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Transport Infrastructure for MED11 Countries

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The author

Until recently **Robin Carruthers** was a Lead Transport Economist in the World Bank, responsible for the quality of its evaluation of transport projects and its transport research, and is the principal author of its Toolkit on Transport Corridors and a major contributor to its guide to Trade and Transport Facilitation. He is now a consultant to several international lending institutions on transport, trade and infrastructure, and their interrelationships. Before joining the World Bank about 20 years ago he spent a decade as partner of a transport consultancy in Buenos Aires and before that, ten years with a transport and civil engineering consultancy in London and Australia. He started his career with the governance of urban planning and transport in London, and the evaluation of airport development proposals for the precursor of UK Civil Aviation Administration.

Abstract

Lack of adequate infrastructure is a significant inhibitor to increased trade of the countries of the Mediterranean region. Bringing their transport infrastructure to standards comparable with countries of a similar per capita GDP will be costly but worthwhile.

We compare the current quantities of six types of transport infrastructure with international, and estimate the additional quantities needed to reach the benchmarks. We also estimate the cost of that infrastructure and express it as a percentage of GDP. Finally we make tentative estimates of how much trade might be generated and how this might impact on GDP. All the estimates are made for each MED11 country and for each of four scenarios.

The highest need for additional infrastructure will be for airport passenger terminals (between 52% and 56%), whereas the lowest need was for more unpaved roads (between 7% and 13%). The investment (including maintenance) cost would be between 0.9% of GDP and 2.4% of GDP, although the investments in some countries would be between 1.4% and 4.5% of GDP.

The impact on non-oil international trade would be substantial, but with differences between imports and exports. The overall trade balance of the MED11 region would be an improvement of between 5.4% and 17.2%, although some countries would continue to have a negative balance.

A final assessment was of the benefit ratio between the increase in GDP and the cost of transport investment. This varied between about 3 and 8, an indication of the high return to be expected from increased investment in transport infrastructure.

1. Introduction

The objective of the analyses described here is to provide estimates of the costs to the MED11 countries of bringing their transport infrastructure to specified standards, and of the macro-economic benefits of those investments. The twin objectives of investment in transport infrastructure are to provide a basis for the transport and logistics services that will be needed to support the projected GDP, and volume of international trade that is associated with that growth. The infrastructure investments and associated transport and logistics services will also contribute to further increases in GDP and trade above those assumed for the base situation.

The report is in three Parts. The first provides a description of the basic benchmarking approach to estimate the current deficiencies in transport infrastructure of the MED11 countries. In the second there is description of how the costs of making good on the transport infrastructure deficiencies are estimated for each of the four “Sessa” framework scenarios (see Ayadi and Sessa, 2011). The method and results of estimating the macro-economic benefits of the indicated investments are provided in the third and final part.

The Report is centered on specifications of transport infrastructure for four scenarios based on those of the “Sessa framework”, defined below. The quantities and qualities of transport infrastructure appropriate for each of the scenarios are based on a benchmarking approach. In this, the current quantities of transport infrastructure (measured on an average of a per area, per capita and per unit of GDP basis) were estimated from a database of current transport infrastructure and macroeconomic and social data for 139 countries. Then average benchmark values were derived for the various country combinations indicated in the specifications of the four scenarios. These averages were then extended up to 2030 by taking account of the population and GDP projections provided in other MED11 reports.

The first scenario is compatible with the Sessa Reference or “Business as Usual” scenario. For the purposes of estimating the necessary transport infrastructure that would be associated with this scenario, the current quantities and qualities of transport infrastructure are compared with the global average benchmark values. For the second scenario (compatible with the Common Development Scenario of the Sessa Framework) the necessary transport infrastructure is related to that currently found in the countries of the EU27. For the third scenario (compatible with

the Polarized Development Scenario) the benchmark infrastructure provisions are the average of those of the countries that comprise the same per capita income group as each of the MED11 countries. A different approach was used for estimating the infrastructure provision for the final scenario (compatible with the Failed Development Scenario of the Sessa Framework). Instead of using quantity and quality benchmarks as the standards, the average investment in transport infrastructure (as a % of GDP) of each of the MED11 countries over the last decade was assumed to continue for the whole of the twenty year assessment period.

Basis of Scenario Infrastructure Benchmarks

| Scenario | Benchmark Infrastructure Standard |
|-----------------------|---|
| Reference | Global average network density |
| Common Development | Based on EU27 network density |
| Polarized Development | Average density of country per capita income group |
| Failed Development | National average infrastructure investment of last decade |

The estimated total investment costs described in the second part of the report cover four transport modes:

- inter-urban roads (including both paved and unpaved roads);
- railways;
- port berths;
- airports (including runways and terminals);

and four types of investment expenditure:

- improving the condition of current transport infrastructure to bring it up to the standards compatible with the relevant scenario;
- upgrading the category of existing infrastructure (such as expanding the capacity of some two lane roads to four lanes) to achieve the standards of the relevant scenario;
- expanding the capacity of infrastructure facilities or extending the length of transport networks so as to provide the capacities and quantities indicate by the benchmark values for each of the scenarios, and;
- maintaining the improved, upgraded and expanded facilities and networks in the condition indicated in the scenario benchmarks.

Part of the justification for proposed transport infrastructure investments is that they will contribute to increases in GDP and international trade. The base level projections of GDP are based on those made in other MED11 reports. We report here only the projected increases above these levels for each Scenario. As a check that the proposed investments are financially feasible, they are also expressed as

percentages of the base level GDP projections. Similarly, estimates of additional international trade are expressed as increases above the base levels of international trade (also expressed as percentages of GDP) derived from other MED11 reports. These GDP and trade projections are the subject matter of the third part of the Report.

2. Transport infrastructure benchmarking

2.1. Transport infrastructure and economic and social development

Roads, railways, ports, and airports deliver economic and social benefits by connecting agricultural, mining and manufacturing producers to international and regional markets. Without reliable and competitively priced freight transport infrastructure and services to connect to international markets, nations have little hope of trading their goods on the most advantageous terms. If they cannot transport products to domestic markets, growth of GDP will be difficult if not impossible. Adequate transport infrastructure and services are needed to make both international and domestic markets work.

When infrastructure is absent or degraded, it no longer fulfills its connective functions, and the economy suffers. As essential transactions and movements are delayed or disrupted, transport costs rise, individuals lose time in unremunerated commuting, and firms must fight harder to compete. To restore the connections, new infrastructure must be built, and existing infrastructure restored or improved.

Transport infrastructure is expensive. The huge investments required to build highways, railways, airports and ports must be well planned. If regularly maintained, transport infrastructure can be long-lived. But without maintenance, these valuable assets can deteriorate in a matter of a few years. Too often, the same roads end up being rebuilt over and over again, at a cost several times higher than if the appropriate maintenance measures had been taken on time.

2.2. Benchmarking

Comparisons of current transport infrastructure

Country transport infrastructure comparisons are used to assess whether the quantity and quality of provision of transport infrastructure are compatible with those of similar countries. If the comparison values show that the quantity and

quality are less than the benchmark standards, a second stage of analysis is to estimate how great is the deficiency and how much additional infrastructure (and/or upgrading and improvement of already existing infrastructure) would be needed to bring the quantity and quality up to the benchmark levels. The third stage of the analysis is to see what public expenditure (or combination of public and private investment) is needed to finance this expansion, upgrading and improvement, and whether that amount is compatible with the funding likely to be available. To facilitate these analyses the investments are expressed in absolute amounts and as percentages of GDP. The last stage is to look at the social and economic impacts of these investments to see if they are worthwhile, that is, whether the value of the additional GDP and international trade is greater than the cost of the investments.

Benchmarking compared to other infrastructure comparison methods

Several factors complicate the estimation of transport investment needs, including the geographical specificity of the transport network and the existence of multiple modes of transport that both substitute for and complement one another. The literature contains several methodological approaches, including macroeconomic models, benchmarking, demand models, and planning-based models that emphasize concepts of connectivity. The various approaches differ substantially in their strengths and weaknesses, as well as in their data requirements (Table 1). As might be expected, those that are least data-intensive also tend to give very general or aggregated conclusions. A more disaggregated estimation of the composition of investment requirements generally demands detailed modeling to reflect the geographical specificities of a given country's transport network.

Macroeconomic models typically exploit cross-country panel datasets to estimate the relationship between infrastructure stocks and a handful of basic social and economic parameters, such as population and GDP. This approach is exemplified by the work of Kohli, Walton and Mody (1994), which estimated the transport investment requirements of the larger East Asian economies at 2–3 percent of GDP. Canning's (1999) seminal paper linked this approach to a Cobb-Douglas production function framework and became the basis for a series of adaptations that were applied by the World Bank (Fay and Yepes, 2003; Calderon and Servén, 2004; and Chatterton and Puerto, 2005). The average transport spending requirement for the MED11 countries that emerged from a review of this literature is 3.2 percent of GDP, including both investment and maintenance. This is higher than the shares of GDP that are indicated by our analyses (see Table 12).

Table 1. Methodologies available to estimate transport investment needs

| | Strengths | Weaknesses |
|--------------------------|--|---|
| Macro-econometric models | Econometrically grounded Exploits variation across countries and time | High level of aggregation Limited explanatory factors Not location specific |
| Benchmarking | Relative simplicity | No clear theoretical foundation Choice of benchmark is arbitrary and may affect results significantly Not location specific |
| Demand models | Explicitly models demand–supply relationship in a framework that reflects specificities of country’s transport network Can be location specific | Data intensive |
| Planning models | Based on detailed geographical model reflecting specificities of country’s transport network Can be location specific | Driven by planning goals rather than by economic trade-offs |

Source: Carruthers et al. (2008).

A further refinement of the macroeconomic approach incorporated threshold effects (Hurlin, 2006). This study found that in the early stages of infrastructure network development, the marginal impact of more investment had productivity effects similar to those of investments elsewhere in the economy, but once the network had passed its “threshold size,” additional investment in the network became much more productive. Then, once the network passed a second threshold, the impact of further investment fell back to the level of other investments.

The *benchmarking approach*, is methodologically much simpler than the macroeconomic approach, and devises normalized indicators of infrastructure performance (such as road density or road condition) and compares them across countries, with countries divided into groups having broadly similar characteristics (Bogetic and Fedderke, 2006), or simply compares infrastructure spending across countries. Benchmarking imposes fewer data requirements than macroeconomic models, other than requiring data for many countries to establish comparable benchmarks. The choice of indicators and normalizations is somewhat arbitrary and can significantly affect the results.

Transport demand models have been used by sector specialists for more than 40 years. A detailed microeconomic model of an individual country’s transport sector is created and used to project aggregate demand for transport based on anticipated economic growth. The model allocates that demand across transport modes, compares demand with the capacity of each segment of the network, and,

on that basis, estimates the additional transport infrastructure needed. Successful recent applications include the World Bank's assistance to the government of China for the development of its transport strategy and the European Union's development of the trans-European transport network. The main drawback of the approach is that it is very data-intensive.

In addition to the three economic approaches just described, it is also possible to estimate transport investment needs using a *planning-based approach* that sets targets for geographical connectivity and estimates the cost of reaching them. The approach, applied in World Bank advisory work in Argentina, China and Africa, has the advantage of reflecting the specificity of each individual country's transport network. However, unlike the previous methodology, the planning approach is very subjective, driven by political choices, and the targets are rarely grounded in an economic balancing of costs and benefits.

Given the lack of data needed for a macroeconomic, transport demand of planning based approach, the analyses presented here are based on a benchmarking approach.

2.3. Transport infrastructure benchmarks for MED11 countries

There are two methods of deriving benchmark standards for quantities of transport infrastructure. The first compares densities of infrastructure with those of comparable countries, while the second uses international best practice infrastructure provision or performance standards. The first method is preferable as it is less subjective, the second method being subject to interpretation as to what is best practice.

Data was available to use the first method for only four of the infrastructure types, albeit those with the highest expected investment costs (paved roads, unpaved roads, railways and airport runways). For two other types of infrastructure (airport passenger terminals and port berths) we used the second method as there is no database of global infrastructure densities that includes these types of infrastructure.

Using the first method, we have estimated benchmark values for paved roads, unpaved roads, railways and airport runway infrastructure, and applied those values to the MED11 region and to each of the countries of the region. The data for the benchmarks comes from a new transport and macroeconomic database of 139 countries using data for 2008. Most of the data comes from the World Bank Data Development Platform time series database. The database excludes all small island states and some small land based and island states (such as Qatar and Singapore) that were considered sufficiently atypical not to be used in the estimation of bench-

marks. It also excludes Zimbabwe and Somalia for which macro-economic data was not available.

First benchmarking method

Using the first benchmarking method, the infrastructure measures used were:

- Km of paved road;
- Km of unpaved road;
- Km of railway in operation;
- Number of runways at airports that have regular passenger services.

Base parameters

Three parameters were used for the compilation of the final benchmarks:

- land area;
- population; and
- total GDP.

So benchmark values were calculated per km² of land area, per million population¹ and per US\$ of GDP.

Normalized benchmark values

Previous applications of the benchmarking method have used only one of the three parameters for defining infrastructure density (as per km² of area, per capita or per unit of GDP), so have not dealt with the issue of combining multiple benchmarks into a single measure. Using different parameters to define infrastructure density gives significantly different outcomes. Countries that perform well using one parameter can perform much less well using one or both of the others. There are few if any conceptual indications to prefer one parameter over another.

One of the few indications that can be applied is that area, being non-time dependent, gives more consistent results than either population or GDP. Using area it is not so important to determine a base year for its measurement, and for a given quantity of infrastructure the benchmark is constant over time. For either population or GDP, the choice of base year influences the measure of the benchmark and for a given quantity of infrastructure the measure changes over time as the value of the parameter changes. Despite this advantage of area as a parameter for estimat-

¹ A different population parameter (number of cities) was used for the airport runway benchmark.

ing benchmarks, some types of infrastructure (such as airport runways or port berths) are not dependent on area, so it is not necessarily the most appropriate parameter to use.

To overcome problems associated with the choice of a single benchmark, which implies that, the density of a particular type of infrastructure is dependent only (or principally) on that single parameter, we have estimated benchmarks for each of the three parameters, then combined them into a single index of infrastructure density. Since the dimensions of the three parameters are different, simply adding the benchmarks for each of them give more weight in the total to those with a higher value than those with a lower value. So each of the three benchmark values was normalized to a value of 100 (based on the global average density for that type of transport infrastructure) before they were added together to give a total (and by dividing by three, an average based on an index value of 100). A normalized index value greater than 100 indicates a higher than global average density over all three parameters, a value less than 100 indicating a lower than global average density over all parameters.

Benchmarks for four Scenarios

An important choice in benchmarking is what to use as the standard of comparison. In our analysis this is the choice of what other countries to use for comparison with the MED11 countries. We have analyzed four Scenarios and assessed the transport investment outcomes for each of them in terms of the affordability measured in terms of the required share of GDP to achieve them over the period of analysis (up to 2030).

Each of the four Scenarios has different benchmark standards and costs of achieving them. The different standards will also have different impacts on the GDP and international trade of each of the MED-11 countries. Each Scenario is defined in terms of the density of its transport infrastructure and the standards to which it is maintained.

The first Scenario (compatible with the Sessa Reference scenario) uses a single set of standards, the global averages for each of the types of infrastructure. The premise of this scenario is that the influence of the integration between the MED-11 countries and the EU would not influence their development, and that the MED-11 countries would continue their integration with the rest of the world.

The second Scenario (compatible with the Sessa Common Development scenario in which the MED11 and EU27 countries become more economically and socially integrated) was designed to bring the transport infrastructure of the MED-11 countries to the same as the average of the EURO-27 in 2008. These are very high standards and have been achieved in the EU-27 after more than a century of

investment in modern transport infrastructure and several decades of implementation of the EU Transport Strategy and policy of development of the TEN transport networks. In working through the costs of this scenario we determined that it was unaffordable within the twenty year horizon to 2030 of the MED11 study.

In these circumstances there are two choices (which in practice have a similar effect). The first is simply to extend the time period beyond 2030 for achievement of the scenario benchmarks, the second is to lower the benchmark values that can be achieved by 2030. We chose the second alternative as this would at least define the benchmark values that could be achieved by 2030, whereas the first alternative would only provide an estimate of the future year in which the original benchmark values could be reached. After reviewing several versions of this alternative, we determined that it would be feasible to reduce the difference between the current infrastructure standards and the EU benchmark values by one third by 2030. So this is how the benchmark standards for the second scenario (Common Development) have been defined. This standard is still significantly higher than those of any of the other scenarios.

The third Scenario (compatible with the Sessa Polarized scenario is in which the MED11 countries become polarized in terms of the economic and social development) was based on rather lower standards, those of the average of the countries that are in the same per capita income range as each of the MED-11 countries. Under this Scenario, the MED-11 countries with higher incomes are set rather higher standards to achieve than those with lower per capita incomes. The income groups are based on the World Bank classification of countries by per capita income into four groups: Low Income, Low Middle Income, High Middle Income and High Income.

Table 2 shows the benchmark values for each type of transport infrastructure and based on each of the three denominator parameters. First are the densities of transport infrastructure per unit of area, second are the densities per capita and third the densities per unit of GDP. The last set of values (“Normalized values”) is a weighted average of the first three sets of values. The last column of Table 2 shows the current benchmark values for the MED11 countries taken as a whole, giving an indication of the deficiencies compared to each of the benchmarks and each Scenario.

Second benchmarking method used for port container berths and airport passenger terminals

This method involves estimating the demand for the type of infrastructure, and then the quantities of infrastructure needed to satisfy this demand, assuming that

such infrastructure utilizes best practice design and/or operating efficiency standards appropriate to the specific scenario (Table3).

Table 2. Transport Infrastructure Benchmark values

| | Scenario 1 | Scenario 2 | Scenario 3 | | | | MED11 Countries |
|---|---------------|------------|------------|---------------------|---------------------|-------------|-----------------|
| | All Countries | EU-27 | Low Income | Lower Middle Income | Upper Middle Income | High Income | |
| <i>Per unit of land area (1,000 km²)</i> | | | | | | | |
| Paved roads | 170 | 1,054 | 20 | 182 | 66 | 363 | 61 |
| Unpaved roads | 75 | 195 | 76 | 100 | 58 | 77 | 58 |
| Railways | 8 | 50 | 3 | 7 | 6 | 15 | 4 |
| Runways | 0.05 | 0.18 | 0.02 | 0.04 | 0.03 | 0.10 | 0.02 |
| <i>Per unit of population (million)</i> | | | | | | | |
| Paved roads | 3,261 | 8,928 | 336 | 1,451 | 2,941 | 11,636 | 1,494 |
| Unpaved roads | 1,440 | 1,650 | 1,294 | 799 | 2,609 | 2,466 | 1,419 |
| Railways | 76 | 425 | 44 | 54 | 270 | 487 | 86 |
| Runways | 0.97 | 3.81 | 0.29 | 0.31 | 1.46 | 3.15 | 1.56 |
| <i>Per unit of GDP (US\$ million)</i> | | | | | | | |
| Paved roads | 352 | 243 | 589 | 655 | 368 | 293 | 260 |
| Unpaved roads | 156 | 45 | 2,271 | 361 | 326 | 62 | 247 |
| Railways | 17 | 12 | 77 | 24 | 34 | 12 | 15 |
| Runways | 0.11 | 0.04 | 0.51 | 0.14 | 0.18 | 0.08 | 0.10 |
| <i>Normalized value</i> | | | | | | | |
| Paved roads | 100 | 301 | 60 | 107 | 75 | 209 | 49 |
| Unpaved roads | 100 | 132 | 540 | 138 | 155 | 104 | 110 |
| Railways | 100 | 311 | 169 | 85 | 145 | 183 | 61 |
| Runways | 100 | 234 | 185 | 81 | 127 | 199 | 48 |

Note. Paved roads, unpaved roads and railways are measured in kms, and runways in number.

Source: Author's estimates based on Author's database.

Port berths

Port berths are conventionally classified as being for general, containerized, dry bulk and liquid bulk freight. We have only estimated the demand for container berths and assumed that no additional general freight berths will be required. Dry

and liquid bulk berths are usually provided to complement specific agricultural, mining or industrial projects. Since we have not looked at specific investments outside of the transport sector, we did not have a basis on which to project the needs for additional bulk solid and bulk liquid berths, so in that respect the projected overall investment requirements are underestimated.

While there are many efficiency parameters for the use of container berths, one of the simplest and most applicable to our analytical method is the number of containers moved per year per berth. Port efficiencies measured by this parameter have improved significantly in the last decade, but this has mostly been through inefficient ports coming closer to the best practice efficiency than there being increases in the best practice efficiency. Using the standard measure of a TEU², the efficient capacity of a standard berth of 300 meters length varies between about 175,000 TEU per year and 400,000 TEU per year depending on the scenario.

We have no reliable and consistent data on the current number of container berths in the ports of the MED11 countries, and even less data on the proportion of this capacity that is taken up by transshipment movements (the transfer of a container from one ship to another via intermediate land storage). So we have assumed that existing container berth capacity is equivalent to the current demand, and have only estimated the additional capacity to deal with increases in demand over the analysis period.

The number of additional container berths needed for each scenario is based on the number of import and export containers. This in turn is based on the total share of trade that is for imports and exports, the share of that trade between land transport, ro-ro shipping (that does not use containers) and bulk solid and bulk liquid freight (also that do not use containers), the average value of the contents of a container, and the balance between import and export containers (as an estimate of the number of empty containers to be returned). While the projections of GDP do not yet take account of the differences between the scenarios, the estimates of the share of trade between imports and exports, and the share of ro-ro and land transport all have minor differences for some of the scenarios.

Although Scenario 4 has a lower demand for container movements than the other scenarios, its lower efficiency of use of its container terminals is more than enough to offset this apparent advantage in the number of additional berths need-

² TEU is an acronym signifying a twenty foot equivalent unit. It is an inexact unit of cargo based on the volume of a 20-foot-long (6.1 m) container. While 20ft long containers were until recently the most frequently used (although their other dimensions were less standardized) they have now been superseded by 40ft long containers, sometimes referred to as FEUs. However, the TEU is still the standard measure of capacity used in maritime transport.

ed. The Reference Scenario has a need for more container terminals than either the Common Development or Failed Development scenarios, but not as many as the Polarized Development. The Polarized Development scenario needs more berths because of the higher share of intra-Arab country trade and this needs a large number of berths for feeder vessels.

Airport passenger terminals

For many airports the critical capacity constraint is no longer the number of runways but the capacity of the passenger terminals. We have projected the number of air passenger movements in each of the MED11 countries, (taking account of projections of GDP and FDI (Foreign Direct Investment) as the basis for business passenger growth and where available, national projections of increases in tourism as the basis for non-business passenger growth) and translated that demand into that for airport passenger terminals. A commonly used design parameter for airports is that the terminal space for each peak period air passenger. With an estimate of the number of peak period air passengers, we have used this design parameter to estimate the area of air passenger terminals that are needed for each country.

Since we have no reliable and consistent data on the area of passenger terminals in each country, we have adopted a similar analytical method to that for container berths – assuming that the current terminal space exactly matches the current demand. We then apply the design benchmark parameters only to the projected increase in demand.

The quantities of new air passenger terminals are more consistent between countries than for most other types of infrastructure. While business passengers to/from lower income countries tend look for the same standards in air passenger terminals as in developed countries, non-business passengers tend to tolerate a slightly lower quality of terminal infrastructure. So in our Scenario analysis, the parameter for the provision of area of air passenger terminals is the same for all Scenarios, but the unit cost per m² is slightly lower than the global standards to take account of the slightly lower infrastructure quality tolerated by non-business passengers to MED11 countries.

2.4. Summary of additional transport infrastructure for each scenario

The quantities of all types of additional infrastructure are summarized in Table 3. These are the infrastructure needs that are taken forward into Part Two of this

report where we estimate the costs of improving, upgrading, expanding and maintaining the infrastructure networks.

The Common Development scenario is the most demanding for paved roads, railways, runways and to a lesser extent, for air passenger terminals. For unpaved roads and container terminals, the Polarized Development scenario is the most demanding.

Table 3. Summary of additions to transport infrastructure for each Scenario

| Type of infrastructure | Units | Reference Scenario | Common Development | Polarized Development | Failed Development |
|-------------------------------|----------------|---------------------------|---------------------------|------------------------------|---------------------------|
| Paved roads | km | 174,436 | 307,145 | 301,234 | 118,918 |
| Unpaved roads | km | 32,296 | 58,995 | 88,313 | 30,152 |
| Railways | km | 4,274 | 16,452 | 4,709 | 2,246 |
| Runways | km | 11 | 92 | 17 | 7 |
| Passenger terminals | m ² | 888,062 | 976,869 | 888,062 | 732,652 |
| Container berths | number | 45 | 42 | 64 | 38 |

Source: Previous Tables in this report.

3. Transport infrastructure investment costs and affordability

In this Part of the report we describe the method of estimating the four principal costs of operating transport infrastructure networks – bringing their condition to a standard that minimizes total investment costs, upgrading their category to provide sufficient capacity and minimizes operating costs, expanding the networks, and maintaining the improved, upgraded and expanded networks in good condition. We express the investment costs for each of the four scenarios as absolute amounts and as a percentage of projected GDP, as this indicates whether the investment needed will be affordable or not.

3.1. Quantities of transport infrastructure

At the end of Part 1 of this Report we indicated the additional quantities of transport infrastructure required to meet the benchmark standards for four different scenarios and for six types of transport infrastructure. When added to the data or estimates of currently existing transport infrastructure, the totals give the quantities that are used in this Part of the report to estimate the investment needs. In Table 4 we show the total quantities of each type of transport infrastructure for each Scenario, these totals being the sum of existing infrastructure and the additions needed for each scenario.

3.2. Types of transport infrastructure investment

For each of the Scenarios we estimated four different types of infrastructure cost:

i. Improving the condition of infrastructure

First are the costs of *improving the condition* of current transport infrastructure, so as to minimize maintenance costs of the infrastructure itself and the operating costs of the vehicles using it. We obtained estimates of, or made assumptions about, the quantity of current infrastructure in each country that is in good, fair, and poor condition. To estimate the cost of bringing infrastructure in fair or poor condition up to good condition, we multiplied the quantities of such infrastructure by the unit costs of improvement – a one-time cost that can be incurred at any time but preferably as soon as possible and before other types of investment.

ii. Upgrading categories of infrastructure

Second are the costs of *upgrading the category* of existing transport infrastructure to a level adequate to the demands made upon it. Representative activities are widening existing roads or upgrading their surface, lengthening airport runways and expanding port berths, and increasing the permissible axle load of railways. We categorize infrastructure by its capacity or level of development. The essential question is whether a piece of infrastructure has the capacity to meet the demands made upon it. Some infrastructure is already adequate. For example, many of the roads already have at least two lanes and hard shoulders giving them adequate capacity. For other roads, the capacity of existing infrastructure is insufficient, such as: roads connecting large cities that have enough traffic to justify four or more lanes but presently have only two; railway networks that have not been fully updated to support 25 ton axle loads, and; airports in some medium-size cities have runways that are too short for mid-size aircraft such as the Airbus A320 or Boeing 737. Such deficiencies are found with respect to all transport modes and markets.

Table 4. Total transport infrastructure for each Scenario

| Type of Infrastructure | Units | Reference Scenario | Common Development | Polarized Development | Failed Development |
|------------------------|----------------|--------------------|--------------------|-----------------------|--------------------|
| Paved roads | Km | 590,442 | 723,151 | 717,240 | 534,924 |
| Unpaved roads | Km | 428,495 | 455,194 | 484,512 | 426,351 |
| Railways | Km | 28,895 | 41,073 | 29,330 | 26,867 |
| Runways | Km | 164 | 245 | 170 | 160 |
| Passenger terminals | m ² | 1,575,407 | 1,664,214 | 1,575,407 | 1,419,997 |
| Container berths | Number | 126 | 123 | 145 | 119 |

Source: Author’s estimates.

We made our own specifications of the desirable categories of infrastructure that are appropriate for each mode and market, based on best practice international standards. Where the total transport investment costs turn out to be unacceptably high, it might be possible to relax some of the standards to give lower investment costs, but this would result in higher operating costs.

We have used engineering estimates of the costs of upgrading each category of infrastructure to the next highest level, but such estimates assume that the infrastructure being upgraded is already in good condition. For that reason, we estimated the cost of upgrading infrastructure in two stages – first improving its condition to good in its present category, and then upgrading it to the next category. In practice, these operations often occur together, but we believe that our two-stage approach accurately reflects the higher cost of upgrading infrastructure that is in less-than-good condition.

The current condition of transport infrastructure can be assessed in several ways. The simplest is for the engineers responsible for maintaining the infrastructure to make a subjective assessment, usually into some combination of the categories very good, good regular or fair, poor and very poor. The second is to use a more objective method, such as the use of the international roughness index for roads. The IRI defines the method and equipment to be used to measure the roughness of the road surface, and then these measurements are used to calculate a roughness index for the road, with the index being scaled between one and ten. Sometimes equivalence between the subjective measures and the IRI is used, so that particular values subjective assessments are considered to be comparable to particular value ranges of the IRI.

A third method, sometimes used for rail track, is to equate particular combinations of speed and axle load restrictions to subjective assessments. For example, a rail track with no such restrictions would be assessed to be in excellent condition, whereas one where a 20% speed restriction on the design speed (whether that design speed were 150km/hr or 60km/hr) would be assessed to be in good condition, a higher speed restriction would relegate the conditions to fair or regular, whereas an axle load restriction would relegate the condition to poor or very poor. So far as we are aware, there are no formal objective categorizations of the condition of airport runways, but the subjective method is sometimes used. By some subjective methods, runways in anything other less than fair or regular condition are unsafe and should not be used.

iii. Extending the length of networks or increasing the number of facilities

Third are the costs of *extending existing networks* and increasing the number of infrastructure assets. The method of estimating the expansion of transport networks to meet global intensity is described in Part 1 of this Report. The costs of expansion were estimated by multiplying the quantities of additional infrastructure indicated by this method by the unit costs of providing new infrastructure. The unit costs were derived from recent projects and studies in countries of the region, including recent EUROMED studies.

iv. Maintaining infrastructure

Fourth, we estimated the costs of *maintaining networks and assets* in their improved, upgraded, or expanded form. The poor condition of transport infrastructure in the MED-11 countries reflects insufficient investment in maintenance. Unless sufficient investment is allocated to maintenance, the benefits of improving the condition, upgrading the category, or expanding the quantity of transport infrastructure will be temporary. The belated realization of the importance of maintenance is the driving force behind the creation in some countries of road funds that enjoy dedicated, protected sources of funding.

Most previous assessments of transport infrastructure investment needs made some attempt to include maintenance costs. The most common method is to add a fixed amount (often 3 percent) of the replacement cost of the infrastructure. However, very few countries invest anywhere near this amount to keep their transport infrastructure in good condition, although many at least maintain it in safe condition. The most common consequences of lower standards of maintenance are lower operating speeds and higher costs of maintaining the vehicles that use the infrastructure.

If rail track is not maintained in good condition, for example, with regular replacement of ballast, sleepers, fastenings, and worn rail (broken rails that impair operational safety are usually replaced as necessary), the first consequence is a reduction in operating speeds, followed by a reduction in axle loads and possibly further reductions in speed. The railway company incurs higher operating and capital costs as well. For example, because trains take more time to cover the same distance, crew costs are higher. Lower axle loads mean that more cars are needed to transport the same quantity of freight. These higher costs may quickly come to exceed the savings realized by reducing investment in maintenance.

For most transport infrastructure we considered two types of maintenance – annual and periodic. Annual maintenance is done to avoid or minimize the deterioration of infrastructure related to climate and weather. For example, annual maintenance includes the clearing of drains to ensure that water does not accumulate on and eventually seep into the surface of the infrastructure, thus accelerating its deterioration. For a railway, annual maintenance includes the replacement of broken fastenings, so sleepers can continue to withstand the pressure of trains and maintain the correct distance between the rails.

Periodic maintenance is usually related to the effects of infrastructure use. For example, the constant passage of vehicles will in time wear away the surface of a road. If the surface is not replaced, the subsurface will become worn and require rehabilitation or replacement. The passage of trains similarly causes the rails to wear. Worn rails increase the risk of derailments.

We take the costs of both types of maintenance into account but convert periodic costs to annual equivalents by dividing their cost by their estimated frequency. We estimate the frequency of periodic maintenance based on average volumes of traffic using the infrastructure. Although similar considerations apply to port berths, the time between periodic maintenance interventions is usually much longer than for other transport modes and thus depends less on use than on elapsed time.

3.3. Unit costs of infrastructure investment

The total cost of each of the four types of infrastructure investment is estimated by multiplying the quantities of infrastructure of each type by the unit costs of improvement, upgrading, expansion and maintenance. The final overall total cost is derived by adding together the totals for each type of activity.

Sources of unit cost information

The unit costs are derived from various sources, and for all of them the costs have been adjusted to end-2010 values and expressed in US\$. Where possible, unit costs from one source have been checked against those from another. The first source is the various studies undertaken between 2004 and 2006 for the EuroMed project. Most of these had a base year of 2004 for their costs and were pre-feasibility studies, for which the costs are typically about 20% to 30% lower than

those that will be incurred when (and if) the project is implemented. So for unit costs from these studies we have, in addition to updating the base year from 2004 to 2010, further adjusted the costs upwards by 20% to bring them closer those that might actually be incurred. A second source is the World Bank ROCKS (Road Costs Knowledge System) database.³ This only includes costs for road projects, but the data is the costs actually incurred in the implementation of World Bank road projects. The base year for the data is 2002, so their reliability, even when updated to a 2010 base, is questionable.

Unit costs of improvement of transport infrastructure

Three other sources derive from the recent World Bank Africa Infrastructure Country Diagnostic (AICD). First is Background Paper 11 (BP11), *Unit Costs of Infrastructure Projects in Sub-Saharan Africa*. This provides a range of unit costs for some rather general activities, including new construction of paved roads (the category of the roads is not distinguished, but the length of the project was found to influence the cost with longer projects having higher unit costs). As with the ROCKS database, the average costs in BP11 are those actually incurred in implementing projects, so no adjustment for being pre-feasibility estimates was necessary, and since the base year was 2006, the updating to 2010 prices is more reliable than that for the ROCKS data. Background Paper 14 from AICD (*The Burden of Maintenance: Roads in Sub-Saharan Africa*) also relates only to roads, but gives the overall cost of different types of road maintenance for each of the 44 countries included in the Diagnostic and from these and other data provided, it is possible to estimate the unit costs of various maintenance activities. Unfortunately these average costs are for the whole road network and not just for those sections for which the total costs were estimated. The third and most comprehensive from this source is Carruthers et al. (2008). This source provides unit costs for four transport modes (roads, railways, ports and airports) and for each of the four investment activities used here.

Most of the unit costs shown in Tables 5 through 8 are based on those of the EuroMed studies and Carruthers et al. (2008), adjusted to take account of slightly different rates for some activities, for inflation and for the difference between estimated and actual costs.

³ http://www.worldbank.org/transport/roads/rd_tools/rocks_main.htm

Table 5. Unit costs of improvement of transport infrastructure

| Type of infrastructure | Improvement categories | | |
|--|-------------------------|-------------------|-------------------|
| | Good to very good | Fair to very good | Poor to very good |
| | US\$ per km or per unit | | |
| 4-lane road | 25,000 | 150,000 | 350,000 |
| 2-lane road | 10,000 | 70,000 | 150,000 |
| 1-lane | 7,500 | 50,000 | 100,000 |
| Unpaved road | 5,000 | 10,000 | 25,000 |
| Single track railway | 50,000 | 500,000 | 500,000 |
| Double track railway | 75,000 | 750,000 | 1,00,000 |
| Single track electric railway | 125,000 | 750,000 | 1,250,000 |
| 1500m runway | 150,000 | 750,000 | 3,000,000 |
| 3000m runway | 250,000 | 1,500,000 | 6,000,000 |
| Container berth | 2,500,000 | 12,000,000 | 12,000,000 |
| Bulk berth | 2,000,000 | 10,000,000 | 10,000,000 |
| General berth | 1,500,000 | 8,000,000 | 8,000,000 |
| Air passenger terminal (m ²) | 100 | 250 | 500 |

Source: Author's estimates.

Unit costs of upgrading the categories of transport infrastructure

The only source of information on the categories of transport infrastructure in the MED-11 countries is the EuroMed studies. Unfortunately, this data relates to 2004 and significant upgrading of much of the infrastructure has taken place since then. We have used our own knowledge of specific recent upgrading projects to update Carruthers et al. (2008) data using that from the EuroMed studies.

The categories used for each type of transport infrastructure are specific to that mode and related to the different types of infrastructure available. The categories usually relate to capacity but sometimes to method of construction. For example, for Scenario 1 at the end of the period, 10% all paved roads should be 4-lane divided highways, 20% should be 4-lane highways but without limited access, 60% should be 2-lane and the balance (10%) could remain as single lane highways. For countries in which the percentages are already met for specific types of infrastructure, no additional investment is assumed to be needed for upgrading categories. There will be many instances where new investment will be needed to reduce congestion (for example, 6-lane or more divided highways in urban areas) but without undertaking specific demand analyses we cannot assess the needs for this additional investment.

Table 6. Unit Costs of Upgrading of categories of transport infrastructure

| Upgrade | Unit | Unit cost (US\$) |
|---|-------------------|------------------|
| 2-lane to 4-lane divided limited access | US\$/km | 1,500,000 |
| 2-lane to 4-lane divided | US\$/km | 1,200,000 |
| 1-lane to 2-lane | US\$/km | 200,000 |
| 1-lane gravel to 1-lane paved | US\$/km | 100,000 |
| 1-lane gravel to 2-lane SST | US\$/km | 100,000 |
| Railways axle load to 25 tons | US\$/track km | 120,000 |
| Non-electrified to electrified railway | US\$/ track km | 750,000 |
| Single track to double track diesel | US\$/ track km | 750,000 |
| Gravel runway to paved runway | US\$ per linear m | 5,000 |
| 1524m paved runway to 3000m runway | US\$ per runway | 12,000,000 |
| 1000m paved runway to 1524m runway | US\$ per runway | 4,800,000 |

Source: Author's estimates.

The unit costs of upgrading existing infrastructure to the higher categories is less than that of constructing new infrastructure to that standard, but it is more than the difference between constructing new to the higher and lower standards. Table 6 shows the unit costs of upgrading infrastructure from its current category to the specified higher categories. For railways, some of the upgrading requires a combination of unit costs, such as for electrification and increasing axle loads.

Unit costs of new infrastructure

The future lengths or quantities of transport infrastructure were based on the benchmarking method described in Part 1. The unit costs of new construction shown in Table 7 were applied to the difference between the benchmark lengths/quantities and those currently available to estimate the costs of expanding the networks to meet the benchmark standards.

Table 7. Unit costs of New Infrastructure

| Type of infrastructure | Unit | Unit cost (US\$) |
|---|---------------------|------------------|
| 4-lane divided paved road | US\$/km | 3,500,000 |
| 2-lane paved road | US\$/km | 1,000,000 |
| 1-lane paved road | US\$/km | 150,000 |
| Railway single track, 25t axle load, diesel | US\$/km | 750,000 |
| Railway single track, 25t axle load, electric | US\$/km | 1,000,000 |
| Railway signaling | US\$/km | 350,000 |
| Airport runway, 3000m | US\$/m | 30,000,000 |
| Airport passenger terminal | US\$/m ² | 500 |
| Container berth | US\$/berth of 300m | 16,000,000 |

Source: Author's estimate.

Unit costs of maintaining transport infrastructure

Most countries, and almost all developing countries, do not invest enough in maintenance of their transport infrastructure to prevent its condition deteriorating over time. The standards to which infrastructure should be upgraded are the same for the first three Scenarios, but since Scenario 4 is resource constrained (to the recent % of GDP that has been invested in transport infrastructure) the standards to which infrastructure can be maintained are less than the “very good” of the other Scenarios and are different for each country.

Unit costs of routine and periodic maintenance

There are two types of maintenance needed for most types of transport infrastructure, annual and periodic. The periodicity of the latter depends on the particular infrastructure and the intensity of its use.

For example, road pavements are usually designed for a life measured in equivalent axle loads (EQAs), since it is the frequency of these axle loads that determine when a road needs a new surface. We have derived an average frequency measured in years based on the average traffic density and composition and EQAs per vehicle.

Given a twenty year analysis period, there would on average be two and a half periodic maintenance activities for each paved road, three for each unpaved road, four reballastings for each rail track and two resurfacings for each runway. We have not included the cost of re-railing or re-sleeping of rail track because of their long periodicity and the fact that we have already included these unit costs in those of improving and upgrading. These costs have been applied to all transport infrastructure – current that will have been improved and upgraded as well as new.

Table 8. Unit Costs of Periodic Maintenance

| Periodic activity | Unit | Total cost in US\$ | Periodicity | Annual cost in US\$ |
|-------------------------------------|---------------------|--------------------|-------------|---------------------|
| Resurfacing 4-lane road | US\$/km | 1,000,000 | 8 | 125,000 |
| Resurfacing 2-lane road | US\$/km | 50,000 | 8 | 6,250 |
| Reballasting railway | US\$/track km | 15,000 | 5 | 3,000 |
| Resurfacing runway | US\$/runway | 5,000,000 | 10 | 500,000 |
| Rehabilitating container berth | US\$/berth | 10,000,000 | 10 | 1,000,000 |
| Refurbishing air passenger terminal | US\$/m ² | 200 | 5 | 40 |

Source: Author’s estimates.

3.4. Results of the cost analysis

The results of the analysis are shown in two parts. The first part reviews the total expected investment by country and type of investment and the share of total investments by country. The second part reviews the investment by country and mode of investment, both parts covering all four scenarios. The following section addresses the affordability of these investments.

Total investment costs and of types of investment

In Table 9 we compare the total investments by type of expenditure for each scenario. Total investment in the Reference Scenario is almost US\$675 billion over the twenty year analysis period, with an average of nearly US\$34 billion per year. The Failed Development Scenario not surprisingly has the lowest total investment, just over US\$500 billion over the twenty years, or just over US\$26 billion per year, about three quarters that of the Reference Scenario. In Part 1 of this Report we saw that the investment demands of Common Development Scenario would be very high and this is confirmed in Table 9 which shows that even with the reduced objective (reducing the difference between current and EU27 benchmark values by one third) it would need more than US1, 200 billion for the MED-11 countries to achieve the benchmark standards. Spread over a period of twenty years this would require an annual investment of more than US\$60 billion, about double that of the Reference Scenario. The Polarized Development Scenario would require a total of more than US\$900 million, equivalent to US\$45 billion per year, about one third more than for the Reference Scenario.

In all the scenarios the maintenance share is high, more than 45% of the total for the Reference and Failed scenarios, about 40% for the Polarized Development Scenario and more than 30% for the Common Development Scenario. Although the Common Development Scenario has the lowest share of investment in Maintenance, it has the highest actual investment. Despite the benchmark standards for the Common Development scenario having been reduced, this scenario still requires almost 50% of investment in new infrastructure. In contrast, the Failed and Reference scenarios need only 29% of their investment in new facilities. The Failed Development scenario compensates by having a high investment shares in upgrading (11%) the existing infrastructure.

Table 9. Investment total and shares by type of activity

| Scenario | Maintenance | Upgrading | Improvement | Expansion | Total |
|-----------------------|--------------------------------|-----------|-------------|-----------|-------|
| | Total investment US\$ billion | | | | |
| Reference | 306 | 61 | 112 | 195 | 674 |
| Common Development | 381 | 111 | 133 | 588 | 1,213 |
| Polarized Development | 362 | 61 | 137 | 343 | 903 |
| Failed Development | 238 | 56 | 69 | 147 | 510 |
| | Annual investment US\$ billion | | | | |
| Reference | 15.3 | 3.0 | 5.6 | 9.8 | 33.7 |
| Common Development | 19.0 | 5.5 | 6.7 | 29.4 | 60.6 |
| Polarized Development | 18.1 | 3.0 | 6.9 | 17.1 | 45.1 |
| Failed Development | 11.9 | 2.8 | 3.4 | 7.4 | 25.5 |
| | Share of total investment (%) | | | | |
| Reference | 45 | 9 | 17 | 29 | 100 |
| Common Development | 31 | 9 | 11 | 48 | 100 |
| Polarized Development | 40 | 7 | 15 | 38 | 100 |
| Failed Development | 47 | 11 | 13 | 29 | 100 |

Source: Author's estimates.

Investments by country

When the investments by country are considered, Scenario 2 (Common Development) is significantly different to the other three. In Scenario 2 there is little variation in the shares of investment allocated to Expansion, the lowest share be 49% (Palestine) and the highest being 70% (Algeria). Given that the Expansion shares do not show much variation and are relatively high, the country shares of the other types of expenditure also show little variation.

In the Reference Scenario and Polarized Development Scenario the ranges of expansion investment vary from 42% (Egypt) to 0.5% (Palestine) and from 31% (also Egypt) to 0% (also Palestine) respectively. Palestine has no need for investment in Expansion for Scenarios 1, 3 and 4 as its paved and unpaved road densities already exceed the benchmarks for those scenarios, and as it currently has no ports, railways or airports we do not allocate any expansion investment to those infrastructures. However, Palestine is currently planning to build a rail network, and until the second Intifada (2000 to 2005) was well advanced on plans to build both a port and an airport. None of these developments are included in our Scenarios, as their economic and financial viability has not been assessed.

In the Reference Scenario, three countries (Algeria, Egypt and Turkey) would account for about 70% of the total investment, leaving the remaining 30% for the other eight countries. Turkey alone would account for one third of the total. At the

other end of the scale, Lebanon and Palestine would each require only about 1% of the total, with Israel and Jordan requiring only 2% each.

Turkey accounts for the highest share of investment in all four scenarios, consistently with more than one third of the total. Algeria and Egypt have the next highest shares of between 10% and 20% but show more variation between scenarios and Egypt has a higher share in Scenarios 1, 3 and 4 and Algeria having a slightly higher share in Scenario 2. Palestine has consistently the lowest share, ranging only between one third and one half of one per cent of the total. Libya has the highest range of its investment share, from a low of just over 5% in the Reference Scenario to more than 12% in the Polarization Development scenario.

Table 10. Country shares of total investment, %

| | Reference Scenario | Common Development | Polarized Development | Failed Development |
|-----------|---------------------------|---------------------------|------------------------------|---------------------------|
| Algeria | 16.7 | 16.5 | 9.8 | 14.6 |
| Egypt | 20.0 | 15.9 | 19.5 | 16.8 |
| Israel | 2.1 | 2.4 | 1.6 | 2.7 |
| Jordan | 2.3 | 2.0 | 2.2 | 2.0 |
| Lebanon | 0.8 | 1.1 | 0.6 | 1.0 |
| Libya | 5.5 | 8.9 | 12.6 | 9.7 |
| Morocco | 9.3 | 8.6 | 8.8 | 8.5 |
| Syria | 5.8 | 5.0 | 5.9 | 5.6 |
| Tunisia | 4.1 | 3.6 | 2.6 | 3.4 |
| Turkey | 33.0 | 35.7 | 36.0 | 34.9 |
| Palestine | 0.5 | 0.3 | 0.4 | 0.7 |
| MED 11 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Author’s estimates.

In the Common Development Scenario, the total investment of more than US\$3,500 billion would have a similar distribution, but Turkey would account for a slightly larger share and Egypt a slightly smaller share than in the Reference Scenario. Palestine’s share would reduce to a little more than half of the 0.5% of the Reference Scenario. Investment would remain heavily concentrated in Turkey, Algeria and Egypt, these three countries accounting for about 68% of the total. Israel, Jordan, Lebanon and Palestine would account for the smallest share of the total, only about 6% of the total between them.

The Polarization Scenario gives Egypt and Libya their largest share of the four scenarios, nearly 20% for Egypt and nearly 13% for Libya. Syria and Jordan also have their largest shares in this Scenario, but not by with such large differences to the other scenarios. Part of the reason for the larger shares of these countries in the

Polarization Scenario is their role as transit countries for higher trade between the MED-11 countries rather than with the EU-27.

Despite having the lowest total investment, the shares of that total between countries in the Failed Development Scenario are not very different from those in the Reference Scenario. Algeria and Egypt have slightly lower shares while Libya has a rather higher share and Turkey a slightly higher share. The shares of all the other countries differ from those of the Reference Scenario by less than one per cent.

Investment by mode

There are two ways of looking at mode shares. The first is to see the total investment for each mode, and this is shown in first part of Table 11 for the four scenarios. The second way is based on the share of investment for each mode, and this is shown in the second part of Table 11. Although there are significant differences in the total investments for each mode, the shares of investment going to each mode are remarkably similar between scenarios with there being a 3% or difference in modal shares.

Table 11. Mode shares and investment by mode for MED-11 countries for each scenario

| Scenario | Roads | Railways | Airports | Ports | Total |
|-----------------------|--|----------|----------|--------|-----------|
| | <i>Total investment, US\$m</i> | | | | |
| Reference | 600,018 | 37,111 | 24,585 | 11,859 | 673,574 |
| Common Development | 1,097,044 | 67,509 | 36,398 | 11,585 | 1,212,537 |
| Polarized Development | 826,171 | 37,146 | 25,440 | 13,759 | 902,515 |
| Failed Development | 600,018 | 37,111 | 24,585 | 11,859 | 510,343 |
| | <i>Share of investment, % of total</i> | | | | |
| Reference | 89 | 6 | 4 | 2 | 100 |
| Common Development | 90 | 6 | 3 | 1 | 100 |
| Polarized Development | 92 | 4 | 3 | 2 | 100 |
| Failed Development | 89 | 6 | 4 | 2 | 100 |

Source: Author's estimates.

Paved and unpaved roads

Roads account for the highest modal investment share for all scenarios, with the lowest share being 89% for the References and Failed Development Scenarios and the highest being for the Polarized Development Scenario at 92%. With this very high share, there is little opportunity for the shares of the other modes to show much variation.

Railways

While the railways share only varies between 4% and 6% of the total, the actual investment varies between US\$37 billion in the Reference, Polarized and Failed Development Scenarios and more than US\$ 67 billion in the Common Development Scenario. Although the rail investment is highest in the Common Development Scenario, its share of investment is similar to those of the Reference and Failed Development Scenarios.

Airports

The pattern for airport runways and passenger terminals is similar to that of railways, that is a very high investment in the Common Development Scenario (more than US\$37 billion for runways and terminals taken together) and lower but similar investments levels in the other scenarios (about US\$25 billion).

Port berths

The investment needed in port berths (expansion only for container berths but improvement, upgrading, improvement and maintenance also for general freight berths) is similar for all four scenarios at about US\$12 billion although the Polarized development has about US\$2 billion more. The Common Development Scenario does not have much higher investments than the other scenarios, as we have assumed that the Scenario will include a large increase in the ro-ro share of MED-11 to E-27 trade and this will detract from the container share. This scenario also has the highest efficiency of use of container berths, also contributing to a lower need for investment.

Modal investments by country

The only three modes that display significant differences between the scenarios in terms the share of modal investments between countries are paved roads, unpaved roads and railways. For these three modes, Turkey would require more than one third of the total investments, except for unpaved roads and railways in the Polarized Development Scenario where the shares would fall to about 21% and 26% respectively.

For paved roads, Algeria's share would be about 17% except for the Polarized Development Scenario where it would fall to about 7%. Egypt's share would fall from about 20% in the Reference Scenario to 15% in the Common Development Scenario. Libya's share of paved road investment is the most variable between scenarios, with 6% in the Reference Scenario, rising to 10% in the Common Development Scenario and to 14% for Polarized Development, but falling to 11% in

the Failed Development Scenario. Israel, Jordan and Lebanon would have consistently low shares of paved road investment, at 3%, 2% and 1% respectively. Morocco would take about 10% of the paved road investment in all scenarios, while Syria would require a consistent 5% and Tunisia a consistent share of between 2% and 4%.

Algeria's share of unpaved road investment would increase from an average of about 22% in the Reference Scenario to more than 29% in the Polarized Development Scenario. Egypt's share would be about 20% in the first three Scenarios, reducing slightly to 16% in the Failed Development Scenario. Israel, Lebanon, Jordan and Palestine require little or no investment in unpaved roads, Libya and Tunisia about 5%, Morocco about 10% (other than in the Reference Scenario where it would only require 4% of the total).

After Turkey, Algeria and Egypt would need the next greatest share of railway investment with about 20% each. Algeria's share would increase to over 30% in the Polarized Development Scenario. Syria and Tunisia would each require about 6% to 7% for all scenarios, the other countries sharing the remainder with between 0% (Palestine and Libya as they currently do not have railways) and 2% (Jordan)

For container berths we have only included the costs of the infrastructure and not the superstructure. The latter includes all the container handling equipment and is usually provided by the terminal operator, now invariably under a concession agreement. Superstructure is not included for any transport infrastructure. The port share is small as it is only container berths. We have not had opportunity to analyze all the data for bulk solid and bulk liquid berths, but most of investment in these is provided by the private sector.

3.5. Affordability of total transport investments

While total investment in transport is an important indicator of how much investment is needed, it does not reflect how affordable that investment would be. For that we look at the investment as a share of GDP. This is reflected in Table 12.

While being an import concept, affordability in terms of investment as a share of income does not have any objective specification – what could be affordable to one country might not be to another that has different economic and social objectives. One criterion that is often used to assess affordability is to compare the investment with what share of investment is actually incurred in other countries, and this comparison is made in the next Section of this Part of the Report. Anticipating the conclusions from this Section, investment of more than 2% of GDP has not

been maintained consistently by any country, although about one third of the reporting countries have invested more than 1% for at least a decade.

Table 12. Transport investment as a share of GDP, %

| | Reference | Common | Polarized | Failed |
|-----------|------------------|---------------|------------------|---------------|
| Algeria | 2.1 | 4.5 | 1.7 | 1.4 |
| Egypt | 1.6 | 2.3 | 2.1 | 1.0 |
| Israel | 0.2 | 0.6 | 0.2 | 0.2 |
| Jordan | 1.5 | 2.6 | 2.0 | 1.0 |
| Lebanon | 0.4 | 1.2 | 0.4 | 0.4 |
| Libya | 1.3 | 4.3 | 4.0 | 1.7 |
| Morocco | 2.0 | 3.8 | 2.6 | 1.3 |
| Syria | 1.9 | 2.5 | 2.7 | 1.4 |
| Tunisia | 1.8 | 3.1 | 1.5 | 1.1 |
| Turkey | 0.9 | 2.1 | 1.3 | 0.7 |
| Palestine | 1.5 | 3.0 | 1.5 | 1.4 |
| MED 11 | 1.2 | 2.4 | 1.6 | 0.9 |

Source: Author's estimates.

The Common Development Scenario would require all countries other than Israel to invest 2% of GDP or more in transport infrastructure, while in the Reference Scenario this level of investment would only be needed by Algeria and Morocco. Egypt, Jordan, Libya, Morocco and Syria would need at least this level of investment for the Polarized Development Scenario, while none of the countries would need it for the Failed Development Scenario.

The only country/Scenario combinations that would need more than 4% of GDP (and therefore perhaps be financially infeasible) would be Algeria and Libya in the Common Development Scenario and Libya in the Polarized Development Scenario.

3.6. International comparisons of transport investment

The International Transport Forum (ITF) produces an annual report on transport investment as a share of GDP by those of its member countries that provided data. About 41 countries have provided more or less complete data for at least three of the last ten years.

These reports show that Western European Countries (WECs) reduced their transport investment share of GDP from about 1.5% of GDP in the 1970s to about

1% of GDP in the 1980s and had reduced the share to about 0.8% by this decade. By 2009, Denmark has the lowest share at about 0.5 % and Spain the highest at about 1.1%.

Interpolating the available data for the last ten years, it appears that three countries invested more than 2% of GDP in transport – Japan, Albania and Croatia. Japan's high average conceals a rapid decline, from more than 3.7% in 2000 to less than 0.6% in 2009. A further three countries (Latvia, Italy and the Czech Republic) invested between 1.5 and 2.0% of GDP. Thirteen more countries invested more than 1% of GDP and twenty two more countries between 0.5% and 1% of GDP. The average of these 41 countries was 1.0% of GDP. The only MED-11 country included in the ITF dataset is Turkey, which invested only between 0.3% and 0.5% of its GDP in transport in each reported year between 2000 and 2009.

Although the ITF data does distinguish between new investment and maintenance, within new investment it does not distinguish between investment in new facilities (in our terminology network expansion), improving condition and upgrading categories. Even for maintenance, its data is very incomplete.

Also, most of the ITF members that do report data are developed countries that have been investing in their transport infrastructure for centuries, whereas most of the MED-11 countries are still developing and have only been investing seriously in transport infrastructure since their independence or since the collapse of the Ottoman Empire by the end of the First World War. So the ITF members do not have the same need to invest in basic transport infrastructure. This difference is reflected in the Normalized infrastructure densities for the MED-11 and EU-27 countries.

Mode shares

In the Western European countries, the share of investment in road infrastructure has declined slowly with a gradual increase in rail investment. While the share of road investment amounted to close to 80% in Western Europe in 1975, figures for 2009 put it at 66% of total investment in transport infrastructure. The share of inland waterways has remained at a constant 2% in recent years. The rail share of investment is particularly high in Austria (65%), the United Kingdom (55%), Luxembourg (52%), Sweden 45% and Belgium (41%). The trend observed in our data for Western Europe is partly a reflection of the political commitment to the railways.

Transport investment in other regions

The transport investment shares of GDP for the MED11 countries are comparable to those of the lower middle income countries of Sub-Sahara Africa (SSA)

(Carruthers et al., 2008). The recent World Bank study on transport infrastructure produced broadly similar results for the 44 countries included in its study as our analysis of the MED-11 countries. Table 13 shows the investment shares of GDP projected in the AICD study for the SSA countries. The study used two scenarios. The standards in the Base Scenario (compatible with those used in our study but based on a Connectivity approach) were considered unaffordable for the lowest income countries, so alternative lower standards were assessed in what was called a Pragmatic Scenario. These lower standards are not relevant to our analyses as none of the MED-11 countries are low income or economically and socially fragile as defined in the AICD study.

For the Base Scenario, the average share of GDP for the Resource-rich and Middle-income (all of which are low Middle-income countries) were 1.7% and 0.7% respectively.

Unlike the ITF countries that already have well developed transport networks, those of the MED-11 and SSA countries are still in the stage of development and so need investment particularly in upgrading and expansion.

Table 13. Projected transport infrastructure investment for Sub-Saharan Africa, % of GDP

| Country group | Base scenario | Pragmatic scenario |
|------------------------------------|----------------------|---------------------------|
| Low-income (fragile) | 8.2 | 4.8 |
| Low-income (not fragile) | 2.9 | 1.7 |
| Resource-rich | 1.7 | 1.0 |
| Middle-income | 0.7 | 0.4 |
| Average for all Sub-Saharan Africa | 2.0 | 1.2 |

Source: Carruthers et al. (2008).

For the MED-11 countries, the share of total investment allocated to expansion of the transport networks is relatively small (between 20% and 40% of the total, overlooking the Common Development Scenario where network expansion would require almost 70% of the total investment, despite the quite extensive additional infrastructure needed to reach the benchmark targets as shown in Table 3 in the Part 1 Report.

Routine and periodic maintenance expenditure would account for the largest share by type of activity, at 40% to 50% share. However, closer examination of the ITF results shows that much of the maintenance expenditure is missing whereas that for new investment appears to be complete, so the maintenance share is under-reported.

When the improvement share (about 20%) which is really deferred maintenance, is added to that of routine and periodic maintenance, the share comes to about 60%. This is closer to the share estimated for 44 Sub-Saharan African countries in a recent World Bank study.

Maintenance share of transport investment in developed countries

The balance between road maintenance and investment has remained relatively constant over time in many regions, with maintenance making up 30% of total road expenditure on average.

The volume of maintenance for road infrastructure in WECs has increased slightly more rapidly than the volume of investment; the former grew by 25%, while the latter by around 21% from 1995 to 2008. This has resulted in an increased share of maintenance in total road expenditure; from 26% in 1997 to 30% in 2009.

Similar to the growth in volume of investment, the volume of maintenance has grown strongly in Central and East European Countries (CEECs). The share of maintenance in total road expenditure has declined slightly, from 30% in 1997 to 27% in 2009. The increase in maintenance volumes in 2006 and 2007 (Figure 4) was partly due to a major increase in road maintenance in Hungary during those years.

In North America, the volume of maintenance has been relatively constant over time. The share of maintenance has declined from 33% in 1997 to 31% in 2009, according to preliminary estimates. As with investment data, data on maintenance is also prone to limitations and uncertainties (such as the allocation of spending between maintenance and renewals).

3.7. Conclusions

We have assessed the costs and affordability of providing the transport infrastructure necessary for the MED-11 countries to achieve their benchmark quantities, and maintaining that infrastructure in a condition that is most likely to optimize the combination of infrastructure maintenance and vehicle (including road and rail vehicles) and in the case of airports and container berths, to avoid severe congestion.

The costs of providing this infrastructure expressed as a % of GDP have been found to be comparable to other developing countries that have reported investing or are expected to invest. The shares of GDP foreseen for transport investment in the MED11 countries are higher than in the EU27 countries over the last decade and comparable with those projected for 44 Sub-Saharan African countries for the next two decades to achieve broadly similar infrastructure quantities and qualities.

4. GDP and trade growth impacts of transport investment

In Part three of the report we deal with the impact of investment in transport infrastructure on GDP and international trade. These two impacts are linked through the standard definition of GDP being the total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports.

$$\text{GDP} = \text{Consumption goods and services (C)} + \text{Gross Investments (I)} + \text{Government Purchases (G)} + (\text{Exports (X)} - \text{Imports (M)})$$

Transport investment contributes directly to GDP through I (gross investments) and possibly through G (government purchases) and less directly through C by facilitating the consumption of goods and services. Although a significant part of those goods and services are related to transport, most of them are for other sectors of the economy. Transport activities typically account for between 6% and 10% of GDP, although this does not include transport activities undertaken on their own behalf by enterprises in other economic sectors. Few reliable estimates are available of these own account transport activities, and to a large degree their size depends on the efficiency of enterprises in the transport sector itself – the less efficient they are the greater the incentive for enterprises in other sectors to undertake transport activities themselves.

In addition to these impacts of investment in transport infrastructure on the value of final goods produced within a country, there is a secondary impact via any net increase in international trade (X-M). We deal first with the impact on the value of domestic goods and services and public and private investment (I +G), and then separately on changes in imports and exports (X-M), and only bring them together at the end of the analysis. This separation follows conventional analyses where the two sets of impacts are treated independently of each other – the impacts on the value of output being measured quite differently to the impact on exports and imports.

In respect of the impact on trade, if this increase is skewed in favor of imports over exports, the impact on GDP will be negative. So if the objective of the

transport investment is to bring about higher GDP (or higher GDP growth) then it is important to distinguish between impacts on exports and imports.

The Part 3 of the Report has three sections. In the first we summarize previous studies of the impact of investment in transport infrastructure on economic growth; in the second we summarize previous studies of the impact of transport infrastructure investment on international trade; the third part comprises an application of the overall conclusions from these previous studies to the investments implied in each of the four scenarios.

Provision and maintenance of transport infrastructure does not of itself contribute anything to economic and social development other than through its direct employment and the multiplier effects of that employment. What the provision and maintenance of more and better infrastructure can do is to facilitate the provision of transport and logistics services that will have more direct economic and social impacts. But even better transport and logistics services are only intermediate products that contribute to the achievement of economic and social objectives. So trying to assess the impact of investment in transport infrastructure on economic and social outcomes requires a long and complex analysis

The difficulties in establishing the links between transport investment and economic and social outcomes are part of the explanation as to why until the last decade there had been few attempts to measure these impacts, and even fewer even partially successful attempts.

4.1. Investment in transport infrastructure and economic growth

Most of the attempts to assess the impact of transport infrastructure on economic wealth (or of changes in transport infrastructure on changes in economic wealth) make use of a version of the Cobb-Douglas production function. Application of the function consists in estimating the parameters of an infrastructure augmented production function.

If we consider countries $i = 1 \dots n$ at a time $t = 1 \dots t$, the model is of the form:

$$Y_{it} = A_i K_{it}^\alpha H_{it}^\beta X_{it}^\gamma V_{it},$$

where Y_{it} is the aggregate added value, K_{it} is a measure of physical capital, and H_{it} of human capital, X_{it} is infrastructure capital and V_{it} is an error term.

Since it is the infrastructure services that impact on value added and this is difficult to measure directly, the application of the model assumes that the quantity of infrastructure services is proportional to the quantity of infrastructure capital. The basic model also assumes constant returns to scale, so that the sum of exponents is one. Dividing through by L_{it} and taking logs, the following expression results:

$$y_{it} = a_i + \alpha k_{it} + \beta h_{it} + \gamma x_{it} + v_{it}$$

where $y_{it} = \log(Y_{it})$ and capital stocks and outputs are in log per worker terms.

The fixed effects a_i capture all the timeless components of the total factor productivity. It is also possible to include in this linear specification some time effects to capture the common factors in the total factor productivity. This is the form of the model most used in assessments of the relationship between transport infrastructure and economic output.

It is difficult to interpret directly the parameters of equation, since infrastructure capital appears twice, once its own but also as a part of aggregate capital K_{it} . Consequently, the parameter γ cannot be interpreted as the infrastructure elasticity. So the elasticity of output with respect to infrastructure is not constant and depends on the ratio of capital stocks. However, infrastructure stocks typically account for relatively small portions of overall capital stock, so the difference between the genuine elasticity evaluated around the sample mean and the naïve estimate should be small.

There are two related but different approaches to estimating the impact of infrastructure on economic growth – the first uses a constant elasticity model while the second allows for variation in elasticity, usually through a threshold approach.

Constant elasticity models

Canning and Bennathan approach

While several previous studies had considered the impact on transport investment on the economic growth of a single country (for example Aschauer, 1989), one of the first analyses using the constant elasticity approach and covering a large number of countries looked at the social rate of return on transport investment by estimating the effect on aggregate output (Canning and Bennathan, 2004).

The approach to finding the benefits of infrastructure was to estimate an aggregate production function for a panel of 97 countries over a period of 40 years (1960 to 2000), including as explanatory variables physical capital and human capital as well as one transport infrastructure variable – paved roads, but also for

electricity generating capacity. The marginal product of infrastructure was measured by its contribution to aggregate output. In contrast to an earlier analysis of the same data (Canning, 1999) this analysis used a translog transformation of the standard Cobb-Douglas production function to avoid the imposition of a declining marginal productivity of capital as the capital output ratio rises. This declining marginal product was believed by the authors to almost guarantee a high rate of return on physical and human capital in low income countries, which they considered to be in conflict with observed rates of return to private capital investment.

The authors concluded that there were diminishing rates of return to paved roads, and that this implied “little support for a policy of purely infrastructure led growth.” However, they also concluded that “infrastructure (paved roads and electricity generation) is found to be strongly complementary with both physical and human capital, giving it an important role in a process of balanced growth. The possibility of acute infrastructure shortages if investment in other types of capital takes off but infrastructure investment lags behind”.

Considering only the results for paved roads, the authors found that the rates of return were similar to or even lower than, those for other forms of capital. For a few middle income countries with an acute shortage of paved roads, there were very high returns on investment in this infrastructure. The authors also observed that these high rates of return followed a period of sustained economic growth during which road building stocks had lagged behind investments in other types of capital, and that this effect was accentuated by the low costs of road construction in middle income countries relative to both poorer and richer countries.

An examination of the study results for paved roads in developing countries produced results that conflicted with the authors’ conclusion about the lower rate of return on paved roads compared to other investments. The authors only provide paved roads results for 41 countries and of these only 26 are developing countries. For these 26 countries, the average rate of return on investment in paved roads is 27.6% while that on other capital is only 5.0%.

Calderon and Serven approach

One of the most authoritative and comprehensive analyses of the effects of transport infrastructure on economic growth is provided in Calderon and Serven (2004). Their panel analyses used data from 121 countries over a forty year time period (1960 to 2000) for four different types of infrastructure (telephone lines, electricity generating capacity, roads and railways and access to safe water) and found that the volume of infrastructure stocks has a significant positive effect on long-run economic growth. This conclusion is robust to changes in the infrastructure measure used as well as the estimation technique applied. They also found a

positive but less robust relationship between infrastructure quality and growth, although they observed that this might reflect limitations of the quality measures available or also the fact that quantity and quality are strongly correlated, so that quality effects on growth are already captured by the quantity measures. The authors also investigated the impact of infrastructure (including transport) on income inequality (measured by the Gini coefficient) and found a statistically significant negative correlation, that is increasing the quantity and quality of transport infrastructure would reduce income inequality. Both conclusions were applicable to all types of infrastructure, including roads and railways.

The authors concluded that these results were obtained in a framework that controlled for reverse causation (one of the greatest sources of doubt in assessments of the relationship between infrastructure and growth), and that they survived a variety of statistical tests that failed to show any evidence of misspecification. From this they concluded that the results reflect causal, and not merely coincidental, effects of infrastructure on growth and inequality.

The measures of the quantities of road and railways used in the analyses were not absolute measures, but were similar to one of the benchmark measures in our analysis of transport infrastructure demand described in Part 1 of this Report. For transport infrastructure the measures were length in kms per unit of total land area. In Part 1 of this Report we observed that using different indicators of transport infrastructure density (by area, per capita or per unit of GDP) produce very different results as the three measures are very weakly correlated and in some cases negatively correlated. We also observed that for many countries, especially those that have large areas of desert or otherwise unproductive areas using total land area (as used by Calderon and Serven, 2004) is a less appropriate parameter to assess transport density than agricultural or arable land area. So if Calderon and Serven (2004) had used a different measure of transport intensity (using population, GDP or agricultural or arable land area to derive the parameter) they would have produced different regression parameters.

For the quality measure of transport infrastructure, the authors used the % of all roads that are paved. The measure of unpaved roads in the database used by Calderon and Serven (2004) is inconsistent between countries. The specification of an unpaved road is imprecise, with some countries including even minor paths and tracks while others only include those for which one the three principal levels of administration (national, regional and local) has a specific responsibility. So if the quantity of unpaved roads is unreliable, then so is the % of unpaved roads as a measure of road quality.

Notwithstanding these reservations, their analysis did provide a robust conclusion of a positive relationship between economic growth and quantity of transport

infrastructure. The focus of their attention was on infrastructure in Latin America, so their examples do not include any MED11 countries. The examples provided by the authors were for countries of Latin America to increase their transport infrastructure density to that of the regional leader (Costa Rica) or to that of the median country in East Asia (Korea). Using Argentina as the base (with a quoted transport density of road and railways together of 0.6km per km²), if it were to reach the density of Korea (with 3km per km²) then economic growth would be 1.4 percentage points higher.

Although the authors do not indicate the financial cost of such an increase, we estimate that in current prices it would require an additional 924,000 km of road (from 231,000km to 1,150,500km) at a cost of about US\$0.5m per 1 km, giving an investment cost of about US\$462 billion. With a 2010 estimated GDP of US\$596 billion and a growth rate of 7%, the 1.4% additional growth rate would require 10 years to generate the US\$462 billion equivalent to the investment cost. However, the investment of US\$462 billion over ten years would be equivalent to 5.2% of GDP, a level achieved by few countries over any recent decade.

A similar approach has been used in our assessment of the four Scenarios. For each Scenario, instead of following Calderon and Serven (2004) and using the highest density within the region as a benchmark, we have used the global average density (Reference Scenario), the average density of the EU27 countries (Common Development Scenario), and the average density of the per capita income group (Polarized Development Scenario). For the Failed Development Scenario we have used the level of investment rather than a benchmarking criterion.

Threshold models

Hurlin model

Subsequent to the work of Calderon and Serven (2004), Hurlin (2006) returned to an earlier consideration, that the elasticities of GDP with respect to quantities of infrastructure investment are not constant. These considerations are based on what are termed network effects, that the creation of an infrastructure network is what generates the basis for economic growth

Hurlin's main conclusion is that there is strong evidence of these network effects, revealed through the presence of thresholds in the relationships between output (measured by an increase in GDP) and private and public inputs (measured as changes in the capital stocks of infrastructure). Hurlin (2006) found that when the available stock of infrastructure is very low (that is, prior to the creation of a network), investment in infrastructure has the same productivity as investment in non-infrastructure. On the contrary, when a minimum network is available, the

marginal productivity of infrastructure investment is greater than the productivity of other investments. Finally, once the networks are established, the marginal productivity of further investment in the same type of infrastructure returns to become similar to that of non-infrastructure investments.

This conclusion is important for our analysis, as it can indicate that the lower levels of investment in transport infrastructure implied by the Failed Development and Reference Scenarios (which are above the first threshold and therefore into the “network development” stage) might have a higher economic justification than the additional investment indicated in the Polarized and Common Development Scenarios (as in these Scenarios, the investment for some countries would push the network densities above the second threshold and so into the third development stage).

Hurlin (2006) used a slightly different formulation of the Cobb-Dougllass production function to that of Calderon and Serven (2004), and this required the use of transport infrastructure per worker instead of per km². Also unlike Calderon and Serven, Hurlin measured road and rail infrastructure separately rather than together. The author assessed models with zero, three and four different thresholds of investment in infrastructure capital, and here we report only those for the three threshold and four state model.

The first state is that before the development of comprehensive transport networks; after the first threshold there is the second state where a basic network is already in place, and the effort of further investment is the enhance and complete that network. Beyond the second threshold where the network is complete is the third state. In this state, further investment is needed to avoid capacity constraints as demand increases and to accommodate new demands that emerge in locations different to those envisaged when the network was planned and created. The final and fourth stage that comes after the third threshold there is a need for additional new investment, but the elasticities are only slightly higher than in the third stage.

Choice of threshold effects model

We have chosen to use a two threshold and three stage threshold effects model. Some of the MED11 countries have underdeveloped road and/or rail networks (and so are in the first stage, below the first threshold), more are in the process of completing their already basic networks (and so are in the second stage of development, above the first threshold), while only two (Libya and Palestine) have reached the third stage, above the second threshold. None of the MED11 countries have yet reached the fourth stage, with densities above the third threshold. Application of a constant elasticity model in these circumstances would have the risk of

giving misleading results. Table 14 shows Hurlin’s (2006) thresholds (the boundaries between the stages measured in km per employee) and the elasticities (in GDP per worker per additional unit of infrastructure).

The most appropriate of Hurlin’s threshold effects models for our purposes is one that used physical capital per worker, human capital per worked and four measures of infrastructure (paved roads, electricity production, telephones and railways) per worker. Here we report only the results for paved roads and railways per worker.

Table 14. Four stage model: Infrastructure thresholds (in km per worker) and elasticities (in GDP per worker in US dollars)

| Network development | Paved roads | Railways |
|----------------------------|--------------------|-----------------|
| First threshold | 0.360 | 0.240 |
| Second threshold | 0.520 | 0.423 |
| Third threshold | 3.480 | 2.651 |
| First stage | 1.140 | 1.165 |
| Second stage | 0.509 | 0.497 |
| Third stage | 1.168 | 0.854 |
| Fourth stage | 1.130 | 0.986 |

Source: Hurlin (2006), Annex Table 4.

For paved roads, there is substantial economic growth impact from investment even before the network is developed (US\$1.14 per worker), and although this reduces to about half once the minimum network threshold is reached it increases to about 2% more than the pre network level in the third stage and remains close to the pre network level in the final stage. For railways, the economic growth impacts are 2% greater than for paved roads in the first stage, but fall rather more quickly in the second stage to about 97% of the road investment productivity. There is a recovery in the third stage but not as much as for road investments. A further 15% increase in the final stage still only brings the output elasticity or rail investment to about 87% of road investment.

The use of network density per employee does not coincide with any of our three benchmark parameters, area, population and GDP. However, by adapting the population benchmarks and using some of the results of Coutinho (2012) we can use Hurlin’s elasticities. Coutinho uses a version of the Cobb Douglas production function that is very similar to that used by Hurlin (2006), and both make use of the same perpetual inventory method of measuring capital stocks.

So there is a reasonable consistency between the two approaches that allows us to adapt results from one to the outputs of the other. Using a km per employee benchmark value for the MED11 countries, most of them are found to be currently

in the first or second stage of development. Only Libya and Palestine for paved roads reach the third network development stage.

Table 15. Paved Road and Railway densities (km per worker)

| | Paved roads | Network Stage | Railways | Network Stage |
|-----------|--------------------|----------------------|-----------------|----------------------|
| Algeria | 0.425 | 2 | 0.212 | 1 |
| Egypt | 0.143 | 1 | 0.144 | 1 |
| Israel | 0.472 | 2 | 0.000 | |
| Jordan | 0.333 | 1 | 0.114 | 1 |
| Lebanon | 0.321 | 1 | 0.000 | |
| Libya | 1.543 | 3 | 0.000 | |
| Morocco | 0.224 | 1 | 0.137 | 1 |
| Syria | 0.199 | 1 | 0.231 | 1 |
| Tunisia | 0.293 | 1 | 0.524 | 2 |
| Turkey | 0.475 | 2 | 0.280 | 2 |
| Palestine | 0.668 | 3 | 0.000 | |

Source: Author's analyses based on Hurlin (2006).

Social, economic and political context for investment in MED11 Countries

While recognizing the difficulties of assessing the direction of causality, we follow the practice of Canning and Bennathan (2000), Calderon and Serven (2004) and Hurlin (2006) in estimating the economic growth impacts of transport investment assuming that there is forward causality, that is that transport investment is likely to provide a context in which economic growth can take place, rather than that transport investment is needed because of past economic growth.

There are several examples of recent investment support to the transport sector in some MED11 countries that could be used as support for the forward causality perspective from the international financial institutions. The African Development Bank has recently (2011) provided E300 million for the expansion and electrification of Moroccan railways and the Islamic Development Bank together with the European Investment Bank (EIB); the World Bank is negotiating with the Government of Jordan to support the creation of a basic US\$3 billion railway network that will link with Saudi Arabia, Syria and Iraq. In recent years the EIB has supported the funding of many other transport infrastructure and trade facilitation projects in the MED11 countries, including port upgrading in Syria and Lebanon. The Islamic Development Bank has helped in the funding of cross border trade and transport facilities between Syria and Turkey. The EIB has been assisting the Government of Egypt in preparing the development of inland container terminals in Cairo, important missing links in the countries international trade infrastructure.

The World Bank has supported expansion of airport facilities in Egypt. In addition to these public sector investments, private investment in transport infrastructure has expanded rapidly in the MED11 countries and promises to continue to do so, so long as the social and political conditions continue to be favorable.

4.2. Infrastructure investment and international trade

Transport infrastructure only has an indirect impact on the volumes of international trade, as it is the transport and logistics services that use the infrastructure that have the direct impact. However, many efforts have been made to relate quantities (and sometimes qualities) of transport infrastructure to volumes of international trade. Most assessments of the impact of transport infrastructure and logistics on international trade make use of a trade gravity model.

The earliest models did not have access to global databases of transport infrastructure or services, and so relied on other measures as proxies for these trade parameters. One of the most usual and most limiting simplifications has been to use great circle distance as a proxy for transport costs. This is doubly unfortunate as it is only a very imprecise substitute for cost, and since it is a fixed measure; it is not susceptible to policy changes. Any policies aimed at reducing transport costs would have no impact on the results of such a model as the great circle distances do not change as costs change.

To overcome this deficiency, most trade gravity models now include a number of other measures that compensate for the deficiency of distance as a proxy for cost. One of the most usual is to include the number of international borders that trade between land-locked and other countries must cross. Although this has allowed estimates of the distance equivalence of a border to be made, But since it is rarely possible to eliminate a border completely, this device is not useful as a policy variable. It is preferable to use the time taken to cross the border as the gravity model variable, so any reduction in the time taken can be estimated using the derived gravity model elasticity for this parameter.

Other models have used proxies for port costs and logistics. Wilson, Mann and Otsuki (2003) developed a gravity model of trade in manufactured products of the ASEAN countries that included composite indices for port efficiency and customs performance (this model was developed before the Logistics Performance Index was available) based on surveys of users' perceptions of how well these functions were performed in each country. The model also included parameters that measured trade tariffs and membership of regional international trade agreements (such

as the Association of Southeast Asia Nations (ASEAN) and the Asia Pacific Economic Cooperation (APEC) forum. Apart from these additional parameters, their model followed standard international gravity model formulation.

The authors used a similar approach to our benchmarking method, estimating the increases in international trade if countries improved their port efficiency and customs performance of the below average performing countries to half the score of the average performers. This benchmarking was applied to the individual countries and to the region as a whole, as improvements in one countries export performance would impact on the imports of all its trading partners, and similarly an improvement on customs performance would impact on the exports of all trading partners. Even these limited improvements were predicted by the model to bring about a 21% increase in trade in manufactured products. About 46% of this increase would come from improvements in port efficiency and the remainder from improvements to customs.

Only the model developed specifically for the MEDPRO analysis of shallow and deep integration (Ghoneim et al, 2011) comes close to what is needed in our analysis. This model was initially designed to estimate the trade impacts of reducing or eliminating trade tariffs and non-tariff measures. The form of the model used was:

$$\ln X_{jk} = \alpha_0 + \alpha_1 \ln \text{SUMGDP}_j + \alpha_2 \ln \text{TAR}_{jk} + \alpha_3 \text{NTM}_{s_{ijk}} + \alpha_4 \ln \text{TRANSCOST}_j \\ + \alpha_5 \ln \text{LANG}_j + \alpha_6 \ln \text{COL}_j + \phi_j + \phi_k + \varepsilon_{ijt}$$

where X_{jk} is the exports of country j of category k (HS 2 level code), SUMGDP is the sum of the GDPs of country and its trade partner Mediterranean countries, TAR_{jk} is the average tariff level of country j on products of HS code k , NTM_{ijk} is a dummy parameter that takes the value 1 if there are non tariff measures between country i and j on products of HS code k , and vale zero otherwise, TRANSCOST_j is the average transport cost of products to country j , LANG_j is another dummy variable that has a value 1 if countries i and j have a common language, and zero otherwise, COL_j is another dummy variable with value 1 if there was a colonial relationship between countries i and j and zero otherwise, and the remaining terms are country fixed effects and error terms.

It included an actual measure of trade costs rather than use distance as a proxy. However, since transportation costs were not the principal focus of the analysis, the trade cost measure chosen (the cost of a container movement between Mediterranean and other EU ports) was not all inclusive as it did not specifically include port costs (other than those reflected in the container tariff) or inland transport costs. It is the port and inland transport costs that are most likely to be influenced

by transport infrastructure investments. However, in the final version of the model, a measure of distance was used, a distance weighted distribution of the population within each country.

An alternative measure of transport costs can be provided by the Logistics Performance Index (LPI) developed by the World Bank. This is not a measure of distance or cost but an weighted average index of seven measures of logistics performance, including efficiency of the clearance process by customs and other border agencies, quality of transport and information technology infrastructure for logistics, ease of arranging international shipments, competence of the local logistics industry, ability to trace and check international shipments, domestic logistics costs as well as timeliness of shipments in reaching destination.

To estimate the trade creation effects of shallow and deep integration, Ghoneim et al (2011) observed that it is important that all the relevant policy measures be considered as a package and not independently as the effects are not additive.

4.3. Economic growth and international trade impacts of the four scenarios

We have used the elasticities and thresholds derived from Hurlin (2006), together with the additions to transport infrastructure indicated in Part 2 of this report, to make estimates of the direct impact of those investments on GDP of each of the MED11 countries for each of the four scenarios. Further, we have used the elasticities derived from Ghoneim et al (2011), together with the same additions to the transport infrastructure stock, to make estimates of the impact of those changes on the imports and exports of each of the MED11 countries. Finally, we have added the net trade impact to the direct GDP impact to derive estimates of the overall impact of the transport investments on GDP. None of the elasticity estimates available apply to ports or airports. So we have approximated the direct GDP impact of investment in these sectors by the using the average elasticities of those for roads and railways.

a. Estimates of economic growth impacts of infrastructure investments

The estimates of the growth impacts of infrastructure investment are based on the infrastructure per employee elasticities and threshold values indicated by Hurlin (2006).

One additional and important assumption needed to be made. The increases in quantities of transport infrastructure are smaller than the increases in population and employment that will take place over the same period. So if we use the future employment rates to calculate the benchmark values, they will all show reductions from the base year (2008) and the model will show an apparent decline in GDP despite the major investments that are suggested. We have therefore used the base year employment numbers to calculate the future year (2030) benchmark values.

In addition, Hurlin (2006) only estimated elasticity values for paved roads and railways, so we have been unable to make any estimates of the GDP growth impact of investment in unpaved roads, ports and airports (runways and terminals). While an omission, we do not think it serious and the major GDP growth impacts are expected to come from paved roads and railways.

To derive indications of the impact of the investments on the level of GDP, we have applied the GDP growth elasticities to the difference between the current and projected benchmark values (quantity/number of employees) for paved roads and railways for each scenario. The GDP data does not distinguish between its various components (consumption, government purchases, gross investment and net trade flows), so the GDP growth factors estimated here are inclusive of those estimated for the trade impacts in the following section.

The growth rates are the average annual impact on GDP over the 20 year planning period.

Table 16. Road and Rail Investment impacts on annual GDP growth

| Country | Reference Scenario | Common Development Scenario | Polarized Development Scenario | Failed Development Scenario |
|-----------|--|-----------------------------|--------------------------------|-----------------------------|
| | <i>Increase in GDP annual growth rate, %</i> | | | |
| Algeria | 0.8 | 1.9 | 1.4 | 0.5 |
| Egypt | 0.7 | 1.3 | 0.6 | 0.3 |
| Israel | 1.2 | 0.5 | 0.0 | 0.0 |
| Jordan | 1.2 | 2.1 | 1.4 | 0.6 |
| Lebanon | 0.0 | 0.4 | 0.0 | 0.0 |
| Libya | 0.7 | 2.2 | 3.8 | 0.9 |
| Morocco | 1.4 | 1.6 | 0.6 | 0.3 |
| Syria | 1.7 | 1.6 | 0.6 | 0.2 |
| Tunisia | 1.5 | 2.4 | 0.3 | 0.2 |
| Turkey | 0.4 | 2.0 | 1.0 | 0.4 |
| Palestine | 0.8 | 1.9 | 1.4 | 0.5 |
| MED11 | 0.7 | 1.7 | 0.9 | 0.3 |

Source: Author's estimates.

Not surprisingly the largest impact of transport investment comes from the Common Development scenario with an average impact on GDP growth of 1.7% per year (weighted by base year GDP per country), with the least impact being for the Failed Development scenario (with only a 0.3% per year impact on GDP). The largest impacts by country are for Libya (all three Development scenarios), Tunisia, Jordan and Turkey for the Common Development scenario, Algeria, Jordan and Palestine for the Polarized scenario, and Jordan, Algeria and Palestine for the Failed Development scenario. Only in the Common Development scenario is there any impact on Lebanon's GDP.

The cumulative sum of increases in GDP over the 20 year analysis period is much greater than the investment cost. The largest ratio of GDP increase to investment costs are for the Common Development scenario, with an average over all eleven MED countries of more than 8.5, while the smallest ratio is for the Failed Development scenario at less than 3.5. For the Reference and Polarized scenarios the ratio is about 6.0.

b. Estimates of trade impacts of infrastructure investments

We have used the version of the Ghoneim et al. (2011) model that uses values of the Logistics Performance Index as one of the independent variables. In Table 12 of Ghoneim et al (2011), the elasticities of imports and exports for the MED11 countries are 1.55 and 2.39 respectively.

The LPI values we have used are those in the 2010 version, and are taken from the LPI website. As observed by Ghoneim et al. (2011), unlike the 2008 version, Morocco and Palestine are the only MED11 countries not included. We have estimated the 2010 Morocco LPI value by attributing Morocco the average MED11 increase from 2008 to 2010. Since Palestine was not included in the 2007 LPI and its characteristics are so different to the other MED11 countries we have not been able to include it in our trade analyses. So with the addition of Morocco, we have the detailed LPI results for each of the six components and the overall average LPI for ten of the MED11 countries.

We have estimated the investment in infrastructure impact on the LPI by considering only the transport infrastructure component of the LPI for each of the ten countries. For each country we have assessed the increase in the LPI score for infrastructure based on the percentage increase in the quantity of infrastructure for each Scenario. A country that would have an average increase of 15% in its quantities of its six types of transport infrastructure (paved roads, unpaved roads, railways, runways, passenger terminals and container berths) would be assessed to have an increase of 15% in its LPI score for infrastructure. These country LPI

increases result in the following average increases in the infrastructure component of the LPI for each Scenario”:

- Reference Scenario: +16%
- Common Development Scenario: +28%
- Polarized Development Scenario: +22%
- Failed Development Scenario: +13%

Table 17. LPI 2009 and its component values

| Country | LPI | Customs | Infra-structure | International shipments | Logistics competence | Tracking and tracing | Time-liness |
|----------------------------|------|---------|-----------------|-------------------------|----------------------|----------------------|-------------|
| Algeria | 2.3 | 1.9 | 2.06 | 2.7 | 2.24 | 2.26 | 2.81 |
| Egypt, Arab Rep. | 2.6 | 2.1 | 2.22 | 2.56 | 2.87 | 2.56 | 3.31 |
| Israel | 3.4 | 3.1 | 3.60 | 3.17 | 3.50 | 3.39 | 3.77 |
| Jordan | 2.7 | 2.3 | 2.69 | 3.11 | 2.49 | 2.33 | 3.39 |
| Lebanon | 3.3 | 3.2 | 3.05 | 2.87 | 3.73 | 3.16 | 3.97 |
| Libya | 2.3 | 2.1 | 2.18 | 2.28 | 2.28 | 2.08 | 2.98 |
| Morocco | 2.5 | 2.3 | 2.51 | 2.89 | 2.24 | 2.10 | 3.00 |
| Syrian Arab Republic | 2.7 | 2.3 | 2.45 | 2.87 | 2.59 | 2.63 | 3.45 |
| Tunisia | 2.8 | 2.4 | 2.56 | 3.36 | 2.36 | 2.56 | 3.57 |
| Turkey | 3.2 | 2.8 | 3.08 | 3.15 | 3.23 | 3.09 | 3.94 |
| Middle East & North Africa | 2.6 | 2.3 | 2.36 | 2.65 | 2.53 | 2.46 | 3.22 |
| Lower middle income | 2.5 | 2.2 | 2.27 | 2.66 | 2.48 | 2.58 | 3.24 |
| Upper Middle income | 2.8 | 2.4 | 2.54 | 2.86 | 2.71 | 2.89 | 3.36 |
| MED9 | 2.8 | 2.5 | 2.68 | 2.96 | 2.84 | 2.73 | 3.52 |
| World | 2.8 | 2.5 | 2.64 | 2.85 | 2.76 | 2.92 | 3.41 |
| Mashreq | 2.6 | 2.3 | 2.38 | 2.60 | 2.78 | 2.52 | 3.27 |
| Maghreb | 2.93 | 2.52 | 2.78 | 3.21 | 2.69 | 2.66 | 3.63 |

Source: LPI, World Bank,

<http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTTTLF/0,,contentMDK:21514122~menuPK:3875957~pagePK:210058~piPK:210062~theSitePK:515434,00.html>.

The resulting percentage changes in the total LPI for each scenario are shown in Table 18. The differences in the percentage changes in the total LPI between countries are small as the transport infrastructure component is only one of six that make up the LPI, and the 2010 LPI transport scores for each country cover a relatively small range of values (a minimum of 2.06 for Algeria and a maximum of 3.60 for Israel).

Table 18. Changes in LPI attributable to transport infrastructure investment, %

| Country | Percentage +Increase in total LPI | | | |
|---------------|-----------------------------------|--------|-----------|--------|
| | Reference | Common | Polarized | Failed |
| Algeria | 11 | 42 | 18 | 8 |
| Egypt | 27 | 42 | 40 | 19 |
| Israel | 5 | 13 | 6 | 4 |
| Jordan | 15 | 25 | 18 | 9 |
| Lebanon | 9 | 16 | 15 | 9 |
| Libya | 8 | 21 | 20 | 8 |
| Morocco | 12 | 35 | 13 | 6 |
| Syrian | 9 | 21 | 13 | 7 |
| Tunisia | 13 | 36 | 12 | 7 |
| Turkey | 10 | 21 | 14 | 8 |
| MED11 Average | 11 | 25 | 15 | 8 |

Source: Author's estimates.

By applying the Ghoneim et al elasticities (2011), we derive the percentage changes in imports and non-oil and gas exports for each country. Since the differences in percentage changes in LPI are small, so are the differences in their impacts on imports and exports. The average impact on the trade balances are shown in Table 19. The impact of transport investment on the trade balance is relatively small in the Failed Development and Reference scenarios, while the impacts in the Common and Polarized Development scenarios are substantial.

Egypt stands to gain the most across all Scenarios, with an average of almost double the MED 11 average (20.2% against 12.4%). Algeria has the next highest average improvement in its trade balance, mostly attributable to its performance under the Common Development Scenario, from which it gains as much as Egypt. Tunisia, Morocco and Jordan are the other counties that have a higher than average improvement in their average trade balance.

Table 19 shows the expected change in the non-oil trade surplus consequent upon implementing the investments indicated for each Scenario, and the first column shows the actual non-oil trade balances for each country. If there were to be no other changes to the trade balance, implementing the transport infrastructure investments would change the balance from a negative 2.6% of GDP in 2006 to an average of positive 7.5% (that is, 10.1%-2.6%). So Jordan and Lebanon would continue with a negative non-oil balance, but Algeria, Egypt, Libya, Morocco, Tunisia and Turkey would change from a negative to a positive balance.

Morocco stands to gain most in terms of exports, with a slightly greater excess (nearly four percentage points) over the MED 11 and Scenario average than for imports. Jordan, Algeria and Tunisia are also next in gains in exports, and Libya and Lebanon have the least to gain.

Table 19. Increase in trade balance (Exports-Imports) as % of GDP

| Country | 2008 Non-oil trade balance | Reference Scenario | Common Development Scenario | Polarized Development Scenario | Failed Development Scenario | Average over all Scenarios |
|---------|----------------------------|--------------------|-----------------------------|--------------------------------|-----------------------------|----------------------------|
| Algeria | -3.8 | 6.7 | 26.5 | 11.2 | 5.2 | 12.4 |
| Egypt | -2.4 | 16.8 | 26.5 | 25.4 | 12.1 | 20.2 |
| Israel | 1.6 | 3.0 | 8.1 | 3.6 | 2.3 | 4.2 |
| Jordan | -22.5 | 9.3 | 15.7 | 11.2 | 5.4 | 10.4 |
| Lebanon | -20.7 | 5.6 | 10.0 | 9.3 | 5.5 | 7.6 |
| Libya | -7.3 | 4.8 | 13.1 | 12.6 | 5.3 | 8.9 |
| Morocco | -8.2 | 7.7 | 22.2 | 8.1 | 4.1 | 10.5 |
| Syria | 0.0 | 5.7 | 13.5 | 8.4 | 4.5 | 8.0 |
| Tunisia | -1.9 | 8.2 | 22.9 | 7.7 | 4.6 | 10.9 |
| Turkey | -0.6 | 6.4 | 13.2 | 8.6 | 4.9 | 8.3 |
| Average | -2.6 | 7.4 | 17.2 | 10.6 | 5.4 | 10.1 |

Source: Author's estimates.

4.4. Conclusions

Investment in transport infrastructure will increase the annual average economic growth rate of the MED11 countries by between 0.3% per year and 1.7% per year, depending on the scenario. The transport investment will also increase the total volume of trade and the positive trade balance, the latter by between 5.4% and 17.2% again depending on the scenario. While the increase in GDP is an annual impact and so is cumulative over the 20 year analysis period, the increase in trade and the trade balance is an average over the whole period. The ratio of total GDP increase to transport investment costs varies between 3.5 for the Failed Development scenario and 8.5 for the Common Development scenario. This not only indicates that the investment in transport is worthwhile in all the scenarios, but also that the marginal increases in investment have positive returns, that it, the higher investment in the Common Development scenario brings greater per unit benefits than the lower (but still worthwhile) investment in the other scenarios.

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