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What prospects for transport infrastructure and impacts on growth in southern and eastern Mediterranean countries?

Robin Carruthers

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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 benchmarks, 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 11 southern and eastern Mediterranean countries (SEMCs) under four scenarios.

The greatest need for additional infrastructure is for airport passenger terminals (between 52% and 56%), whereas the least is 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 11 countries would be an improvement of between 5.4% and 17.2%, although some countries would continue to have a negative balance. A final assessment is made of the benefit ratio between the increase in GDP and the cost of transport investment. This varies between about 3 and 8, an indication of the high return to be expected from increased investment in transport infrastructure.

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1. Introduction

The objective of the analyses described here is to provide estimates of the costs to 11 southern and eastern Mediterranean countries (SEMCs)[1] of bringing their transport infrastructure to specified standards, and of the macroeconomic 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 four sections. Following the introduction, the second section provides a description of the basic benchmarking approach to estimate the current deficiencies in transport infrastructure of the SEMCs. In the third there is a 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 macroeconomic benefits of the indicated investments are provided in the fourth and final section.

The report is centred 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 countries for the various infrastructure 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 reports on the SEMCs.

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 (Table 1). 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 EU-27. For the third scenario (compatible with the Polarised 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 11 SEMCs. A different

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* Until recently Robin Carruthers was a Lead Transport Economist at 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.

[1] The 11 countries are Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia and Turkey.

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 SEMCs over the last decade was assumed to continue for the whole of the 20-year assessment period.

Table 1. Basis of scenario infrastructure benchmarks

Scenario	Benchmark infrastructure standard
Reference	Global average network density
Common Development	Based on the EU-27 network density
Polarised Development	Average density of a country per-capita income group
Failed Development	National average of infrastructure investment of the last decade

Source: Author.

The estimated, total investment costs described in section 3 cover four transport modes and four types of investment expenditure:

Transport modes

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

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 indicated 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 investments in transport infrastructure 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 reports on the 11 SEMCs. 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 reports on the 11 SEMCs. These GDP and trade projections are the subject matter of section 4 of this 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 fulfils 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

Comparisons of country transport infrastructure 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 (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 with other methods of infrastructure comparison

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 emphasise concepts of connectivity. The various approaches differ substantially in their strengths and weaknesses, as well as in their data requirements (Table 2). 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 modelling 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 et al. (1997), which estimated the transport investment requirements of the larger East Asian economies at 2–3% 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 Serven, 2004; and Chatterton and Puerto, 2005). The average requirement for transport spending for the SEMCs that emerged from a review of this literature is 3.2% of GDP, including both investment and maintenance. This is higher than the shares of GDP that are indicated by our analyses (see Table 13).

Table 2. Methodologies available to estimate needs for transport investment

	Strengths	**Weaknesses**
Macroeconometric models	Econometrically grounded Exploit 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 model the demand–supply relationship in a framework that reflects the specificities of a country's transport network Can be location-specific	Data intensive
Planning models	Based on a detailed geographical model reflecting the specificities of a 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 normalised 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 normalisations 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. Yet 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 or planning-based approach, the analyses presented here are based on a benchmarking approach.

2.3 Transport infrastructure benchmarks for the SEMCs

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 for infrastructure provision or performance standards. The first method is preferable as it is less subjective, with the second method being subject to interpretation as to what is best practice.

Data were available for using 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 SEMC region and to each of the 11 countries. The data for the benchmarks come from a new transport and macroeconomic database of 139 countries using data for 2008. Most of the data come from the World Bank's 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 be used in the estimation of benchmarks. It also excludes Zimbabwe and Somalia for which macroeconomic data were not available.

First benchmarking method

In the first benchmarking method, the following infrastructure measures were used:

- km of paved road,
- km of unpaved road,
- km of railway in operation, and
- 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 km^2 of land area, per million population[2] and per US$ of GDP.

Normalised benchmark values

Previous applications of the benchmarking method have used only one of the three parameters for defining infrastructure density (per km^2 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. When 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

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

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 estimating 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 solely (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 gives 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 normalised 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 normalised index value greater than 100 indicates a higher than global average density over all three parameters and a value less than 100 indicates 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 SEMCs. We have analysed four scenarios and assessed the transport investment outcomes for each of them in terms of the affordability measured by 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 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 type of infrastructure. The premise of this scenario is that the influence of integration between the 11 countries and the EU would not affect their development, and that the 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 SEMCs and EU-27 countries become more economically and socially integrated) was designed to bring the transport infrastructure of the 11 SEMCs to the same as the average of the EU-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 Trans-European Transport Networks. In working through the costs of this scenario, we determined that it was unaffordable within the 20-year horizon to 2030 of the MEDPRO 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 Polarised scenario, in which the SEMCs become polarised in terms of their 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 11 SEMCs. Under this scenario, the SEMCs 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's classification of countries by per-capita income into four groups: low income, low middle income, high middle income and high income.

Table 3 shows the benchmark values for each type of transport infrastructure, 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 are the densities per unit of GDP. The last set of values ('normalised values') is a weighted average of the first three sets of values. The last column of Table 3 shows the current benchmark values for the SEMCs taken as a whole, giving an indication of the deficiencies compared with each of the benchmarks and each scenario.

Table 3. Transport infrastructure – Benchmark values

	Scenario 1	**Scenario 2**	**Scenario 3**				
	All countries	**EU-27**	**Low income**	**Lower middle income**	**Upper middle income**	**High income**	**SEMCs**
Per unit of land area (1,000 km^2)							
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
Per unit of population (million)							
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
Per unit of GDP (US$ million)							
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
Normalised value							
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 numbers.

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

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 utilises best practice design and/or operating efficiency standards appropriate to the specific scenario.

Port berths

Port berths are conventionally classified as being for general, containerised, 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 TEU,[3] the efficient capacity of a standard berth of 300 metres in 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 SEMCs, and even less data on the proportion of this capacity that is taken up by transhipment 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 is in turn is based on the total share of trade that is for imports and exports, the share of that trade attributable to land transport, roll-on/roll-off (ro-ro) shipping (which does not use containers) and bulk solid and bulk liquid freight (which also 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 among the scenarios, the estimates of the share of trade between imports and exports, and the share of ro-ro and land transport all entail minor differences for some of the scenarios.

Although scenario 4 has a lower demand for container movements than the other scenarios, its lower efficiency in the use of its container terminals is more than enough to offset this apparent advantage in the number of additional berths needed. 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 Polarised Development one. The Polarised Development scenario needs more berths because of the higher share of intra-Arab country trade, which also requires 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 SEMCs (taking account of projections of GDP and foreign direct investment (FDI) 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 this demand into that for airport passenger terminals. A commonly used design parameter for airports is the terminal space for each peak-period

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

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 among the 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 m^2 is slightly lower than the global standards to take account of the slightly lower infrastructure quality tolerated by non-business passengers to the SEMCs.

2.4 Summary of additional transport infrastructure for each scenario

The quantities of all types of additional infrastructure are summarised in Table 4. These are the infrastructure needs that are taken forward into section 3 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 Polarised Development scenario is the most demanding.

Table 4. Summary of additions to transport infrastructure for each scenario

Type of infrastructure	Units	Reference scenario	Common Development	Polarised 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: Author's estimates based on Table 3.

3. Transport infrastructure investment – Costs and affordability

In this section 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 minimises total investment costs, upgrades their category to provide sufficient capacity, minimises operating costs, expands the networks, and maintains 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.

3.1 Quantities of transport infrastructure

At the end of section 2, 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 section of the report to estimate the investment needs. In Table 5 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.

Table 5. Total transport infrastructure for each scenario

Type of Infrastructure	Units	Reference scenario	Common Development	Polarised 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.

3.2 Types of transport infrastructure investment

For each of the scenarios we estimated four different types of infrastructure costs, as discussed below.

i) Improving the condition of infrastructure

First are the costs of *improving the condition* of the current transport infrastructure, so as to minimise 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 the current infrastructure in each country, in terms of being in good, fair or 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 categorise 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-sized cities that 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.

We made our own specifications of the desirable categories of infrastructure that are appropriate for each mode and market, based on international standards of best practice. 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 a good level 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 in 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 (IRI) 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 of subjective assessments are considered to be comparable with 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 as being in excellent condition, whereas one where a 20% speed restriction on the design speed (whether that design speed were 150 km/hr or 60 km/hr) would be assessed as being in good condition, a higher speed restriction would relegate the conditions to fair or regular and an axle load restriction would relegate the condition to poor or very poor. So far as we are aware, there are no formal objective categorisations 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 section 2 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 forms. The poor condition of transport infrastructure in the SEMCs 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 realisation 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 investment needs for transport infrastructure made some attempt to include maintenance costs. The most common method is to add a fixed amount (often 3%) of the replacement cost of the infrastructure. Yet, 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 realised 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 minimise 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 the 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 to those that might actually be incurred. A second source is the World Bank ROCKS (Road Costs Knowledge System) database.[4] This only includes costs for road projects, but the data are 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 improvements to transport infrastructure

Three other sources of data derive from the World Bank's Africa Infrastructure Country Diagnostic (AICD). First is Background Paper 11 (AICD, 2008), *Unit Costs of Infrastructure Projects in Sub-Saharan Africa*. This provides a range of unit costs for some rather general activities, including the 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 AICD (2008) 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. AICD Background Paper 14 by Gwilliam et al. (2008), *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

[4] The database is at http://www.worldbank.org/transport/roads/rd_tools/rocks_main.htm.

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 6 through 9 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.

Table 6. Unit costs of improvements to 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
1,500 m runway	150,000	750,000	3,000,000
3,000 m 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 11 SEMCs is the EuroMed studies. Unfortunately, these data relate 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 the data of Carruthers et al. (2008) using those 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% of all paved roads should be four-lane divided highways, 20% should be four-lane highways but without limited access, 60% should be two-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, six-lane or more divided highways in urban areas) but without undertaking specific demand analyses we cannot assess the needs for this additional investment.

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 7 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.

Table 7. Unit costs of upgrading 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
1,524 m paved runway to 3,000 m runway	US$ per runway	12,000,000
1,000 m paved runway to 1,524 m runway	US$ per runway	4,800,000

Source: Author's estimates.

Unit costs of new infrastructure

The future lengths or quantities of transport infrastructure were based on the benchmarking method described in section 2. The unit costs of new construction shown in Table 8 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 8. 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 signalling	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 estimates.

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 percentage 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 20-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-sleepering 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 – the current infrastructure that will have been improved and upgraded as well as the new.

Table 9. Unit costs of periodic maintenance

Periodic activity	Unit	Total cost in US$	Periodicity	Annual cost in US$
Resurfacing a 4-lane road	US$/km	1,000,000	8	125,000
Resurfacing a 2-lane road	US$/km	50,000	8	6,250
Reballasting a railway	US$/track km	15,000	5	3,000
Resurfacing a runway	US$/runway	5,000,000	10	500,000
Rehabilitating a container berth	US$/berth	10,000,000	10	1,000,000
Refurbishing an air passenger terminal	US$/$m^2$	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 expenditure and the shares of total investments by country. The second part reviews the investment by country and mode of investment. Both parts cover all four scenarios. The subsequent section addresses the affordability of these investments.

Total investment costs and types of investment

In Table 10 we compare the total investment costs by type of expenditure for each scenario. Total investment in the Reference scenario is almost $675 billion over the 20-year analysis period, with an average of nearly $34 billion per year. The Failed Development scenario not surprisingly has the lowest total investment, just over $500 billion over the 20 years, or just over $26 billion per year, about three-quarters of that in the Reference scenario. In section 2, we saw that the investment demands of the Common Development scenario would be very high and this is confirmed in Table 10, which shows that even with the reduced objective (reducing the difference between the current and EU-27 benchmark values by one-third) more than $1,200 billion would be needed for the 11 SEMCs to achieve the benchmark standards. Spread over a period of 20 years this would require an annual investment of more than $60 billion, about double that of the Reference scenario. The Polarised Development scenario would require a total of more than $900 million, equivalent to $45 billion per year, about one-third more than for the Reference scenario.

Table 10. 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
Polarised 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
Polarised 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
Polarised Development	40	7	15	38	100
Failed Development	47	11	13	29	100

Source: Author's estimates.

In all the scenarios the maintenance share is high, more than 45% of the total in the Reference and Failed Development scenarios, about 40% in the Polarised Development scenario and more than 30% in 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 Development and Reference scenarios need only 29% of their investment in new facilities. The Failed Development scenario compensates by having high investment shares in upgrading (11%) the existing infrastructure.

Investments by country

When the investments by country are considered, scenario 2 (Common Development) is significantly different from the other three. In scenario 2 there is little variation in the shares of investment allocated to expansion, the lowest share being 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 expenditures also show little variation.

In the Reference and Polarised Development scenarios, 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. Palestine is currently planning to build a rail network, however, 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 among the scenarios: Egypt has a higher share in scenarios 1, 3 and 4 and Algeria has a slightly higher share in scenario 2. Palestine consistently has the lowest share, ranging between only one-third and one-half of 1% of the total. Libya has the widest range in its investment share, from a low of just over 5% in the Reference scenario to more than 12% in the Polarised Development scenario (Table 11).

Table 11. Country shares of total investment (%)

	Reference scenario	Common Development	Polarised 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
11 SEMCs	100.0	100.0	100.0	100.0

Source: Author's estimates.

In the Common Development scenario, the total investment of more than $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, with 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 Polarised Development scenario gives Egypt and Libya their largest shares 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 such large differences compared with the other scenarios. Part of the reason for the larger shares of these countries in the Polarised scenario is their role as transit countries in higher trade among the SEMCs rather than with the EU-27.

Despite having the lowest total investment, the shares of that total among 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 1%.

Investment by mode

There are two ways of looking at mode shares. The first is to see the total investment in each mode, and this is shown in the first part of Table 12 for the four scenarios. The second way is based on the share of investment in each mode, and this is shown in the second part of Table 12. Although there are significant differences in the total investments in each mode, the shares of investment going to each mode are remarkably similar among scenarios, with there being a 3% or difference in modal shares.

Table 12. Total investment by mode and mode shares for the SEMCs for each scenario

Scenario	Roads	Railways	Airports	Ports	Total
	Total investment (US$ m)				
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
Polarised Development	826,171	37,146	25,440	13,759	902,515
Failed Development	600,018	37,111	24,585	11,859	510,343
	Share of investment (% of total)				
Reference	89	6	4	2	100
Common Development	90	6	3	1	100
Polarised 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 share of investment in all scenarios, with the lowest share being 89% in the Reference and Failed Development scenarios and the highest being in the Polarised 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 $37 billion in the Reference, Polarised and Failed Development scenarios and more than $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, which is a very high investment in the Common Development scenario (more than $37 billion for runways and terminals taken together) and lower but similar investment levels in the other scenarios (about $25 billion).

Port berths

The investment needed in port berths (expansion alone for container berths but also improvement, upgrading and maintenance for general freight berths) is similar in all four scenarios at about $12 billion, although the Polarised Development scenario has about $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 the SEMCs for EU-27 trade and this will detract from the container share. This scenario additionally has the highest efficiency in the use of container berths, also contributing to a lower need for investment.

Modal investments by country

The only three modes that display significant differences in the scenarios in terms of the share of modal investments among 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 Polarised Development scenario, where the shares would fall to about 21% and 26% respectively.

For paved roads, Algeria's share would be about 17% except in the Polarised 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 among the scenarios, with 6% in the Reference scenario, rising to 10% in the Common Development scenario and to 14% in Polarised 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 Polarised 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, at about 20% each. Algeria's share would increase to over 30% in the Polarised Development scenario. Syria and Tunisia would each require about 6% to 7% in all the scenarios, with the other countries sharing the remainder at 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 in any transport infrastructure. The port share is small as it is only container berths. We have not had the opportunity to analyse all the data for bulk solid and bulk liquid berths, but most of the 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 13.

While being an important 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. 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.

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 in the Polarised Development scenario, while none of the countries would need it in 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 Polarised Development scenario.

Table 13. Transport investment as a share of GDP (%)

	Reference	Common	Polarised	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
11 SEMCs	1.2	2.4	1.6	0.9

Source: Author's estimates.

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.

The latest of these reports (ITF, 2011) shows that Western European countries 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 last decade. By 2009, Denmark had the lowest share at about 0.5% and Spain the highest at about 1.1%.

Interpolating the available data for the last decade, 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 22 more countries between 0.5% and 1% of GDP. The average of these 41 countries was 1.0% of GDP. The only SEMC 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 do distinguish between new investment and maintenance, within new investment they do not distinguish between investment in new facilities (in our terminology network expansion), improving condition and upgrading categories. Even for maintenance, its data are 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 11 SEMCs 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 normalised infrastructure densities for the SEMCs 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 share of rail 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 SEMCs are comparable with those of the lower middle-income countries of Sub-Sahara Africa (SSA) (Carruthers et al., 2008). This World Bank (AICD) study on transport infrastructure produced broadly similar results for the 44 countries included in its study as our analysis of the 11 SEMCs. Table 14 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 SEMCs are low income or economically and socially fragile as defined in the AICD study.

Table 14. Projected investment in transport infrastructure 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 base scenario, the average shares 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, the 11 SEMCs and SSA countries are still at the stage of development and so need investment particularly in upgrading and expansion.

For the 11 SEMCs, 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 4 in section 2.

Routine and periodic maintenance expenditure would account for the largest share by type of activity, at 40% to 50%; 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 the 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 (ITF, 2011).

The volume of maintenance for road infrastructure in Western European countries 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 resulted in an increased share of maintenance in total road expenditure, from 26% in 1997 to 30% in 2009.

Similar to growth in the volume of investment, the volume of maintenance has grown strongly in Central and East European countries. The share of maintenance in total road expenditure declined slightly, from 30% in 1997 to 27% in 2009. The increase in maintenance volumes in 2006 and 2007 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 declined from 33% in 1997 to 31% in 2009, according to preliminary estimates. As with investment data, data on maintenance are 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 11 SEMCs to achieve their benchmark quantities, and maintaining that infrastructure in a condition that is most likely to optimise the combination of infrastructure maintenance and vehicles (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 percentage of GDP have been found to be comparable with other developing countries that have reported investing or are expected to invest. The shares of GDP foreseen for transport investment in the SEMCs are higher than in the EU-27 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 section 4 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.

$$\text{GDP} = \text{Consumption goods and services (C)} + \text{Gross Investments (I)} + \text{Government Purchases (G)} + (\text{Exports (X)} - \text{Imports (M)}) \quad (1)$$

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 through any net increase in international trade (X – M). We deal first with the impact on the value of domestic goods and services and on 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 from the impact on exports and imports.

In respect of the impact on trade, if this increase is skewed in favour 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.

Section 4 of this report has three subsections. In the first we summarise previous studies of the impact of investment in transport infrastructure on economic growth; in the second we summarise 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 still 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 of estimating the parameters of an infrastructure-augmented production function.

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

$$Y_{it} = A_i K_{it}^{\alpha} H_{it}^{\beta} X_{it}^{\gamma} \, V_{it}, \qquad (2)$$

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:

$$y_{it} = a_i + \alpha k_{it} + \beta h_{it} + \gamma x_{it} + v_{it} \qquad (3)$$

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 the equation, since infrastructure capital appears twice, once on 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. Yet 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 of 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 on paved roads, and that this implied "little support for a policy of purely infrastructure led growth". But 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 and 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 with other investments. The authors only provide paved road 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 40-year 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 section 2 of this report. For transport infrastructure, the measures were length in kms per unit of total land area. In section 2, 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 percentage of all roads that are paved. The measure of unpaved roads in the database used by Calderon and Serven (2004) is inconsistent among 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 of 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 percentage 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 SEMCs. 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 0.6 km per km^2), if it were to reach the density of Korea (with 3 km per km^2) 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 231,000 km to 1,150,500 km) at a cost of about $0.5m per 1 km, giving an investment cost of about $462 billion. With a 2010 estimated GDP of $596 billion and a growth rate of 7%, the 1.4% additional growth rate would require ten years to generate the $462 billion equivalent to the investment cost. But the investment of $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 EU-27 countries (Common Development scenario) and the average density of the per-capita income group (Polarised 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. Conversely, 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 at the 'network development' stage) might have a higher economic justification than the additional investment indicated in the Polarised 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-Douglass production function to that of Calderon and Serven (2004), and this required the use of transport infrastructure per worker instead of per km^2. 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-stage model.

The first stage is that before the development of comprehensive transport networks. After the first threshold there is the second stage, where a basic network is already in place, and the effort of further investment is to enhance and complete that network. Beyond the second threshold where the network is complete is the third stage. At this stage, further investment is needed to avoid capacity constraints as demand increases and to accommodate new demands that emerge in locations different from those envisaged when the network was planned and created. At 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 SEMCs have underdeveloped road and/or rail networks (and so are at the first stage, below the first threshold), more are in the process of completing their already basic networks (and so are at 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 SEMCs 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 15 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).

Table 15. 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.

The most appropriate of Hurlin's threshold effects models for our purposes is one that used physical capital per worker, human capital per worker 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.

For paved roads, there is a substantial impact on economic growth from investment even before the network is developed ($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 at the third stage and remains close to the pre-network level at the final stage. For railways, the economic growth impacts are 2% greater than for paved roads at the first stage, but fall rather more quickly at the second stage to about 97% of the road investment productivity. There is a recovery at the third stage but not as much as for road investments. A further 15% increase at 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. But 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 benchmark value of km per employee for the SEMCs, most of them are found to be currently at the first or second stage of development. Only Libya and Palestine (for paved roads) reach the third stage of network development (Table 16).

Table 16. 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 the SEMCs

While recognising 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 for the transport sector in some SEMCs that could be used as support for the forward causality perspective from the international financial institutions. The African Development Bank has recently (2011) provided €300 million for the expansion and electrification of Moroccan railways and the World Bank is negotiating with the government of Jordan to support the creation of a basic $3 billion railway network that will link Saudi Arabia, Syria and Iraq. In recent years, the European Investment Bank (EIB) has supported the funding of many other transport infrastructure and trade facilitation projects in the SEMCs, 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 country's 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 SEMCs and promises to continue to do so, so long as the social and political conditions continue to be favourable.

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. Still, 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, 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 gravity model elasticity derived for this parameter.

Other models have used proxies for port costs and logistics. Wilson et al. (2003) developed a gravity model of trade in manufactured products of the ASEAN (Association of Southeast Asia Nations) 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 ASEAN and the Asia-Pacific Economic Cooperation forum). Apart from these additional parameters, their model followed the standard formulation of an international gravity model.

The authors used a similar approach to our benchmarking method, estimating the increases in international trade if countries performing below average improved their port efficiency and customs

performance 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 country's export performance would impact on the imports of all its trading partners, and similarly an improvement in 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 the following:

$$\ln X_{jk} = \alpha_0 + \alpha_1 \ln SUMGDP_j + \alpha_2 \ln TAR_{jk} + \alpha_3 NTMs_{ijk} + \alpha_4 \ln TRANSCOST_j + \alpha_5 \ln LANG_j + \alpha_6 \ln COL_j + \phi_j + \varphi_k + \varepsilon_{ijt} \quad (4)$$

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 j 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 the value 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 the 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. Yet, 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. In the final version of the model, however, 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 a weighted average index of seven measures of logistics performance, including efficiency of the clearance process by customs and other border agencies, the quality of transport and information technology infrastructure for logistics, the ease of arranging international shipments, the competence of the local logistics industry, the ability to trace and check international shipments, and domestic logistics costs as well as the timeliness of shipments in reaching their 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 section 3 of this report, to derive estimates of the direct impact of those investments on the GDP of each of the SEMCs for each of the four scenarios. Furthermore, we have used the elasticities derived from Ghoneim et al. (2011), together with the same additions to the transport infrastructure stock, to produce estimates of the impact of those changes on the imports and exports of each of the SEMCs. 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 investments in these sectors by using the average elasticities of those for roads and railways.

i) Estimates of the economic growth impacts of infrastructure investment

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 employment numbers of the base year 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 or airports (runways and terminals). While an omission, we do not think it serious and the major impacts on GDP growth 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 (Table 17). The GDP data do not distinguish among their 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 subsection.

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

Table 17. Road and rail investment impacts on annual GDP growth

Country	Reference scenario	Common Development scenario	Polarised Development scenario	Failed Development scenario
	Increase in GDP annual growth rate (%)			
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
11 SEMCs	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 coming from the Failed Development scenario (with an impact on GDP of only 0.3% per year). 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 Polarised 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 11 SEMCs of more then 8.5, while the smallest ratio is for the Failed Development scenario at less than 3.5. For the Reference and Polarised scenarios the ratio is about 6.0.

ii) Estimates of the 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 SEMCs 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 SEMCs not included. We have estimated the 2010 Morocco LPI value by attributing to Morocco the average increase of the 11 SEMCs from 2008 to 2010. Since Palestine was not included in the 2007 LPI and its characteristics are so different from the other SEMCs, 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 SEMCs.

Table 18. LPI 2010 and its component values

Country	LPI	Customs	Infrastructure	International shipments	Logistics competence	Tracking and tracing	Timeliness
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
MED-9	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/EXTTLF/0,,contentMDK:21514122~menuPK:3875957~pagePK:210058~piPK:210062~theSitePK:515434,00.html).

We have estimated the impact on LPI of investment in infrastructure 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 six types of transport infrastructure (paved roads, unpaved roads, railways, runways, passenger terminals and container berths) would be assessed as having 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%
- Polarised Development scenario +22%
- Failed Development scenario +13%.

The resulting percentage changes in the total LPI for each scenario are shown in Table 19. The differences in the percentage changes in the total LPI among 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 19. Changes in LPI attributable to transport infrastructure investment (%)

Country	**Percentage + Increase in total LPI**			
	Reference scenario	**Common Development scenario**	**Polarised Development scenario**	**Failed Development scenario**
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
11 SEMC average	11	25	15	8

Source: Author's estimates.

By applying the elasticities of Ghoneim et al. (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 20. 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 Polarised Development scenarios are substantial.

Table 20. Increase in trade balance (exports–imports) (as % of GDP)

Country	2008 Non-oil trade balance	Reference scenario	Common Development scenario	Polarised 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.

Egypt stands to gain the most across all scenarios, with a mean of almost double the average of the 11 SEMCs (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 countries that have higher than average improvements in their average trade balance.

Table 20 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 positive of 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 11 SEMCs and the scenario average than for imports. Jordan, Algeria and Tunisia are next in gains in exports, while Libya and Lebanon have the least to gain.

4.4 Conclusions

Investment in transport infrastructure will increase the annual average rate of economic growth of the SEMCs 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 is, 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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http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/0,,contentMDK:21525984~isCURL:Y~pagePK:210058~piPK:210062~theSitePK:282823,00.html

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About MEDPRO

MEDPRO – Mediterranean Prospects – is a consortium of 17 highly reputed institutions from throughout the Mediterranean funded under the EU's 7th Framework Programme and coordinated by the Centre for European Policy Studies based in Brussels. At its core, MEDPRO explores the key challenges facing the countries in the Southern Mediterranean region in the coming decades. Towards this end, MEDPRO will undertake a prospective analysis, building on scenarios for regional integration and cooperation with the EU up to 2030 and on various impact assessments. A multi-disciplinary approach is taken to the research, which is organised into seven fields of study: geopolitics and governance; demography, health and ageing; management of environment and natural resources; energy and climate change mitigation; economic integration, trade, investment and sectoral analyses; financial services and capital markets; human capital, social protection, inequality and migration. By carrying out this work, MEDPRO aims to deliver a sound scientific underpinning for future policy decisions at both domestic and EU levels.

Title	MEDPRO – Prospective Analysis for the Mediterranean Region
Description	MEDPRO explores the challenges facing the countries in the South Mediterranean region in the coming decades. The project will undertake a comprehensive foresight analysis to provide a sound scientific underpinning for future policy decisions at both domestic and EU levels.
Mediterranean countries covered	Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia and Turkey
Coordinator	Dr. Rym Ayadi, Centre for European Policy Studies (CEPS), rym.ayadi@ceps.eu
Consortium	Centre for European Policy Studies, **CEPS**, Belgium; Center for Social and Economic Research, **CASE**, Poland; Cyprus Center for European and International Affairs, **CCEIA**, Cyprus; Fondazione Eni Enrico Mattei, **FEEM**, Italy; Forum Euro-Méditerranéen des Instituts de Sciences Economiques, **FEMISE**, France; Faculty of Economics and Political Sciences, **FEPS**, Egypt; Istituto Affari Internazionali, **IAI**, Italy; Institute of Communication and Computer Systems, **ICCS/NTUA**, Greece; Institut Europeu de la Mediterrania, **IEMed**, Spain; Institut Marocain des Relations Internationales, **IMRI**, Morocco; Istituto di Studi per l'Integrazione dei Sistemi, **ISIS**, Italy; Institut Tunisien de la Compétitivité et des Etudes Quantitatives, **ITCEQ**, Tunisia; Mediterranean Agronomic Institute of Bari, **MAIB**, Italy; Palestine Economic Policy Research Institute, **MAS**, Palestine; Netherlands Interdisciplinary Demographic Institute, **NIDI**, Netherlands; Universidad Politecnica de Madrid, **UPM**, Spain; Centre for European Economic Research, **ZEW**, Germany
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EC Scientific Officer	Dr. Domenico Rossetti Di Valdalbero, DG RESEARCH
Website	www.medpro-foresight.eu
Contact e-mail	medpro@ceps.eu