Chapter 12

Aid for Trade and Infrastructure Development for Agriculture

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12.1 Introduction

Agriculture constitutes an important part of most low-income countries' economies, and is generally the primary source of income in rural areas, directly through crop production, and indirectly through on-farm and off-farm employment in agriculture-related industries (Haggblade et al. 1989; Reardon et al. 1998).

The issue of the importance of improving rural infrastructure, and in particular rural roads, is not new in the development community. It is a topic that has long been at the centre of development policy and research; development theorists commonly used to assume that remote areas' disadvantageous position vis-à-vis economic opportunity and social welfare could be remedied with road building (Bryceson et al. 2008).

Investments in rural infrastructure were considered to have important positive effects on agricultural production and trade, and governments and donors invested heavily in the development of rural roads and transport corridors. Yet – perhaps because the importance of such infrastructure for development seemed so obvious – there has for some time been little formal evidence on how and under what conditions roads benefited rural households and agricultural development. By the end of the twentieth century various studies nonetheless showed that the causality between road building and rural development should be more nuanced. The World Bank 1994 *World Development Report* on infrastructure for development highlighted that focusing solely on increasing the quantity of installations was not adequate: more should be done on the quality and efficiency of related services.

Over time an increasing amount of analysis looking at the impact of road construction argued that the simple construction of paved roads did not prove to be enough to foster poverty alleviation in many instances, and that road provision is only part of a wider issue of high transaction costs, market access and inclusion. For instance, in an analysis of the impact of rural roads in Nepal, Jacoby (2000) provides evidence of the effective distributional effect of rural roads, as farmers in remote areas are typically poorer than those in less isolated areas. Although he highlights that, in general, decision makers did not sufficiently target the construction of rural roads in a way that would have supported a reduction in population spatial inequality, he also acknowledges that 'rural road construction is certainly not the magic bullet for poverty alleviation' (Jacoby 2000: 735).

At the beginning of the twenty-first century, the Millennium Development Goals (MDGs) gave more importance to social development projects. The issue of infrastructure development resurfaced in the development agenda and poverty debate with the Aid for Trade (AfT) initiative, but against a different background. The question of developing countries' access to developed markets for agricultural and food products focused for a long time on efforts to reduce traditional barriers to trade, including tariffs and quantitative restrictions. In the debate over trade liberalisation and development, part of the discussion of developing countries' agricultural exports to developed countries' markets switched from tariff issues to the building of effective export capacities, as participants recognised the importance of supply-side constraints for some countries, which prevented them from take advantage of trade liberalisation. For these, the main question was therefore how to relieve those constraints and to provide developing countries' producers with more opportunities to connect with the regional and international market. As Hoekman and Njinkeu (2010: 1) say: 'Market access – which assumes center stage in bilateral and multilateral trade relations and negotiations – is a necessary but insufficient condition for harnessing trade for development. To exploit access to export markets, firms and traders must be able to offer a competitive product.' Trade-related infrastructure is one of the four AfT categories of support – as defined by the Organisation for Economic Co-operation and Development (OECD) and the World Trade Organization (WTO) – along with technical assistance for trade policy and regulations, productive capacity building (including trade development) and trade-related adjustment.

According to new international trade theories based on the assumption of firm heterogeneity, a country's capacity to engage in trade relies on various elements, including, as usual, fixed and variable costs to trade, but also firms' productivity. Accordingly, all other things being equal, only the more productive firms, meaning firms producing at the lower variable costs, can export. However, variations of those models also highlight the importance of quality to the capacity to export specific goods, even if quality means higher costs of production and prices. Although international trade models adopting a quality definition of competitiveness were long considered relevant only for manufactured goods, evidence shows that quality also matters for the capacity to export agricultural products (Jouanjean 2012a).

Since the emergence of the AfT agenda, and along with the changes in the patterns of trade and the further fragmentation of global production, the understanding of the potential scope of AfT has evolved, with the latest debates suggesting a move towards the specific question of developing-country producers' inclusion in global value chains with the final objective of increasing the 'value for trade'.[1]

The AfT agenda stimulated the production of new analyses of the effect of rural infrastructure, taking a more systemic approach that emphasises the indispensable complementarity of soft infrastructure.

As highlighted by Ulimwengu et al. (2009), achieving agricultural growth requires both investments *for* agriculture, which includes investments in rural roads, and investments *in* agriculture, such as research and development, extension services,

irrigation projects and input distribution policies. Hard infrastructure – roads, energy and communication infrastructure – facilitates spatial integration of product and factor markets, in both the agricultural and non-agricultural sectors. By lowering the transactions costs of market exchange they can boost net returns to agricultural production. Better market connections increase the availability of inputs (improved seeds, fertilisers and pesticides) and agricultural extension services, all of which are likely to increase agricultural productivity and, consequently, welfare. The increase in physical and informational connections reduces transaction costs caused by information asymmetry at all stages of production from the supply of inputs to the negotiation of prices.

Various studies (among others, Hettige 2006; Cadot et al. 2010; Porto et al. 2011) also highlighted the importance of tackling governance and policy issues in order to reduce transaction costs. These are often inflated by monopoly and cartels in transport services (for examples in Madagascar and West Africa, see USAID 2011; World Bank 2012) and irregular payments at roadblocks. To highlight the underlying difference in approach from previous analyses, some of the literature refers to the issue of high transport prices, rather than transport costs, in order to differentiate the impact of market structure from the underlying 'physical' cost incurred by operators on the final price of transporting goods. In general, analysis of rural economic infrastructure, and in particular roads, is now focusing more on the systemic inefficiencies arising from transport infrastructure and services (USAID 2011; Raballand and Macchi 2008), and therefore on the key intermediate logistical infrastructures.

The provision of soft infrastructure is key to the reduction of costs but also to the provision of high-quality products. The lack of competition in transport-related services results not only in high transport costs but also in poor services (Porto *et al.* 2011). Access to information on production technologies, quality, and sanitary and phytosanitary (SPS) requirements and to inspection infrastructures is crucial for sustainable productivity increase, but also for inclusion in sophisticated domestic or global value chains. For instance, getting access to the horticultural global value chain requires access to knowledge about good agricultural practices, standards and SPS regulations, knowledge of post-harvest management practices, and infrastructure such as cold storage facilities.

This chapter is an analytical overview of recent literature that provides evidence on the effect of investment in rural infrastructure on market access, trade and, in particular, agricultural trade, and on conditions and complementarities pertaining to maximising the benefit to agricultural development and poverty reduction. It gathers evidence suggesting that investments in hard infrastructure (roads, communication and energy supply) are necessary but are not sufficient for successful market integration. Investments in rural infrastructure should be addressed in terms of a more holistic approach, and should consider complementarities between hard and soft – otherwise called logistic – kinds of infrastructure (in this overview: transport-, extension- and standards-related services), rather than addressing topics in silos. This overview is organised in two main sections. The first addresses the issue of the supply of hard

infrastructure, and in particular roads, and its importance for market integration, development and trade in agriculture from both a macro and a micro perspective. The second part looks at soft infrastructure, here defined as key value chain logistical infrastructures, and looks more specifically at transport, extension and standards-related services.

12.2 Hard infrastructure: on the importance of roads for development and trade in agriculture

12.2.1 Impact of infrastructure on trade: evidence at the regional and international scales

If the role of infrastructure for trade development has been extensively discussed in policy-oriented descriptive analysis, it has been addressed much less in the evidence-based formal literature. Studies on the impact of infrastructure have focused on the effect at the micro level, looking at the impact on income, whether from on- or off-farm new income opportunities. However, some more recent studies have tried to highlight the impact of infrastructure development at a more aggregated level, looking at the impact on regional and international trade of goods, or sometimes more specifically on trade in agriculture products. One impediment to such quantitative analysis is the interactive nature of various types of infrastructure (Bouët et al. 2008). Moreover, no theoretical model provides the basis for this type of interaction between infrastructure and trade. Therefore, when pursuing quantitative analysis, care should be taken to identify the real effect of infrastructure on trade.

Nevertheless, Limão and Venables (1999) find that a drop of 10 per cent in transport costs for landlocked African countries would increase the volume of international trade by as much as 25 per cent. To circumvent the interactive nature of infrastructure, Bouët et al. (2008) use a semi-parametric variant of a gravity equation, the workhorse model of international trade, allowing for unknown, non-linear impacts of infrastructure on trade, and complementarity among several types of infrastructure. They show that poor transport and communication infrastructure accounts for most of Africa's under-trading. Moreover, investments in infrastructure are likely to have a much greater impact if transport and communication infrastructure development are taken jointly. Moïsé et al. (2013) also use a gravity model approach to look at the constraints to trade in agriculture. Their analysis gives further evidence of the importance of quality of transport and trade-related infrastructure for developing countries' exports of agricultural products.

In a study on regional agricultural transport and trade policy, USAID (2011) studies transport costs of cereals in Western Africa. Making use of cereal isoprice maps, it provides evidence of steep price gradients along trade corridors in ECOWAS, indicating the weak linkages between key surplus and deficit markets in the region. According to its analysis, the causes of such weak linkages are constraints to efficient transport along the corridors. More specifically, the analysis shows that the transport and logistical costs of movement of both maize and livestock along key trading corridors between Burkina Faso, Ghana and Benin account for

approximately 59 per cent and 18 per cent of the respective end market prices. Of these, transport costs – that is fees paid to transport-service operators as well as losses in transit – were found to weigh most heavily on the end market price along the corridors studied.

These recent trade analyses use econometric analysis and new indicators to confirm the importance of improving infrastructure as a step to trade integration. However, they also show that the link between trade development and infrastructure goes beyond the provision of roads.

12.2.2 Bring the market to the poor or the poor to the market? Impact of roads on local market development

A supply perspective: the effect of investment in hard infrastructure on market development

Whereas most of the literature looks at the incidence of infrastructure development on the reduction of travel costs to existing markets and institutions, some analyses introduce the possibility that better transport infrastructure could also improve access to markets through inducing relocation of markets and institutions.

According to Hettige (2006), evaluating a rural road investment in Yogyakarta, Indonesia, improved roads and the increased ability to transport goods provided opportunities for those with skills and/or savings to invest in small businesses and small stores in the village, or sometimes to become intermediaries, selling the village's products to nearby market centres. Among project respondents, 64 per cent observed that the number of small businesses in the community had increased since the road was built or rehabilitated. Of the 17 per cent of project respondents who had started a business since road rehabilitation, 69 per cent declared that the road was a factor in their decision to start a business. Furthermore, 54 per cent of households declared that more buyers visited the community than five years before the project, compared with 36 per cent of the control households.

It has usually been the case that, on the ground that rates of returns would be higher there, infrastructure project designers have targeted regions that are already well endowed and have the market institutions necessary to foster further economic development. Mu and van de Walle (2009) ask if, on the contrary, development institutions should focus their resources on areas without such attributes. Referring to the economic geography literature and to literature analysing social development and institutional arrangements in missing market environments (for instance Fafchamps and Minten 1999), they underline the theoretical ambiguity of the impact of better roads on local markets. Indeed, the literature reports a multiplicity of initial conditions that could either encourage the development of local markets or reinforce the importance of established markets. Mu and van de Walle provide evidence from Vietnam and show that, on average, rural road rehabilitations have an impact on the development of local markets through the development of off-farm, mostly service-related, activities. Furthermore, because those areas present more scope for road improvements to help develop markets, market-related institutions and services, their

analysis provides evidence of a larger impact on the poorer communes of their sample. However, other attributes of poor areas – such as poor agro-climactic endowments, a high share of ethnic minorities, high illiteracy rates and less well-functioning credit and other markets – which usually correlate with a higher level of isolation as well as lower population density, tend to work in opposite directions and will clearly mediate impacts of road improvements across communities. Therefore, their analyses do not completely depart from previously mentioned assumptions about the importance of local and human capital on the impact of road improvement. However, at least in the regions of Vietnam which they examined, the high potential return because of the low initial market development was strong enough to outweigh the effect of such attributes.

A demand perspective: transport and transaction costs and the impact of infrastructure on smallholders' market participation decisions

If previously mentioned studies analyse the supply perspective of infrastructure by looking at their impact on market creation, Cadot et al. (2010) and Azam et al. (2012) analyse the demand side by looking at the determinants and causal factors behind farmers' decision to participate in the market instead of adopting a subsistence strategy. The transition from low-productivity, semi-subsistence agriculture to high-productivity, commercialised agriculture has been a core theme of development and agricultural economics for more than two centuries. A large volume of literature looking at farm households emphasises the importance of transaction costs and the institutional environment in households' decisions to participate to markets (for example Key et al. 2000; Vakis et al. 2003; Kydd and Dorward 2004; Poulton et al. 2006; Barrett 2008).

There is evidence that some households in developing countries have seized on emerging opportunities for more remunerative, market-oriented production, often coupled with technological progress and improvements in institutional and physical infrastructure (Kherallah et al 2000; Minten et al. 2007). However, Barrett (1998) and Reardon et al. (1999) show that, in some places, there has been persistence of, and even some level of retreat into, subsistence agriculture, suggesting that there can be multiple equilibria. Such multiple market participation equilibria commonly arise as a result of the fixed costs of investment combined with missing markets and co-ordination failures that hamper households. Barrett and Swallow (2006) find that households with access to adequate assets and infrastructure, and faced with appropriate incentives, engage actively in markets, whereas households that lack one or more of those three essential ingredients – assets, infrastructure and incentives – do not.

Broadly, this literature looking at farmers' decisions to participate in the market finds that differences in transaction costs, as well as differential access to assets and services to mitigate these transaction costs, are possible factors underlying heterogeneous market participation among smallholders. Key et al. (2000) differentiate fixed and variable transaction costs. Fixed transaction costs relate to the cost of searching and screening for the best business partner and the cost of negotiating and implementing a contract,

as well as its follow-up and execution. The agent bears these costs in order to reduce the risk of transaction failure. Such costs are particularly high in situations of asymmetric information. According to the Peruvian survey used by Vakis et al. (2003), costs related to searching, matching and bargaining are important variables in a farmer's decision to participate in the market. The World Development Report (World Bank 2008: ch. 5) mentions a number of initiatives to improve the spread of agricultural information by means of radios, mobile phones and other media. Evidence shows that investment in mobile phones has had an important impact on the reduction of such fixed transaction costs, and therefore in reducing the barriers preventing farmers from taking up market opportunities. Better access to roads, if it gives access to markets, reduces information asymmetry about input quality and prices as well as output prices. Such costs are not directly related to the volume traded, and therefore represent a larger constraint to small producers. Variable transaction costs, which the provision of roads should reduce, represent the unit cost of transferring the product to or from the market.

12.2.3 Which types of infrastructure for which impacts: market access, agricultural productivity and poverty reduction

In addition to reducing the cost of acquiring inputs, better access to markets reduces the impact of shocks and provides new opportunities for more profitable on- or off-farm activities. Many theoretical and empirical papers in the development literature have addressed the issue of transportation and transaction costs, in particular the link between market access and poverty, and more generally the impact of roads and infrastructure on development dynamics (among others, Platteau 1996; Fan and Hazell 2001; Fan 2008). Some have demonstrated that roads encourage agricultural development; for example Van de Walle (2002) and Ulimwengu et al. (2009).

Various studies from the end of the twentieth century and the beginning of the twenty-first argued that, despite a consensus on the importance of rural roads for development (Gannon and Liu 1997), there was very little evaluation of the extent of this impact. Indeed, the limitation relative to the evaluation of impacts at the micro level is the same as at a more aggregate level. Difficulties inherent in estimating the magnitude of the effects are attributable to infrastructure because much infrastructural development is endogenous. Road investments are often targeted, making it difficult to isolate causal impacts from placement effects. Also, it is often difficult to accurately capture the impacts on a diffuse beneficiary group as well as to account for substantial differences in road quality. Nevertheless, an increasing number of evaluations using various household surveys and other indicators provide evidence on the size and nature of the benefits of roads and on the factors affecting the relationship. Among others, Gannon and Liu (1997), Escobal and Ponce (2004), Lokshin and Yemtsov (2005), Dercon et al. (2008) and Khandker et al. (2009) provide evidence about the positive welfare effect of rural roads. Rural roads, reducing transport costs and prices, may allow farmers in remote and often poor rural areas to get higher prices for their output, and/or reduce the prices they face for inputs and consumer goods.

In a study in Indonesia, Kwon (2001) shows that a 1 per cent increase in road investments is associated with a 0.3 per cent decrease in incidence of poverty. In their

paper 'Geographic poverty traps?', Jalan and Ravallion (2002) found that road density was one of the significant determinants of household-level prospects of escaping poverty in rural China: for every 1 per cent increase in kilometre of roads per capita in poor regions in China, household consumption rises by 0.08 per cent. Dercon et al. (2008), drawing from previous analysis (Dercon 2004, 2006), examine the impact of roads on poverty reduction in Ethiopia. They find that access to all-weather roads or good-quality roads – defined as roads capable of supporting (i) truck traffic, and therefore trade, and (ii) bus traffic, facilitating the movement of people during all seasons – increases consumption growth by 16.3 per cent and reduces the incidence of poverty by 6.9 per cent. Dillon et al. (2011) provide evidence about the welfare-improving effects on households of rural investments in roads in Nepal as measured by land values, consumption growth, poverty reduction or agricultural income growth. An advantage of this approach is that it can form the basis of benefit–cost ratios and thus allow researchers to compare investments in infrastructure with other forms of public spending.

Other analyses look more specifically at agricultural production and productivity. Fan et al. (2000) relate country- or regional-level public expenditure data to changes in agricultural productivity. The advantage of this approach is that it allows researchers to compare investments in infrastructure with other forms of public spending. They find that, in rural India, public investment in rural roads had the largest positive impact on agricultural productivity growth. Other analyses based on household data about the effect of road connectivity on input use, crop output and household income, such as those by Chamberlin et al. (2007) in Ethiopia and Stifel and Minten (2008) in Madagascar, suggest that isolation, defined as travel time during the dry season from the commune centre to the nearest urban centre, implies lower agricultural productivity, increased transport and transaction costs, increased insecurity and a reduction in per capita consumption. In other words, they find a relationship between isolation, poverty and agricultural productivity at the household level; Stifel and Minten observe that distance to a passable road and the cost of transporting rice significantly decrease the use of fertiliser in rice production. Controlling for soil fertility, and therefore for the non-random placement of roads, they demonstrate that crop yields for the three major staples in Madagascar, rice, maize and cassava, are lower in isolated areas than in areas that are not isolated. However, as highlighted by Dercon et al. (2008), these approaches do not tell which component of infrastructure spending generates these benefits. Moreover, Raballand et al. (2010) believe that, even if many of these analyses use sophisticated econometric analysis, many still share severe limitations in not dealing with the endogeneity bias in the poverty equation. They argue that road placement appears to be non-random, i.e. that roads might be constructed in already more productive areas.

Using geographic information systems (GIS), Ulimwengu et al. (2009) and Dorosh et al. (2010) look at the link between road connectivity and agricultural production in the Democratic Republic of Congo and sub-Saharan Africa. They estimate the long-run relationship between market access and agricultural production. Although the results are much less emphatic in the former paper, both analyses show that agricultural production is highly correlated with proximity to urban markets as measured by travel

time, not physical distance to the market. In other words, reducing travel time to major cities has significant effects on agricultural productivity in sub-Saharan Africa.

Renkow et al. (2004) develop a conceptual framework for quantifying fixed transaction costs facing semi-subsistence maize farmers in Kenya. Their analysis shows that, on average, households they analysed face fixed transaction costs that are equivalent to a 28 per cent *ad valorem* tax and that both remoteness and infrastructure quality have significant impacts on transaction costs. More importantly, if transaction costs are higher for poor households, the authors believe that public investment in infrastructure to lower transaction costs is more likely to increase the welfare of households already participating in input and output markets rather than to change the situation of autarkic households. Therefore, they conclude that, for public investment in infrastructure to provide direct support to the poor, it needs to be specifically targeted towards supporting autarkic households.

Where and how to better allocate investments in infrastructure is discussed by Fan and Chan-Kang (2005), Fan et al. (2000), Fan and Hazell (2001) and Fan et al. (2002). Their conclusion is that donors' investments should be directed to the construction and maintenance of rural, low-quality roads and not to roads for trucks, which they consider irrelevant to coping with the issue of rural poverty. They note that the predominant view is that, even though investing in what they define as less-favoured or low-potential rain-fed areas might have a greater impact on the poor living in those areas, social returns were the highest for investments in irrigated and high-potential rain-fed lands. One popular hypothesis is also that benefits are highly dependent on local human capital endowments necessary to take advantage of the opportunities provided by new roads. Fan and Hazell (2001) look at both India and China, two countries that have biased their past public investments towards high-potential areas. Although it allowed both countries to achieve large productivity gains in those specific high-potential areas, less-favoured areas are still lagging behind. Fan and Chan-Kang (2005) investigate the cost–benefit ratio for GDP of investment in low-quality (mostly rural) roads versus high-quality roads. They find that the former is about four times as much as than the latter. Moreover, they show that, whereas high-quality roads do not have a statistically significant impact on agricultural GDP, low-quality roads generate as much as 1.57 yuan of agricultural GDP for every yuan invested. Finally, they find that investments in low-quality roads have a much larger impact on poverty rates per yuan invested than high-quality roads.

A related question is whether infrastructure investments should focus on a 'transport corridors' development strategy or on a 'rural feeder road' strategy. There is a consensus in the literature that investments in corridors do not have large effects on smallholders and agricultural production. Rather, as reported by Byiers (2013) in a study of corridors in Tanzania and Mozambique, they are most likely to be 'corridors of power', benefiting relatively few, rather than 'corridors of plenty', with 90 per cent of smallholders likely to be left out of value chains. Byiers (2013) concludes that smallholders should be provided with additional opportunities and support to benefit from corridors by linking those large infrastructure developments with the upgrading of feeder roads and storage facilities.

Van de Walle (2002) and Mu and van de Walle (2011) also examine how rural road investment projects should be selected when the specific objective is taken to be poverty reduction. A second issue relating to the appraisal of the benefits to investment in rural infrastructures is that a sizable share of the benefits cannot be measured in monetary terms to be aggregated consistently with monetary measures of other benefits and costs. The acknowledgement of this issue by development institutions led them to adopt hybrid road investments appraisal methods combining the usual cost–benefit methods with cost-effectiveness calculation. Mu and van de Walle (2011) look more specifically at the determinants – geographical, community and household factors – explaining the variance of the impact of rural road rehabilitation on market development in rural Vietnam. On average, they confirm the significant impact of such projects on rural communities and on the development of rural markets, but they also show that impacts are significantly higher for poorer communes as a result of lower levels of initial market development.

Uganda has a low level of physical infrastructure and public services, with more than three-quarters of its population living two or more hours from any market centre. The impact of such poor infrastructure development on agriculture has been extensively addressed by various recent analyses. Gollin and Rogerson (2010) look at the relationship between high transport costs and low productivity of the agricultural sector and between transport costs and the size of the quasi-subsistence sector, and they provide detailed information about the scale of transport costs in Uganda. They find that the high variation of prices across space reflects the underlying transport costs preventing any arbitrage between regions. Their analysis is supported by a study conducted by the Government of Uganda's Plan for the Modernization of Agriculture, which estimates transport costs or distributional costs[2] associated with moving food from rural to urban areas. With a farm gate price between USh50/kg and USh65/kg for maize, transport from farm gate to primary market was estimated at USh10/kg, with an additional USh5/kg to USh10/kg for further transport to secondary markets. The cost of logistic services was estimated to add around USh10/kg. Finally, adding other transportation costs in order to reach urban markets, the pure transport cost of moving maize to wholesale markets was estimated as USh55/kg, about the same as the farm gate price. Comparing a matching situation in the USA, Gollin and Rogerson (2010) estimate that the implied unit transport cost in Uganda is about seven times the cost in the United States. Finally, using a static general equilibrium model to test various scenarios of changes in policies and interventions, they show that the welfare gains of an improvement in agricultural total factor productivity (TFC) along with a reduction in transportation costs exceed those achieved from the two interventions separately. They conclude that this result suggests an interaction effect between the two interventions.

12.2.4 Evidence of the impact of roads infrastructure on changes in agricultural technology

Woelcke (2006) presents an analysis of Uganda's Lake Victoria Crescent region, in which agricultural production was characterised by low input–output systems even though

the region presented comparative advantages for intensive agricultural production: high agricultural potential, high market access and high population density. His analysis finds that farm households would not pursue sustainable intensification under current socio-economic conditions: high transaction costs, including transport costs, imperfect credit market, no agricultural services (extension and ancillary services) and no economic incentives for the adoption of environmentally sound production methods. The consequence was a lack of dynamism in agricultural production in the region despite its seeming potential; in fact, productivity in the agricultural sector in Uganda had either stagnated or declined (APSEC 2000).

The literature mentions many other case studies relating the effect of the reduction of transaction costs on change in agricultural production technology and, in particular, on better agricultural practice and management of natural resources leading to increased agricultural productivity. Dercon and Hoddinott (2005) provide evidence that improvement in road quality increases the likelihood of purchasing inputs by 29 per cent to 35 per cent according to the season. Nkonya et al. (2011) find that, by reducing transaction costs and linking farmers to the market, rural services – rural roads, extension services, communication infrastructure, markets etc. – increase the returns to investment and, as a consequence, influence farmers' decisions to adopt and invest in better land management technologies. They mention the example of improved access to roads and markets in Machakos, Kenya, which led land users to increase investments in soil erosion prevention methods, thereby increasing agricultural productivity. The same holds in Uganda, where Okoboi and Barungi (2012) show that low access to credit and constrained access to input and output markets due to distance are key constraints on fertiliser use.

In Nigeria, small-scale private irrigation (SPRI) schemes have been popular among farmers. They multiply by ten the average irrigated surface compared with the traditional irrigation devises and fill in the labour gap associated with the ageing of farmers, which is becoming a serious issue in Nigeria, compounded by rapid out-migration from rural communities. However, the pace of adopting irrigation pumps is low relative to their potential. Takeshima et al. (2010) show that transaction costs, defined by farmers as the cost of identifying sellers, making certain of the pump's quality, and the time and transportation costs for purchasing it, are an important impediment to the adoption of SPRI. In comparison with pure transport costs and prices, such transaction costs are unobservable, difficult to quantify and therefore difficult to include in cost–benefit analysis of infrastructure investment. Moreover, investment in SPRI often comes along with investment in whole packages of complementary inputs (farmland, water, improved seeds, fertiliser, fuel and electricity), further increasing potential sources of transaction costs and the complexity of their estimation. Hence, investment in irrigation pumps may also be limited by low output price and little access to complementary inputs. More interestingly, although Takeshima et al. (2010), like other researchers looking at farmers' investment decisions in environments of high transaction risks, find that household characteristics affect the level of those transaction costs directly related to the action of investing in irrigation pumps; they nonetheless emphasise that those characteristics may not affect the expected profitability once the investment

has been made. This suggests that large agricultural productivity increases have been forgone in Nigeria as a result of the single transaction costs for purchasing irrigation pumps.

12.3 Soft infrastructure: key intermediate logistical infrastructures

This section provides evidence of the importance of investment in logistical infrastructure to maximising the benefice of investments in hard infrastructure. It covers four types of logistical infrastructure identified as key to the competitiveness of agricultural value chains: competition in transport services, provision of agricultural extension services, storage capacity, and sanitary and phytosanitary (SPS) institutions including inspection infrastructures.

12.3.1 Competition in transport services

The Asian Development Bank (ADB) Operations Evaluation Department (Hettige 2006) conducted an analysis based on case studies of road improvement with the objective of understanding when and how rural roads benefit the poor. It questions the assumption according to which investment in roads should spontaneously leads to the provision of transport services by the private sector, so that the increase in competition rapidly leads to cheaper and better transport. Their case studies do not provide evidence of a straightforward relationship among rural road investment, transport services development and competition. In each case study, investments in rural roads decreased travel time and led to the emergence of a variety of transport modes, but increases in transport volume and decreases in fares occurred only when there was competition among transport providers. Therefore, competition seems a critical precondition for transport services' development and accessibility to the poorest.

Moser et al. (2005), Raballand and Macchi (2008), Teravaninthorn and Raballand (2009), Raballand et al. (2010), USAID (2011) and Porto et al. (2011) confirm this analysis and show that, in Africa, transport costs are not necessarily excessively high, but rather the lack of competition and regulation in the trucking services increases transport prices.

In Madagascar, Moser et al. (2005) analyse the spatial integration of rice markets to identify some of the factors that explain the observed considerable forgone arbitrage opportunities leading to poor price transmission and price equalisation within the country. Their analysis shows that reducing transportation costs is necessary, but not sufficient, for a better integration of markets at the national level. For 63 per cent of *communes*, trade at the regional level appears profitable but the lack of competition allows excess rents to persist. Therefore, policies intended to improve the performance of food markets should focus not only on reducing market pure transport costs through main trunk road improvements, but also on competition policies.

Teravaninthorn and Raballand (2009), reviewing the international corridors in Africa, find that the transport of freight between Sahelian countries and their ports – and thus the world market – features prices that significantly exceed the underlying

costs. Their analysis suggests that most of this situation is due to rent-seeking road-transport cartels benefiting from oligopolies. Of particular concern is that the trucking industry in West and Central Africa is characterised by cartels offering high prices and low service quality. East Africa's competitive market environment seems more mature but degraded by fuel prices and border controls. Therefore, they conclude that poor condition of the road infrastructure may not be the most critical factor behind transport prices and that much of the transport price burden along African corridors therefore seems to depend on the political economy of freight logistics.

However, Raballand et al. (2010) highlight that a one-size-fits-all approach to the development of roads and transport services is irrelevant. They argue that the level of production influences which policies will be most effective: because of high risk and low returns, low agricultural production means low competition between truckers. Truckers need to cover their marginal costs, which in low-production areas can already be difficult for a single trucker.

12.3.2 Extension services

Technological change, adoption of inputs such as organic and non-organic fertilisers, new agricultural and resource management practices, and use of improved seeds can sustainably increase agricultural productivity. Technological change therefore plays a pivotal role in rural poverty reduction. Agricultural extension services can inform farmers of new agricultural technologies, advise them on best agricultural practices and help them deal with adverse shocks such as insect infestation or plant disease (Dercon et al. 2008). The ADB analysis of various case studies (Hettige 2006) shows that the construction of a farm road near Yogyakarta in Indonesia helped extension officers to achieve more efficient coverage of their areas of responsibility and to deliver more regular and reliable service. Before the project, basic and extension services from the government did not seem to be reaching farmers. Agricultural extension services rarely came to the village because transport was unavailable. Roads and communication infrastructures are essential to the development and efficiency of extension and ancillary services. However, as the ADB evaluation highlights, those services are also essential for farmers and, in particular, poorer smallholders to take full advantage of new opportunities created by the development of roads.

Okoboi and Barungi (2012) look at the constraints on fertiliser use in Uganda. Declining soil fertility is one important factor in low productivity of agricultural production in Uganda. Their analysis shows that, in addition to credit constraints and distance to the market, the constraints that most limit the adoption of both organic and inorganic fertilisers are the lack of knowledge about their use and the lack of market information because access to fertiliser-specific extension services is limited.

Focusing on three resettlement areas of rural Zimbabwe, Owens et al. (2001) find that access to agricultural extension services – defined as receiving one or two visits per agricultural year – raises the value of crop production by about 15 per cent.

Finally, Dercon et al. (2008) wrote one of the first papers providing empirical evidence of the direct impact of extension services on poverty in a developing country. Their

analysis looks at whether or not public investments in road quality and increased access to agricultural extension services led to faster consumption growth and lower rates of poverty in 15 rural villages in Ethiopia. They find that receiving at least one extension visit increases consumption growth by 7.1 per cent and reduces poverty incidence by nearly 10 per cent.

12.3.3 Storage capacity

Post-harvest management capacity is an issue in developing countries. About 25 per cent of food production is estimated to be left to rot in fields because of the lack of labour capacity to harvest and the lack of storage infrastructures. Such storage infrastructures allow perishable products to be preserved better, and give farmers an opportunity for time arbitrage for less perishable products.

Basavaraja et al. (2007) note that 'agricultural commodities produced on the farm fields have to undergo a series of operations such as harvesting, threshing, winnowing, bagging, transportation, storage, processing and exchange before they reach the consumer, and there are appreciable losses in crop output at all these stages'. Reducing losses at each of those stages is, therefore, critical. Better post-harvest management technologies and infrastructure are crucial to the increase in effective – as effectively consumed – agricultural production. They are important tools for increased food security as well as for better market integration. They not only allow time arbitrage but also increase product quality.

USAID (2011) conducted a series of analyses on trade and agribusiness competitiveness in Western Africa (Schacht 2010). They highlight that generally improving agricultural productivity, storage life and product quality are among the top priorities of the agricultural value chain actors. Within ECOWAS member states, USAID (2011) mentions the existence of a demand from producers and traders for better storage and warehousing of cereals as well for the establishment of regional quality standards for cereals, to promote trade.

Indeed, their analysis finds significant inefficiencies in trade arising from post-harvest handling and storage practices. In the country analysed, it appears that high post-harvest losses are related to spoilage due to the shortage of cold and dry storage facilities, as well as to low-quality packing and inefficient handling and transport. For maize, they estimate direct transport costs at US$81 per metric ton (MT), but product losses due to storage and handling problems between the farm and the end market are estimated at $79 per MT. More generally, Schacht (2010) estimates that poor product quality and poor storage – that is storage lacking properly designed granaries with cement floors, controlled air flows, barriers against vermin, proper preservation techniques such as sacks stacked off the floor on palettes, and regular use of pesticides and fungicides – are responsible for almost 40 per cent of the extra costs in the value chain. A second analysis estimates that they represent approximately 20 per cent of market logistics costs and more than 85 per cent of avoidable market costs (USAID 2011).

The lack of high-quality warehousing to store cereals in good-quality conditions limits bulking, which would enable more traders to conclude contracts with large buyers. Hence, although the improvement of regional policy and reducing the costs of transport are the

most important recommendations identified by USAID in terms of overall regional impacts on food security, it highlights the importance of addressing other constraints on the competitiveness of value chains. USAID suggests that action could be taken towards improving the management of existing regional storage infrastructure in order to increase trade competitiveness. Also, the implementation of a regional warehouse scheme or increasing access to credit for storage and equipment could allow traders to take advantage of economies of scale and to invest in equipment and storage.

As in the trucking sector, there also seems to be a lack of competition and transparency within the private sector for warehousing. Even if this is not further analysed in the USAID study, we can easily guess that the same reasons of low productivity and cost coverage prevail and maintain this state.

The FAO (2008) promotes the use of metal silos – a post-harvest storage technology for staple grains – as a key post-harvest technology in the fight against hunger and for food security. According to the FAO, not only do they have a great potential for saving post-harvest losses, but also they allow small or medium-sized farmers to store surpluses more safely and efficiently for off-season sale when prices are more attractive, thus increasing household income. Bokusheva et al. (2012) look at the effect of the dissemination of such silos in four Latin American countries by the Swiss Agency for Development and Cooperation (SDC) from 1983 to 2003, and they find that, compared with the non-adopters, the households that adopted silos experienced a significantly higher improvement in their food security and well-being from 2005 to 2009.

The lack of proper storage facilities is a problem for cereals, but it is an even more important constraint on the development of value chains for highly perishable fruits and vegetables. Cold storage is very energy-intensive and many rural areas do not have any reliable connection to the national grid. The only solution is, therefore, to rely on decentralised power production. Better access to electricity seems, therefore, an important measure for the development of high-value agricultural trade such as trade in fruits and vegetables.

12.3.4 SPS institutions and inspection infrastructures

Quality matters to the capacity to access and sustain exports to developed-country markets, but so does reputation (Easterly and Reshef 2010; Jouanjean 2012a; Jouanjean et al. 2012). The capacity to provide evidence of quality as well as a consistent supply of high-quality products is, therefore, a prerequisite to ensure the sustainability of agricultural exports. Many developing countries' SPS agencies lack the adequate expertise and physical infrastructures to conduct proper SPS inspections and controls.

Many standard-setting and controlling agencies have been built, often using donor support. However, partly because of limited budget allocation from the government, many struggle to secure financial viability to sustain their operations (World Bank 2012). As a consequence, many have been trying to raise revenues from their inspection and certification activities rather than assisting. The World Bank (2012) provides the example of Tanzania, where the Plant Health Service (PHS) of the Ministry of Agriculture, Food Security and Co-operatives has around 150 inspectors posted at

only 28 out of a total of 56 entry points, mainly international airports, major sea and lake ports, and selected border posts. Moreover, all of them lack basic pest inspection tools and only six are equipped with a computer. This is a problem not only for exports, but also for the protection of domestic plants and animals, with little capacity to prevent and monitor pests and outbreaks of disease within the country. For maize in Western Africa, the cost of control procedures, such as obtaining an SPS certificate or paying a bribe at the border, was calculated by USAID (2011) at US$40 per tonne. Jouanjean (2012b) also provides examples of the difficulty of many developing countries in developing proper institutions and infrastructures necessary to enforce any phytosanitary regulations and to implement pest risk assessments (PRA), often mandatory in order to gain access to various developed but also developing countries' markets. In a presentation to the International Plant Health Risk Analysis Workshop in 2005, the Director of the Plant Protection and Regulatory Services Directorate of the Ghanaian Ministry of Food and Agriculture highlighted the difficulties Ghana was encountering when implementing PRA, in the context of new foreign market access but also when protecting its own agriculture of imported pests:

- weak human and equipment resources resulting in incomplete pest records;
- poor and unreliable data generation;
- difficulties in implementing surveillance as well as having access to adequate information resources (ICT);
- limited expertise in and capacity for export inspection and certification;
- limited research support by government; and
- outdated phytosanitary legislation and inappropriate regulatory frameworks.

Because of the lack of proper institutions and infrastructures, some importing countries directly set up temporary inspections infrastructures in the exporting country. For instance, the United States has agreed to import mangoes from India on condition that both countries implement a co-operation and trust fund agreement to pay for the cost of preclearance activities in India. If the preclearance system as implemented by the United States can be described as a way to create and facilitate trade, the corollary is that countries' capacity to enter and implement a co-operation agreement with the United States for preclearance becomes a determinant of access to their market. One can easily figure that, for many budget-constrained governments in developing countries, such agreements can be particularly burdensome to implement.

Therefore, investments in soft infrastructure, from standards-setting institutions to extension services and other rural infrastructure determining the increase in agricultural productivity and efficiency of the agricultural value chain, seem as important as the reduction of pure transport costs through the construction of rural roads.

12.4 Conclusion

The recent literature provides new evidence about the impact of rural infrastructures on agricultural productivity, trade and poverty. It confirms that rural roads are

important for poverty reduction, increasing agricultural productivity and market access. However, there is little evidence that roads have a direct impact on the poorest communities, and studies suggest that they rather benefit from indirect job creation.

International trade analysis provides evidence that road quality is important for trade. However, from a welfare impact point of view, evidence shows that (low-quality) rural feeder roads are more essential to poor rural households than high-quality roads for trucks. Nevertheless, if roads, and in particular rural feeder roads, still appear an undisputable necessity, they are still not sufficient to guarantee any escape from poverty.

The key recommendation that can be drawn from the recent debate over trade, agriculture and infrastructure, and from the analysis presented in this overview, is that rural infrastructure development projects should be appraised in a more holistic way, and should consider combining investments in hard infrastructure with investments in soft infrastructure to address systemic inefficiencies decreasing agricultural value chains' competitiveness. Soft infrastructure is crucial in fostering agricultural productivity and to help subsistence farmers overcome some of their constraints and connect to the market. Also, both consumers and farmers will benefit significantly if transport and transaction costs are reduced simultaneously.

Since the launch of the global initiative on AfT in 2005, efforts by donors, partner agencies and recipients to strengthen trade capacity and improve trade-related infrastructure have been driven by the public sector. With part of the AfT initiative's shift in focus to the issue of developing-country producers' inclusion in global value chains, the scope of the initiative should more than ever open to the private sector. Indeed, as mentioned by the World Bank (2011: 7), 'With a growing number of companies looking to the developing world for new markets, the private sector has a profound interest in ensuring sound investments through access to trade-related infrastructure, an educated workforce, and quality standards for inputs to their goods.' Therefore, private sector participation could stand as a powerful tool in the identification of key infrastructure investments that should not be forgone by the AfT community.

Notes

1 See OECD (2012: 4): The value for trade is measured in terms of: direct and indirect job creation; increased level and predictability of income; economic and social upgrading; diffusion of technology and knowledge; better and more sustainable use of resources; political and economic stability.
2 Cost of shipping agricultural goods, to which can potentially be added cost of grading, bagging, storing and milling, among others.

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