Report

Targeting infrastructure development to foster agricultural trade and market integration in developing countries: an analytical review

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Abbreviations

Abbreviation	Description
ECOWAS	Economic Community of West African States
GDP	Gross domestic product
SPS	Sanitary and phytosanitary
USh	Ugandan shilling
WTO	World Trade Organisation

1 Introduction

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

The issue of the importance of improving rural infrastructure, and in particular rural roads, is not new in the development community. This topic has long been at the centre of development policies, supported by the popular assumption among development theorists 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 20th 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, because farmers in remote areas are typically poorer than those in less-isolated areas. However, 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. But he also acknowledges that 'rural road construction is certainly not the magic bullet for poverty alleviation' (Jacoby, 2000: 735)

At the beginning of the 21st century the UN Millennium Development Goals drew the attention of the development community to social development projects, and infrastructure development was only given a new impetus with the World Trade Organisation (WTO)-led Aid for Trade initiative. Trade-related infrastructure is one of the four Aid for Trade categories of support – as defined by the Organisation for Economic Co-operation and Development and the WTO – along with technical assistance for trade policy and regulations, productive capacity building (including trade development) and trade-related adjustment. For a long time discussions of developing countries' access to developed markets for agricultural and food products focused 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 with the recognition of the importance of supply-side constraints that prevent producers from taking advantage of trade liberalisation. The main question supporting the Aid for Trade agenda was, therefore, how to limit or eliminate these constraints and provide developing countries' producers with more opportunities to connect with the regional and international market. As Hoekman and Njinkeu (2010) say:

> Market access – which assumes centre 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.

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 – i.e. firms producing at the lower variable costs – can export. But variations of these models also highlight the importance of quality to the capacity to export specific goods, even if quality means higher production costs and therefore higher prices. Although international trade models adopting a quality definition of competitiveness were long considered relevant only for manufactured goods, evidence shows that agricultural products can no longer only be seen as homogeneous commodities and therefore that quality also matters to the capacity to export (Jouanjean, 2012a).

Since the emergence of the Aid for Trade agenda, and along with the changes in the patterns of trade and the further fragmentation of global production, our understanding of the potential scope of Aid for Trade 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 to increase the 'value for trade'.[1]

The Aid for Trade agenda has stimulated the production of new analyses of the effect of rural 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 R&D, extension services, irrigation projects, input distribution policies, etc. Hard infrastructure – roads, energy and communication infrastructure – facilitate the 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 agriculture 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 (e.g. Cadot et al., 2010; Hettige, 2006; Porto et al., 2011) have 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 (examples in Madagascar and West Africa are given in USAID, 2011 and World Bank, 2012) and irregular payments at roadblocks. To highlight the underlying difference in approach compared to previous analysis, some of the literature refers to the issue of high transport prices rather than transport costs to differentiate the impact of market structure

[1] See OECD (2012): the value for trade is measured in terms of direct and indirect job creation, increased levels and predictability of income, economic and social upgrading, the diffusion of technology and knowledge, better and more sustainable use of resources, and political and economic stability.

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 shifting to focus on the systemic inefficiencies arising from key types of intermediate logistic infrastructure (USAID, 2011; Raballand et al., 2008).

Various other studies look at the provision of soft infrastructure as key to the reduction of costs, but also to the provision of 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 infrastructure is crucial for sustainable productivity increase, but also for inclusion in high-value domestic or global value chains. For instance, obtaining access to the horticultural global value chain requires access to knowledge about good agricultural practices, standards and SPS regulations, and post-harvest management practices, as well as access to infrastructure such as cold-storage facilities.

This paper is an analytical overview of this 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 the maximisation of 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 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 each topic in silos. This overview is organised in two main sections. The first addresses the issue of the supply of hard infrastructure, 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 logistic infrastructure, and looks more specifically at transport-, extension- and standards-related services.

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

2.1 Impact of infrastructure on trade: evidence at the regional and international levels

If the role of infrastructure in 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 usually focus on the effect at the micro level and look 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 the regional and international trade in goods, or sometimes more specifically on trade in agricultural 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 such interactions between infrastructure and trade. Therefore, care should be taken when undertaking quantitative analysis to identify the real effect of infrastructure on trade.

Nevertheless, a range of analyses have suggested various methodologies to quantify the relationship between infrastructure and trade. Limão and Venables (1999) find that a drop of 10% in transport costs for landlocked African countries would increase the volume of their international trade by as much as 25%. 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 is undertaken 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 an analysis of regional agricultural transport and trade policy, USAID (2011) studies the transport costs of cereals in West Africa. Making use of cereal isoprice maps, it provides evidence of steep price gradients along trade corridors in the Economic Community of West African States (ECOWAS), indicating the weak linkages between key surplus and deficit markets in the region. According to this study, the reasons behind such weak linkages are constraints on efficient transport along regional corridors. More specifically, this analysis

shows that the transport and logistics costs of moving maize and livestock along key trading corridors between Burkina Faso, Ghana and Benin account for approximately 59% and 18% of the respective end-market prices. Of these, transport costs – i.e. fees paid to transport-service operators and losses in transit – were found to weigh most heavily on the end-market price along the corridors studied.

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

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

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

While most of the literature looks at the effect 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 by inducing the relocation of markets and institutions.

According to Hettige (2006), who evaluated a rural road investment near 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 studied village, or sometimes to become intermediaries, selling the village's products to nearby market centres. Among project respondents, 64% observed that the number of small businesses in the community had increased since the road was built or rehabilitated. Among the 17% of project respondents who had started a business since the road's rehabilitation, 69% declared that the road was a factor in their decision to start a business. Also, 54% of households declared that more buyers visited the community than five years prior to the rehabilitation project, compared with 36% of the control households.

It has usually been the case that infrastructure project designers have targeted regions that are already well endowed and possess the market institutions necessary to foster further economic development, on the grounds that rates of returns would be higher in such regions. Mu and Van de Walle (2009) ask whether, 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 (e.g. Fafchamps and Minten, 1999), they underline the theoretical ambiguity of the impact of better roads on local markets. 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 (1999) 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 communities of their sample. However, other poor areas' attributes, 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 and lower population density, tend to work in opposite directions and will clearly mediate the impact of road improvements across communities. Therefore, their analysis does not completely depart from previously mentioned assumptions about the importance of local and human capital on the impact of road improvement. Yet, at least in the regions Mu and

Van de Walle (1999) examined, the high potential return due to the low initial market development was strong enough to outweigh the effect of such attributes.

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

While 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 in markets (e.g. Barrett, 2008; Key et al., 2000; Kydd and Dorward, 2004; Poulton et al., 2006; Vakis et al., 2003).

Key et al. (2000) differentiate the effect of fixed and variable transaction costs. Fixed transaction costs are the costs of searching and screening for the best business partner, and of negotiating and implementing a contract, and 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 asymmetrical information. According to the Peruvian survey used by Vakis et al. (2003), costs related to searching, matching and bargaining are important variables in a farmers' decision to participate in the market. The *World development report 2008* (World Bank, 2008: ch. 5) mentions a number of initiatives to improve the spread of agricultural information via radios, mobile phones and other media. The evidence shows that investment in mobile phones has had an important impact on the reduction of such fixed transactions 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 for small producers. Variable transaction costs, which the provision of roads should reduce, represent the per-unit cost of transferring the product to or from the market.

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 a persistence of, and even some level of retreat into, subsistence agriculture, suggesting the existence of multiple equilibria. Such multiple market participation equilibria commonly arise because of the fixed costs of investment, combined with missing markets and coordination 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, while those who lack one or more of those three essential ingredients do not. Broadly speaking, this literature looking at farmers' decisions to participate in the market finds that differences in transaction costs and differential access to assets and services to mitigate these costs are possible factors underlying heterogeneous market participation among smallholders.

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- and off-farm activities. Many theoretical and empirical studies in the development literature have addressed the issue of transportation and transaction costs, in particular by looking at the

link between market access and poverty, and more generally the impact of roads and infrastructure on development dynamics (e.g. Fan, 2008; Fan and Hazell, 2001; Platteau, 1996). Some studies have demonstrated that roads encourage agricultural development (e.g. Van de Walle, 2002; Ulimwengu et al., 2009).

Various studies from the end of the 20th and the beginning of the 21st century argued that, despite a general consensus on the importance of rural roads for development (Gannon and Liu, 1997), there was very little evaluation of the extent of this impact. The limitations relative to the evaluation of impacts at the micro level are the same as at the macro level, with inherent difficulties in estimating the magnitude of the effects attributable to infrastructure, due to the endogeneity of much infrastructural development. 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 and account for substantial differences in road quality. Nevertheless, an increasing number of evaluations using household surveys and various indicators provide evidence on the factors influencing the extent of the benefits of investing in roads, including these roads' size and nature. Among others, Gannon and Liu (1997), Escobal and Ponce (2004), Lokshin and Yemtsov (2005), Dercon et al. (2006) and Khandker et al. (2009) provide evidence about the positive welfare effect of rural roads. Rural roads, by 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 Indonesia, Kwon (2001) shows that a 1% increase in road investments is associated with a 0.3% decrease in the incidence of poverty. Jalan and Ravallion (2002) find that road density was one of the significant determinants of household-level prospects of escaping poverty in rural China: for every 1% increase in the number of kilometres of roads per capita in poor regions in China, household consumption rises by 0.08%. Dercon et al. (2006), 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 quality roads – defined as roads capable of supporting (1) truck traffic and therefore trade and (2) bus traffic, therefore facilitating the movement of people in all seasons – increases consumption growth by 16.3% and reduces the incidence of poverty by 6.9%. Dillon et al. (2011) provide evidence about the welfare-improving effects of rural investments in roads in Nepal on households, measured by land values, consumption growth, poverty reduction or agricultural income growth.

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. An advantage of this approach is that it can form the basis of establishing benefit-cost ratios and thus allows researchers to compare investments in infrastructure with other forms of public spending. Fan et al. (2000) find that in rural India, public investment in rural roads had the largest positive impact on agricultural productivity growth. Other studies based on household data look at the effect of road connectivity on input use, crop output and household income, such as Chamberlin et al. (2007) in Ethiopia and Stifel and Minten (2008) in Madagascar, and suggest that isolation – defined as travel time during the dry season from a rural community 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, these studies find a relationship among isolation, poverty and agricultural productivity at the household level: Stifel and Minten (2008) 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, which they link to 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. However, Dercon et al. (2006) highlight that 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, they still share

severe limitations that lie in the absence of any or sufficient treatment of the endogeneity bias in the poverty equation with non-random road placement, i.e. that roads might be constructed in already more productive areas.

Using geographic information systems, 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 of a much lower intensity in the former study, both analyses show that agricultural production is highly correlated with proximity to urban markets as measured by time travel, 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 faced by semi-subsistence maize farmers in Kenya. Their analysis shows that, on average, the households they analysed face fixed transaction costs that are equivalent to a 28% ad valorem tax, and that both remoteness and infrastructure quality have significant impacts on transaction costs. But, more importantly, if transaction costs are higher for poor households, these 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 at supporting autarkic households.

Fan and Chan-Kang (2005), Fan et al. (2000) and Fan and Hazell (2001) discuss where and how to better allocate investments in infrastructure. Their conclusion is that donors' investments should be directed to the construction and maintenance of low-quality rural roads and not to roads for trucks, which they consider irrelevant to attempts to cope 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 people living in these 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 the local human capital endowments needed 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 toward high-potential areas. Although these investments 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 gross domestic product (GDP) of investment in low-quality (mostly rural) roads versus high-quality roads. They find that the former is about four times greater than the latter. Moreover, they show that in China, while high-quality roads do not have a statistically significant impact on agricultural GDP, low-quality roads generate 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 corridor' development strategy or on a 'rural feeder road' strategy. There is consensus in the literature on the fact that investments in corridors do not have large effect on smallholders and agricultural production. Rather, as reported by Byers and Rampa (2013) in a study of corridors in Tanzania and Mozambique, these routes are likely to be 'corridors of power' that benefit relatively few rather than 'corridors of plenty', with 90% of smallholders likely to be left out of value chains. Byers and Rampa (2013) conclude that additional opportunities and support should be provided to smallholders to help them 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 assumed to be poverty reduction. A second issue relating to the appraisal of the benefits of investment in rural infrastructure is that a sizable share of such benefits cannot be measured in monetary terms so as 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-investment appraisal methods combining the usual cost-benefit methods with cost-effectiveness calculations. Mu and Van de Walle (2011) look more specifically at the determinants – geographic, community and household factors – explaining the variations in the impact of rural road rehabilitation on market development in rural Vietnam. On average, they confirm the significant impacts of such projects on rural communities and the development of rural markets, but also show that the impacts are significantly higher for poorer communities due to 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 in the country has been extensively addressed by various recent analyses. Gollin and Rogerson (2010) look at the relationship between the high transportation costs and low productivity of the agricultural sector and between transport costs and the size of the quasi-subsistence sector and provide detailed information about the scale of transportation costs in Uganda. They find that the high dispersion of prices across geographic space reflects the underlying transportation costs, preventing any arbitrage between regions. Their analysis is supported by a study conducted by the Ugandan government's Plan for the Modernisation 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 50 USh/kg and 65 USh/kg for maize, transport costs from farm gate to primary market were estimated at 10 USh/kg, with an additional 5–10 USh/kg for further transport to secondary markets. The cost of logistical services was estimated to add around 10 USh/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 55 USh/kg, about the same as the farm-gate price. Comparing a matching situation in the US, Gollin and Rogerson (2010) estimate that the implied unit transport cost in Uganda is about seven times the cost in the US. 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 along with a reduction in transportation costs exceeds those achieved from the two interventions separately. They conclude that this result suggests an interaction effect between the interventions.

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, market access and population density. His analysis finds that farm households would not pursue sustainable intensification under current socio-economic conditions, i.e. high transaction costs, including transport costs; credit market imperfection; no agricultural services (extension and ancillary services); and no economic incentives to adopt environmentally sound production methods. The consequence was a lack of any agricultural production dynamic in the region, despite its seeming potential; more so,

[2] Cost of shipping agricultural goods, to which can be potentially added cost of grading, bagging, storing and milling, among others.

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 changes in agricultural production technology and in particular on better agricultural practice and the management of natural resources, leading to increased agricultural productivity. Dercon and Hoddinott (2005) provide evidence that improvement in road quality increases the likelihood of farmers' purchasing inputs by 29–35% 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 returns on 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 that led land users to increase their 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 to fertiliser use.

In Nigeria, small-scale private irrigation schemes have been popular among farmers. They multiply by ten the average irrigated surface compared to the traditional irrigation devices and fill in the labour gap associated with the aging of farmers, which is becoming a serious issue in Nigeria, compounded by rapid out-migration from rural communities. Moreover, 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, ensuring the pump's quality, and the time and transportation costs for purchasing it – are an important impediment to the adoption of small-scale private irrigation schemes. In comparison to pure transport costs and prices, such transaction costs are unobservable, difficult to quantify and therefore difficult to include in cost-benefit infrastructure investment analyses. Moreover, investment in small-scale private irrigation schemes 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, while Takeshima at al. (2010), like other studies looking at farmers' investment decisions in high-transactions-risk environments, find that household characteristics affect the level of these transaction costs directly related to the process of investing in irrigation pumps, they nonetheless underline that these characteristics may not affect the expected profitability once the investment has been made. This suggests large foregone agricultural productivity increases in Nigeria from single irrigation-pump purchase transaction costs.

3 Soft infrastructure: key intermediate logistic infrastructure

This section provides evidence of the importance of investment in logistic infrastructure to maximise the benefice of investments in hard infrastructure. It covers four types of logistic infrastructure identified as key to the competitiveness of agricultural value chains: transport services, agricultural extension services, storage capacity, and SPS institutions, including inspection infrastructure.

3.1 Competition in transport services

The Asian Development Bank's Operations Evaluation Department (Hettige, 2006) conducted an analysis based on case studies of road improvements with the objective of understanding when and how rural roads benefit the poor. The analysis questions the assumption that investment in roads should spontaneously lead to the provision of transport services by the private sector, so that the increase in competition rapidly leads to cheaper and better transport. These case studies do not provide evidence of a straightforward relationship between rural road investment and transport services development. 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 that the lack of competition and regulation in trucking services increases transport prices.

In Madagascar, Moser et al. (2005) analyse the spatial integration of the rice market to identify some of the factors that explain the observed considerable foregone arbitrage opportunities, leading to poor price transmission and price equalisation in 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% of communities, trade at the regional level appears profitable, but the lack of competition allows excessive rents to persist. Therefore, policies intending to improve the performance of food markets should focus not only on reducing pure market transport costs through main trunk road improvements, but also on competition policies.

Raballand and Teravaninthorn (2009), in an evaluation of international corridors in Africa, find that the transport of freight between Sahel 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, the trucking industry in West and Central Africa is characterised by cartels offering high prices and low service quality. The East Africa competitive and market environment seems more mature, but is degraded by fuel prices and border controls. Therefore, Raballand and Teravaninthorn (2009) conclude that the poor condition of road infrastructure may not be the most critical factor behind transport prices and that much of the transport price burden along African corridors seems therefore 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 does not work. 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 among truckers. Truckers need to cover their marginal costs, which in low-production areas can already be difficult for a single trucker.

3.2 Extension services

Technological change, the adoption of inputs, new agricultural and resource management practices, and the adoption of improved seeds can sustainably increase agricultural productivity. Technological change therefore plays a pivotal role in rural poverty reduction. The provision of agricultural extension services allows farmers to be informed of new agricultural technologies, obtain advice on best agricultural practices, and obtain assistance with dealing with adverse shocks such as insect infestation or plant disease (Dercon et al., 2006). The Asian Development Bank's 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 deliver more regular and reliable services. Before the project, government basic and extension services did not seem to be reaching farmers. Agricultural extension services rarely came to the village because of unavailable transportation. While these case studies show that roads and communication infrastructure is essential to the development and efficiency of extension and ancillary services, these 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, where declining soil fertility is an important factor of the low productivity of agricultural production. Their analysis shows that, in addition to credit constraints and distance to the market, the lack of knowledge about the use of inputs and the lack of market information due to limited access to fertiliser-specific extension services are the most limiting constraints to the adoption of both organic and inorganic fertilisers.

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%.

Finally, the study of Dercon et al. (2006) is one of the first to provide empirical evidence of the direct impact of extension services on poverty in a developing country context. Their analysis looks at whether public investments in road quality and increased access to agricultural extension services led to faster consumption growth and lower rates of poverty in rural 15 rural villages in Ethiopia. They find that receiving at least one extension visit increases consumption growth by 7.1% and reduces poverty incidence by nearly 10%.

3.3 Storage capacity

Post-harvest management capacity is an important issue in developing countries: on average, about 25% of food production is estimated to be left to rot in the fields because of the lack of labour capacity to harvest it and the lack of storage infrastructure. In particular, storage infrastructure allows for the better preservation of perishable products and gives farmers further opportunities for time arbitrage.

Basavaraja et al. (2007: 117) 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 these stages is therefore critical. Better post-harvest management technologies and infrastructure are crucial to increasing effective – i.e. effectively consumed – agricultural production. Because of their importance for the level of food supply and product quality, they are important tools for increased food security and better market integration.

USAID conducted a series of analyses on trade and agribusiness competitiveness in West Africa (USAID, 2011; Schacht, 2010). Interviews of agricultural value chain actors in ECOWAS member states confirm that improving agricultural productivity, storage life and product quality is among their top priorities. More specifically, USAID (2011) mentions the existence of a demand from producers and traders for facilities for the better storage and warehousing of cereals, and for the establishment of regional quality standards for cereals to promote trade. Indeed, the 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, and to low-quality packing and inefficient handling and transport. For maize, USAID (2011) estimates direct transport costs at $81 per metric ton, but product losses due to storage and handling problems between the farm and the end market are estimated at $79 per metric ton. More generally, Schacht (2010) estimates that poor product quality and poor storage – i.e. storage lacking properly designed granaries with cement floors, controlled air flows, controls to prevent vermin access, proper preservation techniques such as sacks stacked off the floor on palettes, and the regular use of pesticides and fungicides – are responsible for almost 40% of the extra costs in the value chain. USAID (2011) estimates that these factors represent approximately 20% of market logistics costs and more than 85% of avoidable market costs.

The lack of high-quality warehousing to store cereals in quality conditions limits bulking, which would enable more traders to conclude contracts with large buyers. Hence, while the improvement of regional policy and reducing the costs of transport are the most important recommendations identified by USAID (2011) in terms of overall regional impacts on food security, this study highlights the importance of addressing other constraints on the competitiveness of value chains. USAID (2011) suggests that action could be taken to improve the management of existing regional storage infrastructure. Also, the implementation of a regional warehouse scheme or the provision of increased access to credit for storage facilities and equipment could allow traders to take advantage of economies of scale and invest in equipment and storage facilities.

As in the trucking sector, there also seems to be a lack of competition and transparency in the private warehousing sector. Even if this is not further analysed in the USAID (2011) study, we can easily guess that the same issues of low productivity and cost coverage prevail.

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 food

insecurity. These silos not only have a high potential to prevent post-harvest losses, but they also allow small and medium-sized farms to more safely and efficiently store surpluses for off-season sale when prices are more attractive, thus increasing households' incomes. Looking at the effect of the installation of such silos in four Latin American countries by the Swiss Agency for Development and Cooperation from 1983 to 2003, Bokusheva et al. (2012) find that from 2005 to 2009 the households that adopted silos experienced a significantly higher improvement in their food security and well-being compared to non-adopters.

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

3.4 SPS institutions and inspection infrastructure

Both quality and reputation matter to the capacity to access and sustain exports to developed countries markets (Easterly and Reshef, 2010; Jouanjean, 2012a; Jouanjean et al., 2012). The capacity to provide both evidence of quality and a consistent supply of quality products is therefore a prerequisite to ensure the sustainability of agricultural exports. Many developing countries' SPS agencies lack the adequate expertise and physical infrastructure to conduct proper SPS inspections and controls.

Donors have already supported the creation of many standards-setting and -controlling agencies in developing countries. However, partly because of limited budget allocation from the governments of these countries, many such agencies 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 trade. The World Bank (2012) provides the example of Tanzania, where the Plant Health Service of the Ministry of Agriculture, Food Security and Cooperatives 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 computers. This is a problem not only for exports, but also for the protection of domestic plants and animals, because there is little capacity to prevent and monitor pests and diseases outbreak within the country. For maize in West Africa, the cost of control procedures such as obtaining an SPS-standards certificate or paying a bribe at the border was calculated by USAID (2011) at $40 per tonne. Jouanjean (2012b) also provides examples of the difficulty that many developing countries face when attempting to develop the proper institutions and infrastructure necessary to enforce SPS regulations and implement pest-risk assessments – both of which are often mandatory for accessing both developed and 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 that Ghana was encountering when implementing pest-risk assessments, either in the context of new foreign market access or when protecting its own agriculture from imported pests. These difficulties included:

- weak human and equipment resources, resulting in incomplete pest records
- poor and unreliable data generation
- difficulties in implementing surveillance and obtaining access to adequate information resources

- limited expertise and capacity for export inspection and certification
- limited research support by government
- out-dated SPS legislation and inappropriate regulatory frameworks.

Because of the lack of proper institutions and infrastructure, some importing countries directly establish temporary inspections infrastructure in the exporting country. For instance, the US has agreed to import mangoes from India on condition that both countries implement a cooperation and trust fund agreement to pay for the cost of pre-clearance activities in India. If the US pre-clearance system can be described as a way to create and facilitate trade, the corollary is that countries' capacity to enter and implement a cooperation agreement with the US for pre-clearance becomes a determinant of access to the US market. One can easily see that for many budget-constrained governments in developing countries such agreements can be particularly burdensome to implement.

Therefore, investment in soft infrastructure – standards-setting institutions and infrastructure, extension services, and other rural services infrastructure constraining the increase in agricultural productivity and the efficiency of the agricultural value chain – seems as important as reducing pure transport costs through the construction of rural roads.

4 Conclusion

The recent literature provides new evidence about the impact of various kinds of rural infrastructure on agricultural productivity, trade and poverty. It confirms that rural roads are important for poverty reduction, and can increase agricultural productivity and market access. However, there is little evidence that roads have a direct impact on the poorest communities, and studies suggest that such communities rather benefit from indirect job creation.

International trade analysis provides evidence that road quality is important for trade. However, from the point of view of their impact on welfare, evidence shows that low-quality rural feeder roads are more essential to poor rural households than high-quality roads for truck. Yet, if roads, and in particular rural feeder roads, still appear to be an indisputable necessity, they are nonetheless not sufficient to guarantee any graduation 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 that decrease the competitiveness of agricultural value chains. Soft infrastructure is crucial in fostering agricultural productivity and helping subsistence farmers to overcome some of the constraints they face 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 Aid for Trade 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 Aid for Trade initiative shifting focus toward the issue of developing-country producers' inclusion in global value chains, the scope of the initiative should more than ever be opened up to the private sector. Indeed, as 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 be a powerful tool in the identification of key infrastructure investments that should not be foregone by the Aid for Trade community.

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