross domestic product

Source: Michael Wegener, SASI Model Description, Working Paper 08/01, August 2008, p 8

Submodel European Developments

The European Developments submodel prepares exogenous assumptions about the wider economic and policy framework of the simulations, and makes sure that external development and trends are considered. For each simulation period, the simulation model requires the following assumptions about European developments:

- 1. Assumptions about the performance of the European economy as a whole (represented by observed values of sectoral GDP for the study area as a whole for past years and forecasts until 2031).
- 2. Assumptions about net migration across Europe's borders, represented by observed annual net migration of the study area as a whole for past years, and forecasts for future years until 2031.

These two groups of assumptions serve as constraints to ensure that the regional forecasts of economic development and population remain consistent with external developments not modeled in the reference scenario.

- 3. Assumptions about transfer payments by the European Union via Structural Funds and the Common Agricultural Policy or by national governments to support specific regions.
- 4. Assumptions about European integration. The accessibility measures used in the SASI model take account of existing barriers between countries, such as border waiting times and political, cultural, and language barriers.
- 5. Assumptions about the development of TEN-T, for road, rail, and air. A policy scenario can either consist of an investment program (a time-sequenced program for adding or upgrading links of the trans-European road, rail, and air networks) or of other transport policies (e.g. applying social marginal cost pricing in transport services).

Submodel Regional Accessibility

The regional accessibility submodel calculates regional accessibility indicators expressing the location advantage of each region, with respect to destinations in the region and in other regions, as a function of the generalized travel cost needed to reach these destinations by the road, rail, and air networks.

Submodel Regional GDP

The regional GDP submodel is based on a quasi-production function incorporating accessibility as additional production factor. The economic output of a region is forecast separately for the six economic sectors (agriculture; construction; financial services; manufacturing; tourism; trade and transport; and other services), to take different requirements for production by each sector into account.

Figure 3.3 Region Production Function, Extended Production Function

Regional production function *Extended production function:*



where A is potential accessibility:

	Destinations in region <i>j</i>	Travel cost between regions <i>i</i> and <i>j</i>
Accessibility of region <i>i</i>	$Ai = \sum_{j} W_{j} exp$	(-β c _{ij})

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Note: α , β , γ , and δ are regression coefficients Source: Michael Wegener, SASI Model Description, Working Paper 08/01, August 2008

Submodel Regional Employment

Regional employment by industrial sector is derived from regional GDP by industrial sector and regional labor productivity. Regional labor productivity is forecast in the SASI model exogenously, based on exogenous forecasts of labor productivity in each country.

Submodel Regional Population

The regional population submodel forecasts regional population by 5-year age groups and sex through natural change (fertility, mortality) and migration. Population forecasts are needed to represent the demand side of regional labor markets. Changes in population due to births and deaths are modeled by a cohort-survival model, subject to exogenous forecasts of regional fertility and mortality rates.

Migration within the European Union and immigration from non-EU countries is modeled in a simplified migration model as annual regional net migration, a function of regional indicators expressing the attractiveness of a region as a place of employment and residency, to take into account job-oriented migration and retirement migration.

Figure 3.4 Regional Production Function, Net Migration Function

Regional production function

Net migration function:



where

- $q_i(t-3)$ is GDP per capita of region *i*
- q(t-3) is average European GDP per capita $v_i(t-3)$ is quality of life of region *i*
- v(t–3) is average European quality of life ... all lagged by three years

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GDP = gross domestic product Note: α and β are regression coefficients Source: Michael Wegener, SASI Model Description, Working Paper 08/01, August 2008

Submodel Regional Labor Force

The regional labor force is derived from regional population and regional labor force participation.

Submodel Socioeconomic Indicators

From regional accessibility and GDP per capita forecast by the model, equity or cohesion indicators describing their distribution across regions are calculated. Cohesion indicators are macroanalytical indicators, combining the indicators of individual regions into one measure of their spatial concentration. Changes in the cohesion indicators predicted by the model for future transport policies reveal whether these policies are likely to reduce or increase existing disparities in accessibility and GDP per capita between the regions.

In the SASI model, five cohesion indicators are calculated:

- coefficient of variation;
- Gini coefficient;
- geometric and/or arithmetic mean;
- correlation between relative change and level; and
- correlation between absolute change and level.

Study Area

The model comprises 1,330 regions within the EU (as well as Norway and Switzerland), of which five are in Estonia, six are in Latvia, 10 are in Lithuania, and over 40 are in regions outside the EU.

Model Data

The data required to perform a typical simulation run with the SASI model can be grouped into base-year data and time-series data.

Base-year data describe the state of the regions and the strategic road, rail, and air networks in the base year 1981.

Time-series data describe exogenous developments or policies defined to control or constrain the simulation. They are either collected or estimated from actual events for the time between the base year and the present or are assumptions or policies for the future. Time-series data must be defined for each simulation period, but in practice may be entered only for specific (not necessarily equidistant) years, with the simulation model interpolating between them.

Exogenous assumptions are required concerning changes in regional labor productivity, regional educational attainment and regional labor force participation. All other regional base-year values such as GDP, employment, or labor force are calculated by the model. Network data specify the road, rail, and air networks used for accessibility calculations, and the evolution of the networks over the simulation period is needed as input.

Calibration and/or Validation Data

The regional production function in the regional GDP submodel and the migration function in the regional population submodel are the only model functions calibrated using statistical estimation techniques. All other model functions are validated by comparing the output of the whole model with observed values for the period between the base year and the present.

Calibration data are data used for calibrating the regional production functions in the regional GDP submodel and the migration function in the regional population submodel. The 4 years 1981, 1986, 1991, and 1996 are used to gain insights into changes in parameter values over time; however, only the parameter estimates for 2001 are used in the simulation. The calibration data of 1981 are identical with the simulation data for the same year.

Regional data (1,330 regions)

- Regional GDP per capita by industrial sector in 1981, 1986, 1991, 1996, and 2001;
- Regional labor productivity by industrial sector in 1981, 1986, 1991, 1996, and 2001;
- Regional endowment factors in 1981, 1986, 1991, 1996, and 2001;
- Regional labor force in 1981, 1986, 1991, 1996, and 2001; and
- Regional transfers in 1981, 1986, 1991, 1996, and 2001.

Network Data

- Node and link data of strategic road network in 1981, 1986, 1991, 1996, and 2001;
- Node and link data of strategic rail network in 1981, 1986, 1991, 1996, and 2001; and
- Node and link data of air network in 1981, 1986, 1991, 1996, and 2001.

Validation data are reference data with which results from the period between the base year and the present are compared to assess the validity of the model.

Regional Data (1,330 regions)

- Regional population (by age and sex) in 1981, 1986, 1991, 1996, and 2001;
- Regional GDP (by industrial sector) in 1981, 1986, 1991, 1996, and 2001;
- Regional labor force (by sex) in 1981, 1986, 1991, 1996, and 2001; and
- Regional employment (by industrial sector) in 1981, 1986, 1991, 1996, and 2001.

Simulation Data

Simulation data are the data required to perform a typical simulation. They can be grouped into base-year data and time-series data.

Base-year data describe the state of the regions and the strategic transport networks in the base year and so are either regional or network data. Regional base-year data provide base values for the regional GDP submodel and the regional population submodel as well as base values for exogenous forecasts of changes in regional educational attainment and regional labor force participation.

Network base-year data specify the road, rail, and air networks used for accessibility calculations in the base year.

Regional Data (1,330 regions)

- Regional GDP per capita by industrial sector in 1981;
- Regional labor productivity (GDP per worker) by industrial sector in 1981;
- Regional population by 5-year age group and sex in 1981;
- Regional educational attainment in 1981;
- Regional labor force participation rate by sex in 1981; and
- Regional quality-of-life indicators in 1981.

Network Data

- Node and link data of strategic road network in 1981;
- Node and link data of strategic rail network in 1981; and
- Node and link data of air network in 1981.

Time-series data describe exogenous developments or policies defined to control or constrain the simulation. They are either collected or estimated from actual events for the time between the base year and the present or are assumptions or policies for the future. Time-series are defined for each simulation period. All GDP data are converted to prices of 2006.

European Data (34 countries)

- Total European GDP by industrial sector, 1981–2031; and
- Total European net migration, 1981–2031.

National Data (34 countries)

- National GDP per worker by industrial sector, 1981–2031;
- National fertility rates by five-year age group and sex, 1981–2031;
- National mortality rates by five-year age group and sex, 1981–2031;
- National educational attainment, 1981–2031; and
- National labor force participation by sex, 1981–2031.

Regional Data (1,330 regions)

- Regional endowment factors, 1981–2031; and
- Regional transfers, 1981–2031.

Network Data

- Changes of node and link data of strategic road network, 1981–2031;
- Changes of node and link data of strategic rail network, 1981–2031; and
- Changes of node and link data of air network, 1981–2031.

Model Output

The main outputs of the SASI model are accessibility and GDP per capita for each region for each year of the simulation. However, a great number of other regional indicators are generated during the simulation. These indicators can be examined during the simulation by observing time-series diagrams, maps, or three-dimensional representations of variables of interest on the computer display.

Two Examples of Use of the Model in Policy Studies

Introduction

This section describes the approach and results of two strategic studies carried out on behalf of the European Commission, in which the results from simulations with the SASI model provided crucial information. The two studies are:

- Strategic Evaluation of Transport Investment Priorities under Structural and Cohesion Funds for the Programming Period 2007–2013 (2006);²⁵ and
- Ex-Ante Evaluation of the TEN-T Multi-Annual Programme 2007–2013 (2007).²⁶

The section shortly describes the general purposes and outcomes of these two studies and highlights the recommendations. In addition, a short reflection will be given on the strategic level of these recommendations in relation to the development of corridors in Central Asia.

Strategic Evaluation of Transport Investment Priorities under Structural and Cohesion Funds for the Programming Period 2007–2013

One of the key elements of the cohesion policy of the Commission is the contribution of the development of new transport infrastructure to regional economic development. Regions with better access to locations of input materials and markets will, all things being equal, be more productive, more competitive, and more successful than remote and isolated regions.

For the programming period 2007–2013, the Commission sought to strengthen the strategic dimension of cohesion policy to ensure that community priorities are better integrated into national and regional development programs. For this reason, the Commission initiated a strategic evaluation. The evaluation on transport fed into the process of determining transport investment priorities and the preparation of the national strategic reference frameworks and operational programs. As such, it served to enhance the quality, effectiveness, and consistency of the Fund's assistance.

Identification of Investment Priorities

The SASI model has been used to assess the impacts of various investment scenarios on the objectives of cohesion policy. Various indicators have been used to describe these impacts, of which the following will be used in the next sections:

²⁵ ECORYS Nederland BV, in cooperation with Spiekerman & Wegener, (for the European Commission). (2006). Strategic Evaluation of Transport Investment Priorities under Structural and Cohesion Funds for the Programming Period 2007–2013. Rotterdam. http://ec.europa.eu/regional_policy/sources/docgener/evaluation/ pdf/strategic_trans.pdf.

²⁶ ECORYS Nederland BV, in cooperation with Spiekerman & Wegener (for the European Commission). (2007). Ex-Ante Evaluation of the TEN-T Multi-Annual Programme 2007–2013 Rotterdam. http://ec.europa.eu/ten/ transport/studies/doc/2007_ten_t_map_2007_2013_ex_ante_en.pdf

- Competitiveness: GDP per capita, average speeds of interregional road or rail trips; and
- Territorial cohesion: Gini coefficient of distribution of accessibility and GDP per capita among the countries regions.

The following conclusions were drawn from the analysis of the outcomes of the scenarios:

- The impact of the infrastructure improvements on the structural level of GDP per capita is generally modest and is typically between 0.2% and 0.6%.²⁷
- The impact on average interregional transport speeds is larger than on GDP. In many countries the investments increase road speeds by 5%–10% and rail speeds by 10%.
- The investments have limited impact on the income distribution between regions as measured by the Gini coefficient of GDP per capita. All regions within a country appear to profit from the increased accessibility and the ensuing economic growth.
- In general, the relative impact of transport investments is strongest in smaller countries, especially if these investments succeed in connecting countries to the economic core of Europe. If these countries are surrounded by other European countries where transport is further developed, the impact is getting an additional impetus. An important conclusion is the large European impact of projects outside the country in which the investment takes place, in particular if these investments fit within European transport corridors. This clearly identifies the strong need for cross-border coordination in realizing these corridors.

Ex Ante Evaluation of the Trans-European Transport Network Multi-Annual Program 2007–2013

Background

The Directorate General for Energy and Transport designed and prepared a proposal for the renewed community multi-annual TEN-T programme for the period 2007–2013. This renewed multi-annual programme TEN-T was required to undergo an ex ante evaluation. The primary objective of the study was to answer the following question: in what way can the small (relative to other financing sources) budget of the multi-annual programme TEN-T speed-up the realization of TEN-T, while providing European Added Value.

The analysis has been based on a problem analysis, in which the major problems hindering the successful implementation of the TEN-T were found to be:

- insufficient budget to complete the TEN-T within the originally foreseen time frame of 2020;
- poor project preparation and poor administrative and technical management by project promoters; and
- inefficient or lack of cross-border cooperation, due to conflicting national needs and the needs of the EU.

Investment Options

Although the multi-annual programme TEN-T budget was limited in relation to the total investments needed, the budget could be used as a catalyst to accelerate the

²⁷ The level of impact depends on the size of the investments foreseen.

implementation of transport projects of European interest. The policy options identified for further research focus on providing concentrated multiannual programme TEN-T support:

- Option 1 "Corridor concept": Cofunding a mix of cross-border and bottleneck projects situated on the predefined priority axes and/or projects;
- Option 2 "Cross-border focus": Cofunding only a set of cross-border projects situated on the priority axes and/or projects;
- Option 3 "Bottleneck focus": Cofunding only a set of bottleneck projects situated on the priority axes and/or projects; and
- Option 4 "European Added Value": Cofunding a set of projects that bring benefits to several European countries (i.e. are with high European Value Added) situated on the priority axes and/or projects.

On the basis of a multicriteria analysis involving economic, environmental, and social impacts, the corridor concept was recommended above the cross-border focus and European added value focus. In other words, in the European situation, a coherent approach with respect to completing transport corridors was assessed to give (slightly) better results than one focusing predominantly on cross border projects, even though such projects were found to be handicapped by cross-border cooperation.

Ex Ante Results for Baltic States

Introduction

Within Europe, the Baltic states are at the periphery of the transport networks. The main corridors run from Finland, through the Baltic states, through Poland, to Western Europe. Besides this corridor, each of the Baltic states has corridor connections to the Russian Federation. As the economic development level of the Baltic states is below the EU average, substantial funds have been earmarked for development of the infrastructure in and to these countries. Investments in rail and road infrastructure were an integral part of both analyses described in previous sections. This section briefly describes the results of the analysis carried out for the Strategic Evaluation of Transport Investments Priorities study for the Baltic states.

Results from the Strategic Evaluation

The results of the analysis carried out under the Strategic Evaluation of Transport Investments Priorities study for the Baltic states depend on the particular investment projects that have been assumed in the simulation. As these packages differ per scenario, country, and modality, the estimated effects also differ. Nevertheless, some general conclusions can be drawn.

Overall Results for Baltic States

Table 3.1 shows the structural increase in GDP per capita as a result of the priority projects in road and railways corridors. The effect varies per scenario, but generally the effect of projects at the national level (only those within the boundaries of the country), as well as the effects of all European projects, are higher than the EU average.

Table 3.1Structural Increase in Gross Domestic Product Per Capita
(as a result of Road and Rail Corridor Projects)

	Structural Increase GDP per Capita (Only Projects within Nation)	Structural Increase GDP per Capita (All Projects in EU)
Estonia	0.1% - 1.7%	1.4% - 2.2%
Latvia	1.6% - 1.8 %	2.1% - 2.7 %
Lithuania	1.8% - 1.9%	2.5% - 2.7%

EU = European Union; GDP = gross domestic product

Source: Ecorys Netherlands, in cooperation with Spiekerman & Wegener, Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion Funds for the Programming-Period 2007–2013, 2006.

Results for Individual Countries

Estonia

From a European perspective, Estonia is disadvantaged by its peripheral location, its maritime position, and its long border with the Russian Federation. The average travel speed from Estonian regions to other regions in Europe is very low both by road and by rail.

Road: Seen from a national perspective, road travel speeds are relatively evenly distributed across the country. As no road investments were foreseen in the scenarios, the change in road accessibility is limited and mainly due to projects outside Estonia.

Rail: There are larger disparities in average rail speeds. Tallinn and the Tartu region have better rail accessibility, in relative terms, than the coastal regions of Pärmu and Kohtka Järve, and the central region of Paide. In all cases, however, the starting situation (as shown in the graph) was substantially below the EU average (being 1.0 in Figure 3.5).

The improvements in rail accessibility due to the investments in the Rail Baltica noticeably benefit the central regions along the rail corridor, whereas the western and eastern parts of the country are less affected by the investment. Compared to the EU average, the center of the country is expected to have improved access (i.e. closer to EU average).



Figure 3.5 Accessibility Problem Index Rail (Estonia 2006)

km = kilometer

Note: An index 1 means that the rail accessibility is at the average of all European regions. A figure below 1 means that the rail accessibility is better than average (i.e. the problem is lower). A figure above 1 means the opposite. Source: Ecorys Netherlands, in cooperation with Spiekerman & Wegener, Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion Funds for the Programming -Period 2007–2013, 2006, Annex Estonia.



Figure 3.6 Accessibility Problem Index Rail (Estonia 2016)

km = kilometer

Note: An index 1 means that the rail accessibility is at the average of all European regions. A figure below 1 means that the rail accessibility is better than average (i.e. the problem is lower). A figure above 1 means the opposite. Source: Ecorys Netherlands, in cooperation with Spiekerman & Wegener, Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion Funds for the Programming -Period 2007–2013, 2006, Annex Estonia.

Latvia

Due to its peripheral location, its maritime position, and its borders with Belarus and the Russian Federation, there are relatively few overland connections with other European countries, which are relatively long distance. The average travel speed from Latvian regions to other regions in Europe is relatively low by road and by rail.

Road: Road travel speeds are relatively evenly distributed across the country. Riga has even slightly lower average travel speeds than the other regions in Latvia. Road accessibility will improve in both the national perspective and the European perspective compared to 2006. As there are no TEN-T priority road projects involved, these improvements are due to road improvements in other countries and the influence of further reductions in border waiting times.

Rail: The disparities in average rail speeds within the country are generally small in the starting situation (without investments).



Figure 3.7 Accessibility Problem Index Rail (Latvia 2006)

km = kilometer

Note: An index 1 means that the rail accessibility is at the average of all European regions. A figure below 1 means that the rail accessibility is better than average (i.e. the problem is lower). A figure above 1 means the opposite. Source: Ecorys Netherlands, in cooperation with Spiekerman & Wegener, Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion Funds for the Programming -Period 2007–2013, 2006, Annex Latvia.

From a European perspective, these small differences almost disappear due to the foreseen rail investments, in contrast to the much larger disparities in Estonia in the north and Lithuania in the south: after the completion of the Rail Baltica, rail travel speeds to other European regions from Latvia will be very close to the European average.



Figure 3.8: Accessibility Problem Index Rail (Latvia 2016)

km = kilometer

Note: An index 1 means that the rail accessibility is at the average of all European regions. A figure below 1 means that the rail accessibility is better than average (i.e. the problem is lower). A figure above 1 means the opposite. Source: Ecorys Netherlands, in cooperation with Spiekerman & Wegener, Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion Funds for the Programming-Period 2007–2013, 2006, Annex Latvia

Lithuania

Also Lithuania is, from the European perspective, disadvantaged by its peripheral location, its maritime position, and its borders with Belarus and Kaliningrad, an enclave of the Russian Federation. The average travel speed from Lithuanian regions to other regions in Europe is below the European average, less so by road than by rail.

Road: Road travel speeds are relatively evenly distributed across the country. The eastern regions, including Vilnius, have lower average road travel speeds to other European regions than the regions along the border to Latvia. Road accessibility will improve only slightly compared to 2006, relatively to the European average. As there are no TEN-T priority road projects involved, these improvements are due to road improvements in other countries and the influence of further reductions in border waiting times.

Rail: Only the regions along the rail corridor between Vilnius and Riga have rail speeds above the national average, but below the European average in the starting situation. The remaining regions have serious deficits in rail accessibility.





km = kilometer

Note: An index 1 means that the rail accessibility is at the average of all European regions. A figure below 1 means that the rail accessibility is better than average (i.e. the problem is lower). A figure above 1 means the opposite. Source: Ecorys Netherlands, in cooperation with Spiekerman & Wegener, Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion Funds for the Programming-Period 2007–2013, 2006, Annex Lithuania

The investment in the Rail Baltica again shows that rail accessibility in Lithuania improves. In this case, like Estonia, mainly the regions along the rail corridor between Vilnius and Riga benefit significantly, whereas serious deficiencies in rail accessibility compared with the European average remain in some of the other regions of Plunge, Taurage, and Utenos.



Figure 3.10: Accessibility Problem Index Rail (Lithuania 2016)

km = kilometer

Note: An index 1 means that the rail accessibility is at the average of all European regions. A figure below 1 means that the rail accessibility is better than average (i.e. the problem is lower). A figure above 1 means the opposite. Source: Ecorys Netherlands, in cooperation with Spiekerman & Wegener, Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion Funds for the Programming-Period 2007–2013, 2006, Annex Lithuania.

Conclusions

The above shows that the Baltic states are expected to benefit from investments in transport corridors, in particular in the railway network. It also shows that, generally, regions closer to the network benefit more than those further away, which can be explained by the additional transshipment needed in these cases. With respect to road investments, the effects of investments are more evenly spread over the country, which can be attributed to the more developed scale of the network.

Evidence from Evaluations So Far

Introduction

There is no comprehensive ex post evaluation available on the investments under the TEN-T program, nor are there evaluations of economic impacts of investments. However, two reports do give some indications on the effectiveness of the program and individual projects. The mid-term evaluation on the TEN-T program 2007–2013 highlights various issues relating to the TEN-T program.²⁸ It also draws lessons on difficulties that arise with implementation of a corridor program. Some of these have relevance for development of corridors in Central Asia.

²⁸ Steer Davies Gleave, Mid-Term Evaluation of the TEN-T Programme (2007–2013), Final Report. March 2011.

Secondly, a less recent European Investment Bank evaluation on cross border projects gives some evidence on the level of individual projects.²⁹

Some conclusions from the mid-term evaluation of the trans-European transport network program:

The midterm evaluation of the TEN-T program concludes that the priority projects, which form the spine of the TEN-T network, are not delivering the expected effects. A few priority projects are completed and numerous sections are finalized, but some key parts, such as cross-border sections, are still missing. This explains why the TEN-T network is an assembly of largely national sections, often poorly interlinked, rather than a proper physical and interoperable network.

Further, it was concluded that most priority projects focus on rail: 18 address rail and two address inland waterways, without achieving a coherent network.

Thirdly, some cross-border issues were noted, such as a lack of international cooperation, different infrastructure or operating standards, a lack of common working methods, and a lack of international binding treaties.

Some conclusions from the European Investment Bank evaluation of cross border projects:

The European Investment Bank evaluation covers 11 transport projects. It evaluates these projects against common European Investment Bank criteria. Below are some conclusions on these projects.

For cross-border projects, coordination and management is often particularly complex due to different sets of regulations and laws, but also due to cultural and/or language barriers. For large-scale transport infrastructure projects in conjunction with the physical cross-border infrastructure, social connections have to be built, since country-specific differences might hamper the exploitation of the full benefits of the physical connection.

The evaluation showed that while levels of regional impacts of projects deviate from sector to sector, the hypothesis that the larger the project, the higher the regional impacts are, could not be validated. The most important regional impacts are related to accessibility: the possibility to attract new and often project-related industries and socioeconomic activities.

While employment effects are often an important policy objective and a concern for regional politicians promoting a project, the long-term employment effects are often limited. However, the port and airport projects had important employment, as well as wider economic, implications. Only one of the projects contributed significantly to cross-border cooperation (cultural and commercial).

In an attempt to understand the reasons behind the differences in regional impacts across the projects, the level of enabling factors (institutional and policy framework) or policy multipliers offers a plausible explanation. Deliberate policy actions initiated by regional stakeholders appear to have contributed greatly to the positive regional impacts.

²⁹ European Investment Bank. (2006). Evaluation of Cross-Border TEN Projects (Synthesis Report). Luxembourg. http://www.eib.org/attachments/ev/ev_cross_border_ten_en.pdf

Reflection on European Union Experience in View of Applicability for Asian Development Bank Study

This paper has described some experience with developing transport corridors within the EU. It also gives a description of an economic model that has been developed with the specific aim to capture the economic effects of investments in transport infrastructure, including GDP per capita and transport speeds. The present section tries to reflect on these experiences with a view to developing an instrument to appraise investments in corridors in Central Asia.

A main conclusion can be that, given the data problems that had to be overcome, the SASI model seems a valuable tool in assessing the impacts of transport improvements on regional economic development. The model can give answers at a strategic level. The strategic analyses with the SASI model need to be followed up with more in-depth project appraisals. It requires a substantial database, though, with a long time series.

The ex ante analysis with the SASI model shows that some characteristics may make that investments are more promising:

- In general, the relative impact of transport investments is strongest in smaller countries.
- Relative impacts are especially strong if investments succeed in connecting countries to the economic core of Europe.
- If smaller countries are surrounded by other European countries where transport is further developed, the impact is increased.
- There is a large European impact of projects outside the country in which the investment takes place, in particular if these investments fit within European transport corridors. This clearly identifies the strong need for cross-border coordination in realizing these corridors.

It can also be concluded that ex post evidence of the impact of investments in transport corridors is quite scarce. The available evaluations concentrate on organizational and program aspects, or assess implementation against original schedule. The midterm evaluation of the present program is critical on the selection process of the corridors and the speed of implementation of projects.

The European Investment Bank evaluation of cross-border projects shows that generally ex post economic rate of return calculations are higher than ex ante calculations, because of either higher traffic demand or lower than anticipated transport costs.

A fourth conclusion is that there have been major problems over the past decades with developing cross-border corridors. Such problems are likely to lead to delays in implementation and a loss of economic efficiency. Measures need to be taken beforehand to ensure swift implementation of such projects.

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4

Evaluating Investments in Economic Corridor Development: Lessons from the South Asia Subregional Economic Cooperation Study

Hans-Peter Brunner, Asian Development Bank and Kislaya Prasad, University of Maryland

Introduction

n the South Asia Subregional Economic Cooperation (SASEC) study, we were part of a team that developed a novel methodology to evaluate the potential impact of Aid for Trade (AfT) infrastructure investments. The methodology was grounded in economic theory (in particular, in its use of general equilibrium and economic geography principles) and incorporated detailed information about the region. The project also involved significant data collection. This data was combined with data from secondary sources and provided as input to a computational model, which was used to compare AfT investment projects with respect to benefits and costs. The evaluation methodology developed in the study is ex ante in nature—intended to assist policy makers in deciding which among a competing set of alternatives to choose. This is to be distinguished from the equally important, but conceptually distinct, approach to evaluation once the decision to go ahead with a project has been made. In the latter case, the concern may be whether the project is progressing on the planned implementation schedule at reasonable cost. In contrast, the decision to go ahead with a particular project should depend on the anticipated benefits and costs of alternatives. A final mode of analysis would be expost, where one would analyze, retrospectively, what the effect of a project turned out to be. Such an analysis would be particularly valuable for determining whether assumptions about impact in an ex ante study were in fact borne out. Such an expost analysis would provide input for subsequent ex ante studies.

The most distinctive feature of our model is that it is explicitly located in the geography of South Asia. The geography was matched along key dimensions (such as population, location of resources, and commercial centers, etc.) with the actual region of interest. Conceptually, we imagined a number of markets located in various geographical areas. Each market was called a tile (which may be thought of as an independent local economy). The area of a tile is small enough for transportation costs within the tile to be negligible. Production, consumption, and trade can take place in tiles. Trade can also occur between tiles. However, costs of transportation (time and resource costs) need to be taken into account for intertile trade. Individuals make consumption, production, and trading decisions based on relative prices and prices in the model adjust to clear all markets (i.e. prices are such that demand and supply are equal in all markets). Infrastructure investments have an impact by affecting the costs of transportation between tiles. Their long-term impact is on the overall geographic distribution of production, consumption, and incomes. This allows for an assessment of regional impacts of infrastructure investments. Such an assessment is especially critical when projects and their impact spill across international boundaries. In the SASEC study, the model was used to devise policies (in this instance, transit fees) to ensure that benefits of infrastructure investment projects are shared across all stakeholder countries.

A second distinctive feature of the model is the explicit representation of value chains, and the possibility for their reoptimization. The production of most goods tends to be geographically dispersed. For instance, primary resources may be extracted or farmed at one location; processed at another; combined with other inputs and converted to a finished or semifinished product at a third location; etc. Infrastructure investments are likely to affect the geographical organization of production of a single product as well. As a consequence, inputs may be sourced from different locations; stages of production may be combined or disaggregated; and so on. Our model includes intermediate goods, which, combined with the indexing of goods by location, allows us to evaluate the effect of investments on value chains.

We examine the effects of investments via their effects on time and resource costs of transportation between tiles. The model is quite flexible and allows for both single as well as multimodal transportation. The approach has the advantage that we are able to incorporate hard investments (roads, bridges, etc.) and soft investments (refrigeration facilities, lead-free certification of pottery, etc.).

This paper is an exposition of the overall framework with a view to its application in other regions. As such, we do not stress the specific findings and policy applications as they pertain to the SASEC region.³⁰ Instead, the focus is on the lessons learned from the experience of that study.

Theoretical Foundations

We provide here a nontechnical exposition of our approach. The technical model is included as an appendix. As outlined in the introduction, the need is for a model that can be used to evaluate how a specific project (such as the extension of a road corridor) will create "value," and whether this value is justified by the costs. There could be multiple measures of value for public projects (income levels and growth rates in the region, output of specific industries, impact on vulnerable populations, etc.) and of cost (dollar cost of a project, environmental impact, distributional impact, etc.). The value of transportation infrastructure investment lies in its enabling faster and cheaper movement of goods and people. The improvements are likely to affect the decisions of people in the region—for instance, in the location of economic activity. Another possible consequence is that consumption could move farther from the sources of production, and resources could be repurposed to produce goods for trade rather than local consumption. The most significant effects are likely to arise from the better integration

³⁰ For SASEC study details refer to ADB. 2013. *Aid for Trade—An Investment-Benefit Road Map from South Asia.* Manila.

of previously remote locations to economic centers (and hence into the regional and world economy). It is generally hoped that these effects will be positive, but it is worth noting that better integration is a two-way street. It could well be accompanied by the flooding of local markets with goods imported from major economic centers (whether domestic or foreign). While traditional trade theory tells us that the overall effects will be positive, it is quite possible that there might be negative effects in regions.

So how does one go about measuring value and cost of economic corridors in such a setting? Regardless of how we choose to measure value and cost, a proper measurement would need to be grounded in the answer to a secondary question—how would infrastructure investment change the existing patterns of production and trade? For this, we need to develop answers for some key questions.

- 1. What does the current geography of production look like? In other words, what are the main goods being produced in the region of interest? From where are the productive inputs procured? In which markets do the produced goods end up, etc.?
- 2. What is the existing transportation structure, and how is it being used (i.e. pattern of flow of people and goods)? Data from (1) and (2) define the baseline against which we will compare interventions.
- 3. What will be the impact of infrastructure investment on the time and cost of moving goods and people between two locations, and what will be the impact on the pattern of movement of goods and people? For instance, will an extension of a road mean changes to the mode of transport or to the route used to transport some goods? The alternative investments being considered by policy makers define the scenarios.

How will these changes in transport patterns affect the pattern of production and consumption (e.g. the location of economic activities)?

In the SASEC study, we decided to focus on the effect on per capita income as the primary measure of the value of a project (a secondary focus was on trade flows).

In our representation of the economy, the region was split up into smaller subregions. The economy in a tile is modeled as a simple general equilibrium model. Since we were interested in value chains for single goods, we included one final good. To model a non-trivial value chain, we included an intermediate good. In addition, the model includes labor and land as factors of production. However, the number of final and intermediate goods, as well as inputs, can easily be increased. As agents, the model has consumers, firms, workers, and landlords. Individual households provide factors of production to firms, and earn wages and rents in return. Incomes are used to consume the final good. Both the final and intermediate goods are produced by firms after the purchase of inputs.

We now describe the economy within each tile—which will be a general equilibrium system. From the consumers' decision problem, we obtain the demand for the final good and the supply for labor. From the firms' decision problem, we obtain the demand for labor and of the intermediate good. The supply of the final and the intermediate goods are also derived. Note that demand and supply functions will typically be functions of all prices. We obtain market clearing prices for all goods in the model by simultaneously solving the system of equations. This computation is done using numerical methods. Within each tile, we aggregate demand and supply curves and solve for equilibrium prices. The aggregation allows us to abstract from the process of price formation. The model becomes more agent-based in flavor when intertile trade is considered. In a model with no intertile trade, fundamentals determine prices. These prices will differ across tiles depending on population, income, raw material endowments, etc. Price differences induce movement of economic activity into other markets. Since the possibility of physical migration is excluded, we have individuals moving their demands to markets where a good is cheaper. They consume remotely produced goods if these are cheaper after an accounting for transportation costs. In reality, this process is likely facilitated by the profit maximizing actions of arbitrageurs, but such agents are not explicitly modeled here. Here, as is the norm in agent-based modeling, we assume simple adaptive behavior, with agents moving their demand in response to the spatial distribution of prices. The intertile trade induced by price differences will cause prices within tiles to change (to fall if consumers start consuming from other markets, and to rise if consumers from other markets are attracted to this tile). The new set of prices that emerge will reflect underlying transportation costs. Associated with these prices will be intertile trading volumes, and consumption and production patterns.

Modeling Transportation Costs

We focus now on the representation of transportation costs in that model. This is the basis for the representation scheme (data frame) described in subsequent sections. Costs vary with distance transported (freight may additionally vary with weight and volume), time taken, and characteristics of the good (e.g. whether perishable or durable). It is assumed that these costs vary in a linear fashion with only distance and time. In case costs are different for different types of cargo, we can compute different such cost functions. Generalization to include other factors, and nonlinear costs, are straightforward.

In the SASEC study we used the Iceberg Model for costs. In other words, some fraction of the transported good is lost during transportation. Assuming that the depreciation rate is constant, this can be modeled as follows: Let exp(V0) denote the value of the good at the point of origin.³¹ Then the value at any other location j (when the point of origin is i), V_{ij}, is given by

$$Vij = \exp\{V_0 - b_1 t_{ii} - b_2 d_{ii}\}$$

where tij is the time taken to transport goods, and dij is the distance traveled. In this case, 100b1 is the percentage loss in value for every period spent in transit. Similarly, 100b2 is the percentage loss in value for every unit of distance from the point of origin. We can add to this a hard time T, such that 100% of the value is lost if the good is not delivered by time T. Location indices will hereafter be dropped, and we will use the equivalent formulation,

$$ln(V) = V_{0} - b_{1} t - b_{2} d$$
⁽¹⁾

The next graph depicts the depreciation in value at the point of origin (d = 0) when the initial value is 1 and the depreciation rate is 5%.

The framework can be flexibly extended. For instance, we can include an indicator variable I for whether the good is a perishable or not. In which case, we could have

$$\ln(V) = V_0 - b_1 t - b_2 d - b_3 l - b_4 (l^* t) - b_5 (l^* d)$$
(2)

³¹ The exp and In functions are used just to get constant percentage depreciation rates of value with distance.

Here, b4 and b5 capture the difference in depreciation rates between durables and perishables. The depreciation over time will be higher for perishables than for durables.





Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

However, this model could also take into account differences in freight rates. Suppose, for instance, that multiple means of transportation are available, with different freight rates. For any desired movement of goods between two points, we could compute remaining value under each possible mode of transport. The assumption will be that sellers pick the least expensive means of transportation.

In the SASEC study, we were particularly interested in costs of goods produced through the value chain (and how this affects the location of production). As goods proceed through the value chain they are transported, and processing can change the costs (by changing the characteristics of the good). Consequently, different cost formulae need to be applied for goods at different levels of processing. In particular, there would need to be separate cost functions (depreciation rates) for intermediate and final goods. For instance, fruit pulp may be perishable, but once processed into jam it may not perish in the time it takes to transport it to final consumers. In this case, the time depreciation rate for fruit pulp would be different from that of jam. This matters for where the processing of pulp into jam takes place.

Effect of Infrastructure on Cost

New infrastructure has the effect of changing costs. Clearly, a bridge across a river will reduce transportation costs by changing distance as well as time spent moving goods between points on opposite sides of the river. At the same depreciation rates, a larger fraction of the value is retained during transit. Similarly, refrigeration facilities will change the rate at which perishables depreciate. In the same vein, a processing plant near the source of, say, perishable fruit pulp will mean that less pulp is lost during transportation to its processing facility. Relatively less perishable jam can be transported with smaller losses.

Illustration

Consider the following example that illustrates the principle. We start with two matrices that illustrate the time and distance between three locations A, B, and C, (which happen to lie on a straight line, one unit of distance apart, although the route from B to C is mountainous).

Table 4.1 Time Cost Matrix

Time	A	В	С
А	0	10	30
В	10	0	20
С	30	20	0

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

Table 4.2. Distance Cost Matrix

Distance	А	В	С
А	0	1	2
В	1	0	1
С	2	1	0

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

Suppose the time depreciation rate is 0.01 and the distance depreciation rate is 0.02. Then the value remaining (given 100 units at the beginning) is

Table 4.3. Value Matrix

Value	А	В	С
А	100.00	88.69	71.18
В	88.69	100.00	80.25
С	71.18	80.25	100.00

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

Of course, if we had alternative means of transportation we would need to derive the matrix that has minimum loss in value between any pair of locations (i.e. the value assuming the optimal mode of transport). Now we would be able to solve the model fully. Infrastructure investments lead to new time and distance matrices (and hence, the value matrix). Solving the model again, we could compare the effect on economic activity.

Now consider what happens if infrastructure investments reduce the transportation time to the following matrix:

Table 4.4. Time Cost Matrix after Investments

Time	А	В	С
А	0	5	15
В	5	0	10
С	15	10	0

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

The new value matrix is:

Table 4.5 Value Cost Matrix after Investments

Value	А	В	С
А	100.00	93.24	82.70
В	93.24	100.00	88.69
С	82.70	88.69	100.00

Source: ADB. 2013. *Aid for Trade—An Investment-Benefit Road Map from South Asia*. Manila. As expected, a much larger proportion of the value is retained.

The illustration shows, in the simplest terms, what is needed in terms of cost and travel time data. However, there are several complications, and we will get to that in the next section.

Data Representation

Reality is much more complicated than indicated by the simple illustration above. The first complication involves the real geography of a region. We need to split this into subregions between which transportation occurs. Each subregion should be small enough such that transportation costs are negligible within a region. Then the cost and value functions can focus on transportation between regions. The problem that arises is that economic data—incomes, population, land use, etc.—are available only for much larger subregions (e.g. districts and other administrative boundaries).

Geography

In the SASEC study, we divided the region into 50 kilometer (km) \times 50km subregions called tiles. The following map illustrates:



Figure 4.2. South Asia Subregional Economic Cooperation Region Subdivided into Tiles

Note: Color shading reflects altitudes.

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

In this instance, we see the map for the area covered by the SASEC study with a grid of tiles overlaid. We can then number the tiles (say there are N) and define the N \times N matrix where entries are distances between two tiles as in the illustration above. Multiple definitions of distance are possible. For instance, imagine a matrix whose entries are ones and zeros with an entry of one exactly when two tiles are adjacent to one another. (E.g. suppose the tile in the extreme northwest corner is tile 1, and the tile in the extreme southeast corner is tile N). These two tiles are not adjacent to one another, so the entry for (1, N) is 0. If 2 is the second tile in the first row, the entry for (1, 2) is 1. Alternatively, the entries could be distance by current roads from one tile to another. In this latter case, the problem is that there could be multiple routes for getting from one point to another. With this in mind, we can construct a matrix that only has shortest distances to the adjacent tiles. The distances to more remote tiles can then be computed as the minimum distance using the matrix (with only adjacent distance entries). The same procedure can be used for rail transport - tiles that are one train stop away are defined to be adjacent, and the distance entries for these adjacent stops can be used to compute distances between more remote locations. The same procedure can be followed for waterway transport as well. Finally, it is possible to combine modes of transport to get from one tile to another. Costs and delays at transit points (or at borders) are easily accounted for. The case for time matrices is exactly analogous.

In the region above, there were international boundaries. This was accounted for by imposing a larger cost for crossing an international boundary. A more complicated problem arises at the boundaries of the entire region. In the SASEC case, the relatively quiet Myanmar boundary, the Himalayas, and the Bay of Bengal make the region relatively self-contained. We modeled connections with the external world via the ports, but India (which is only partially included in the region) was problematic.

Local Economic Data

There is a need for basic demographic information for the tiles and other pertinent information to model the region's economy. A minimal list of variables would include: population, wages, rents, income distribution, land-use patterns, goods produced, goods consumed, etc. Additionally, some data will be used for calibration of the model—principally, prices of final and intermediate goods. Much of this data was obtained from government sources and from international organizations.

One reason for choosing the given tile dimensions is that this made it convenient for the use of Landsat data. However, a difficulty here is that administrative regions for which data are available do not necessarily correspond to the tiles. This requires some method for allocating numbers from the administrative regions to tiles and vice versa. In essence, we used ad hoc approximations. One way around this problem is to use administrative regions instead of tiles. The downside is that these may be large, so that within region transportation costs are not negligible. Then we would have the reverse problem of matching Landsat data to administrative regions.

Transportation Infrastructure

Clear understanding of the transportation infrastructure is required. This information is then captured in the distance and time matrices described above. The simplifying assumption used is that there is a single road route between two adjacent tiles. In practice, there may be more than one route (e.g. by highway or local routes). It is often the case that some routes are longer (or more expensive) but faster, while others are shorter (or cheaper) but take more time. Roughly, the time differences are compensated with cost differences. So, the assumption of a single road route is acceptable if we are collecting information along multiple dimensions (particularly, cost and time)—the aggregated cost of different travel methods should be similar. So, to summarize, we would have matrices (spreadsheets) with rail travel times, rail travel costs, road travel times, and road travel costs between adjacent locations. If waterways or air cargo are relevant, similar matrices can be constructed for them as well. The cost data underlying the SASEC study was gathered from primary sources: ground experts provided information on travel times and freight costs, which are reflective of the current condition of the transportation infrastructure. We ensured that we at least had information on costs for road transportation between adjacent tiles. Appropriate algorithms compute distances between non-adjacent locations using the assumption that the least cost mode of transportation will be used (using multiple modes of transportation is assumed feasible).

How are proposed improvements in the transportation infrastructure to be accounted for? These could take the form of new or improved roads, new rail lines, improved transit facilities, refrigerated storage or transport facilities, shortening of time and costs at national borders, bridges, etc. For this, based on design and engineering specifications, we forecast reductions in time taken to travel (transport goods) between two locations. Where relevant, we would also modify the distance matrix (e.g. a new road connecting two locations).

In essence, "before" and "after" distance and time matrices are used to account for infrastructure investments. Demand for different modes of transportation depends only upon time and distance of the alternatives. (Transportation infrastructure is a public good, and not priced in markets).

The parameters of the "Value Remaining" functions present additional options. The rate of depreciation of goods can also be changed (for instance, because of refrigeration facilities, better law and order, etc.).

Data Format

As the descriptions above indicate, all data can be stored as 2×2 arrays. We stored them as Excel files. These were read by algorithms that made any additional calculations needed.

Application to Value Chains

As goods proceed through the value chain, they are both processed and transported. Processing can change the transportation costs (by changing the characteristics of the good). Consequently, different cost formulae need to be applied for goods at different levels of processing. In particular, separate cost functions (and depreciation rates) are needed for intermediate and final goods. For instance, fruit pulp may be perishable, but once processed into jam it may not perish in the time it takes to transport it to final consumers. In this case, the time depreciation rate for fruit pulp would be different from that of jam. This point is critical for understanding the geographical distribution of production. The time, distance and other costs of transportation will determine the optimal geographical organization of production. For instance, if these costs are high for a key raw material, but relatively low for the finished good, then production will occur near the source of the raw material. To summarize:

Differences in cost functions for intermediate and final goods will influence the geographical distribution of production—i.e. where raw materials are processed, where intermediate goods are produced, and where final goods are produced.

A key strength of the model developed for the SASEC study was the incorporation of nontrivial value chains into a rigorous model of production and transportation. In principle, we can start with raw materials, end with finished products, and have intermediate stages of production spread out geographically. The final delivery of goods can be in "international markets," and inputs can be sourced from "international markets" as well. In the framework of this note, international markets are distinct tiles with fixed prices, and defined transportation costs from ports and other transportation hubs. In other words, we can trace the entire value chain—from raw materials to export—and clearly identify how final prices (hence competitiveness) depend upon infrastructure investments.

Such a framework proved to be very useful for studying a single good for which we were able to examine exactly the type of intervention (e.g. reducing the cost of exporting to international markets, or removing a significant transportation hurdle) that would make it more competitive in the global economy. A key part of the data gathering effort has to be to identify the goods in which the region has demonstrated some competitive advantage, as well as goods for which it could be competitive *given the appropriate infrastructure investments*. In the SASEC study, this took the shape of conducting detailed studies of individual goods (existing or potential) in which a country could become competitive given the appropriate investments in infrastructure. The value chains were mapped out, and significant bottlenecks identified. We determined what investments were necessary to ensure that this good reaches international markets at competitive prices. We were also able to prioritize investments on the basis of the competitive advantage they would create.

Results

The results of the SASEC study are too extensive to be presented here in full.³² The focus in this section is on presenting a sampling of results to give a sense for the possibilities of the kind of modeling exercise we engaged in.

After the model is calibrated with data, it can be used for comparison in two ways. First, we can examine the incremental effects of infrastructure investments in terms of gains in per capita income. Policy makers, who will be aware of the costs of the investments, can then determine if benefits justify costs. Second, in case there is a choice between two alternative investment projects, we can compare the gains in income and costs under the alternatives. Both methods require that we calibrate against a benchmark—how the economy would perform without additional infrastructure investments. In this section we describe an experiment of the first variety. We establish a benchmark, and then examine the gains that arise from two kinds of infrastructure investments. Two sets of investment projects were identified. The first set was a group of "hard" investments—previously identified infrastructure improvement initiatives as part of the South Asian Association for Regional Cooperation corridors. A second set of "soft" investments were also identified—perishable infrastructure improvements such as refrigerated warehouses.

As was described in detail above, we first translate the effects of investments on the costs of transporting goods between any two tiles (or, equivalently, on the value remaining after

³² For a complete explanation of results, see ADB. 2013. *Aid for Trade—An Investment-Benefit Road Map from South Asia*. Manila
transportation). Then we allow agents to make production and consumption choices, and for prices to evolve, until we are at equilibrium. After establishing the benchmark, we compute the equilibrium for the post-investment cost and/or value configurations. We can then compare prices, incomes, and other relevant economic variables. Income is of course a natural metric for welfare. We are interested primarily in how much per capita income increases. Policy makers may also be interested in the interregional distribution of income and in mitigating disparities.

Three specific scenarios (S) are simulated:

- (S1) A benchmark scenario in which economic activity with existing (present day) network of roads and trains is simulated;
- (S2) Economic activity after enhancement of the transport network in (S1) with a set of nonperishable road and/or rail infrastructure investments;
- (S3) Economic activity after a full set of investments including both the nonperishable infrastructure of (S2) and additional investments in perishable infrastructure improvements (e.g. refrigerated or automated warehouses or stockpile storage locations).

Comparisons between the three scenarios S1–S3 can be made both in final equilibrium outcomes (costs, welfare, etc.) and in dynamics leading up to equilibrium. The results are described at the level of individual tiles, at the level of administrative districts, and at the aggregate level for the entire population affected by AfT.

We will present here our results for districts. Results are for income growth only. For ease of illustration, results are presented in the form of a geographical map of the entire AfT area. Full dynamic simulation animations showing changes in the map through time are available from the authors upon request.

Income Growth by District

To capture income growth rates, we plotted the difference in income observed at the ending time step in each scenario to measure growth achieved through investment. Scenario S1 (benchmark) is compared to scenario S2 (nonperishable investments only) (Figure 4.3), S2 is compared to S3 (perishable and nonperishable investments) (Figure 4.2), and the overall growth from S1 to S3 is calculated (Figure 4.3). Each map displays district boundaries, regional color-coding, and geographic centroid dots. The size and color of the dots capture the magnitude of observed change in ending income (computed as average ending income from the relevant scenario minus average ending income from the previous scenario) for each district. Note that dots that change from red to pink are still improving, but at a lower rate.



Figure 4.3 District-Income: Income Growth above Baseline Due to Scenario 2 Investments

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila. Note: Iteration 708 denotes the end of the simulation. Income differences are in normalized units, which can be converted to dollars, as in Table 4.6 below. See source for details.





Note: Color shading reflects altitudes.

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila. Note: Iteration 708 denotes the end of the simulation. Income differences are in normalized units, which can be converted to dollars, as in Table 4.6 below. See source for details.

Note: Color shading reflects altitudes.



Figure 4.5. District Income Growth above Baseline Full Aid for Trade Investment Package.

Note: Color shading reflects altitudes.

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila. Note: Iteration 708 denotes the end of the simulation. Income differences are in normalized units which can be converted to dollars, as in Table 4.6 below. See source for details.

Figure 4.3 shows the change in income from baseline (S1) generated by the full implementation of the AfT (S3). Three central conclusions can be observed: no district is worse off after AfT investment, all districts show measurable improvement in income, and many districts enjoy dramatic improvement. Through numerous simulations, we were able to establish that:

- overall, average incomes increase due to AfT investments, but regionally there are winners and losers;
- both "hard" and "soft" investments are important for welfare;
- significant variation is observed across the study region in the benefits from AfT transport and trade investments;
- many regions in the economic periphery enjoy dramatic improvement in income from investments; and
- regions that become "well connected" due to infrastructure investments gain the most.

This last point deserves some elaboration. An important qualitative result to come out of the study is that regions that become well connected to high demand regions gain the most.

Perhaps the most striking thing to come out of the study was the regionally disparate impact of the investments. This is not altogether surprising since the underlying logic of the model is derived from trade theory, and that theory tells us that trade creates winners and losers. In this instance the winners and losers just happen to be different regions. In the SASEC study, the gains mostly accrue to regions in India, whereas areas in Bangladesh lag, if not suffer. The advantage of a model such as ours is that it can also be used to devise remedial policies, so that the overall gains can be more equitably spread. In the present instance, we did this by examining alternative transit fees.³³

³³ For more details, see ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

Incomes, trading volumes, etc. can be aggregated up to any desired level. Policy makers would be interested in gains at the national level. In the case of the SASEC investments, the income gains and increase in trade volumes are reported in Tables 4.6 and 4.7 respectively.

	Pop. (millions)	Scenario 1	Scenario 2	Scenario 3
India (Eastern)	300	2522.34	2554.26	2574.03
Bangladesh	140	2027.54	2028.8	2030.49
Nepal	25	2575.61	2603.06	2607.06
Bhutan	1	2431.13	2467.33	2492.33
All	466	2388.56	2411.74	2425.13

Table 4.6. Gains in Average Income in All Study Countries (\$, PPP)

Pop. = population, PPP = purchasing power parity

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

This table quantifies what was already apparent from the previous figures—that gains for India are substantial, whereas gains Bangladesh are minimal. The next table shows the percentage increase in the total volume of intertile trade (overall, and split up by country). Both hard and soft investments increase trade volumes. However, while trade grows in all countries, the effects are seen to be uneven.

	Nepal	Bhutan	Bangladesh	India	All
Scenario 2	4.05	9.10	2.62	4.74	4.12
Scenario 3	5.24	15.97	4.42	7.22	6.34
Increment	1.19	6.86	1.79	2.48	2.14

Figure 4.7. Volume of Intertile Trade Overall and By Country (% change)

Source: ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

Conclusion

In conclusion, we will focus on key lessons learned from the study. Although much deliberation had already gone into the design of the study, we were also fortunate to get considerable feedback from multiple audiences at seminars and presentations. In particular, we presented findings and recommendations to government officials in the region, and made both policy and technical presentations at ADB in Manila. The interactions highlighted the interests and concerns of the various stakeholders in infrastructure projects.

First, this study highlights the need for clarity in defining the metrics by which success of a project would be measured. The claimed benefits of economic corridor projects tend to be increases in incomes, reductions in poverty, alleviation of regional disparities etc. However, success of projects is often measured using a distinct set of metrics—such as reductions in travel costs and times. In other words, there is a fundamental mismatch between the criteria used to define success and the data used to measure success. No doubt this is because an accurate assessment of effects on social welfare (here measured by per capita income) is difficult. However, as the SASEC experience illustrates, such an exercise is not infeasible.

The second thing highlighted by this study was the fact that corridor projects are likely to have a regionally disparate impact. Even when the overall benefits of a project are positive,

some regions may fail to register gains (and may even incur net losses). Regions and countries are often aware of this, which can hinder the implementation of projects that have potentially large gains in the aggregate. A modeling effort such as ours can add clarity to the picture by quantifying gains and losses. This reduction in uncertainty can facilitate negotiations and foster agreements that ensure that all parties gain. In the SASEC case, the model was used to assess the likely impact of transit fees assessed by Bangladesh on cargo that crossed through from one part of India to another.

A third valuable thing to come out of the study was the specification of the data requirements for studies that address the two points highlighted above. The specifications— and the data framework—are likely to be essential even for studies that choose a methodological approach distinct from ours (for instance, one based on statistics rather than simulation). The essential elements of the data framework were laid out in detail in this paper, and include a framework for modeling transportation costs, as well as a framework for capturing the effect of infrastructure investments on costs. The availability of such data is probably the greatest hurdle for developing models that can be used to do meaningful ex ante evaluation of alternative investment proposals.

Reference

ADB. 2013. Aid for Trade—An Investment-Benefit Road Map from South Asia. Manila.

5

Future of Global Value Chains in the Greater Mekong Subregion

Mark Goh, National University of Singapore

Coording to Banga (2013), "the notion of the global value chain first emerged as regional supply chains in East Asia."³⁴ Indeed, Japanese investors were instrumental in fostering the practice of this paradigm. For instance, Toshiba products, which are being sold in Japan and globally, typically sourced components in from the People's Republic of China (PRC) and Southeast Asia, then processed the components into semifinished goods in locations with cheaper labor cost and/or that were less technology intensive. Goods were then routed to Japan for the final assembly and testing for quality control before being marketed internationally under a trusted brand. The exit path for this journey is the flow back to those same countries for the sales and distribution of the finished goods. There are other similar examples.³⁵ This supports the notional definition of the global value chain (GVC), as one in which various processes occur in the parts of the world that add value to that specific aspect of the process. But eventually, better economies-of-scale electronics, which often suffer technological obsolescence, soon permeated other product realms, and have now moved into the services realm.³⁶

Clearly, the reasons for siting and using the production bases then were (and still are, for those export-oriented economies and cost-sensitive enterprises) tax incentives, location advantages, availability of labor, and the ease of transport connectivity. At the same time, by joining a GVC, smaller enterprises serving as lower-tiered suppliers to transnational enterprises now have the opportunity to transform their businesses, through technology transfers and access to better corporate practices, into international operations offering greater options, wider reaches, and richer markets.

³⁴ R. Banga. (2013). *Measuring Value in Global Value Chains*, Published report of UNCTAD, Background paper RVC-8. p. 6.

³⁵ World Economic Forum (2012). *The Shifting Geography of Global Value Chains: Implications for Developing Countries and Trade Policy.*

³⁶ van Dijk, M. P. & J. Trienekens (2012). *Global Value Chains - Linking Local Producers from Developing Countries* to International Markets, Amsterdam University Press: Amsterdam.

Supply Chain Perspective

Taking a supply chain perspective, the GVC is a full range of value-added business activities that realize a product and deliver it to the end consumers, through more cost-efficient design, cheaper sourcing of raw materials and intermediate inputs, economies of scale in production, synchronized marketing, coordinated sales and distribution, finance, human resource, and integrated after-market product care services across international borders.³⁷ The production activities in a GVC are geographically spread across several economies or countries, and an enterprise can be involved in one or more activities in such a GVC. In this sense, the GVC's architecture involves the six key drivers of supply chain management, namely, those of a global inventory mindset, greater information visibility, strategically placed distribution infrastructure, leveraged procurement of materials and services, consolidated transportation, and a single product price. To date, there are three main types of GVC: producer-driven, buyer-driven, and multipolar, but all focus on creating value of the goods and services at each stage of a globalized production network.³⁸

Transformation Trajectory

With the renewed focus on an increasingly open climate of economic liberalization, greater technological development and improvement in transportation modalities and communication infrastructure, product markets today are becoming increasingly integrated to serve a one-world marketplace; and the GVCs have emerged offering an increasingly broad range of product groups or industries.

Several factors account for the fast rise and sustainability pathway of the GVCs.³⁹ These include:

- emerging markets, such as Brazil, PRC, India, the Russian Federation, and the continent of Africa;
- ecological sustainability and the scarcity of natural resources, and the increasing global awareness of environmental issues;
- new regulations, rules and compliance, and economic partnership agreements;
- natural disasters and pandemics;
- shifts in demographics, such as greying populations and urbanization;
- new information communication technologies such as cloud computing;
- more demanding and empowered consumers, particularly those from the growing middle-income base in the emerging markets of today and tomorrow;
- redesign and innovation of supply chain solutions for a global world and;
- complexity and transparency of information flow especially that of enterprise business analytics.

GVCs are playing an increasingly important role in the global economy. A recent report from the United Nations Conference on Trade and Development highlighted that GVCs

³⁷ Asia-Pacific Economic Cooperation (APEC). (2012). *Concepts and Trends in Global Supply, Global Value and Global Production Chains*, Issues Paper No. 1, Publication of APEC Policy Support Unit, May.

³⁸ Organisation for Economic Co-Operation and Development (OECD). (2007). *Moving Up the Value Chain: Staying Competitive in the Global Economy.*

³⁹ G. Gereffi, J. Humphrey, & T. Sturgeon (2005). *The Governance of Global Value Chains, Review of International Political Economy*, Vol. 12, Iss. 1, pp. 78–104.

shaped by the transnational enterprises account for about 80% of global trade, and that global investment and trade are inextricably intertwined.⁴⁰ In addition, GVCs make extensive use of the services sector (involving the functions of finance and human resource) for both developed and developing economies. Further, more developing countries are now participating in the GVCs, from 20% in 1990, to 30% in 2000, to more than 40% in 2012.⁴¹ Given this, the GVC linkages formed through economic and supply chain extensions have been more beneficial to the GDP growth of developing countries, compared to the developed countries.

Indeed, despite the concern regarding the historical pattern of footloose GVC-related industries⁴² and the potential danger of a developing economy being locked in a production regime of low-value-added activities, GVCs have proved to be a potential avenue through which developing economies can rapidly ramp up productive capacity, achieve faster economic growth through technology dissemination and skill building, and open up opportunities for longer-term industry upgrading for the domestic enterprises.

Global Value Chains and Small- and Medium-Sized Enterprises— Is There a Convergence?

The emergence of the GVCs inevitably creates a complex web of supporting industries and businesses based in emerging economies to engage and participate in the associated international production networks.⁴³ In the case of the Association of Southeast Asian Nations (ASEAN), and the Greater Mekong Subregion (GMS) comprising Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, Viet Nam, and the Yunnan province of PRC, this offers potentially significant opportunities for integrating the vast number of GMS enterprises, particularly the million or so small- and medium-sized enterprises (SMEs) more effectively into the regional ASEAN and international economies. From the development perspective, there is indeed a convergence of the GVCs and SMEs. First, the GMS is one of the fastest growing regions in the world and the economies within the GMS are at various levels of economic development (Thailand is far ahead of the pack) and their endowments complement each other. Next, the SMEs in the GMS form at least 96% of all establishments in their countries, and contribute to at least 70% of employment overall.⁴⁴ Being aligned to the GVCs helps domestic SMEs in the GMS leapfrog out of the domestic market more readily, embrace better quality standards and practices, and be more plugged into an international market. At the same time, Abe et al. (2012) report that such SMEs have a higher propensity to adopt new technology, and a greater capacity to innovate, alleviating the significant constraints and challenges on the SMEs' capabilities to survive in global markets. For instance, the participation of smaller suppliers in the GVCs led by global producers such as Nestlé require that SMEs change their way of doing business to conform

⁴⁰ United Nations Conference on Trade and Development (UNCTAD). (2013). *Global Value Chains and Development: Investment and Value Added Trade in the Global Economy.*

⁴¹ UNCTAD (2013).

⁴² C. Markides, & N. Berg (1988). *Manufacturing Offshore is Bad Business, Harvard Business Review*, Vol. 66, No. 5, pp. 113-120.

⁴³ G. Abonyi. (2007). Linking Greater Mekong Subregion Enterprises to International Markets: The Role of Global Value Chains, International Production Networks and Enterprise Clusters, UNESCAP Studies in Trade and Investment Vol. 59.

⁴⁴ ASEAN (2012b). ASEAN Strategic Action Plan for SME Development (2010–2015), retrieved from www.asean. org/communities/asean-economic-community/category/small-and-medium-enterprises, 10 pp.

to a stricter harmonized standard of good manufacturing practices. While this threatens the exclusion of suppliers unable to meet such requirements, it also provides significant opportunities for those that can. A dynamic SME sector is crucial for broad-based economic development, and one way of achieving it is to grow with GVCs.

As mentioned in the ASEAN blueprint for SME development 2010–2015, which includes most of the GMS actors, initiatives and actions for closer subregional cooperation are proposed to build the competitiveness of the SMEs and to expand their presence in the international markets through participation in GVC.⁴⁵ In this regard, supply chain connectivity is key.⁴⁶ Action plans include developing more efficient logistics systems to support the relevant economic corridors of the GVCs, building stronger and deeper transport linkages and collaborations in the GMS and across borders, and introducing more effective and transparent cross-border trade facilitation arrangements and more transparent and harmonized customs clearance procedures for import and/or export movements. In addition, it is useful to conduct trainings and establish resource centers for advisory services to help SMEs acquire a better understanding of the role of the GVCs in intra-GMS trade capacity building, to improve access to information and to boost communication among the GMS member countries and industries.⁴⁷

Concluding Remarks

No doubt, the GVCs and SMEs share a common destiny especially in the context of the GMS. In this regard, GVCs have a future in the GMS. However, there are nevertheless practical challenges, which with time and proper policy calibration can be adequately addressed. The imperative is on how to provide or create an enabling environment for the successful integration of the SMEs into the larger network offered by the GVCs. The future role of the GVCs in the GMS lies in the sustainability of suitable economic corridors to support the smooth functioning of such GVCs and the SMEs. At the moment, this need for an economic corridor is not abating. The call for action is to have a GVC-focused GMS co-operation, which can harness the respective strengths of the respective SME supplier community clusters within and across the GMS member economies.

⁴⁵ ASEAN (2012b).

⁴⁶ M. Goh. (2013). Supply Chain Connectivity and Trade in Asia, In *Global Value Chain in a Changing World*, D.K. Elms and P. Low (eds.), WTO Publications.

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6

The Greater Mekong Subregion Economic Corridors— Operationalizing Spatial Planning Tools for Environmentally Sound Corridor Investment

Lothar Linde, GMS Core Environment Program

Background

The Greater Mekong Subregion

The Greater Mekong Subregion (GMS) comprises six countries that are linked by the Mekong River—Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, Viet Nam, and parts of the People's Republic of China (PRC), (Yunnan Province and Guangxi Zhuang Autonomous Region). Since the early 1990s, the GMS countries have seen unprecedented economic growth, facilitating the region's transformation into regional economic powerhouse.⁴⁸

This growth has not benefitted all parts of society evenly: while urban centers are disproportionally growing, the rural population—particularly in remote areas—remains largely disconnected from this progress. To counteract increasing disparities and realize its goal of a poverty-free and environmentally rich GMS, the Asian Development Bank (ADB) has developed the economic corridor model, embedded in its GMS economic cooperation program (GMS program).⁴⁹ At the core of this model is the development of transboundary roads between major economic centers. These roads are aligned through remote and impoverished areas to establish connectivity with the economic hubs at the end-nodes and "stepping stone" markets along the road. This is followed by corridor and sector plans laying out options for sector investments and further connectivity enhancements (e.g. feeder roads,

⁴⁸ Gross domestic product (GDP) in the region grew at an average annual rate of 8.1% between 1993 and 1996 and 6.1% between 2000 and 2008 (GMS without PRC). Source: http://www.gms-eoc.org/resources/ proceedings-gms-2020-international-conference, page 13.

⁴⁹ The corridor concept has provided a holistic approach to the spatial development of the poorer areas of the GMS by focusing on investments in priority sectors (e.g., agro-industry, energy, telecommunications, tourism, transport, trade and investment).

rail, and river). Together they transform corridor roads into full-fledged economic corridors that provide new livelihood opportunities for previously marginalized population.

Currently, ADB is developing nine corridors in the GMS: 1) Northern Corridor, 2) North–South Economic Corridor, 3) Northeastern Corridor 4) Eastern Corridor, 5) East–West Economic Corridor, 6) Central Corridor, 7) Southern Corridor, 8) Southern Coastal Corridor, and 9) Western Corridor. Alignment is shown in Figure 6.1.



Figure 6.1: Map of Greater Mekong Subregion Economic Corridors

Source: ADB. 2012. GMS Atlas of the Environment, 2nd Edition. Manila.

Much of the economic growth and related social achievements generated by these corridors is fuelled and sustained by the corridor's natural capital.⁵⁰ However, many developments along these corridor roads are exceeding the regeneration and coping capacity of the natural capital (resilience), leading to natural resource depletion, land degradation, loss of biodiversity and genetic diversity, and extensive water, soil, and air pollution. In turn, the loss in natural capital has direct implications on the performance of GMS program investments along the corridors, particularly sector investments that rely heavily on intact ecosystem services (hydropower, ecotourism). It is also putting broader socioeconomic development targets at risk as the ecosystems regulatory services (e.g. water regulation, soil protection) are essential to maintaining food security, disaster protection (flood, landslides), and pest control.

Key Economic Characteristics of Selected Corridors

Economic characteristics and the zoning of each corridor is summarized by the regional multisector investment framework transport study. Nine corridors have currently been identified, with the North–South Economic Corridor and the East–West Economic Corridor being among the most developed. A basic screening and comparison of characteristics of these both corridors is summarized in Table 6.1.

Corridor		NSEC	EWEC
Demographic situation	Population and/or economic centers	Bangkok and Chiang Rai (Thailand), Jinghong and Kunming (Yunnan Province of PRC)	Da Nang (Viet Nam), Savannakhet (Lao PDR), Mukdahan, Khon Kaen and Sukhothai (Thailand), Mawlamyine, (Myanmar)
	Population profile	Large urban population in Bangkok, Thailand (8.3m) and Kunming, Yunnan Province of PRC (3m), otherwise largely rural and remote (subsistence)	Urban (Da Nang, Viet Nam; Kon Kaen, Thailand; and Mawlayine, Myanmar), otherwise largely rural (Isaan)
	Ethnic minorities	Particularly between Chiang Rai, Thailand; Lao section, and until Jinghong, Yunnan Province of PRC	Particularly in Quang Tri, Viet Nam; Savannakhet, Lao PDR and Myanmar section
Infrastructure	Current traffic volume	Likely highest traffic volume considering its end point, Bangkok, Thailand. In northern section, part of the exports might divert to Hai Phong, Viet Nam.	Likely strongest toward end points. Isaan agriculture produce might divert to Bangkok, Thailand via Central Corridor.

Table 6.1 North–South and the East–West Economic Corridors, Features

continued on next page

⁵⁰ "Natural capital is natural assets in their role of providing natural resource inputs and environmental services for economic production. Natural capital is generally considered to comprise three principal categories: natural resource stocks, land and ecosystems. All are considered essential to the long-term sustainability of development for their provision of "functions" to the economy, as well as to mankind outside the economy and other living beings." Source: Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.

Corridor		NSEC	EWEC
Connectivity	Number of airports along the route	15 (5 international)	9 (1 international)
	Proximity to railroad	Largely parallel, from Bangkok to Chiang Mai (Thailand), section planned parallel from Chiang Rai (Thailand) to Menyang (Yunnan Province of PRC) and again from Mo-Chiang to Kunming (partly under construction)	Mostly crossing, at Khon Kaen, Mawlamyine, Phitsanulok, and parallel from Dong Ha to Da Nang
	Access to sea ports	Bangkok (Thailand). Connection from Tak (Thailand) to Mawlamyine (Myanmar) or Bangkok (Thailand) to Dawei (Myanmar) might reduce time to Europe.	Da Nang (Viet Nam) and Mawlamyine (Myanmar)
Assets	Forest resources (timber and wood processing)	Corridor aligns with large forest areas between Tak (Thailand) and Jinghong (Yunnan Province of PRC).	Corridor crosses large forest areas (Central Annamites, Western Forest Complex)
	Agriculture potential	Rice paddy in Chao Phraya basin, upland rice in Lao PDR section, rice and mixed agriculture (fruits) in Xishuangbanna section (PRC)	Rice paddy in Chao Phraya basin and Isaan (Korat Plateau), smaller in Western Savannakhet province of Lao PDR, high density paddy in coastal Quang Tri to Da Nang (Viet Nam)
	Plantations	Large rubber concessions in Xishuangbanna section (PRC), spilling increasingly into northern Lao PDR. Teak.	Eucalyptus, growing amount of rubber in Central Annamites (central and southern Lao PDR).

Table 6.1 continued on next page

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Corridor		NSEC	EWEC
	Mining potential	Northern Lao PDR section	Annamite mountains in the Lao PDR–Viet Nam border area.
	Tourism potential	Eco- and ethnic tourism around Chiang Rai (Thailand), Luangnamtha (Lao PDR), and Jinghong (PRC), 1 World Heritage site in Sukhothai (Thailand)	Ecotourism in Western Forest Complex, eco- and/ or ethnotourism and history (Indochina war) in the Central Annamite section, 3 World Heritage sites concentrated in Viet Nam (Hue, My Son, Hoi An). Large tourism potential in Myanmar, increasingly developed
	Energy sector	Extensive HP development in the UMB in Yunnan, HP potential in Thailand largely realized. Potential to connect to HP potential in Shan.	Large HP potential currently realized (NT2, 3S, Mekong mainstream dams). Power interconnection Lao PDR (NT2)–Thailand through Savannakhet (Lao PDR) and to Da Nang (Viet Nam)
Processing, markets, and export nodes	Processing	Large concentration of EZ's around Bangkok (Thailand). BEZ at border crossings	Medium concentration of EZ's around Da Nang (Viet Nam). BEZ at border crossings. EZ concentration expected to increase along Andaman coast (Yangon– Mawlamyine–Dawei, Myanmar)
	Export nodes and/ or market access capabilities	Kunming, PRC (airport), Boten and Chiang Kong, Lao PDR (BEZ), Bangkok, Thailand (airport, port)	Da Nang, Viet Nam (airport, port).
	Industrial composition of exports	Electronics, car and car parts, food and food products, chemicals, timber (Lao PDR section)	Food and food products, timber

3s = Sesan, Sekong and Sre Pok river basins; BEZ = Border Economic Zone; PRC = People's Republic of China; EZ = economic zone; HP = hydropower; EWEC = East – West Economic Corridor; Lao PDR = Lao People's Democratic Republic, NSEC = North South Economic Corridor; NT2 = Nam Theun 2; UMB = Upper Mekong Basin Source: author's own compilations

The Core Environment Program and Biodiversity Conservation Corridors Initiative

Responding to the potential conflict between corridor development and natural capital depletion, ADB and GMS countries designed the Core Environment Program and Biodiversity Conservation Initiative (CEP-BCI) to achieve a sustainable GMS program, including environmentally sound economic corridors. The main goal is to embed environmental considerations into all steps of the planning cycle, in particular through introducing sound environmental assessment and evaluation techniques to strategic and investment planners, piloting green investments and exploring links to market mechanisms, and promoting sound monitoring and performance assessments.

Introducing and building capacity on integrated spatial planning and decision support tools is an important element of all these aspects of CEP-BCI's work. They are used to provide a "preview" of potential future outcomes of development decisions, and facilitate holistic and integrated assessment of environmental cost-benefits. Results aim to help decision makers better recognize the connection between environmental integrity and good economic performance, and to appropriately reflect this in their planning decisions.

CEP-BCI's integrated spatial planning is distinctively different from modeling for regional or global environmental reporting purposes. To ensure that its spatial planning support is leading to better planning outcomes, application of modeling tools adheres to the following principles:

- Focus at the strategic level (policy, plan, and program) to integrate environment costs and /or benefits as early in planning as possible.
- Tie and tailor analysis to a specific planning process.
- Plug in directly with the national planning agency and involve them in the analytical process (on-the-job training).
- Engage before or while the plan is developed (ex ante) to maximize the potential of model results to influence planning outcomes.
- Transparently quantify economic opportunities, social benefits, and environmental costs and objectively evaluate them (no advocacy for either).
- Promote solutions that are cost efficient and can be sustained by GMS government agencies.

To introduce how this approach helps plan sustainable GMS economic corridors, this paper will review present spatial data sources and gaps, summarize basic GMS economic corridor characteristics, and introduce two ex ante modeling applications that aim to optimize investments along corridors.

Overview of Available Data, Data Gaps, and Limitations

The economic corridor concept is based on geographic entities (roads) and is intrinsically tied to the geography surrounding them. As such, the success of corridor alignment and corridor widening is directly tied to the resolution of spatial data, the availability of relevant themes, and a model that can connect multiple scales of spatial datasets and predict their dynamics.

Spatial data are generally available in two basic formats: Geographic Information System (GIS) formats that can be readily overlaid onto each other (raster⁵¹ or vector data), and statistical data, which often have a spatial dimension (province, district, etc.) but are not connected to the respective GIS file and therefore do not easily integrate with other GIS layers.

An overview of presently available spatial data, and statistical data with spatial dimension, is shown in Table 6.2. The table lists both global and/or regional datasets and national datasets, because the first have often undergone a certain level of standardization that makes them more suitable for regional corridor modeling purposes.

Considering the number of national ministries, nongovernment organizations, and international organization involved in spatial and statistical data production, it is impossible to provide a complete overview of the current situation without a thorough fact finding mission. Datasets or sources identified are confirmed to have related information, although the sources might not always be the data producer (something that is not always easy to establish due to a common lack of metadata with most datasets). Themes and countries for which no dataset or source could be identified in this short review are marked "?".

It is paramount to highlight that for regional mapping and modeling purposes, consistent quality data is required to cover the entire region, not only an individual country. Therefore, the availability of a useful dataset in one country (e.g. Viet Nam) can be fully utilized for modeling only if available in the same quality and time frame for the other countries.

The availability of precise and up-to-date spatial data is a binding constraint in most cases while all GMS countries generally have national base datasets of 1:50,000 or 1:100,000 scale, the speed of development in these countries requires all but terrain information to be updated on a regular basis. However, government organizations are often not aware of the benefit of spatial data or do not have the skills to leverage their value in their work. That leads to limited investment in spatial data development and maintenance.

This problem is further aggravated by operational fragmentation—particularly on the national level—and a lack of clear data sharing regulations among ministries. Overlapping or unclear planning mandates of government agencies, particularly in natural resources sectors, often lead to competition between agencies and a duplication of efforts. Even within the same government agency, vertical information sharing and synchronization of methods and standards remain patchy, increasing the risk of parallel data collection and incompatible databases.

In comparison with some other regions in Asia, data availability and quality in GMS are arguably better at this time, notwithstanding the shortcomings highlighted here. The Environment Operations Center and its CEP-BCI effort work to improve the data situation, in terms of completeness, quality, and regional coherence.

⁵¹ In computer graphics, a raster graphics image represents a generally rectangular grid filled with pixels or points of color.

Toward Environmentally Sound Corridor Investments: Two Modeling Applications

Strategic Environmental Assessment of the Quang Nam Land Use Plan 2011–2020

Quang Nam Province is located in Central Viet Nam, where the East–West Economic Corridor and the Eastern Economic Corridor intersect (Figure 6.1). It is characterized by a unique development challenge: To the west rise the Central Annamites, a mountain range rich in biodiversity and natural resources. Inhabited by ethnic minorities, the forests have been sustainably used by them for non-timber forest products and small-scale subsistence farming for centuries. In stark contrast, the coastal plains to the east have been transformed into intensive farming systems and aquaculture. Additionally, the neighboring city of Da Nang— Central Viet Nam's largest business hub—has catalyzed the development of manufacturing industry and related transport networks. Much of the growth and corresponding natural resources (timber) and energy demand is sourced directly from its environmentally and socially sensitive mountainous hinterlands. Population growth is adding pressure through increased demand for farmland, which no longer can be satisfied in the coastal plains alone.

Considering that the present and future economic performance of the province is heavily dependent on sectors that build on a healthy natural resource base (agriculture, forestry, tourism, hydropower), environmentally sound planning approaches need to be piloted and institutionalized. To ensure its allocation of land and natural resources is aligned with the carrying capacity of the underlying environment, the Environment Operations Center supported the Quang Nam Department of Environment and Natural Resources in conducting a Strategic Environmental Assessment of its land use plan for 2011–2020.

To highlight the geographic implications of different development priorities with the Department of Environment and Natural Resources land use planning team, the CLUE-s land demand allocation model—short for "Conversion of Land Use and its Effects for small regional scales— was tested in a pilot application. It provided an important preview of where priorities and land demand projections are likely to trigger land conversion in the future, and how these changes are associated with the interests of other development sectors (e.g. tourism and energy, specifically hydropower) whose performance depends on intact forest ecosystem services.

Important components of the model are:

- the definition of future land use requirements (land demand);
- the explanation of typical land conversion trajectories (e.g. primary forest to extensive agriculture, secondary forest to primary forest);
- the identification of legal restrictions (e.g. protected areas, existing concessions), and
- the correlation of land use types with underlying environmental and sociodemographic conditions (e.g. forest concentrated on steep slopes and ridges, agriculture where fertile soils occur.)

All of these components were developed in consultation with Department of Natural Resources and Environment and line agencies, which provided the spatial data and expert knowledge (e.g. scenarios) required to configure and execute the model.

After the model was configured with these knowledge inputs and spatial data, two land conversion maps were produced for the year 2020. One showed the consequences of traditional agricultural expansion, and the second provided a preview of a future landscape,

		Region	Country		
Theme	Data	GMS	Cambodia	PRC	
Transportation Infrastructure	Economic corridor roads	GMS Atlas of the Enviro datasets and GPS tracking	nment 2nd Edition, com ng	oiled from national road	
	Feeder roads (national, provincial, local roads)	Open street map, CIESIN (gROADS)	MoE (periodical updates of JICA road dataset produced from topographic maps	YIES (probably not primary sources), VMAP0	
	Vehicle and/or fleet data (sales, registration)	?	Ministry of Public Works and Transport	?	
	Road user data and/or traffic	UNESCAP Asian Highway Database (for some roads)	Ministry of Public Works and Transport	?	
	Travel time	Drive time polygons and/or analysis and/or network analysis from road datasets, but requires surface and traffic data that is not continuously available.			
	Railways	GMS Atlas of the Environment 2nd Edition, compiled from VMAP0 and ADB schematic maps (planned railways)	MoE (from JICA)	?	
	Waterways	FAO / WWF HydroSheds	MoE (from JICA)	?	
	Airports	GMS Atlas of the Environment 2nd Edition, compiled from Openflights database	MoE	YEPD, GEPD	
	Flight connections (passengers)	GMS Atlas of the Environment 2nd Edition, compiled from Openflights database	?	?	
Administration	Boundaries	FAO Global Administrative Unit Layer (level 0,1 and 2)	MoE	YEPD, GEPD	
Demographic information	Population	ORNL LandScan Global Ambient Population at 1km resolution, 2011, Columbia University CIESIN	?	Provincial Statistical Yearbooks (down to county level)	
	Income	ADB, World Bank, OECD			

Table 6.2 Spatial Data and Statistical Data with Spatial Dimension, An Initial Overview (Work in Progress)

Lao PDR	Myanmar	Thailand	Viet Nam
Ministry of Public Works and Transport	UNDP MIMU	Ministry of Transport	Ministry of Transport
Ministry of Public Works and Transport	Ministry of Transport (offline, if at all)	Ministry of Transport, Department of Highways (online)	Ministry of Transport (offline)
Ministry of Public Works and Transport	Ministry of Transport (offline, if at all)	Ministry of Transport, Department of Highways (online)	Ministry of Transport (offline)
Currently no railway	UNDP MIMU	Ministry of Transport	Ministry of Transport
MONRE	UNDP MIMU (likely from MOCAF digitized from topomaps)	?	?
MONRE	MOCAF	ONEP	MONRE
?	?	?	?
MONRE	MOCAF	ONEP	MONRE
Socio-Economic Atlas of the Lao PDR (University of Bern and MPI)	?	?	General Statistics Office (province level online, commune level offline)

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Table 6.2 continued

		Region	Country	
Theme	Data	GMS	Cambodia	PRC
	Urban areas	University of Wisconsin- Global Environment (SA	Madison Center for Susta GE) MODIS 500m Global	ainability and the Urban Extent
	Settlements	FAO Populated Places	Toposheets	Toposheets
	Poverty	Columbia University CIESIN Global Poverty Mapping Project (World Bank)	World Bank poverty mapping	World Bank poverty mapping
Geobiophysical information	Forest cover	ESA GlobCover Version 2.3	MAFF (2002, 2006, 2010)	YEIS (Yunnan), XTBG (only Xishuangbanna)
	Elevation	SRTM90, ASTER DEM	Toposheets (contour lines)	Toposheets (contour lines)
	Slope	derived from above	derived from above	derived from above
	Soils	FAO DSMW (Digital Soil Map of the World)	MOE	?
	Rivers and water bodies	FAO AGLW Hydrological Basins of Southeast Asia, WWF HydroSheds, MRC (only LMB)	Toposheets	Toposheets
	Basins and watersheds	FAO AGLW Hydrological Basins of Southeast Asia, WWF HydroSheds, MRC (only LMB)	?	?
Sector information - Agriculture	Land use	GlobCover V2.3	MoE (prepared by JICA 2002, updated by DANIDA [Atlas])	?
	Agricultural concessions	N/A	MoE (probably from MAF)	?
	Yield	FAOSTAT, IRRI (rice production)	?	?
	Hydropower	World Register of Dams (ICOLD), Global Reservoir and Dams Database (GRanD), MRC (only LMB)	Ministry of Industry, Mines and Energy	?

Lao PDR	Lao PDR Myanmar		Viet Nam	
Toposheets	Toposheets	Toposheets	Toposheets	
Socio-Economic Atlas of the Lao PDR (University of Bern and MPI)	?	NESDB (down to commune level)	IFPRI poverty and inequality in Viet Nam (2002, commune level); World Bank poverty mapping	
FIPD of MAF	MOCAF (probably)	ONEP	FIPI of MARD	
Toposheets (contour lines)	Toposheets (contour lines)	Toposheets (contour lines)	Toposheets (contour lines)	
derived from above	derived from above	derived from above	derived from above	
MAF	?	ONEP (?)	MONRE	
Toposheets	Toposheets	Toposheets	Toposheets	
?	?	?	?	
Included in FIPD dataset, but not very detailed, JICA produced detail FCLU dataset recently, but details not known.	?	Land Development Department	MONRE (every 5 years, last one 2010)	
?	?	?	?	
?	?	?	General Statistics Office (province level online, commune level offline)	
Ministry of Energy and Mines	?	Environment Operations Center	Institute of Energy of MOIT	

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Table 6.2 continued

		Region	Country	
Theme	Data	GMS	Cambodia	PRC
Sector information - energy	Thermal power	?	?	?
	Nuclear power	?	?	?
	Alternative energy (solar, wind)	?	?	?
	Power interconnection	GMS Atlas of the Environment 2nd Edition (from ADB maps)	Ministry of Industry, Mines and Energy	?
Sector information - forestry	Forest concessions	N/A	MAFF	?
Sector information - environment	Protected areas	UNEP WCMC (WDPA)	MoE	YEPD, GEPD
	Key biodiversity areas	CEPF (Cl and Birdlife Intl)	?	?
Sector information - Mining	Mineral assets	USGS Mineral Resources Data System	MIME (Danida Atlas)	?
	Mineral concessions	WWF Greater Mekong Program	?	?
Sector information - Tourism	Cultural and/or historical and/or spiritual assets	GMS Atlas of the Environment 2nd Edition (top 10-15 sites per country from reports and travel portals	?	?
Sector information - Multisector	Special economic zones, border economic zones, industrial zones	GMS Environment Operations Center (digitized from national data as indicated)	?	?

ADB = Asian Development Bank; FAO-AGLW = Food and Agriculture Organization Water Resources, Development and Management Services; CDE = Center for Development and Environment; CEPF = Critical Ecosystem Partnership Fund; CI = Conservation International; CIESIN = Center for International Earth Science Information Network; PRC = People's Republic of China; Danida = Ministry of Foreign Affairs of Denmark; DNP = Department of National Parks; DSMW = Digital Soil Map of the World; FCLU = forest cover and land use; FIPD = Forest Inventory Planning Division; FIPI = Forest Inventory and Planning Institute; FAO = Food and Agriculture Organization; GEPD = Guangxi Environmental Protection Department; GMS = Greater Mekong Subregion; GPS = global positioning system; GRanD = Global Reservoir and Dams Database; gRoads = Global Roads Open Access Data Set; GTZ = Deutsche Gesellschaft für Internationale Zusammenarbeit; ICOLD = World Register of Dams; Intl. = international; IRRI = International Rice Research Institute; JICA = Japan International Cooperation Agency; Lao PDR = Lao People's Democratic Republic; LMB = Lower Mekong Basin; MAFF = Ministry of Agriculture Forestry and Fisheries; MARD = Ministry of Agriculture and Rural Development; MEM = Ministry of Energy and Mines, MIMU = Myanmar Information Management Unit; MoE = Ministry of Environment; MOECAF = Ministry of Environmental Conservation, Agriculture, and Forestry; MOIT = Ministry of Industry and Trade; MONRE = Ministry of Natural Resources and the Environment; MPI = Ministry of Planning and Investment: MRC = Mekong River Commission: N/A = Not applicable: ONEP = Office of Natural Resources and Environmental Policy and Planning; ORNL = Oak Ridge National Laboratory; RFD = Royal Forest Department; RIVM = National Institute for Public Health and the Environment (Netherlands): SRTM = Shuttle Radar Topography Mission; UNDP = United Nations Development Program; UNEP = United Nations Environment Programme; UNESCAP = United Nations Economic and Social Commission for Asia and the Pacific; USGS = United States Geological Survey; VMAP0 = vector map level 0 ; WWF = World Wide Fund for Nature; XTBG = Xishuangbanna Tropical Botanical Garden; YIES = Yunnan Institute for Environmental Science

Note: This table is a first assessment and inventory of data along key economic corridor characteristics, and does no claim completeness.Source: author's own compilation

Lao PDR	Myanmar	Thailand	Viet Nam
?	?	?	Institute of Energy of MOIT
?	?	?	Institute of Energy of MOIT
?	?	?	?
Ministry of Energy and Mines	?	?	Institute of Energy of MOIT
MAF, GIZ GPS point mapping (report published by CDE)	?	?	MONRE, MARD
MONRE	MOECAF (probably)	DNP of RFD	MONRE
?	?	?	?
MEM	?	?	Seen for Quang Nam Province but original source unkown.
GIZ GPS point mapping (report published by CDE)	?	?	?
National Tourism Authority (paper maps, digitized and amended by EOC)	?	Tourism Authority of Thailand	?
?	?	?	?

servicing and maximizing the growth potential of the hydropower and tourism sectors. Highlighting forest conversion areas and overlaying the location of protected areas (tourism potential) and hydropower catchments (energy security—Figure 2) provided an initial impression of the potential impact of land conversion on these sectors, depending on which planning priority is followed.



Figure 6.2 Potential Forest to Non-Forest Conversion Areas, by Scenario

ha = hectare; HP = hydropower;

Note: Hydropower catchments overlaid. Inset table shows summary values by catchment and scenario. Source: Linde, L and Van Rooij, Wilbert (2012): Modeling the Implications of Land Demand for Hydropower Catchments - SEA of Viet Nam's Quang Nam Province Land Use Plan 2011-2020, International Association for Impact Assessment peer-reviewed conference paper.

The CLUE-s results supported land use planners to establish overall costs and benefits. Economic contributions of the energy and tourism sector were understood, and their need for intact forest ecosystem services recognized. Land use plans demand figures were adjusted and areas in need of protection, highlighted. In this particular case, the CLUE-s model—through the Strategic Environmental Assessment—directly facilitated the protection of \$230 million of ADB investments into hydropower (the Song Bung 4 Hydropower Project) and biodiversity (the Biodiversity Conservation Corridor Initiative).

Land demand allocation modeling was also piloted as part of the Strategic Environmental Assessment of the North–South Economic Corridor strategy and action plan. Both "businessas-usual" and "environmentally optimized" land demand scenarios were translated into maps showing areas at risk of land conversion. This supported the Strategic Environmental Assessment team to identify threatened primary forest patches and advised the strategy and action plan writing team where investments should not be placed and conservation efforts should be intensified.

Greater Mekong Subregion Regional Investment Framework 2013–2017

The GMS leaders endorsed the new GMS Strategic Framework (2012–2022) at the 4th Summit held in December 2011 in Nay Pyi Taw, Myanmar. The countries also supported the need to undertake a regional planning exercise to identify and prepare a new generation of multisector and other investment projects, covering both infrastructure and software requirements, to implement the new GMS Strategic Framework. ADB approved a regional technical assistance project—"Support for Regional Multisector Investment Framework (RIF) for GMS Development (Phase 1)"— in December 2011 to facilitate this process.

With investment volume increasing (regional multisector investment framework currently identifies \$52.7 billion worth of investments as of August 2013) but much of the land and natural resources already allocated, finding suitable areas for additional investments becomes increasingly challenging. Remaining areas might not only be secondary choices with regard to resource quality and therefore economic opportunity, but also fall into remote and vulnerable areas that impose higher environmental and social costs. Additionally, the increasing density of sector investments also requires factoring in the cumulative impacts of new investments on already existing ones (e.g. the impacts of a logging operation in the catchment of a hydropower dam). If this increased complexity is not appropriately considered and addressed in planning and allocating future investments, they might be placed in areas that yield more costs than benefits to both the investor and society.

The regional multisector investment framework will facilitate empirically informed and analytically sound policy formulation and investment decisions for the next decade of GMS cooperation. The Environment Operations Center, as the environmental arm of the GMS program, supports this process with a rapid Spatial Multi-Criteria Assessment (SMCA) to identify environmental risks and opportunities. Considering that the GMS Economic Corridor Concept is geographically explicit, this SMCA is enhancing traditional multicriteria assessment (MCA) analysis through adding information on spatial distribution and association.

The process behind SMCA is largely based on the building of a criteria tree, which identifies all involved variables and serves as the framework of analysis. Regardless of the specific planning context, the development of an SMCA criteria tree requires the following inputs:

- 1. Formulate the planning question (e.g. Where does environmental risk outweigh economic opportunity?);
- 2. Identify suitability and vulnerability factors to be considered (e.g. labor, accessibility, existing land use, ecosystem quality);
- 3. Provide a measure for each factor on what is suitable or vulnerable (e.g. accessibility: only if within 20 km to market, slope: only if slope is between 10 and 25 degrees).
- 4. Separate out areas that are legally restricted to certain or all investments (e.g. protected areas, existing land rights, army and border zones);
- 5. Group the remaining factors into thematic categories (e.g. economic factors, environmental factors, social factors);

- 6. Rank and weigh factors according to their relative importance or national priority (e.g. economic: 50%, environment: 20%, social: 30%); and
- 7. Connect each factor with a map layer to establish the geographic reference (e.g. digital slope model).

Executing this geographic criteria tree in a GIS produces a feasibility layer that integrates economic suitability with environmental and social vulnerability and its associated cost implications. Such a layer provides planners with a comprehensive picture of opportunities and implications, reducing the risk for wrongly allocating a specific investment and maximizing the opportunities between competing sectors.

This functionality is currently demonstrated as part of the development of the regional multisector investment framework. In a first step, the Environment Operations Center has—supported by its recent development of the 2nd Edition of the GMS Atlas—developed a wide range of regionally integrated GIS layers, including a) economic corridor roads, b) special economic zones, c) markets and export nodes, d) sector assets (agriculture, hydropower, tourism), e) environmental quality (forest type, key biodiversity areas, biodiversity landscapes), f) risk factors (e.g. terrain), and g) environmental protection (protected areas and key biodiversity areas' database). In addition to these layers, proximity layers were developed.

Based on these layers, the Environment Operations Center developed with the regional multisector investment framework team a criteria tree that weighs proxy parameters for basic environmental value (e.g. forest quality, slope, distance to protected area and key biodiversity area) against environmental exposure parameters (e.g. distance to urban center, population density, distance to road, railway, seaport, airport and special economic zone.

- The resulting map shows environmental sensitivity (Figure 6.3), which can be translated into three broad landscape categories (Figure 6.4) to guide growth sector investments:
- Protected landscapes: suitable for investments such as environmental protection, low density ecotourism, small hydropower, Payment for Forest Ecosystem Services (PFES) and the United Nations Reducing Emissions from Deforestation and Degradation (REDD)+ Program
- Supporting service landscapes: suitable for investments such as large-scale hydropower with PFES, tourism, organic and sustainable niche agriculture.
- Productive service landscapes: suitable for intensive agriculture, irrigation development, commercial forestry, processing and/or manufacturing and high volume transport infrastructure.

Apart from its use in the regional multisector investment framework planning, SMCA has also been used in other GMS economic corridor planning. In the strategic environmental assessment of the North–South Economic Corridor strategy and action plan, SMCA was used to explore the optimal alignment of the North–South Economic Corridor (Lao PDR section) using a least-cost path calculation on a SMCA suitability layer. SMCA was also demonstrated as a tool to identify broader target areas for Jatropha plantations in Cambodia, and to identify the potential for carbon sequestration as part of the Carbon Neutral Transport Corridor feasibility study.



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Central Asia Regional Economic Cooperation Case Study—Bringing the Economic Corridor in from the Cold?

Roman Vakulchuk, Norwegian Institute of International Affairs and Farrukh Irnazarov, Central Asian Development Institute

Literature and Data Availability Overview: State of the Art and Solutions to Data Limitations

In 1991, as a result of the collapse of the Union of Soviet Socialist Republics, five new independent states—Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan—formed in Central Asia. These countries have large reserves of hydrocarbons (oil and natural gas) and mineral resource and thus, have large export potential that should be realized by means of developed and modern transport infrastructure. The system of road connections in Central Asia comprises about 66,000 kilometers (km) of roads, of which 29,000 km bear the brunt of regional and international transport. The rail system in Central Asia stretches to more than 22,000 km. Kazakhstan possesses the largest and most exploited railway, which is 66% of the total length of railways in the region and performs 84% of all freight. In Uzbekistan, it takes about 18% of the regional railway lines, which account for about 11% of all traffic. Turkmenistan has about 12% of regional rail and 4% of the total transport. The slow development of the economies of these countries is in good part due to significant "economic distance" to the world commodity markets. Consequently, for the countries of the region, promoting the development of transit routes is important as they seek to become a trade, transport, and economic bridge between the PRC and Southeast Asia and the Russian Federation and European Union countries, providing these transport routes with modern infrastructure, and developing information, retail, and industrial logistics centers.⁵²

²² Association for Development of Business Logistics (2012): Obzor Sostoyania Transportnoi Logistiki v Respublike Uzbekistan (Overview of the Transport Logistics of the Republic of Uzbekistan), Report, available at: http:// www.adbl.uz/images/obzor.pdf, accessed 11 July 2013.

The Central Asia Regional Economic Cooperation Program

The Central Asia Regional Economic Cooperation (CAREC) Program has three overarching goals:

- 1. to establish competitive corridors across the CAREC region;
- 2. to facilitate efficient movement of people and goods through CAREC corridors and across borders; and
- 3. to develop sustainable, safe, user-friendly transport and trade networks.53

According to the Asian Development Bank (ADB), "It is the policy of the governments of CAREC countries to provide safe, dependable, effective, efficient, and fully integrated transport operations and infrastructure to support social and economic development in the CAREC region. This is to be achieved by improving levels of service, minimizing costs, and improving infrastructure, management, and technology in an economically and environmentally sustainable manner. In addition, the efficiency of the transport systems in the region will be enhanced to allow the CAREC region to exploit its unique geographical position."⁵⁴

The strategy emphasizes a selective transport corridor approach, concentrating resources for both investment and operational management, and focusing on balanced improvement of infrastructure, management, and technology.

The corridors reflect current and potential trade flow patterns. The selection of corridors is based on the inclusion rule of at least two CAREC countries and the following five criteria: 1) current traffic volume; 2) prospects for economic and traffic growth; 3) ability to increase connectivity between regional economic and population centers; 4) prospects of mitigating delays and other hindrances such as the number of cross-border points and the number of gauge changes; 5) and economic and financial sustainability of infrastructure, management, and technology improvements.⁵⁵

Box 7.1. Six Central Asia Regional Economic Cooperation Corridors

CAREC 1: Europe–East Asia CAREC 2: Mediterranean–East Asia CAREC 3: Russian Federation–Middle East and South Asia CAREC 4: Russian Federation–East Asia CAREC 5: East Asia–Middle East and South Asia CAREC 6: Europe–Middle East and South Asia

CAREC = Central Asia Region Economic Cooperation

⁵³ Asian Development Bank (ADB). (2008). REG: Central Asia Regional Economic Cooperation Transport Sector Strategy Study: Technical Assistance Consultant's Report, Project Number: 37362 (RETA-6347), TERA International Group, Asian Development Bank, available at: http://www.carecinstitute.org/uploads/corridors/ CAREC-Transport-Sector-Strategy-Study-TACR.pdf, accessed 11 July 2013:153

⁵⁴ ADB, 2008: 7

⁵⁵ ADB, 2008

Figure 7.1 (below) illustrates six CAREC corridors. Within the plan to link Central Asia to global markets, 7,000 km of high quality road and rail links have been constructed which connect "innumerable communities along routes that often trace the ancient Silk Road."⁵⁶ "More than \$14 billion had been invested from 2001 to 2011 in 85 CAREC-related transport projects along the six CAREC corridor routes, where the potential for economic development and returns is greatest."⁵⁷



Figure 7.1 Central Asia Region Economic Cooperation Corridors

CAREC = Central Asia Region Economic Cooperation

Sources: ADB (2009): CAREC Transport and Trade Facilitation: Partnership for Prosperity; ADB (2012a): From Landlocked to Linked in The Central Asia Regional Economic Cooperation Program, Manila.

The analysis of existing databases on transportation infrastructure in general, and CAREC corridors in particular in Central Asia shows various degree of data availability, data consistency, and completeness.

The Agency of Statistics of the Republic of Kazakhstan (2013) provides a comprehensive overview of the transport sector development and transport-related trade and investment activities in Kazakhstan for the period 2003–2011. The database, which is publicly available, provides the detailed information on passenger and freight turnover of all modes

⁵⁶ ADB. (2012a). From Landlocked to Linked in The Central Asia Regional Economic Cooperation Program, Asian Development Bank, Central Asia Regional Economic Cooperation Program, Manila, Philippines, available at: http://www.carecprogram.org/uploads/docs/CAREC-Publications/2012/From-Landlocked-to-Linked-In.pdf, accessed 11 July 2013: 6

⁵⁷ ADB, 2012a: 6

of transport in the country. The strength of the database is that it contains the regionspecific data on dynamics of passenger and freight turnover in Kazakhstan. The database is accompanied with helpful methodological explanations of calculation mechanisms. The weakness of the database is that it does not have information on cross-border movement of people and goods.

The State Committee of the Republic of Uzbekistan on Statistics (2013) offers its own database available online, yet, it remains largely incomplete. In particular, the database only comments on the general figures, and fails to reflect details on transport, logistics and passenger turnover. Also, being available in three languages, the database is unsynchronized and non-identical. Information found in Uzbek, for example, is missing in its English version. In contrast to the Kazakhstani database, one of the largest disadvantages is short time span. Most of the data appears to be from 2009 only.

Similarly to the Kazakhstan's statistics portal, the National Statistics Committee of the Kyrgyz Republic (2013) provides comprehensive data on freight and freight turnover by all types of transport, passenger turnover going back to 1990. The Agency on Statistics under President of the Republic of Tajikistan (2013) contains significant gaps as regards comprehensiveness of data on the transport sector in the country.

Thus, the country databases presented above are, to a large degree, unsynchronized and non-identical (e. g. see Table 7.1).

	Time period	Completeness	Region-specific (oblasts)	Data gaps
Agency of Statistics of Kazakhstan	From 2003	High	Yes	Purely domestic; little information on cross-border transactions
Agency of Statistics of Kyrgyz Republic	1990	Medium	Yes	Purely domestic; no information on cross-border transactions; incomprehensive
Agency of Statistics of Tajikistan	2000	Low	No	Micro-level data
Agency of Statistics of Uzbekistan	2009	Medium	Yes	Purely domestic; little information on cross-border transactions; incomprehensive

Table 7.1 Data on Passenger and Freight Turnover of All Modes of Transport

Note: An oblast is an administrative division, as in "province." Source: authors' own compilation.

Regarding other data sources, the Central Asian Development Institute database on road infrastructure includes aggregate data on firm characteristics involved in providing road construction services. The database became one of the final outputs of a big research project (2010–2013) on effective governance and the efficiency of the road construction services in

Kazakhstan and Uzbekistan. In the project, a comparative study of the local roads and the regional roads, built as part of the CAREC program, was done.⁵⁸

Another source of data is provided by the Norwegian Institute of International Affairs and the Organization for Security and Cooperation (OSCE) Academy, which established the Central Asia Data-Gathering and Analysis Team (CADGAT), the purpose of which is to produce and update new cross-regional data on the transport sector (as well as other issues) in Central Asia. The 2012 reports contains data on the national and regional transport strategies; the regional railway system, which includes the data on the number of train routes between Central Asian states, number of railway stations within each country, total length of railway lines and the number of regional railway border check-points; air transport, in particular the number of international and domestic flights in each Central Asian republic, the number of domestic and international airports; the average travel costs between the main cities of five Central Asian states, in particular the average flight, train, and taxi costs; up-to-date information on motor road entry and transit tariffs in Central Asia; bilateral trade agreements on road transport in Central Asia; the number of roads which involve at least one neighboring country; the estimated travel time by car between Central Asian capitals (see Table 7.2 for example); road border points between Central Asian countries and other neighboring states; and a list of functioning road border points in Central Asia.59

	Astana	Bishkek	Dushanbe	Ashgabat	Tashkent
Astana,		13.5 hours	27 hours	34 hours	19 hours
Kazakhstan		(1187 km)	(1964 km) ¹	(2811 km)	(1599 km)
Bishkek,	13.5 hours		27 hours	23 hours	8.5 hours
Kyrgyz Republic	(1187 km)		(1872 km)	(1791 km)²	(579 km)
Dushanbe,	27 hours	27 hours		23 hours	6.5 hours
Tajikistan	(1964 km) ³	(1872 km)		(1577 km)⁴	(365 km)
Ashgabat,	34 hours	23 hours	23 hours		14.5 hours
Turkmenistan	(2811 km)	(1791 km)⁵	(1577 km) ⁶		(1212 km)
Tashkent,	19 hours	8.5 hours	6.5 hours	14.5 hours	
Uzbekistan	(1599 km)	(579 km)	(365 km)	(1212 km)	

Table 7.2 Estimated Travel Time by Car Between Central Asian Capitals⁶⁰

km = kilometer

Source: CADGAT (2012). Road Transportation in Central Asia, available at: http://www.osce-academy.net/en/cadgat/, accessed 9 May 2013.

The major conclusion of the two reports is that roads are the main means of transport in Central Asia.⁶¹ Road development is the focus of strategies for transport sector development

⁵⁸ Irnazarov, F., Vakulchuk, R., Libman, A., Salmanov, Z. (2013): Effective Governance Perspectives in Central Asia: The Case of Transport Sector of Kazakhstan and Uzbekistan, Final Report, Global Development Network (GDN), Varieties of Governance: Effective Public Service Delivery, available at: http://www.gdn.int/admin/uploads/ editor/files/Gov Kaz Uzb.pdf, accessed 10 May 2013.

⁵⁹ Pilot methodology is currently being tested for composing a regional integration index on trade and transportation in Central Asia.

⁶⁰ Estimate based on speed 90 km/hour, stopping for no more than 30 minutes at border point(s).

⁶¹ CADGAT (2012a): Road Transportation in Central Asia, available at: http://www.osce-academy.net/en/cadgat/, accessed 9 May 2013. CADGAT (2012b): The Transport Sector in Central Asia, available at: http://www.osceacademy.net/en/cadgat/, accessed 9 May 2013

in all five countries. Road quality is a huge challenge, especially in mountainous terrain where road building requires not only considerable initial investments, but also funds for continued maintenance and reconstruction. The five Central Asian countries vary significantly in their financial capacity to invest in transport; many major infrastructure development projects are initiated and funded by donors and/or international organizations. Rail transport is becoming more important, especially for freight traffic and supplies to Afghanistan. Uzbekistan has a fairly well developed rail network, and Turkmenistan is investing in its rail connections to the north and south. Moving people or goods from one Central Asian country to another is complicated by the limited number of direct flights between some of the main cities, few rail connections and time-consuming border procedures.⁶²

The CAREC Federation of Carrier and Forwarder Associations (CFCFA) provides comprehensive and regular performance measurement and monitoring of six priority CAREC corridors, to assess the situation along the links and nodes of each corridor, identify bottlenecks, and determine courses of action to address these bottlenecks.⁶³It uses a modified time/cost/ distance methodology, using survey instruments, associations of freight forwarders, and road carriers in each CAREC country to collect time and cost data on a regular basis. The methodology allows policy makers and road carriers and/or freight forwarders to:

- analyze the factors that affect the cost and time required to transport goods using certain routes;
- compare—over a period of time—the changes in costs and/or time required to transport goods on a certain route; and
- compare and evaluate competing modes of transport operating on the same route; and consider alternative transit routes.

Based on the submitted and analyzed time/cost/distance, quarterly reports are prepared focusing on the following indicators: time taken to clear border crossing (in hours), costs incurred at border crossing clearance (\$), speed taken (km per hour) to travel and costs incurred (\$) to travel corridor section. The quarterly reports are presented to the partner associations for validation before they are finalized.⁶⁴

Asian Highway Database of the United Nations Economic and Social Commission for Asia and the Pacific provides detailed data on domestic road characteristics, including types and detailed technical characteristics of roads, years of road construction and rehabilitation, traffic volume by vehicle type, traffic accident data for each CAREC corridor.⁶⁵

Tera International Group provides the detailed overview of main characteristics of all six CAREC transport corridors, including its linkages to regional and global trade, overview of traffic volume, prospect of economic and traffic growth, potential capacity for increasing connectivity between regional economic and population centers, potential to mitigate delays and other obstacles (number of cross-border points and number of gauge changes).⁶⁶ They

⁶² CADGAT, 2012 b

⁶³ ADB, 2012b; CFCFA (2013): CPMM, CAREC Federation of Carrier and Forwarder Associations (CFCFA), available at: http://cfcfa.net/cpmm/, accessed 11 July 2013.

⁶⁴ CFCFA, 2013

⁶⁵ United Nations ESCAP (2010): Asian Highway Database, Asian Highway Database 2010: AH Network in Member Countries, available at: http://www.unescap.org/ttdw/common/tis/ah/member%20countries.asp, accessed 9 May 2013.

⁶⁶ ADB, 2008.

also provide the overview of the dynamics of the corridors. The major weakness is that the report provides the overview of potential effects. The analysis of the real impact for the following criteria is yet to be assessed: overview of traffic volume, current economic and traffic growth levels, capacity for increasing connectivity between regional economic and population centers, potential to mitigate delays and other obstacles (e.g. number of cross-border points and number of gauge changes).

Eurasian Development Bank Integration Indicators (2012) provides the annual overview of regional integration indicators, including the dynamics of trade integration between the Central Asian states (Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan), Armenia, Azerbaijan, Belarus, Georgia, Moldova, the Russian Federation, and Ukraine.

Logistics.uz (2013) provides information on services on forwarding, insurance, and customs clearance of cargoes. The portal contains information aimed at reducing transport and logistics expenditures in the prime cost of goods imported or exported to major sale markets through achieving an efficient use of vehicles. Logistika.uz has an extensive database for logistics purposes and contains road atlas, a guide book, information about presence, location, and object conditions of wayside transport infrastructure (motorway filling stations, service, meal, medical stations, hotels and etc.) as well as border inspection post and post clearance control. The disadvantage of the portal is the unavailability of data on various challenges on the route such as delays, customs checks on border-crossing points, and costs.

International Road Federation (2012) offers for purchase an annual report on world road statistics. It comprises data on country profiles, road networks, road traffic, multimodal traffic comparisons, vehicles in use, road accidents, road expenditures, road-related energy and environmental characteristics.

A thorough investigation of the available literature shows that, at the moment, the vast amount of the scholarly and technical work has mainly focused on periodic publications around the themes related to CAREC corridors, their economic importance, technical characteristics of roads, customs regulations, country specific and transport infrastructure. Yet no well-organized efforts have been taken on the integration of the available data into single database ensuring easy access to the needed data. The encountered available data is either outdated, information is unsynchronized with other data sources, at times contradictory and insufficient. Besides, not much information is available when it comes to analyzing the six CAREC corridors on separate grounds; rather the information is given as the aggregate or in the generalized form.

Data limitations and gaps in existing national and international datasets on transport infrastructure and investment are the following:

- The data on cross-border movement of goods and people in Central Asia remain largely unavailable.
- The separate data on roadside infrastructure are not available.
- There are high variations in terms of data availability and quality across the countries.

Given the existing databases, it is possible to compose regionally compatible scales of analysis at the requisite scales but only for those corridor characteristics for which data are available. The solutions to fill the data completeness gaps are the following:

- Cross-border patterns of movement of goods and people in Central Asia. While data
 on movement of people and goods between regions (oblasts) in each country is
 available, the data on cross-border movement of goods and people in Central Asia
 remains largely unavailable. Conducting a survey on the ground to assess formal
 trade and population (migration) dynamics would be essential to better understand
 their impact on transport infrastructure and investment potential of economic
 corridors.
- 2. The estimate of cross-border trade operations is largely missing due to the existence of informal trade networks, which in many instances lead to the emergence of informal trade barriers. This can be resolved by applying the methodology to measure the impact of informal trade barriers on firm productivity and internationalization levels in Central Asia.⁶⁷
- 3. As many traders (including shuttle traders) tend to under-invoice the price of transported goods to soften the tax and customs burden, the official data on trade volumes in CAREC states are highly distorted and barely reflect the real scope of trade. It is necessary to conduct anonymous surveys of traders to elicit the real volume of traded goods and, as a result, identify the potential of economic corridors. It may also help provide specific recommendations to governments of Central Asian republics on pursuing reforms in tax and customs sectors.
- 4. As for data on roadside infrastructure, it is essential to distinguish between inclusive growth and growth of hubs with high economic potential. The latter is easy, as hubs already exist (especially around major cities) and to detect the specific investment targets to achieve economic growth, a series of focus group discussions with experts should suffice. As far as inclusive growth concerned, this task is more challenging as it will require spotting the vulnerable locations across the corridors; identifying their potential and prospects to make use of the corridors; and attracting investment at domestic or international level, which will most probably be time consuming and expensive. It is also important to identify economically deprived populations within those locations to ensure inclusiveness. Therefore, a series of surveys in each region across the economic corridors is necessary to elicit the target region, strata of population, and nature of required investment (including size and return on investment).
- 5. Last but not least, it is important to ensure comparability of data sets, as some national data sets focus on domestic issues only, whereas other international data sets address completely different issues. In this regard, the challenging task is to bring these data sets to one common denominator and/or add up some other research findings to existing databases. This, in turn, helps validate our results for economic corridors analysis as well as provide a solid platform for modeling applicable scenarios for Central Asian states.

⁶⁷ Elaborated by Vakulchuk, Irnazarov and Libman (2012) and Vakulchuk, R., Irnazarov, F. (2013): Assessing the Impact of Informal Obstacles on Cross-Border Trade in Key Industries of Kazakhstan and Uzbekistan, AIEN Working Paper.
Presentation and Analysis of Key Economic Characteristics of Road Corridors

Table 7.3 below provides the detailed Strengths, Weaknesses, Opportunities, Threat analysis of six CAREC corridors. While the corridors share the same objectives, the economic geography does not allow them to be equally comparable and equally competitive in terms of different types of characteristics.

However, all of the corridors create good opportunities and offer potential to initiate largescale investment projects, especially around the most populous areas along the routes. Of the 6 corridors, Corridor 1, which links Europe to PRC through Kazakhstan, is currently the most actively used corridor. The route traverses from the border with the Russian Federation to the PRC via Kazakhstan and the Kyrgyz Republic. Compared to other corridors, Corridor 3 registered a relatively faster travel speed. This corridor facilitates north–south traffic, linking the Russian Federation to the seaports in the south via CAREC. Travel speed variations are mainly caused by the number of border crossings and the time used for changing gauges. Oil, cotton, and agricultural goods are the major commodities travelling through the corridors for exports. Corridor 6 has the most number of airports located along the route which crosses the largest Central Asian states—Kazakhstan and Uzbekistan.

Jo Lo	Corridor 3 Corridor 4	Corridor 5	Corridor 6
most This is a TRACECA idor for corridor, significant a export volumes for Central ort and Asia export and/or fic both import d rail	ntly limited Western corridor t volume Western corridor een the low. Eastern corridor and Federation traffic (4b) both rail andar Abbas and road is high gh Central Asia an to Bandar	Traffic varies along R stretches but tr remains low in al Kyrgyz Republic and al Tajikistan except Pc between Kabul and Peshawar	Relatively high rail raffic on the Uzbek ind Kazakh part ind at the Afghan- akistan border
or Trade prospect growth along the corridor is ry good. e high Transport pattern urope by oil products will on of the by oil products will on of the with construction of additional pipelines	ect is good for With completion of ts of timber, als and metals arian and ation and the Russian expected between expected bet	Substantial prospect Fifor Pakistan–PRC to trade. The corridor is a better alternative al Karakoram Highway	aster and cheaper oute from Europe o Arabian Sea mplies potential or the corridor to ompete with the II-sea route
provide This corridor brings lation strong connectivity (both economic and population centers) y ough Asia maty shkek (1c)	connectivity Little population llation and connectivity for 4a omic centers) with some important lso connects economic centers products and connectivity g regions in along 4a. and gulf oil Good economic and population connectivity along	Potential for increased economic in exchanges between e PRC and Pakistan a a	Potential for ncreased economic xchanges between vorth of Europe ind Gulf region

Table 7.3 Strengths, Weaknesses, Opportunities, and Threats Analysis

continued on next page

CAREC	Corridor 1	Corridor 2	Corridor 3	Corridor 4	Corridor 5	Corridor 6
Potential to mitigate delays and other hindrances	Construction of Khorgos rail line will resolve capacity problems. Few border crossings and therefore high prospect to mitigate delays	This corridor has strong intermodal (by sea via Black Sea and Caspian Sea; by road in KGZ; plus rail in others) potential. Relatively high number of border crossings scores average on this criterion	Because of change of railway gauge and numerous border crossings, this corridor scores low on this criterion	Prospects for mitigation of delays are very good on this corridor	This is a typical inter modal corridor. Because of numerous border crossings, scores low on this criterion	Because of railway gauge changes and numerous border crossings, this corridor scores low on this criterion
Economic & financial sustainability when investing in corridor improvements	Good prospect for investments; EDI is already being used on a limited basis and logistic centers exist or are going to be established	Prospect to implement logistic centers are good. The fact that it involves many countries may act as a limitation	This is a railway corridor, which should make use of block trains. The fact that it involves many countries may act as a limitation	Good possibility for technology improvements (EDI)	Situation in Afghanistan and efficiency of the Pakistan Railway may limit prospect for improvement	Situation in Afghanistan and efficiency of the Pakistan Railway may limit prospect for improvement
Data on provinces or districts	Astana, Bishkek, Urumqi	Ashgabat, Baku	Almaty, Dushanbe, Tashkent	Ulaanbaatar, Urumqi	Dushanbe, Kabul	Dushanbe, Kabul, Tashkent
Number of airports along the route	10	11	11	3	C	14
Industrial compos of exports	Oil, manufactured goods, textiles, cotton	Oil, Cotton, textiles, minerals, grain	Oil, manufactured goods, textiles, cotton	Manufactured goods, agricultural goods	Minerals, cotton	Oil, manufactured goods, textiles, cotton
						continued on next page

Table 7.3 continued

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CAREC	Corridor 1	Corridor 2	Corridor 3		Corridor 5	Corridor 6
Travel speeds	Highest speed without delays 48km/h	Highest speed without delays 37km/h	Highest speed without delays 30km/h	Highest speed without delays 9km/h	Highest speed without delays 24km/h	Highest speed without delays 38km/h
Travel costs	\$441/ per 500km	\$1860 per 500km	\$270/ per 500km	\$2311/ per 500km	\$307/ per 500km	284/ per 500km
Market access capabilities	CAREC Corridor 1, linking Europe to the PRC through Kazakhstan, is currently the most active corridor. The route traverses from the border with Russian Federation to the PRC via Kyrgyz Republic	CAREC Corridor 2 connects East Asia with southern Europe, Iran, and Turkey via Central Asia	CAREC Corridor 3 connects the western and southern Siberian regions of the Russian Federation to the Middle East and South Asia through Central Asia	CAREC Corridor 4 connects the Russian Federation to East Asia via Mongolia and the People's Republic of China. The route comprises 2,400 km of roads and 1,100 km of railways	CAREC Corridor 5 connects East Asia to the Arabian Sea through Central Asia. The route covers the People's Republic of China, the Kyrgyz Republic, Tajikistan, and Afghanistan. The corridor has 3,700 km of roads and 2,000 km of railways	CAREC Corridor 6 includes three routes linking Europe and the Russia Federation to the Arabian Sea port of Karachi and Gwadar or Bandar Abbas in the Persian Gulf. The route has 10,600 km of roads and 7,200 km of railways

\$ = US dollars; 4b = Eastern economic corridor; CAREC = Central Asia Regional Economic Cooperation; EDI = Electronic Data Interchange; KGZ = Kyrgyz Republic; km = kilometer; km/h = kilometers per hour; PRC = People's Republic of China; TRACECA = Transport Corridor Europe-Caucasus-Asia Sources: ADB reports (2008; 2009; 2010; 2012b); Agency of Statistics of the Republic of Kazakhstan (2013), Agency on Statistics under President of the Republic of Tajikistan (2013), National Statistics Committee of the Kyrgyz Republic (2013), The State Committee of the Republic of Uzbekistan on Statistics (2013).

Modeling Investments Scenarios and Strategies for Comprehensive Development of Economic Corridors in Central Asia

One of the priority issues of the CAREC is integration of the Central Asian region into the global supply chain system. To proceed with investment scenarios for the development of economic corridors, it is crucial first to solve significant data gaps as identified in the previous section. A dynamic network database should be established to fill these data gaps. Overall, most data can be obtained for each scenario. Yet, while regional (oblast) level data is obtainable, district (rayony) level data is difficult to obtain.

CAREC economic corridors should be treated separately due to heterogeneity of the region. Investment scenarios for each corridor should take into account such components as inclusive development and poverty reduction, small- and medium-sized enterprises, and entrepreneurship, the issue of labor migration, investment potential, energy export potential, traded goods, and existing economic zones. Each economic corridor should focus on one or two major components, depending on its characteristics and comparative advantages. Moreover, as identified in the workshop discussion paper, given low economic density of the region, the hub-and-spoke development and investment scenarios should be elaborated and implemented.⁶⁸ Furthermore, according to regional economic characteristics, urban areas are the dominant centers of regional economic activity. The degree of economic activity in big cities is disproportionally higher than in rural areas. Investment projects have to be focused on the major urban zones, which should serve as major gravitation points for developing CAREC economic corridors. To make CAREC transport corridors successful economic corridors, inclusive growth and the growth of hubs with high economic potential should go hand in hand.⁶⁹

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Economic Corridor Development for Inclusive Asian Regional Integration

Modeling Approach to Economic Corridors

The question underlying the entirety of this publication is: "How can viable economic corridors be called into existence by dint of government and multilateral support?" The authors answer this guestion by examining the experience of economic corridor development of different regions from across continents. There are important lessons to be learned for successful corridor development from the experiences of the European Union and South Asia Subregional Economic Cooperation regions. In each case, detailed models were constructed to assess the economic impact of corridor investments. What emerged from a consideration of these two cases (as well as broader discussions) was a framework for evidence-based policy analysis. When key policy makers and stakeholders pursue measurable outcomes for the development of regional economic corridors, the model and data framework (at a standard economic scale of relevance) allows for an investment-relevant development of scenarios, which will be monitored within an effective organizational process. Such a process, with all the elements of an evidence-based policy in place, is highly likely to generate successful economic corridor development, which would realize envisaged opportunities within the regions. Two priority regions in Asia, the Greater Mekong Subregion and the Central Asia Regional Economic Cooperation, face different opportunities.

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