ROADS- A WAY OUT OF POVERTY?

A TWO REGION, GENERAL EQUILIBRIUM PERSPECTIVE FOR VIETNAM*

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Abstract

There are good reasons to emphasise road investments in developing countries. Road infrastructures are directly or indirectly related to all eight Millennium Development Goals (MDG). Furthermore, the effective protection caused by the lack of roads is for many countries considerably higher than those caused by tariffs, hampering the empowerment of people to benefit from trade liberalisation and economic growth. In addition, earlier problems of infrastructure projects have been identified and a stronger emphasis on accountability, capacity building and decentralisation can be expected to contribute to more effective and efficient capital allocation. Infrastructure investments require comprehensive appraisal methods. Traditional tools, so far, have taken a project or sector perspective that did not capture economy-wide effects. In addition to these inter-sectoral effects, investments in infrastructure can have long-term impacts on national capital formation, the government budget and foreign trade balance. To address this research gap, this paper puts forward a two-region computable general equilibrium (CGE) model with post-simulation poverty analysis. Two major results- one general and one country specific- emerge from this analysis. CGE models have the ability to incorporate several dimensions of infrastructure investments that are missed by traditional analyses. By comparing investments in urban and rural roads in Vietnam we find that especially rural road investments can contribute to economic growth and poverty reduction.

Keywords: roads, poverty, multi-region, CGE

JEL: I32, J61, R13

1. Setting the stage

Regional development objectives are increasingly included in poverty reduction strategy papers (PRSP) to address the growing divergence within countries and to promote growth in disadvantaged regions (WORLD BANK et al., 2003; UN, 2002). Within these plans, renewed focus is on the importance of *physical infrastructure* in the development process. Empirical evidence supports the importance of infrastructure. It has the potential to contribute to growth and poverty reduction by kick-starting regional economies, attracting private investments and increasing productivity (WORLD BANK, 1994; DFID, 2002; JBIC, 2003). However, large-scale infrastructures investments in roads, water systems or power plants have often not benefited the poor due to bad governance, the neglect of environmental and maintenance issues and the bias towards large-scale capital projects ("white elephants") (DFID, 2002; OECD, 2005).

Increasing attention on infrastructure investments can be expected for three reasons. First, infrastructure is directly or indirectly related to all MDGs. Second, bilateral and multilateral trade liberalisation led to a substantial decrease in tariffs over the last two decades. As a result, the effective protection caused by transport costs is for many countries considerably higher than those caused by tariffs. Third, earlier problems have been identified and a stronger emphasis towards accountability, capacity building and decentralisation in infrastructure can contribute to a more effective and efficient capital investments in this sector (WORLD BANK, 1999B; LIMAO AND VENABLES, 2001; DFID, 2002; JBIC, 2003).

A renewed focus on assessing impacts of investments and a pro-poor orientation of infrastructure also requires sound feasibility and appraisal tools. Ideally, these take financial, economic, social and environmental impacts into account. However, socio-economic impacts alone have multiple dimensions, which make comprehensive assessments a difficult task. Traditional tools for socio-economic assessment of the impacts of public investments take a project or sector perspective and do not capture economy-wide effects. The *Incremental Capital to Output Ratio (ICOR)* is used as an aggregate indicator of how efficiently public capital is invested. It is the amount of additional investment required to increase gross domestic product (GDP) by one unit or the reciprocal of the marginal product of capital. This aggregate indicator can also be used to assess the sectoral or regional performance of public investments. Given the availability of data, ICOR can thus provide important insights into the performance and efficiency of public investments. However, it can not provide insights into distributional and poverty impacts of investment projects. A more micro-level appraisal tool to infrastructure investments are *cost benefit analyses* (CBA). In fact, they are standard tools and appraisal agencies often rely on standard indicators such as the net present value (NPV) or the internal rate of return (IRR) (WORLD BANK ET AL., 2004). Project appraisals have become more comprehensive over time and look beyond financial aspects. Especially for large-scale infrastructure projects they consider environmental, cultural, social and other impacts. DEVARAJAN et al. (1995) argue that traditional project appraisal fail to take private sector responses and fiscal impacts into account. A major drawback of these tools is thus their inability to take macroeconomic and indirect impacts into consideration.[1] The understanding and quantifying of indirect impacts, however, can contribute to the designing of such large-scale infrastructures in order to achieve their full development potential.

Econometric analysis in the field of infrastructure and its impacts on the economy extends the conventional production function and makes use of cross-country and cross-regional data. According to this approach, output is not only a function of labour, capital and land, but also by infrastructure. FAN et al. (2004) extend this approach in the context of rural infrastructure and poverty by modelling poverty in a simultaneous equation system. Poverty is a function of growth in agricultural production, changes in rural wages, growth in rural non-farm employment and changes in agricultural prices. The second equation models agricultural production as a function of conventional inputs and public investment variables such high yielding crop varieties, irrigation, roads etc. Finally, rural wages and non-farm employment are modelled as functions of growth in agricultural production as well as public investment variables (FAN et al., 2004). It is thus possible, to get insights into the relative impacts of different infrastructure variables on economic growth and poverty. Such analyses can give important insights into specific relationships and causal links. However, econometric studies using such production or cost function approaches are not able to capture indirect effects.

All three analytical tools presented above are partial models. ICOR, CBA and econometric models can not capture general equilibrium effects. An economy-wide model is needed in the landscape of economic tools for public investment assessments.

This might lead to a situation, where infrastructure investments are evaluated to be poverty reducing and growth enhancing from a sector perspective. However, if negative effects from the same investment occur in other sectors, economy-wide impacts are certainly lower and might even be negative. To prevent such misleading results and to capture indirect effects, a macro-economic model is required. Such type of model can incorporate indirect effects between economic sectors and can account for linkages between infrastructure investments and macroeconomic variables such as the government budget and the trade balance. Due to rising regional disparities and spatially diverging impacts of investment projects, such a macro model should ideally also incorporate region-specific features. In addition, such a multi-region macro-economic model should be complemented by a micro model that can capture distributional and poverty impacts. The resulting combined macro-micro model can be expected to contribute to a better understanding of underlying mechanisms and economy-wide effects of infrastructure investments. It can thus also contribute to a more effective and efficient allocation of infrastructure investments. This paper concentrates on road infrastructure investments and take Vietnam as the case study country.[2]

Vietnam is an emerging economy and one of the fastest growing countries in the world (THE ECONOMIST, 2006). At the same time, the country has shown a rapid reduction in poverty rates over the last two decades. Its status as a World Trade Organisation (WTO) accession candidate confirms Vietnam's increasing integration into the world economy and marks another milestone in the transition from an inward-looking agriculture-based economy to an outward-looking economy, which is increasingly dominated by the industry and services sector. This rapid development makes the country not only a success story among developing countries but also an interesting case study. On the one hand, it can provide insights into the drivers of growth and poverty reduction. On the other hand, it features many challenges and problems that are characteristic for transition economies. High growth came at the price of widening regional disparities and stagnating economic development in disadvantaged regions. The virtuous circle created in the export oriented growth centres find their counterparts in the mountainous regions of Vietnam, which are trapped in vicious circles of poverty. The north-western mountainous province of Son La is a typical example for a disadvantaged and poor region. This province will constitute one of the regions of the model, which is analysed in this paper.

The *first objective* of this paper is to present a multi-region macro-micro model to evaluate its potential contribution to the assessment of road investments. The *second objective* of the study is to analyse the economic impacts of roads in Vietnam in general, and their poverty reducing potential in a lagging northern mountainous province in specific. The paper proceeds as follows: Section 2 puts forward a general framework of infrastructures and poverty. Section 3 presents the model.. Section 4 defines the road simulations. Section 5 highlights selected results and section 6 concludes.

2. Infrastructure and poverty: a general framework

To account for the diversity of impacts, Figure 1 puts infrastructure investments into an economy-wide context. It includes macroeconomic conditions, governance, production activities, factors, households, commodity markets and the rest of the world. Even though the following model can easily be adopted to all types of infrastructures, I explicitly focus on roads in this paper. The discussion proceeds from the top to the base of Figure 1, starting from the government budget and macroeconomic policies (I) to the household level (IV).

- (I) Government budget, macroeconomic policies, governance and institutions

Sound and stable *macroeconomic conditions*, institutions and market policies as prerequisites for successful development have led to sustainable economic growth (WORLD BANK, 2000). The size of the budget per se is a major determinant of public investment opportunities in various kinds of physical infrastructure and service provision. The size of the budget is determined by fiscal policies, interest rates, performance of state owned enterprises etc. and thus ultimately by the performance of the economy as a whole. Sound macroeconomic policies and stability are essential prerequisites for PPG, including low inflation, limited budget deficits and openness to trade (WORLD BANK, 1990; WORLD BANK, 2000; KRAAY, 2004). Fewer consensus exists on more specific tasks such as the level of state intervention in the exchange rate regime, the mix between tax increases and expenditure cuts and sustainable levels of imbalances and deficits (KLASEN, 2005). Regarding financial markets, it seems favourable for developing countries to take a gradual approach towards liberalisation. Such a gradual approach allows for the development of a domestic banking and financial market system prior to full liberalisation (BMZ, 2005A).[3] Regarding *trade liberalisation*, it is increasingly acknowledged that in the short- and medium run losers from liberalisation do exist and that they should be compensated (WINTERS, 2000; BMZ, 2005B). To give the poor the opportunity to share the benefits of trade liberalisation, intra-country-trade barriers, such as high transaction cost, have to be reduced, human capital investments have to be made and the negative bias against agriculture in developing countries as well as in the trade policies of industrialised countries have to be reduced (BMZ, 2005B).[4] *Good governance* at the national and local level is crucial for successful infrastructure investments. Accordingly, the 2005 Vietnam Development Report (VDR) documents the importance of decentralisation, the participation of local governments and authorities and the fight against corruption in the context of infrastructure (WORLD BANK et al., 2004). The quality and responsibility of decision-making at the different hierarchical level and the collaboration between them are important determinants of good governance (TACOLI, 2003).

- (II) Regional and sectoral dimensions

From a *sector perspective*, several studies find that agricultural growth has been more pro-poor than industrial growth, implying that particularly rural roads can contribute to poverty reduction. The *regional dimension* of infrastructure investments is gaining in importance, since intra-country disparities in many countries such as China, Vietnam, India, Russia, Mexico etc. are on the rise. Geographically disadvantaged regions in developing countries have some common characteristics: these include geographic remoteness, unsustainable population growth, low quality and quantity of agricultural land, a lack of physical infrastructure, unfavourable climatic conditions, low human capital endowments and problems with governance.

The role of infrastructure for disadvantaged regions has been examined in several studies. JACOBY (2000) finds in a case study for Nepal that rural infrastructure can contribute much to economic development and bring about substantial benefits for poor households. FAN and CHANG-KANG (2005) underline the importance of investing in low-quality and rural roads. They find for China that rural roads will generate larger marginal returns, reduce poverty and regional development disparities more per yuan invested than investments in high-quality roads. HEIDHUES and SCHRIEDER (1993) find that access to credit is significantly affected by the permanent accessibility of villages. From the geographic perspective it becomes clear that strategies that aim at PPG and poverty reduction have to focus on regions, where the poor live. Infrastructure can contribute to reducing spatial disparities by increasing productivity and reducing transaction costs.

- (III) Factors of production and production activities

In general, the poor tend to be less endowed with all factors of production, including human capital (expressed as unskilled labour), land and capital. For the factor dimension of infrastructure it is also useful to differentiate between direct and indirect impacts: access, quality and cost to infrastructure for factors of production activities, where the poor are directly engaged or access, quality and cost to infrastructure for factors of production activities, where the poor are indirectly affected. Both the direct and the indirect effects cause at least two *impacts on production*: activating the regional economy and attracting new investors who will set up new businesses. The creation of new economic opportunities and the productivity enhancement of existing economic activities play a significant role in development. In the case of rural economies experiencing investment in large-scale infrastructure, the intensification and specialisation of agricultural production and the expansion of off-farm business activities to remote areas, such as trading, small-scale manufacturing and tourism, can contribute to an economic development (JBIC, 2003). However, the supply-side effects occur generally in the longer term – the earliest when the project is implemented – and often in broader spheres, which makes their benefits less obvious and the evaluation more difficult (WORLD BANK, 1994; DFID, 2002).

- (IV) Households and commodity markets

The nature and impact of infrastructure investments for poverty reduction depends upon the *characteristics of the poor*. For agricultural households, income is largely determined by the access and availability of production factors, inputs and prices. For non-farm households, labour income is determined by employment opportunities and wages. Five channels can be identified through which these households are affected by economic infrastructure such as roads: commodity price changes and the availability of goods, factor prices changes and employment effects, growth effects caused by changes in incentives for investment and innovation, vulnerability and short run risks to negative external shocks and government income and redistribution (WINTERS, 2000).[5] Since households tend to be more specialised in income than in expenditure, factor markets might be the most important linkage between trade and household welfare (REIMER, 2002; HERTEL AND REIMER, 2004). The main channels captured by the general equilibrium models through which households are affected by LSI are commodity price changes and factor income changes. Due to the fact that the poor spend a large part of their income on food and are by the same time often producers of food, lower food prices have a particularly large effect. A decrease in prices leads to higher real incomes of households and lower production costs for local activities. This stimulates demand for locally produced goods and services and alters their comparative advantage. The size of these impacts clearly depends upon the nature of the consumption basket and market participation. For poor subsistence farmers for examples, impacts might be small. On the consumption side, this is due to the fact that such households rely to a large extent on home-produced food and that their consumption basket includes few traded items. On the income side, subsistence production activities are extensive and thus use few imported intermediate inputs. That means that without structural changes towards market-orientation and intensification, these groups are not likely to share the benefits of improved infrastructure.

The CGE model presented in the following section mathematically links these sectors, factors and institutions in order to quantify the impacts of selected infrastructure investments scenarios.

3. The model

The two-region CGE model presented in this section uses a provincial SAM and a national SAM as its database. The regional SAM has been build by BREISINGER AND HEIDHUES (2004) and BREISINGER AND ECKER (2005) The SAM represents the year 2002 and comprises 28 provincial production activities, 32 commodities, 4 factor types, 6 household groups and private and public enterprises. The government receives income from 2 tax accounts and the rest of the world includes national and international transactions. Regarding factor markets, the SAM distinguishes between capital as well as skilled and unskilled labour. Table 1 shows the SAM disaggregation in detail. The documentation of the 2002 Son La SAM is

available on the author's website.
http://www.unihohenheim.de/i3v/00065700/88701041.PDF. The national SAM was assembled for Vietnam (VIETSAM) at the Central Institute for Economic Management (CIEM) and covers 97 activities, 97 commodities, 14 factors of production and 16 household types. In addition, it contains 3 enterprises, accounts for the government, savings and investments. Information on foreign trade flows is disaggregated by 88 trading partners. The construction and detailed structure of the SAM is documented in TARP et al. (2002).

In a first step, both SAMs are aggregated to the same dimensions, including the number of activities, commodities, factors and institutions to facilitate the merging process. In the case of this paper, I choose a 30 sector, 4 factor, 2 households and 3 enterprises disaggregation.[6]. The SAMs represent different base years (2000 and 2002). It has thus to be considered to make adjustments in one of the SAMs to account for inflation, economic growth and structural changes.[7] However, each attempt to adjust the two databases to the same year bears the risk of undermining their consistency. In the present case, where REGSAM only accounts for a marginal share of VIETSAM data, the trade-off between temporal and internal consistency favours the use of the original SAMs. Merging the region and the ROC SAM results in a 60 activity, 30 commodity, 6 factor and 6 institutions SAM. The resulting SAM serves as a basis for the CGE model described below. It is based on the standard CGE set up and used at IFPRI (LÖFGREN et al. 2002). Following the tradition of DERVIS et al. (1982), LÖFGREN et al. (2002) have complemented the model with features such as household consumption of self-produced and non-marketed goods, explicit treatment of transaction costs for nationally and internationally marketed goods and the ability of one commodity to be produced by different activities and vice versa. All of these features are of particular relevance for policy analysis in developing countries.

The two-region Vietnam CGE explains all the payment flows between activities, commodities, factors and institutions in a set of linear and non-linear equations (Figure 2). Activities, factors and households are region-specific, while the commodities are traded on a single national market. Each region thus has its local production activities, factors and households and the major linkage of the model is the interregional (intra-country) trade on a perfectly competitive commodity market. Linkages in the factor markets represent the flows of capital and the movement of labour and capital across regions. The assumption of the basic model is that the factor markets are segmented, effectively excluding the possibility of migration.

- Production and factor markets

Regional producers maximise profits according to prices and a production technology, which at its top level uses a Leontief production function to make the decision between the substitution of intermediates and factors of production. The second choice of how to combine different factors of production, i.e. value-added is modelled as a constant elasticity of substitution (CES) function; aggregate intermediate inputs are determined by a Leontief function of sectoral intermediate inputs. There is a one to one mapping between production activities, except for the case, where no regional production of the respective commodity takes place. In both cases, aggregate intermediate inputs are determined by a Leontief function of sectoral intermediate inputs. The behaviour of producers and institutions and the set up of the macroeconomic balances in scenarios are equal. To account for un- and underemployment in the unskilled labour market, each activity can employ any desired quantity at its fixed and activity specific wage. It assumes labour mobility among activities and serves as an indication of the impact of a more flexible labour market. The elasticity of substitution between factors and the elasticity of substitution between aggregate factor and intermediate inputs reflect the levels of substitutability. For the skilled labour market it is assumed that factors are fully employed and wages flexible. This best reflects the situation in the study region, which is characterised by un- and underemployment among low skilled workers. Labour can not upgrade skills and cannot migrate between the regions. The elasticity of substitution between factors and the elasticity of substitution between aggregate factors and intermediate inputs are set at 1.2 and 0.8 in all simulations to ensure comparability.[8] Sensitivity analysis for the present model and its impact on the results are discussed in section 4. Capital is assumed to be fully employed and mobile in all scenarios.

- Commodity markets and trade

Each commodity can be produced by different regional activities. The national market is thus served by regionally produced goods and services. In the case of regionalised production, output from regional activities is imperfectly substitutable due to differences in e.g. timing, quality and geographic location. The first step in Figure 3 thus shows that a CES function is used to aggregate production output from different regions (QXAC (ROC, REG)). In a second step, aggregate national output (QXD) is divided between national sales (QD) and exports (QE) to ROW. A constant elasticity of transformation (CET) is used to determine this decision. Aggregate producers maximise their sales revenue for any given output level, subject to imperfect transformability between exports and domestic sales. The small country assumption is used for the case of exports, implying that demand from ROW is indefinitely elastic at constant world market prices. Prices received by producers are adjusted by transaction costs and trade taxes. A composite commodity (QQ) is demanded from region-specific households and intermediate consumption as well as from aggregate government consumption and investment. Demand for this composite is determined by the assumption that domestic consumers minimise costs subject to imperfect substitutability, captured by a CES function. The Armington assumption is used for the specification of trade flows (ARMINGTON, 1969). Sectoral exports are determined by CET[9] and sectoral imports by CES functions.[10] The model assumes a uniform substitutability between REG and ROC products and the ROW. CET is set at 1.5 for primary and secondary sectors and to 0.5 for services. CES are set at 3 for the primary and secondary sectors and to 0.5 for services. The lower values for the service sector, are due to the fact that services are mostly local in their nature, and tradability therefore lower. [11] The consumer price index (CPI) is the model numeraire. The CPI is one measure of inflation, and nominal changes in prices and incomes have to be interpreted in the context of the CPI. Table 2 summarises the trade and production related parameters.

- Institutions

A RHA is chosen for the model. Geography is implicitly included by the regional focus of the model. In addition, each region's households are split into rural and urban. The regional households receive income from the factors of production, transfers from the government and remittances from the rest of the country/rest of the world. On the expenditure side, household consumption differentiates between products, purchased at market prices and self-produced items valued at producer prices. Total household consumption is allocated across market and home-consumed commodities according to linear expenditure system (LES) demand functions. Expenditure elasticities by commodity and household are derived from IFPRI (2003). Elasticities for agricultural products classified by rural and urban were estimated by IFPRI, 2003 for the northern mountainous region and used for parameter specification. The following elasticities are used for agricultural products: rice: 0.100 for rural and 0.344 for urban households, coffee and tea: 1.185 for urban and 1.167 for rural households, other crops are set at unity for all households, livestock: 1.096 for urban and 1.302 for rural households, fishery: 0.699 for urban and 0.931 for rural households, processed food: 1.123 for urban and 1.370 for rural households. For industrial and service products it is assumed that they are uniform across commodities and set at unity for all households. Furthermore, households pay ad valorem taxes and save. Savings of all households are fixed. The Frisch parameter, which determines the subsistence spending of households, is set at -2 for all households. The national government receives its income from regional taxpayers and from the rest of the country. Taxes are fixed at ad valorem rates and government savings are flexible. Government consumption is fixed in real terms and government transfers to households and enterprises are indexed to the CPI.

- Macroeconomic settings

The macroeconomic closure rules determine how an equilibrium is achieved in the trade balance, the government balance and the savings-investment account. In the present model, the real exchange rate is fixed, which allows the trade balance and foreign savings to vary. Savings drive investment. Savings of households and enterprises are fixed. The quantity of each commodity in the investment basket is multiplied by a flexible scalar to equal investment costs and savings value. Savings-driven investments, which practically mean that marginal savings propensities are fixed, investment demand quantity adjustment factors and absorption shares for investment demand are flexible. For the government closure, all tax rates are fixed and government savings are flexible.

- Transaction costs

The CGE model includes transaction costs in the prices paid by demanders, reflecting the cost incurred for moving the commodity from the domestic supplier to the demander, or in the case of exported goods and services from the producer to international markets. In the following equation, the parameter $icd_{c'c}$ describes the trade input of c per unit of commodity cp produced and sold domestically.

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_c * icd_{c'c} \quad (1)$$

where, PDD_c denotes the demand price of domestic non-traded goods, PDS_c the supply price for commodity c produced and sold domestically, PQ_c the price of composite good c. Demand for transportation and trade is a fixed coefficient per unit of sold goods or services. A reduction of $icd_{c'c}$ thus leads to lower demander prices and benefits producers (through lower costs for intermediate goods) and consumers of the respective commodities.

- Factor productivity

In several scenarios, FP is changed exogenously. Equation 6 states that the quantity of value added for each activity is a CES function of disaggregated factor quantities. Simulations involving a change in FP therefore allow each factor unit to produce one unit more value added in the production process. The formalisation is as follows:

$$QVA_{\mathbf{a}} = \alpha_{\mathrm{a}}^{\mathrm{va}} * \left(\sum_{f \in F} \delta_{fa}^{va} * QF_{fa}^{-p_a^{va}} \right)^{-\frac{1}{p_a^{va}}} \tag{2}$$

where $QVA_{\mathbf{a}}$ is the quantity of aggregate value added, $\alpha_{\mathrm{a}}^{\mathrm{va}}$ is the efficiency parameter in the CES value added function, δ_{fa}^{va} the CES value added function share parameter for factor f in activity a, QF_{fa} the quantity demanded of factor *f* from activity *a*, and $-p_a^{va}$ is the CES value added function exponent.

Practically, a one percent increase in the simulation enables each unit of the production factor to produce one percent more value added. There is no substitution between factors and intermediates, since I use a Leontief function at the top of the technology nest. FP increases change the productivity of all factors including labour, capital and land. Substitution between factors in this process is determined at the bottom of the technology nest by the elasticity of substitution. The mechanisms through which markets are influenced by FP increases depend on demand elasticities, trade elasticities and factor market equilibrating rules. A FP increase in activity *a* will lead to increased output in this sector. Depending on domestic and international demand, prices for commodity *a* decrease, but due to higher quantities sold, labour income rises. Rising income leads to an increase in income and consumption and thus a reduction in poverty. These trends can be expected to be more poverty reducing, the more poor people are employed in the targeted sector or enjoy the benefits of relatively higher incomes.

To take these intra-group distributional patterns into account and to analyse changes in poverty levels that stem from exogenous shocks induced by infrastructure investments, I use an macro-micro approach. This approach allows for connecting the CGE model with more disaggregated household data. Base run and simulation results of the CGE model are used to calculate this micro-accounting model.[12]

4. Road simulations

Motivation

Roads are vital drivers of growth and the adequacy of road infrastructure plays a key role in the participation and empowerment of remote regions in the successful development of

Vietnam. An aggregate view on road infrastructure in Vietnam reveals that Vietnam has an average road density of 0.63 km per square km of surface, which is about the average of other ASEAN countries (WORLD BANK et al., 2004). Paved roads account for 84 percent of all roads and the number of communes without access to district centres has been reduced to 2.6 percent (WORLD BANK et al., 2004). This is the result of an increasing share of public spending that was allocated towards road networks. Investments grew at 13.5 percent per annum (FAN et al., 2004). However, investments into interregional and rural road networks and other large-scale infrastructure systems are still not sufficient and fail to meet international quality standards (SRV, 2003). In addition, higher investments in roads mean lower expenditure allocated for recurrent expenditures. This leads to a neglect of operation and maintenance costs (FAN et al., 2004). Given the limited resources, the CPRGS thus emphasises the upgrading of existing road networks while assessing new projects according to their impact socio-economic development (SRV, 2003).

Road density and economic development in Vietnam are clearly interlinked. Statistics show that 85.9 percent of communes without access to a road network were poor; in the Northern Mountains poor communes without road access accounted for 18.5 percent of the total poor communes (FAN et al., 2004). For Son La province 8 out of the 201 communes are not accessible by bus (GSO SL, 2003A).[13] In addition, seasonally impassable roads, an insufficient number of physical market places, market information and a lack of a sound legal framework for buyers and sellers function as trade barriers and increase transaction costs. This leads to substantial price differences of traded goods compared to other regions of Vietnam (CUONG, 2005).

To address the strong disparities in both infrastructure endowments and poverty in urban and rural areas it is important to differentiate between rural and urban road investments. This differentiation can give insights into the impacts of the respective road types and add an economy-wide perspective on this issue to the existing literature.

Simulations

Improvements in road infrastructure are implemented through two different mechanisms, the reduction of transaction costs and increases in FP. To account for the strong rural/ urban disparities, I differentiate between investments in rural roads and urban roads by assuming that rural roads benefit mainly the agricultural sector and urban roads benefit mainly the industrial sector. In both cases, a reduction of transaction costs will benefit producers through lower costs of production and consumers through lower demand prices. Simulation TRADE1 takes a national perspective and reduces domestic transaction costs of agricultural commodities by 20 percent, while simulation TRADE2 reduces transaction costs of industrial and manufactured goods by 20 percent.

Simulation TRADE3 and TRADE4 look at the impacts on the regional level. To implement the simulations, I follow the empirical evidence that improvements in physical infrastructure increase the FP. Again, to compare investments in rural and urban roads, TRADE3 looks at the impacts of FP increases in agricultural production activities, while TRADE4 examines the case of manufacturing and industry. An overview of the simulations is provided in Table 8. The comparison of results within the categories can be expected to give interesting insights not only in the size of impacts but also to the direction of impacts. This is due to the fact that they use different approaches of implementing the simulation. Finally, it is important to note that the objective of these simulations is to capture the economy-wide impacts of investments. Quantifying the cost of reducing transaction costs and increasing FP is beyond the scope of this thesis.

In general, the model reacts to these shocks as follows. The reduction of transaction costs lowers the costs for moving the commodity from domestic suppliers to the demanders, or in the case of exported goods from the producer to international markets. A reduction of transaction costs thus leads to lower prices and benefits producers (through lower costs for intermediate goods) and consumers of the respective commodities. Higher productivity leads to higher output, which meets increased domestic demand of consumers. Since both the domestic producer and consumer benefit, overall impacts on the domestic economy are expected to be positive. Losers in this process could be the service providers of transactions, including traders, transportation services etc. This sector might shrink, if the net effect of additionally created trade and the forgone income caused by more efficient transactions is negative. In addition, domestic economic growth effects depend on changes in the current account balance. Since the model assumes a fixed nominal exchange rate, the trade balance is the major determinant for the balance of payments.

5. Results

5.1 Baseline

Tables 4 and 5 present major features of the two model regions, which make up the Vietnamese economy. Production output, GDP and trade are analysed by four aggregate sectors. The ROC economy is dominated by services and industry, which contribute 37 percent and 32 percent to GDP, respectively. Agriculture contributes 26 percent to GDP and 16 percent to total ROC output. The contribution of construction to GDP has an almost equal share in ROC and REG and stands at 6 and 7 percent of both regions' GDP, respectively. Regarding trade, 38 percent of total industrial production is exported. At the same time, most of the imports occur in this sector, leading to a negative trade balance in industrial goods. The trade balance of agriculture is positive. 16 percent of agricultural production is exported, as compared to 2 percent of output value that is imported. Construction is not internationally traded.

GDP of the REG economy stood at 2.516 trillion VND or 165 USD per capita, which is considerably below the nationwide average of 437 USD and an average figure for Hanoi of 945 USD (GSO, 2004). As compared to the secondary sector-dominated structure of the ROC economy, agriculture plays the most important role in the contribution to GDP in REG. The economy is simply structured with a low level of diversification in production sectors. In 2002, 59 percent of the total GDP was generated by the primary sector (agriculture, forestry and fishery), 11 percent by the secondary sector (industry and construction) and 31 percent by the tertiary sector (services).[14] The structure of the REG economy will be further investigated and analysed in section 5.1.2.

Transaction costs play a vital role in the functioning of domestic markets and the participation in the global economy. The model accounts for domestic transaction costs and for transaction costs for exported goods, respectively. Table 6 shows that the share of transaction costs in Vietnam for exported goods as compared to the share of transaction costs of domestically traded goods is lower for both agricultural and industrial commodities. Especially the difference for industrial goods is substantial. The share of transaction cost for exports accounts for 8 percent of the total export value as compared to a 14 percent share for domestic transaction costs of domestically marketed output. This might be counterintuitive at first glance. However, it can be explained by the fact that a large share of exported industrial goods is produced around the three export hubs Hanoi, Danang and Ho Chi Minh City. All three exports centres are located close to the sea, have good export infrastructure and therefore comparably lower transaction costs.

For agricultural commodities, domestic transaction costs for export and domestic use are almost similar (9 percent and 10 percent, respectively). This is in line with the general characteristics of the transportation network. Once the agricultural commodities are moved out of rural areas with generally weak infrastructure, transaction cost to export hubs are on average as high as to other domestic markets.

Son La has 942,000 inhabitants compared to 77,685,000 of Vietnam's total population (GSO SL, 2003A). In 2002, 89 percent of the inhabitants were identified as rural and 11 percent as urban. Table 7 indicates that disparities between urban and rural households in the province are distinct. In the baseline, annual per capita expenditure of urban households is about 2.4 times higher than of rural households. Accordingly, poverty rates among rural households are much higher. While 63 percent of all rural households are below the poverty line, only 2 percent of their urban counterparts are below that line.

Substantial differences also exist in the depth of poverty, measured by the poverty gap indicator. While the distance between expenditure levels and the poverty line for urban households was 112,000 VND, the poverty gap of rural households was almost 5 times higher. Differences also exist in household size. It varies from 2 to 18 household members, with a clear tendency of larger household sizes in rural areas. Finally, subsistency levels are clearly higher in rural areas. While 95 percent of goods and services consumed by urban households originate from markets, this share for rural households is only 57 percent. The relatively high share of home produce and a low share of imported goods in the consumption basket of households among rural households should therefore buffer the direct impacts of price changes of traded commodities.

5.2. Simulation results

Table 9 shows macroeconomic changes for the simulations TRADE1 to TRADE4. Table entries indicate percentage changes as compared to the baseline. The comparison of macroeconomic indicators between rural and urban roads on the national level (TRADE1 and TRADE2) reveals that size and direction of impacts vary strongly. Rural roads lead to an increase in private consumption and spark investment. This leads to a rise in the domestic demand and the domestic price index and a lower PPP of the VND compared to foreign currencies. The trade deficit grows, since real exports decrease and real imports increase. Imports increase due to an increase of domestic demand and domestic prices for non-tradeables. Urban roads have a positive influence on the trade balance and reduce the deficit. This effect is due to both increasing exports and decreasing imports. Real household consumption increases by about the same percentage than under the rural road simulation. However, real investment is shrinking, which can be explained by the increase of the real exchange rate combined with lower foreign savings. Government consumption remains constant, while government savings slightly increase. Revenues from imports and direct taxes only slightly change. Simulations TRADE3 and TRADE4 look at the impacts of roads from a one-region perspective (REG), which explains the generally much lower national macroeconomic impacts and impacts on ROC sectors and households. Only rural roads in REG have sizeable impacts on the national level. Total absorption, household consumption, investment and imports increase, other macroeconomic indicators remain unchanged.

These macroeconomic changes are not substantial and only of limited importance for the analysis of structural changes and poverty impacts of roads. There are other mechanisms at work such as trade policies, exchange rate policies and capital market regulations that have much more influence on these macroeconomic indicators. This depicts a certain dilemma: incorporating other policy developments into infrastructure analyses would contribute to the understanding of the overall macroeconomic development. But at the same time, such an approach would not allow to isolate infrastructure induced impacts. However, taking these effects into account provides a sound basis and a good starting point for further analysis of changes in economic sectors.

The sector perspective confirms the positive impacts of roads and provides further interesting details between the impacts of rural and urban roads (Tables 10 and 11). As can be expected, rural roads lead to a strong output and GDP growth in agriculture. This growth is substantially higher in REG, indicating that the marginal benefit of rural roads in poor agriculture-based regions is higher. Agricultural growth leads to increasing real income of the rural population. Due to this substantial increase in purchasing power and the high income elasticities of demand for primary products, the demand for agricultural products grows. This increasing demand it partly satisfied through a substitution between exports and domestically marketed goods. This decrease in exports is not sufficient to satisfy demand and is accompanied by an increase in agricultural imports. However, it is not only the agricultural sector that benefits from rural roads.

Industry is growing at almost the same pace as agriculture in REG, although less in ROC. Construction shows strong growth in the case of rural roads and a modestly recessive trend in the case of urban roads.[15] Besides the construction sector in the case of urban roads, services can not benefit from the reduction of transaction costs and even show decreasing outputs. This is due to two reasons: the database structure and the model structure. Even though service activities use trade and transportation services as inputs, no information is available for national and international transaction costs of services. Consequently, the model does not account for potential benefits for the service sector from roads. The actually incurred losses stem from the fact that reduced transaction costs lead to reduced demand for related services. This result is a rather short- to medium term interpretation caused by the static nature of the model. In the longer run, benefit for services should occur through an increasing demand of other sectors and institutions that benefit from the road investments.

In sum, rural roads lead to higher aggregate GDP growth, which is about twice as high as in REG as that induced by urban roads. This result is surprising for two reasons: first the industrial sector's output value is about three times higher than in the agricultural sector. One might thus expect stronger impacts of lower transaction costs. Second, initial domestic transaction costs as a share of output for industrial goods are higher as the costs of agricultural goods. The marginal benefit of a percentage reduction of these transaction costs could therefore be expected to lead to higher overall effects. However, results indicate that marginal benefits of improvements of urban roads are smaller than those of rural roads indicating that the initial quality and quantity determines the size of the impacts.[16] Strong intersectoral effects and strong linkages of agriculture with the rest of the economy particularly in REG lead to the effect that industrial sector is growing by the same rate in the rural road simulation than in the urban road simulation. On the contrary, urban roads do not benefit the rural sectors to same extent. This finding underlines the importance of taking economy-wide effects into account. The following two simulations aim at substantiating these findings. In the following simulations, roads are simulated by increasing the FP of rural and urban production activities in REG (Tables 12 and 13).

These simulations confirm the results of TRADE1 and TRADE2. Rural roads induce higher economy-wide growth and lead to higher multiplier effects. However, a closer look at the results reveals some differences. Due to the relatively small size of the regional economy, roads in REG do not have big impacts on ROC sectors or foreign trade. Only the strong growth in agriculture caused by rural roads slightly changes the agricultural trade balance by increasing national exports and reducing imports. In addition, there are substitution effects in the construction sector, where the ROC construction sector is taking shares from the REG construction.

Sectoral changes in the region are more pronounced than in TRADE1 and TRADE2. Rural roads lead to almost 30 percent GDP growth in the agricultural sector. However, the regional industry stagnates, which can be explained by the fact that major intermediate consumption goods of agricultural production such as fertilizer, fuel and pesticides are not produced in REG. In addition, many investment and consumer goods, e.g. machinery, chemicals, are imported to REG. On the contrary, due to its local nature, the service sector can benefit from rural roads and substantially contribute to overall growth. Urban roads lead to GDP growth of about 13 percent in the industrial sectors. Also construction and services gain from the performance of the industrial sector. The relatively bad performance of agriculture compared to services is based on the local nature of most services, which are often related to urban areas. Industrial growth does therefore not seem to trickle down to rural areas. A reason for this could be the relatively small size of the sector, which does not allow for relevant intersectoral effects. Consequently, total regional GDP grows only modestly. This result suggests that broad growth has to come from agriculture, since both aggregate growth and trickle down effects are substantially bigger.

A major channel through which economic shocks are transmitted to households are factor markets. For the rural population in REG, unskilled labour markets are of special relevance since they receive about 82 percent of their income from that factor. In addition, most of the rural people are farmers and generate income from land. Table 14 shows that rural roads generally have positive impacts on all factor categories. Results confirm that unskilled labour and land benefit most from rural roads. The impacts on REG unskilled factor markets in TRADE1 and TRADE3 are quite similar, ranging around an increase of 10 percent and are major drivers of poverty reduction. Urban roads have the strongest effect on skilled labour at the national level, followed by unskilled labour. Urban roads on the regional level equally benefit skilled and unskilled labour, followed by capital and land. For both rural and urban REG households expenditures increase from roads. The benefits range from 3.4 to 3.8 percent in the case of urban and 5.6 to 11.5 percent in the case of rural households. As compared to that, urban roads lead to expenditure changes of between 1.6 and -0.2 for urban and 3.1 to -0.2 for rural households. The slightly negative impact of TRADE4 stems from the small GDP decrease in agriculture, which can not be compensated by growth in the other sectors.

In ROC, however, rural and urban households benefit almost equally from rural roads and urban roads. In REG, rural households have higher percentage increases in expenditure in all simulations. This result is somewhat surprising at a first glance. An explanation for this outcome can be found in linkages in labour markets, especially rural unskilled labour employed in urban industrial sector contribute to this outcome. In addition, rural households benefit from the growth in the agricultural sector. However, due to their substantially lower initial expenditure, the absolute changes are generally lower for rural households. The real changes in welfare can best be analysed by taking poverty effects into account. It should be noted that initial poverty among REG households were distinctively different between urban and rural households. While the poverty rate among urban households is at 2 percent, 63 percent of rural households were classified as poor. The poverty gap for rural households was almost five times higher, 112,000 VND per capita for urban households as compared to 537,000 VND per capita for rural households. It should be kept in mind that the poverty impact analysis only refers to REG.

Despite these positive impacts, the examination of the poverty gap index reveals some worrisome results with far reaching policy implications. The impacts on the poverty gap are much lower than on poverty incidence - the changes range between an increase of 0.5 percent to a decrease of 5.5 percent. The poverty gap remains very high and in all cases above 500,000 VND per capita. This means that roads can contribute to lifting a substantial number of people out of poverty, but these tend to be people who live close to the poverty line. For the large majority of the poor, the relatively small absolute gains do not contribute much to improve their economic situation. Sensitivity test are presented in the annex.

6. Conclusions

Several conclusions can be drawn from this study. First, multi-region CGE models have the ability to incorporate several dimensions of infrastructure investments that cannot be captured by traditional appraisal tools. The major advantage lies in the incorporation of *intersectoral and interregional multiplier* effects. It can, therefore, be assumed that the stronger these effects are, the more useful is the use of economy-wide models. Second, considering *macroeconomic effects* in the model provides a sound basis and a good starting point for a comprehensive analysis of changes in economic growth and poverty. However, not each single large-scale infrastructure project might require a specific CGE model. Rather, lessons on the direction and size of impacts of certain investments might be transferable across regions and countries. Third, rural roads lead to higher aggregate output and GDP growth, which is about twice as high as that induced by urban roads. This effect is in the lagging region as compared to the rest of Vietnam, indicating that the marginal benefit of rural roads in poor regions of Vietnam is higher. Rural roads can induce additional economic growth of between 4 and 13 percentage points in Son La province, which translates into rural poverty reduction of between 11 and 14 percentage points. Fourth, positive economy-wide and poverty reducing impacts of *roads* emphasise the importance of *connecting disadvantaged regions* to national and international markets. They have to play a vital part in national strategies that aim at reducing regional disparities and poverty. In the case of Vietnam, public investments in rural roads are crucial to prevent the further increase in regional disparities and to create opportunities for the rural poor to gain from growth in the national growth centers and the WTO accession of the country.

Tables and Figures

Table 1: 2002 Son La Micro SAM disaggregation

Activities/ commodities	**Financial Services**
Rice	Science and Technology
Coffee	State Management
Tea	Education and Training
Other Crops	Health
Livestock	Other Services
Forestry	Factors/Value Added
Fishery	Skilled Labour
Mining	Unskilled Labour
Food Processing	Capital
Textiles, Garment, Leather	Households
Forestry Products	Urban Kinh Household
Publishing and Printing	Urban Ethnic Minority Household
Other Goods	Rural Kinh Household
Cement	Rural Thai Household
Other Construction Material	Rural Hmong Household
Metal	Other Rural Household
Chemicals	Enterprises
Machinery	State owned Enterprise
Electricity, Gas, Water	Private Enterprise
Fuel and Lubricants	Taxes
Agricultural Services	Value Added Tax
Construction	Direct Taxes
Trade and Repair	
Restaurant and Hotel	Government
Transport	Savings and Investments
Post and Communication	Rest of the World (ROW)

Table 2: Overview of model parameters (trade and production)

	Trade elasticities		**Substitution elasticities between production factors**	**Substitution elasticities between factors and intermediates**
	CES	CET		
Primary and secondary sectors	3.0	1.5	1.2	0.8
Services	0.5	0.5	1.2	0.8

Table 3: Overview of household characteristics for micro accounting

	Population in Son La province	Households in VHLSS (2002)	Household size	Average expenditure per capita	Exp. max	Exp. min
Households total	941901	350	6.7	2.223		
Urban	103764	103	4.2	4.465	19.117	1.849
Rural	838137	247	5.8	1.893	6.866	0.321

Source: GSO, 2003; GSO, 2004

Notes:

Exp. max: maximal expenditure per household in sample

Exp. min: minimal expenditure per household in sample

Table 4: Structure of the economy by region and sector (in trillion VND)

	Output		GDP		Trade	
	ROC	REG	ROC	REG	E	I
AGR	155.7	1.9	100.2	1.5	25.3	3.5
IND	440.2	0.3	124.1	0.1	165.9	182.9
CONSTR	87.0	0.6	21.8	0.2		
SERV	261.3	1.1	143.4	0.8	33.8	25.1
TOTAL	944.3	3.9	389.6	2.5	225.0	211.5

Notes:

E: Exports

I: Imports

GDP: at factor cost (real)

Table 5: Structure of the economy by region and sector (as share of total)

	Output		GDP		Trade	
	ROC	REG	ROC	REG	Ei/Yi	Mi/Yi
AGR	0.16	0.49	0.26	0.59	0.16	0.02
IND	0.47	0.08	0.32	0.04	0.38	0.42
CONST	0.09	0.14	0.06	0.07	0.00	0.00
SERV	0.28	0.29	0.37	0.31	0.13	0.10
TOTAL	1.00	1.00	1.00	1.00	0.24	0.22

Notes:

Ei/Yi: share of exports in total value of output in sector i

Mi/Yi: share of imports in total value of output in sector i

GDP: at factor costs (real)

Table 6: Overview of transaction costs by sector

	MM-E billion VND	MM-D billion VND	MM-E/E	MM-D/Y
AGR	2502	14844	0.09	0.10
IND	14396	56693	0.08	0.14

Notes:

MM-E: transaction costs for exports

MM-D: domestic transaction costs

MM-E/E: transaction costs for exports as a share of total exports

MM-D/Y: domestic transaction costs as a share of total domestic production

Table 7: Poverty characteristics of households

	Population (in 1000)	**Average household size**	**EXP** (1000 VND)	**HC/TC** (%)	**POV** (%)	**POVGAP** (1000 VND)
Urban	104	4.2	4.465	0.05	0.02	112
Rural	838	5.8	1.893	0.43	0.63	537
Total households	942	5.6	2.223	0.34	0.55	

Notes:

EXP: expenditure per household

HC/TC: home consumption of self-produce as a share of household consumption

POV: headcount poverty rate

POVGAP: poverty gap

Table 8: Overview of road simulations

Scenario 1: **Investments in road infrastructure**	
TRADE1	Investment in rural roads: 20 percent reduction in domestic and export transaction costs for agricultural commodities
TRADE2	Investment in urban roads: 20 percent reduction in domestic and export transaction costs for industry, manufacturing and construction
TRADE3	Investment in rural roads: 20 percent FP increase in regional agriculture
TRADE4	Investment in urban roads: 20 percent FP increase in regional industry, manufacturing, transport and trade

Table 9: Macroeconomic changes of road investment scenarios (percentage real change from base)

	TRADE1	TRADE2	TRADE3	TRADE4
Absorption	4.1	1.1	0.1	0.0
Household consumption	2.3	2.4	0.1	0.0
Investment	9.3	-1.4	0.2	0.1
Government consumption	0.0	0.0	0.0	0.0
Exports	-2.3	1.9	0.0	0.0
Imports	2.4	-0.9	0.1	0.0
PPP real exchange rate (LCUs per FCU)	-0.9	0.4	0.0	0.0
Domestic (non-tradables) price index	0.9	-0.4	0.0	0.0
Private (household + enterprise) savings	-0.1	0.0	0.0	0.0
Foreign savings	2.5	-1.5	0.0	0.0
Trade deficit	2.2	-1.6	0.0	0.0
Government savings	0.2	0.1	0.0	0.0
Import tax revenue	0.0	-0.1	0.0	0.0
Direct tax revenue	0.0	0.1	0.0	0.0

Table 10: Changes by economic sector TRADE1 (percentage real change from base)

	Output		GDP		Trade	
	ROC	REG	ROC	REG	E	I
AGR	1.5	5.9	1.4	5.8	-4.4	6.2
IND	0.5	4.8	-0.2	4.3	-2.0	2.7
CONST	9.2	13.4	9.2	13.4	0.0	0.0
SERV	-2.6	-1.1	-2.3	-1.0	-2.1	-0.4
TOTAL	0.6	4.9	0.0	4.2	-2.3	2.4

Table 11: Changes by economic sector TRADE2 (percentage real change from base)

	Output		GDP		Trade	
	ROC	REG	ROC	REG	E	I
AGR	0.6	4.0	0.5	4.0	-4.5	10.7
IND	4.7	4.1	2.7	4.2	3.4	-1.1
CONST	-1.4	-0.5	-1.4	-0.5	0.0	0.0
SERV	-2.9	-0.7	-2.6	-0.5	-2.2	-0.3
TOTAL	1.4	2.0	-0.1	2.3	1.7	-0.8

Table 12: Changes by economic sector TRADE3 (percentage real change from base)

	Output		**GDP**		**Trade**	
	ROC	REG	ROC	REG	E	I
AGR	0.0	27.7	0.0	28.4	0.5	-1.0
IND	0.0	1.0	0.0	0.6	-0.1	0.1
CONST	0.2	-0.2	0.2	-0.2	0.0	0.0
SERV	0.0	-1.0	0.0	-1.0	0.0	0.0
TOTAL	0.0	13.3	0.0	16.4	0.0	0.1

Table 13: Changes by economic sector TRADE4 (percentage real change from base)

	Output		**GDP**		**Trade**	
	ROC	REG	ROC	REG	E	I
AGR	0.0	-0.1	0.0	-0.1	0.0	0.1
IND	0.0	12.9	0.0	14.9	0.0	0.0
CONST	0.0	11.7	0.0	11.7	0.0	0.0
SERV	0.0	8.0	0.0	7.6	0.0	0.0
TOTAL	0.0	5.0	0.0	3.6	0.0	0.0

Table 14: Changes in factor income (percentage real change from base)

	TRADE1	**TRADE2**	**TRADE3**	**TRADE4**
LUSK-ROC	5.3	2.3	0.1	0.1
LUSK-REG	9.8	-0.6	8.4	3.7
LSK-ROC	3.9	2.8	0.1	0.0
LSK-REG	6.9	-0.6	5.0	3.7
CAPI-ROC	4.9	2.1	0.1	0.1
CAPI-REG	5.6	-1.3	2.1	2.9
LAND-ROC	6.6	0.9	0.1	0.1
LAND-REG	9.3	0.1	9.7	2.8

Notes:

LUSK: Unskilled labour

LSK: Skilled labour

CAPI: Capital

LAND: Land

Table 15: Changes in real household expenditure and poverty

		EXP		POV		POVGAP	
		ROC	REG	%	No.	(1000 VND)	%
Urban	TRADE1	2.1	3.4	2.2	0.0	47.3	-57.6
	TRADE2	2.4	1.6	2.2	0.0	81.4	-27.1
	TRADE3	0.1	3.8	2.2	0.0	39.7	-64.4
	TRADE4	0.0	-0.2	2.2	0.0	115.5	3.4
Rural	TRADE1	2.5	5.6	54.4	71448	536.9	0.1
	TRADE2	2.4	3.1	58.4	38472	533.7	-0.5
	TRADE3	0.1	11.5	49.5	112668	507.2	-5.5
	TRADE4	0.0	-0.2	63.0	0.0	539.4	0.5

Notes:

EXP: Real expenditure change (as percent from base)

POV: Poverty. % expresses the new poverty rate under the respective simulation. No. indicates changes in the number of poor people.

POVGAP: Poverty gap. % shows the percentage change in the poverty gap as compared to the base poverty gap

Figure 1: Theoretical framework for economy-wide impacts of infrastructure investments

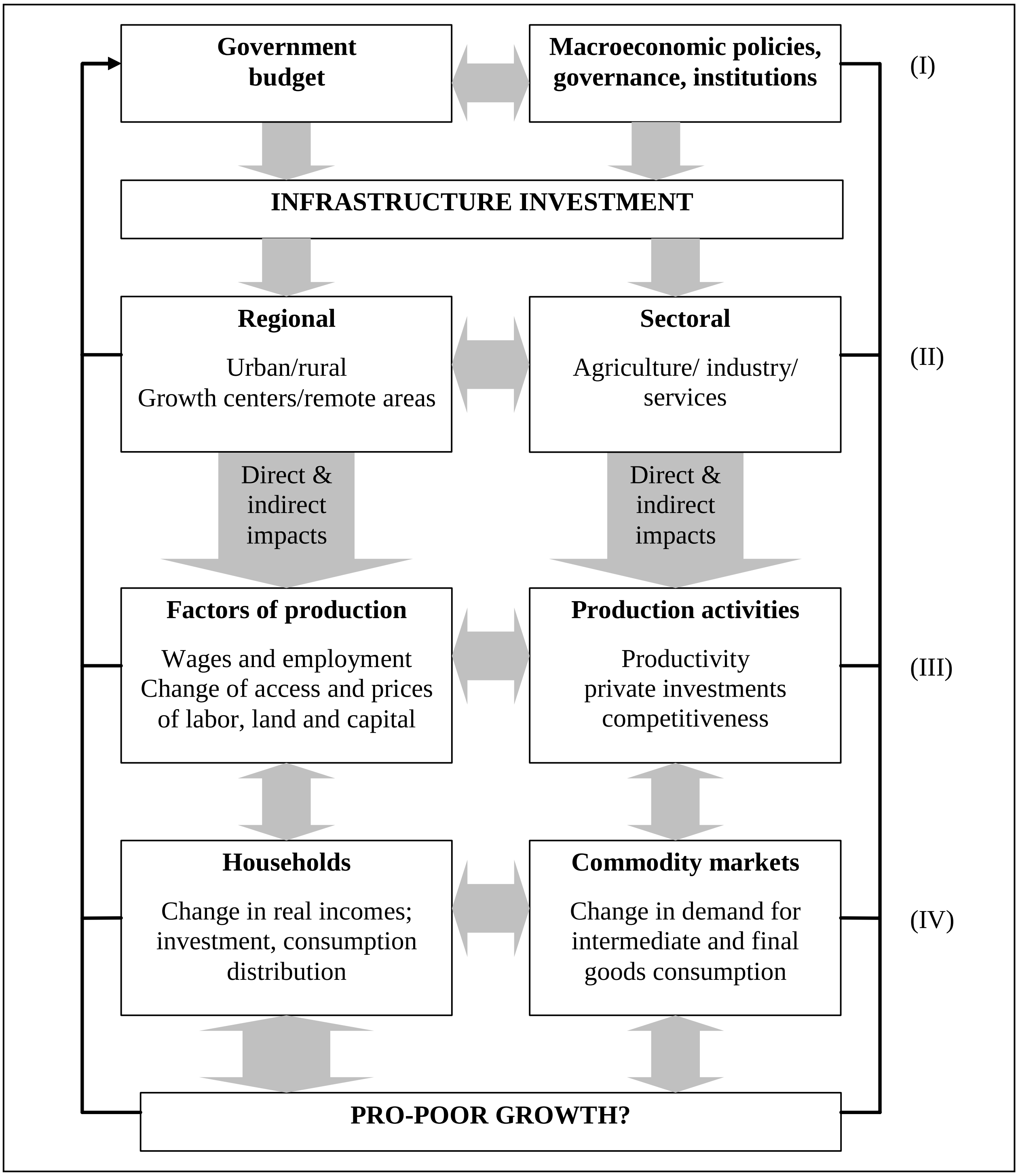
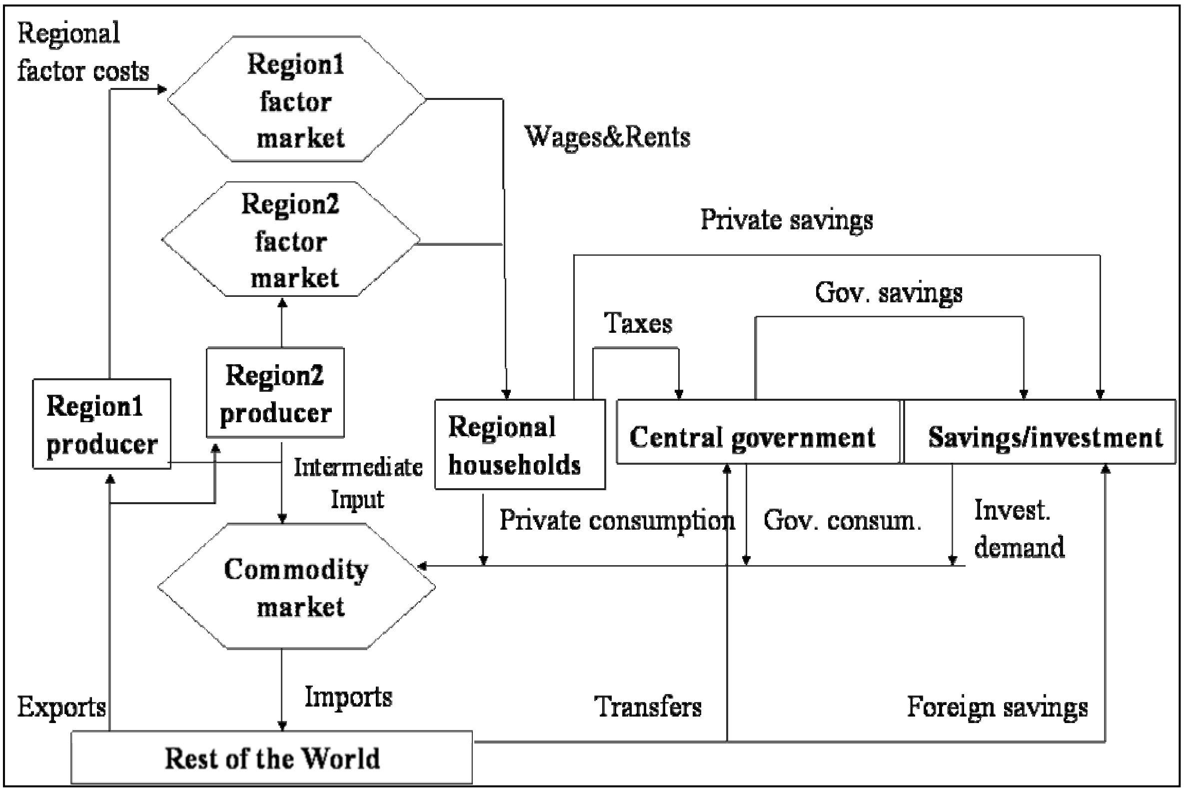
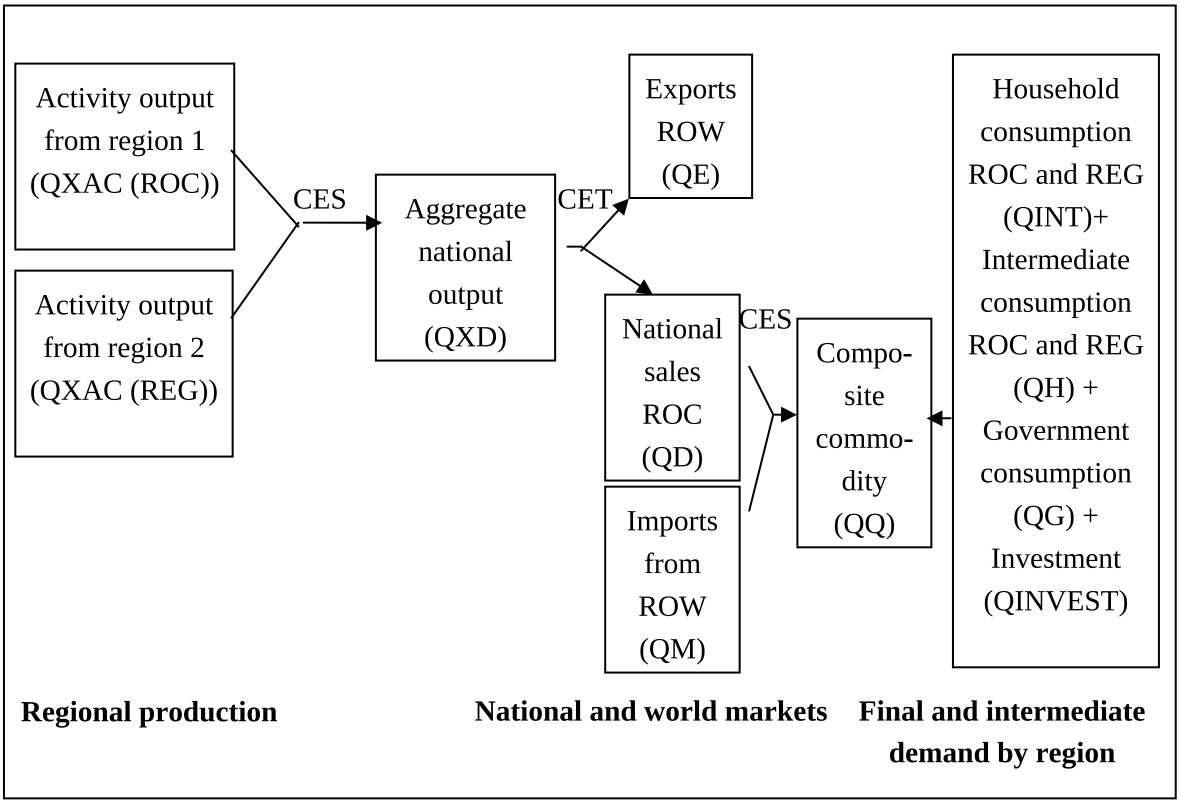


Figure 2: Flowchart of two-region Vietnam CGE model



Source: own figure, based on LÖFGREN et al., (2002)

Figure 3: Flow of marketed commodities: 3-market and region-specific production activity



Source: own figure, based on LÖFGREN et al., (2002)

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Annex: Sensitivity analyses

Assessing the role of regionally segmented factor markets

The major linkage in the CGE model between the two regions is the common commodity market. Major regional features include the differentiation between production activities and institutions. In addition, each region has its own factor markets, effectively prohibiting migration of labourers and the movement of capital between the two regions. It can thus be argued that this assumption of factor immobility does not properly reflect reality and might distort results of the model. To test the validity of this argument and to estimate the impact of inter-regional factor mobility versus segmented factor markets, Table 16 presents the results of a modified version of the CGE model. The difference between the models is that the new version of the model allows for perfect mobility of labour and capital between the regions. Besides testing the robustness of the model, this test can provide useful insights into the role of factor mobility and give indications of accelerator effects of the previously presented investments and interventions scenarios.

Table 16 presents the results of the comparison of changes in GDP growth in both regions in the case, where factors are regionally segmented (FACREG) and alternatively the case of nationally perfect factor mobility (FACMOB) across all ten simulations.

Table 16: Comparison of original model results with model of interregional factor mobility (percentage change)

	Changes in real GDP (percent)					
	ROC			REG		
	FACREG	FACMOB	Diff	FACREG	FACMOB	Diff
TRADE1	-0.05	2.93	2.98	4.18	6.27	2.09
TRADE2	-0.06	3.18	3.24	2.31	4.86	2.54
TRADE3	0.00	0.06	0.06	16.37	15.67	-0.71
TRADE4	0.00	0.01	0.01	3.64	3.71	0.07

Notes:

FACREG: Regional factors markets are segmented

FACMOB: Factors are mobile across regions

Diff: Difference between FACREG and FACMOB (in percentage points)

* AVERAGE: The average total difference between the two cases is calculated as the arithmetic mean value of percentage changes across the simulations.

The difference in results between the two models across all four simulations is below one percentage point in GDP growth on average. This aggregate result suggests that interregional mobility of factors does only have limited impacts on model results and confirms the robustness of the model. In addition, the aggregate view shows that labour mobility has positive effects on model outcomes in most of the cases.

However, a more simulation-specific analysis reveals differences between model outcomes in several cases. Especially the nation-wide simulations TRADE1 and TRADE2 show substantially differing GDP growth rates. GDP growth in all two cases is about twice as high in the model with mobile factors compared to the segmented factor market model. In TRADE1 and TRADE2, differences in growth rates of 2.1 to3.2 percent points occur in REG and ROC between FACREG and REGMOB. In both cases, mobile factors contribute to higher growth, implying that the benefits of both urban and rural roads can be altered by interregional factor mobility. However, it seems that ROC benefits more from mobile factors, effectively taking over some of the growth otherwise occurring in REG. In all simulations except TRADE1 and TRADE2, differences between FACREG and FACMOB range between -0.71 and +0.6 percentage points and can therefore be assumed not to distort the results of the model.

Three conclusions can be drawn from this analysis: first, the model is robust regarding the assumption of regionally segmented factor markets in the case of region-specific simulations. Second, in the case of nation-wide simulations, factor mobility does substantially enhance economic growth in both regions, implying that growth induced by infrastructure investments can be accelerated by increased flexibility in factor markets. Third, it appears that neither totally segmented nor fully mobile factor markets reflect reality well. An extension to the model could therefore attempt to model the behaviour of interregional factor flows.

Robustness of elasticities

The elasticity parameters used in the model are exogenous. Their values in this study are inspired by several country case studies that use the IFPRI CGE model (LÖFGREN et al, 2002). To test the sensitivity of the model, several elasticities are changed to get a feeling for the model and to judge, whether results are robust. These elasticities concern the substitution between factors of production, the substitution between domestically produced and foreign goods, including the Armington function for imports and the CES function for exports, and the LES demand elasticities. I change the value of each of these elasticities by 20 percent in each direction, i.e. their base value is reduced and increased. This is done one by one and for four simulations. Table 17 and 18 show the results of these tests. Column two indicates the percentage change in the respective scenario under the initial elasticity values. The subsequent columns report the percentage changes of the respective scenario induced by the changed elasticity value, which are indicated at the top of the table. Values that differ by less than 0.1 percentage points are omitted from the table.

Table 17: Sensitivity analysis for TRADE1 (in percent)

	Result TRADE1	**PRODELA1**		**SIGMAQ**		**SIGMAT**		**LESELA**	
		0.9	1.5	3.6	2.4	1.8	1.2		
Output									
ROC	0.6		0.7			0.7			
REG	4.9	4.5	5.2		4.8		4.8	4.7	5.0
Trade									
E	-2.3	-2.0	-2.7			-2.6	-1.9		
I	2.4	2.1	2.6		2.2	2.5	2.2		2.3
Consumption									
HHUr-ROC	2.1						2.0		
HHRu-ROC	2.5		2.4						
HHUR-R	3.4	3.5	3.3		3.3	3.3		3.2	3.5
HHRu-R	5.6	5.3	6.0	5.7			5.7	5.4	5.8

Notes:

PRODELA1: Elasticity of substitution between factors

SIGMAQ: elasticity of substitution between imports and domestic output in domestic demand

SIGMAT: elasticity of transformation for domestic marketed output between exports and domestic supplies.

LESELA: LES demand elasticites

Table 18: Sensitivity analysis for TRADE2

	Result TRADE2	**PRODELA1**		**SIGMAQ**		**SIGMAT**		**LESELA**	
		0.9	1.5	3.6	2.4	1.8	1.2		
Output									
ROC	1.4	1.2	1.5				1.3		
REG	2.0			1.7	2.4	2.1	1.9	1.9	2.1
Trade								0.0	0.0
E	1.7	1.2	2.1	1.8	1.5	1.3	2.0		1.6
I	-0.8		-0.9	-1.4	-0.2	-0.7	-1.0		-0.9
Consumption								0.0	0.0
HHUr-ROC	2.4			2.3			2.3		
HHRu-ROC	2.4	2.5			2.5	2.5			
HHUR-R	1.6	1.7	1.5	1.4	1.9				1.7
HHRu-R	3.1	3.0	3.2	2.8	3.4	3.0	3.1	3.0	3.2

Table 19: Sensitivity analysis for TRADE3

	Result TRADE3	**PRODELA1**		**SIGMAQ**		**SIGMAT**		**LESELA**	
		0.9	1.5	3.6	2.4	1.8	1.2		
Output									
ROC	0.0								
REG	13.3	13.1	13.5					13.0	13.5
Trade								0.0	0.0
E	0.0								
I	0.1								
Consumption									
HHUr-ROC	0.1								
HHRu-ROC	0.1								
HHUR-R	3.8	3.9	3.7					3.6	4.0
HHRu-R	11.5	11.3	11.8	11.6		11.6	11.5	11.1	11.9

This analysis shows that the model results are fairly robust to changes in elasticities across the simulations. In many cases, the deviation between initial model results and the changed values is below 0.1 percentage point. The most sensitive elasticity parameter appears to be the substitution between factors. However, a 20 percent change of the initial values does not substantially change results. The differences range between 0.5 and -0.4 percentage points. In the case of unskilled labour, which constitutes a large share of total factor income in Vietnam, high underemployment and fixed wages contribute to this relatively modest impact and the robustness of results. As can be expected, lower values tend to decrease the size of the initial change, whereas increased substitutability increases the effects.

Trade elasticities are less sensitive on average. Most deviations occur in the flows of exports and imports and range between -0.3 and +0.4 percent points. More open borders tend to increase the expenditure across all household groups, indicating that more open markets can accelerate growth and household incomes of road investments.

Demand elasticities are fairly insensitive to changes. Most of the deviation from initial results is below or around 0.1 percentage points. The direction of changes clearly follows the model structure and is supported by intuition: higher demand elasticities lead to more consumption per unit of real income increases. This in turns leads to increased domestic demand and the associated multiplier effects.

By looking at the results from a regional perspective, it can be concluded that the region-specific simulations TRADE3 and TRADE4 are much less sensitive to parameter changes.[1] In the case of demand elasticities and trade elasticities, this is caused by the single commodity market and the small size of the REG economy. This does also play a role for the insensitivity of factor substitution elasticities, however, the low values also confirm the robustness of the model.

In conclusion, it can be noted that deviations of the chosen values for the different exogenous elasticity parameter only modestly affect the results of this study and confirm the robustness of results. In addition, increasing openness to trade and flexibility of factor markets have a clear tendency to increase and accelerate trade, production output and household welfare.

[1] Results for TRADE4 are not reported, since all changes are below 0.1 percent except for LESELA increase, which leads to a decrease of consumption of HHRu-R by 0.1 percentage point.

Endnotes

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[1] See FITZGERALD (1978) for a comprehensive discussion of appraisal tools for public sector investments, GITTINGER (1982) for agricultural project assessment and WCD (2000) for financial, economic and distributional analysis of dams.

[2] See Breisinger (2006) for a CGE application to a large-scale hydropower plant.

[3] The negative effect of the liberalisation of the capital account is caused by the increase in volatility. Since the poor tend to be relatively less capable to insure against risk, they might tend to disfavour fierce liberalisation. Furthermore, structural effects tend to weaken the poor, which necessitates state action to antagonise undesirable effects (BMZ, 2005A).

[4] Anti poor bias exists in many developing countries through anti-agricultural price bias. This is often caused by exchange rate manipulation or domestic measures to artificially reduce food prices for urban consumers (see e.g. EASTWOOD AND LIPTON, 2001).

[5] Winters formulates these impacts on households for the case of trade liberalisation. However, due to the comparable price effects, they are equally applicable to large-scale infrastructure investments, especially roads.

[6] For the secor mapping between the 112 commodities documented in the national I/O table and the national SAM to 30 sectors see Appendix 2.

[7] This would practically mean to build a new SAM, either a national SAM for 2002, or a 2000 SAM for Son La province.

[8] These values are chosen in accordance with a standard setting in IFPRI's model.

[9] Elasticity of transformation for domestic marketed output between exports and domestic supplies (SIGMAT in IFPRI Standard model).

[10] Elasticity of substitution bw. imports and domestic output in domestic demand (SIGMAQ in IFPRI Standard model).

[11] These value are also oriented on standard values used in CGE modelling (see e.g. LÖFGREN et al., 2002).

[12] The general steps suggested by AGÉNOR et al. (2004) are followed to build such a micro-accounting module. The study uses a poverty line calculated, which is documented in the VDR 2000 (WORLD BANK, 1999A).

[13] More exact data on road accessibility and road condition for the province was not available. According to personal experience there is definitely scope for road improvement and the reduction of transaction costs.

[14] Annual GDP of the Son La Province in 2002: Total: VND 2,502 billion; primary sector: VND 1,426 billion; secondary sector: VND 292 billion; tertiary sector: VND 793 billion (GSO SL, 2003A).

[15] This finding is counterintuitive, since a decrease in transaction costs through improved roads is associated with road construction works. However, this decrease might be caused by the private rather than the public construction and due to generally shrinking total investments in TRADE2.

[16] This finding is confirmed for the impacts of roads on access to credit in Cameroon (HEIDHUES and SCHRIEDER, 1993).