

INFRASTRUCTURE & TRADE IN SUB-SAHARAN AFRICA: *COSTS AND BENEFITS OF REFORMS*

1 Introduction

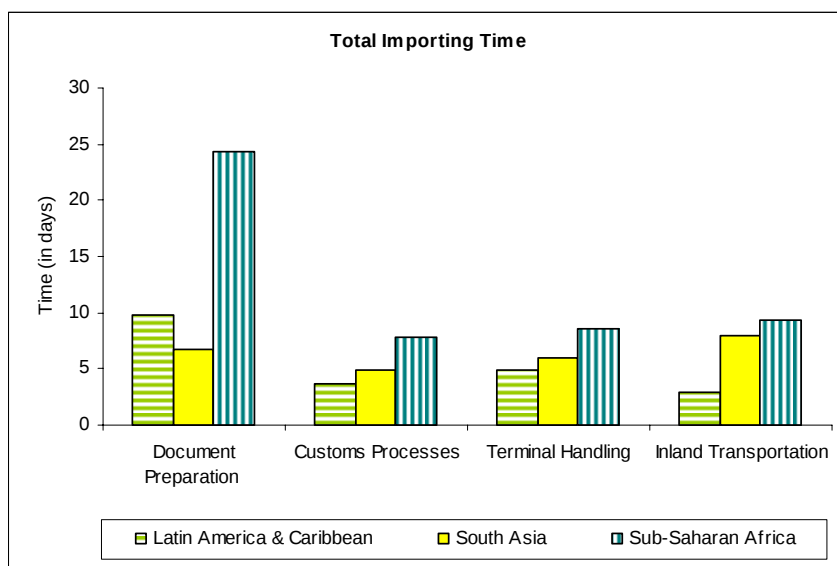
Developing countries continually under-invest on trade facilitation-related efforts even though economic models estimate that significant trade gains can be attained by expanding trading capacities. A recent literature on trade frictions characterizes the inadequacies of trading infrastructure and inefficiencies in procedures as a major impediment to international trade flows (Limao & Venables, 2001; Hummels, 2001; Francois and Manchin, 2007). Economic research predicts that developments of trade-related logistics and facilities have large prospects for export growth and diversification (Dennis & Shepherd, 2007; Djankov, Freund and Pham, 2006). Yet, many developing regions such as Sub-Saharan Africa lag far behind in taking initiatives for investments and as a result suffer high trade costs that inhibit market potentials (Wilson & Perez, 2009; Njinkeu, Wilson and Fosso, 2008). What is missing in existing models that cannot tell a complete story of why some countries invest more than others? Economic models primarily estimate benefits of trade facilitation without accounting for costs of investments. Then the question becomes, can we provide structure to cost-side story to better predict deterrents of investments? Using a combination of partial and general equilibrium models this paper constructs a unique approach to estimate benefits of trade facilitation net of opportunity costs of investments. The newly-designed framework is used to analyze economy-wide impacts of infrastructure investments in Sub-Saharan Africa by assessing both costs and benefits of reforms.

Inadequate trading facilities go hand-in-hand with strikingly low global market participation in Sub-Saharan Africa (SSA). SSA's exports comprises of about 2.1% of total global exports, while that of EU accounts for more than 41.3% and East Asia about 25.2%¹. The key for the successful growth of the newly-industrialized economies of East Asia, such as China and Hong Kong, has come through obtaining greater shares in global export markets. To target export expansion as a development platform, SSA must first address various trading inefficiencies that inflate export prices, which can have an even more severe effect on low-valued commodities that in fact comprises of a large portion of exports.

¹ Author's calculations from GTAP Database v7, 2004

To bring facts to the table, Figure 1 compares time taken for various import-related procedures in SSA with other developing regions. It takes a total of 52 days in SSA countries on average to complete procedures related to imports, which is larger than any other developing regions (for example, 42 days in South Asia, and 28 days in Latin America). The graph further illustrates that SSA lags behind in all aspects from document preparation and customs procedures to terminal handling and inland transportation. SSA is worse off in document preparation (24 days) and customs (8 days) suggesting a large portion of costs simply accrue from artificial inefficiencies created in institutional structures. The network of land infrastructure constituting of roads and highways are of poor quality in SSA requiring an average of 9 days in transportation. These costs are even larger for the 15 landlocked countries relying largely on poorly maintained land transportation networks, as well as logistics and transit rules and restrictions in other countries. Transportation costs in landlocked countries constitute 14% of the value of exports, relative to 8.6% in coastal countries; for some countries the proportion of transportation costs can be as high as 77% of total trade value (ARIA I, 2004). Unfortunately, in a world of intense competition in trading markets lengthy time and uncertainty in delivery have large bearings on prospects for trade as substantiated by research studies.

Figure 1: Time for completing Import-related procedures



The goal of this paper is to develop a framework where investments on infrastructure are costly. Given the need for a comprehensive assessment of economic impacts, the GTAP-based CGE framework developed by Hertel and Tsigas (1997) becomes ideal for this analysis. The standard model is extended by building a separate capital investments sector that improves trade-related technology. Since building capital requires economic resources, there are large opportunity costs of public investments. The existing structure is further extended by supplementing the model with additional data and parameters to characterize the quality of border efficiency across countries and their impacts on trade. The various elements are put together to estimate costs of reforms in SSA, and predict net benefits from trade gains that are relevant to policy decisions in SSA.

The rest of the paper is organized in the following way. First, a few studies are discussed to highlight the contribution of the paper in the relevant field of literature. Section 2 consists of the analytical framework which describes data and model developments to design an ideal scenario for analysis of trade facilitation reforms in SSA, and potentially other developing regions. Section 3 develops a dual experimental set-up to simulate the effects of infrastructural investments in SSA in Period 0, and estimate benefits accrued in Period 1. This section also provides predictions of model results and provides a comparative scenario to analyze costs and benefits of reforms. The last section concludes.

2 Background

The first obstacle to conduct research on the effects of trading infrastructure is the availability of data. Trade facilitation covers a wide spectrum of aspects related to creating an improved trading environment at the borders, which may include improving processes of customs and security clearance, capacity building through increasing the number of berths and ports, enhancing the quality of roads connecting major cities to the borders, developing electronic business facilities, and a wide variety of other aspects. Given the eclectic nature of the topic in hand, researchers use a variety of methodologies to quantify these border barriers and evaluate their impacts on trade. The development of new data that are cross-country comparable played a major role in the development of this research. Wilson, Mann and Otsuki (2003) are the first to develop a set of proxies to measure different aspects of border logistics for many countries, namely port efficiency, customs environment, regulatory environment and e-business facilities for 75 countries.

These are used in econometric models to evaluate the elasticities of trade with respect to each of these quality measures.

Other researchers have extended this work by using similar indices to measure trade facilitation to assess regional impacts. Soloado, Wilson and Mejía (2006) study impacts on Mexican exports; Francois and Manchin (2007) use data on institutional quality and infrastructure panel data within a selection-based gravity modeling framework; Portugal-Perez and Wilson (2008) estimates expansion potentials for exports for a sample of African countries. Several researchers use data on time measures of trade obtained from the 'Doing Business' (DB) indicators to explain the trade impacts of lengthy time at the borders for completing necessary paperwork, customs, handling and waiting or cargo at terminals.

Persson (2007) uses such data on actual time of trade to study impacts on bilateral trade between EU and the African, Caribbean and Pacific regions. Djankov, Freund and Pham (2007) estimate a difference equation motivated by incorporating firm-heterogeneity using time measures. Nordas, Pinali and Grosso (2006) look at sectoral impacts for lengthy time and find certain labor-intensive sectors, such as clothing and electronics, to be more time-sensitive than others. Mirza and Hertel (2008) use indices developed by the WB to estimate prospects for regional integration in South Asia from SAFTA's (South Asian Free Trade Agreement) efforts to improve trading capacity. Using a variety of data and econometric models these papers are consistent in finding positive and statistically significant impacts on trade.

Taking a step beyond partial equilibrium econometric models, other researchers study impacts of facilitation within a general equilibrium framework. Walkenhorst (2004) uses the GTAP-based CGE model to look at the economy-wide impacts of reducing border-related trade and transaction costs. These include direct costs associated with complicated customs-clearance procedures, complex and non-transparent documentation requirements, long turnaround times for feeder vessels, indirect costs associated with additional waiting time at the borders, and unexpected delays due to political turmoil and strikes. Experiments are designed to cut costs of trading by 50%, which is achieved through productivity improvements in trading. Ivanic and Wilson (2005) study trade impacts of extending foreign aid to developing countries. They estimate the effect of trade

capacity expenditure on the cost of trade and the potential for trade expansion. Using estimates on trade expansions, they simulate the effect of trade facilitation within an applied general equilibrium model and find significant trade and welfare gains for developing countries. Minor and Tsigas (2008) develop a unique methodology to estimate product and region specific tariff-equivalents for time spent in trading. From these estimates they simulate the effect of reducing time costs with the iceberg approach on prices and estimate trade impacts. Abe and Wilson (2008) study the impacts of enhancing transparency in the Asia Pacific Economic Cooperation (APEC) Region. They calibrate the GTAP-based CGE model with econometric estimates, and find nominal trade to increase by 11%, amounting to USD 406 million in global welfare gains.

However, there is something fundamentally missing in the design of all of the above studies. Particularly, the effect of trade facilitation is simulated by means of implementing ‘exogenous’ technology improvements in the economy. These ‘shocks’ entail no initial investments. This implies technology improvements are free-of-cost and no economic agents are paying for the improved productivity gains. A complete general equilibrium model of trade facilitation will link productivity improvements along with the opportunity cost of investments which will fully internalize costs within the GE model.

One significant contribution of this paper is modeling the costs of trade facilitation. The paper attempts to overcome the ‘free’ technology improvement shocks used in CGE models by providing structure to the cost side of the story. In particular, a newly-developed capital goods sector is introduced into the model that enhances productivity behavior related to trade. Modeling facilitation through the capital goods sector clearly embeds the cost side through several channels. Firstly, capital goods are produced using limited resources that have competing uses such as the production of consumables. Secondly, funds for investments need to be obtained by setting aside a fixed portion of income as savings. This makes investments costly in the model, such that there are no free-of-cost technology improvements.

3 Analytical Framework

The existing literature provides fairly consistent estimates of the trade impacts of efficiency gains. We want to take a step further and ask ‘what are the costs of these efficiency gains?’ Naturally,

infrastructural investments and deep-rooted institutional reforms entail significant costs in terms of resources and financial expenditures. We ideally want to be able to estimate the costs of fixed investments. How do we approach this problem? We begin by developing data on the trade-related capital stocks across countries. These include capital stocks related to the infrastructure of countries, such as roads and highways, telecommunication facilities, air and ocean ports, and other forms of public capital associated with trading. This data serves as inputs for producing improved border efficiency, where border efficiency is measured using an index that rank countries according to their perceived border quality.

If fixed investment costs outweigh trade gains from reforms then SSA can potentially benefit from costly investments. To what extent do initial costs exceed benefits from trade expansions and economic growth opportunities in SSA? Providing a complete link from investments to welfare gains requires the development of a complete model with multiple countries that are interlinked by trade. On this aspect partial equilibrium models are limited on several accounts. For instance, econometric models estimate the direct impacts of trade that do not include indirect welfare gains, such as that resulting from changes in production structure, or export-led economic growth effects. Furthermore, these abstract away from various desirable features that are present in general equilibrium models, including balance of payment constraints, supply inelasticity of endowments, and behavioral relationships that link agents and markets to make a fully integrated model.

A framework well-suited for our research interests is the Global Trade Analysis Project (GTAP) CGE model (Hertel, 1997). This is a many-country and many-goods model constructed to aid analysis on a wide variety of national and international issues, including trade, energy, environment, poverty and migration. Input-output tables obtained from individual country's statistical agencies lay out the economic structure for each economy. International data on trade and transportation complements independent country datasets to provide a global framework where regions are interlinked through trade. Within each economy production behavior is characterized by profit maximizing firms that combine natural endowments and intermediate inputs in a nested CES structure with imperfect substitutability at each stage of production. The regional household dispenses income through private household consumption, public consumption of government as an agent, and future consumption in the form of savings. Savings from each region are collected by

the global bank and distributed across regions in the form of capital good investments dictated by rates of return. In this paper we extend the standard framework to incorporate investments on border-related capital goods which increases trading efficiency.

The data used is from the version seven GTAP database (Narayanan and Walmsley, 2008) that incorporates production, consumption and trade data for 113 regions and 57 commodities. This data describes the global economy for the year 2004. The specific aggregation used constitutes of 7 regions and 5 sectors as shown in Table 1. The regional aggregation brings together geographically proximate countries and sub-regions and those with similar border qualities and groups them into a single region. The aggregated developing regions are Sub-Saharan Africa (SSA), South Asia (SA), Latin America (LA), and the Rest of the World (ROW). These regions on average depict poor levels of border logistics. Economies with improved border logistics are grouped into USA and Oceania (USAUS), Eu25 (EU) and High Income East Asia (EA). Having several developing and developed regions enables us to study how individual country reforms impact regions with similar and dissimilar border logistics.

Table 1: Aggregated Regions and Sectors

7 Regions	5 Sectors
• East Asia (EAsia) • South Asia (SAsia) • Usa&Oceania (USA) • Latin America (Latin) • EU (EU) • SubSaharan Africa (SSA) • Rest of the World (ROW)	• Agriculture (Agr) • Extraction (Extr) • Textiles & Wearing Apparel (TexWap) • Manufacturing (Mnfcs) • Services (Svces)

3.1 Extensions to the Database

The first step of our analysis is to establish consistent measures of investment costs. As proposed earlier the idea is to develop a trade-specific capital goods sector to portray costly investments. Here we would ideally need cross-country data on border-related investments.

However, such data are quite specific, difficult to measure, and not generally reported by countries. Furthermore, countries use different methodologies for defining variables and measuring the data. Some countries do report data on infrastructural expenditures such as investments on roads and highways, telecommunications, and electricity. This data is extensively used by the literature that estimates the causal effect of infrastructure on economic growth (Aschaeur, 1999; Munell 1990; Bougheas, Demetriades and Morgenroth, 1999). Most of these studies are done using time-series data for a single region, since it is difficult to find data at the cross-country level.

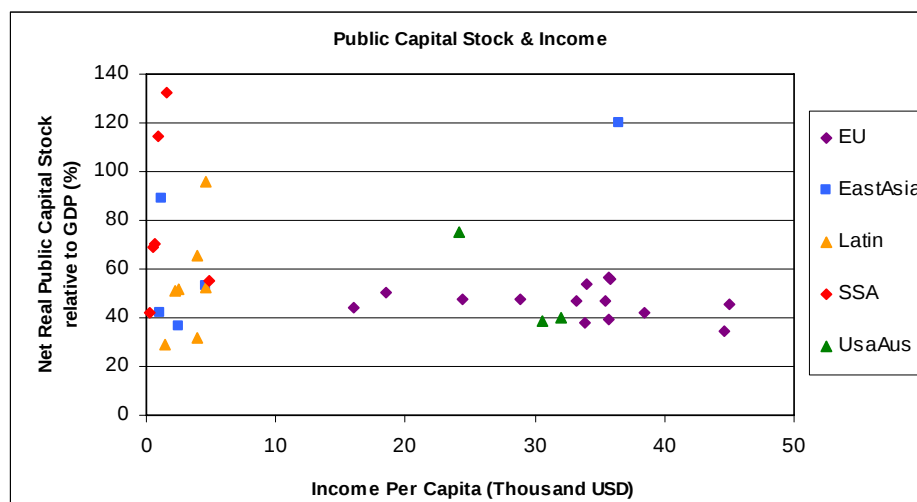
For our purposes we need a more specific type of public investment data, plus we need them at the cross-country level. Given that this is not readily available the alternative is to build this dataset. As a simple platform we begin with the existing data on capital investments that are already available for all countries in the GTAP database. This dataset is obtained from the Development Economics Prospects Group of the World Bank for the year 2004 in version 7 of the database (Narayanan and Walmsley, 2008). The capital stock data obtained is available on a regional basis and consists of both private and public capital. Public investments on trade facilitation-related capital stocks are embedded within the regional stock estimate and we extract this by means of two splits. The first split involves decomposing regional capital stock into public versus private capital stock. The second step involves extracting the fraction of public goods that are allocated particularly for border investments.

The first split requires estimates of public-private ratios. Internationally comparable data on public capital stocks is scarce, particularly since methodologies for estimation vary across countries. There is very limited research to develop public capital stock estimates for multiple countries. Among the few researchers who have attempted to obtain estimates of the ratios of public-private capital stock across countries is Kamps (2004). He exploits the OECD's Analytical Database that provides time series data on ratios of government investments to total annual investments. He uses the perpetual inventory method (PIM) to develop capital stock data for 22 OECD countries for the year 1960-2001. Arestoff and Herlin (2006) are the first to develop public capital stock estimates for a number of developing countries. They use data on capital expenditures by the central government to obtain estimates on public capital to GDP ratios. Also using the PIM they obtain net real public capital stock estimates for 26 developing countries across Asia, Africa, Latin America and Europe.

Data collected from these papers provide estimates for about half of the individual countries in GTAP.

A quick scan at the data reveals similarity in public capital stock shares in GDP across countries that are geographically proximate. Figure 2 plots estimated shares of net real public capital stocks as a percentage of income against income per capita. The plot shows no noticeable correlation between countries' income levels and the relative size of the public sectors. However, there exists similarity across regional groups of countries. EU countries have net capital stock to GDP estimates that lie between 40-60%, and this does not vary across income levels. Countries with lower income levels such as Sub-Saharan Africa and East Asia have larger capital stock estimates with greater variance, while Latin America has a lower average of 52%. Given the similarity across regional groupings, missing data are extrapolated by assuming identical ratios of public-private splits for countries that are proximate. This is less problematic since we use largely aggregated regions in the model, and regions for which data is missing within the same aggregation are assumed to have the average from countries of the region for which data is available.

Figure 2: Public Capital Stock & Income



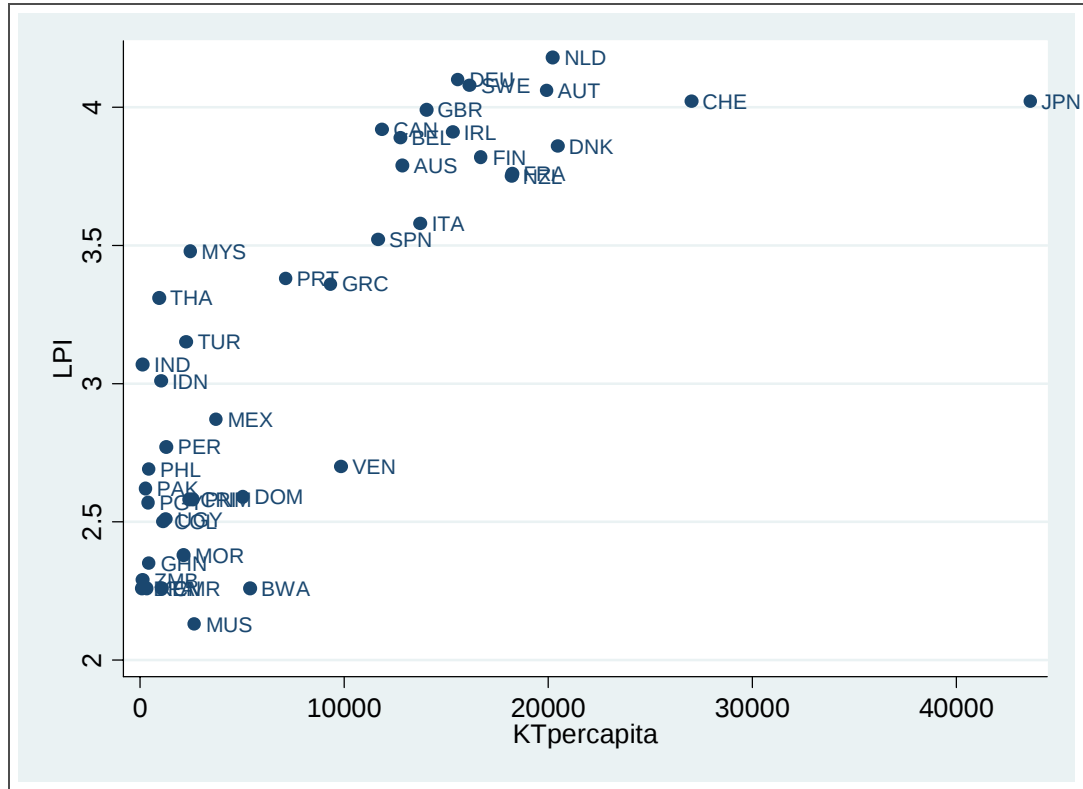
The next step is to identify data associated with public capital goods that are related to the stock of trade facilitation capital. The public capital sector includes a wide range of government activities associated with education, health, social benefits, infrastructural development, and other

public goods and services. A portion of this is spent on the transportation of goods across countries and facilitation of trade. Individual countries often report estimates on government's finances directed towards the development of infrastructure that involves telecommunications, physical infrastructure such as roads and highways, port facilities, border services and other factors that help build trading capacity. We guesstimate that approximately 10% of public capital formation is associated with trade-related activities, and use this constant fraction to split the data into TF-related and non TF-related capital stocks for each country. There is no great danger from such assumption since countries that have large public expenditures also tend to have better public amenities including trading facilities, and hence the information on larger versus smaller trade-related stocks across countries are still preserved after the assumption.

Another external dataset that is added to the GTAP database is an index-based measure of trade facilitation, called the Logistics Performance Index (LPI), developed by the WB's Trade and Transportation Division (2006). This dataset is developed from surveys completed by employees of multinational shipping companies. The index ranks countries on a scale of 1-5 depending upon their perceived notion of border quality. This dataset is robust from various statistical testing, and provides an excellent basis for cross-country comparison of border quality. Wider coverage also allows greater variability in data to obtain consistent estimates on trade elasticities.

We derive a link between the newly constructed data on trading-capital stock (KT) and the perceived notion of border quality (LPI). This estimated elasticity is used in the model to link capital investments to border quality. Figure 3 plots the relationship between LPI and KT standardized by population for the 43 countries. As expected the data depicts a high correlation of KT to LPI of 0.79. The curve slopes upwards with negative second order conditions, suggesting diminishing marginal returns to reforms. This relationship suggests that countries with larger KT have lower returns from investments. We take the motivation from the data to establish a more concrete relationship between the two.

Figure 3: Relationship between Border Quality (LPI)
And TF-related Capital Stock (KT)
Standardized by population for 43 countries



An econometric model is designed to estimate consistently the impact of additions to trade-related public capital stock on improvements in border quality. This is a particularly difficult model to estimate since countries that have better border quality are likely to have other good attributes that may be captured in the elasticity. As such two factors are critical to control for: i) size; and ii) income. Two countries may have the same quality of infrastructure, but one may have larger trade than the other due to which they may also have larger border-related capital stock. Then each dollar invested on trade-related capital stocks on a country border that has say 10 ports versus 2 ports are likely to have differential effects on the improvement in border quality. The size of the country is hence used as a control, and the total level of trade is included as an explanatory variable. The income level of the country is an excellent measure of the level of sophistication. Countries that already have well-developed infrastructure will have diminishing returns to further reforms. For example, each dollar invested on the border of Netherlands, that already has excellent trade infrastructure, is likely to have a much smaller effect than that invested at the border of Nepal.

Hence the income level of the country is controlled for using GDP per capita as an explanatory variable. This also serves to control for other good attributes of the country, such as better institutional structures, improved trade policies, etc, that may have effects on border quality.

The first control of country-size is indispensable but problematic. As argued in Chapter 2, there exists an endogenous relationship between trade and border quality. This implies that estimates from a single equations model will be biased. To control for this an instrument for trade is developed using geographical attributes of the country. The gravity literature suggests that distance between two countries and other geographical attributes have large explanatory power for trade. Here we follow the approach of Frankel and Romer (1999) to use geographical factors to derive an instrument for trade. Particularly, distance, common border, lanlockedness, area and population are used as explanatory variables. These of course are endowed features of each country and clearly exogenous to the degree of trade. The instrument is developed by obtaining fitted values of trade obtained from this regression.

Data on aggregated trade is obtained from the GTAP Database v7 (originally derived from COMTRADE) reflecting aggregated values of bilateral trade across countries using *cif* prices for the year 2004. Data on income and other geographical attributes are obtained from the WB and CIA's World Factbook. The two independent single-equation regressions are :

$$\ln LPI_X = \delta_0 + \delta_{KT} \ln KT_X + \delta_T \ln Trade_{XM} + \delta_G \ln GDPpc_X + \mu_{XM}$$

$$\ln Trade_{XM} = \theta_0 + \theta_D \ln Dist_{XM} + \theta_B \ln Bor_{XM} + \theta_L \ln LanLoc_{XM} + \theta_A \ln Area_{XM} + \theta_P \ln Pop_{XM} + \varepsilon_{XM}$$

where,

X = exporting country

M = importing country

Table 2 presents results for the regression that estimates trade using geographical attributes for 4613 bilateral observations. This model has relatively good explanatory power with an R-squared of 0.35, confirming the belief that geographical characteristics have large explanatory power for bilateral trade. The elasticity of distance is -1.32, suggesting that if the great arc distance between two countries increases by 1% trade will decrease by 1.32%. The elasticity of border and landlockedness are of expected signs and consistent with estimates from the gravity literature. This regression is

used to obtain the fitted values of trade to control for endogeneity between trade and border quality. The fitted values are aggregated by summing over all importers to be consistent with unilateral observations in the latter regression.

Table 2a: Estimating Trade using Geographical Characteristics

Dependent Variable: Log of Bilateral Trade	Coefficient	Std. Error.
Log of Population	0.63	0.02
Log of Distance	-1.32	0.05
Log of Areas	-0.15	0.02
Common Language	1.78	0.24
Landlocked	-1.12	0.06
Constant	2.05	0.50
R-squared	0.35	
F(5, 4607); Prob>F	486; 0.0000	
Number of Observations	4613	

Results are statistically significant at the 1% level for all variables

Table 2b: Estimating the Elasticity of Border Quality (LPI) w.r.t. Trade-related Public Capital Stock (KT)

For Countries with Low Capital Stock

Dependent Variable: Log of Border Quality (LPI)	Coefficient	Std. Error.
Log of Trade-related Public Capital Stock (KT)	0.063	0.020
Log of Total Trade (Fitted Values)	0.000	0.015
Log of Per Capita Real GDP	0.074	0.014
Constant	0.035	0.171
R-squared	0.82	
F(3, 25); Prob>F	40; 0.0000	
Number of observations	29	

Results are statistically significant at the 1% level for all variables,

Except fitted values of Total Trade

The instrument developed for trade is used in the second regression as an indicator of country size. Results from this regression are shown in Table 2b. The elasticity of LPI with respect to KT is 0.063, which suggests that a 1% improvement in KT increases the perceived border quality by 0.063%. To bring these to some meaningful comparisons, 10% investments in border-related capital stock increases total KT in SSA by 11.6 billion, which corresponds to an increase in LPI from 2.442 to 2.457. The estimated model has a fairly high R-squared value of 0.82 suggesting good explanatory power of the variables. The coefficient estimate of income is significant and positive, as expected. However, the coefficient of size is not significant. This is likely to result from the high correlation between trade and trade-related capital stock. The problem of multicollinearity increases the standard errors leading to insignificant estimates for trade. However, this is not expected to have any effect on the elasticity estimate of KT, which is the interest of this exercise.

The above results are obtained from estimates of a subset of 29 countries for which trade-related capital stock is less than USD 50 billion. This estimate varies across subsets of countries depending upon where these countries lie on the curve in Figure 3. This curve shows a pattern of diminishing returns to reforms; the slope of the curve is steepest for countries with lower capital stocks and gradually becomes flatter. Re-estimating this elasticity for various subsets of countries in the steeper and flatter regions we find that they estimate varies from 0.02 to 0.07. We choose an estimate of 0.04 to be used in the following GE analysis.

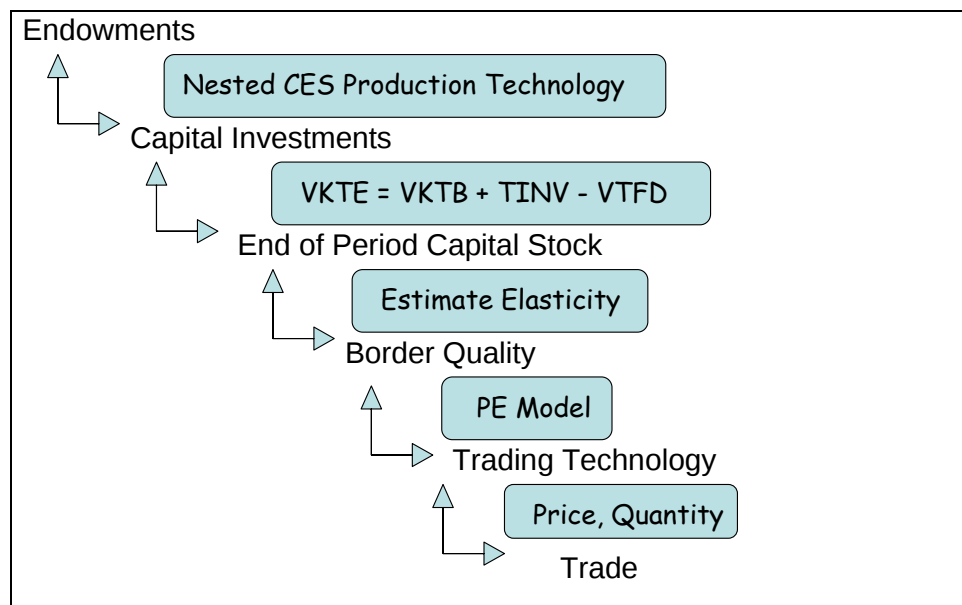
3.2 Extensions to the Model

Before proceeding towards the model extensions it is useful to provide a roadmap. Figure 4 shows how investments in infrastructure capital translate into trade gains. The first link describes the production function for capital goods. Capital investments targeted to build borders are in many ways similar to the capital goods sector in GTAP, with a few additional features. Production technology for border-related investments is identical to the capital goods sector. A nested CES structure combines domestic and foreign intermediates to produce capital output. Since limited resources are channeled into trade-related investments there is no ‘free’ productivity improvements, which clearly embeds costs of investments in terms of resources used. Capital investments then become a part of the total capital stock with some 4% being lost in depreciation. This is shown in

the equation for VKTE (trade-related end-of-period capital stock), which equals the corresponding beginning-of-period stock (VKTB) with added investments (TINV) and depreciation (VTFD).

The end-of-period trade-related capital stock improves the perceived quality of the border. This is the same elasticity estimated in Section 3.3.1. The next step is to link border quality to trade flows. The GTAP model consists of such a trade-increasing technological change variable, ams_{irs} , that increases the trading technology of good i from region r to region s . As described further below, ams_{irs} , impacts trade through an effect of prices and quantity of tradables. The only missing link is how border quality (LPI) is linked to trading technology (ams_{irs}). In the next section a partial equilibrium model is derived which develops this link, which then completes the chain of effects from investments in capital at the borders to its impacts on trade.

Figure 4: Model Summary



3.2.1 PE Model to Link Quality with Technology

The structure of the partial equilibrium model is summarized in Table 3. The model presents a set of 4 equations with variables written in percentage change forms denoted by small letters $\left(qxs_{irs} = \frac{\Delta QXS_{irs}}{QXS_{irs}} * 100 \right)$. The PE model is derived from the larger general equilibrium model, where excerpts are based on equations and variables that are linked to border-related technological improvements and trade; please refer to the section on notations at the end of this chapter for variable definitions. Detailed descriptions of the derivation of the equations in Table 3 (in their standard forms) can be found in Hertel, 1997. Equation (1) describes the production technology for traded goods within the nested CES production function. The Armington (1969) assumption of unique goods from individual countries is embedded within this. This equation shows the quantity of traded good i from region r to region s , qxs_{irs} , depends upon prices, derived demand, and technology. The first component is the substitution effect: when prices of good i from some region r , pms_{irs} , is small relative to prices from other regions as measured by the price index, pim_{is} , then the quantity of imports from r is relatively larger; the aggregate price index, pim_{is} is defined in Eqn (2), where the net impact of changes in bilateral price are weighted by their import shares, $c_{irs} = \frac{VIWS_{irs}}{VIW_{is}}$. The second component, qim_{is} , is the aggregate level of imports and depicts the expansion effect that comes from increases in demand from the destination region s .

Table 3: Partial Equilibrium Model

All small letter variables are in % change form

(1): $qxs_{irs} = -\sigma_i(pms_{irs} - ams_{irs} - pim_{is}) + qim_{is} - ams_{irs}$ demand for bilateral trade (2): $pim_{is} = \sum_r c_{irs}(pms_{irs} - ams_{irs})$ composite import price (3a): $qim_{is} = \gamma_M lpi_{is}$ aggregate imports (3b): $qiw_{ir} = \frac{\sum_s VIMS_{irs} qxs_{irs}}{VIM_{ir}} = \gamma_X lpi_r$ aggregate exports (4): $ams_{irs} = ams_{is} + ams_{ir}$ import and export -augmenting technology effects	
Importer's Effect: <i>PE assumptions:</i> $\overline{ams}_{ir}, \overline{qxs}_{irs}, \overline{pms}_{irs}, \forall i, \forall r, \forall s$ <i>PE Solution:</i> $ams_{is} = \gamma_M \cdot lpi_s$	Exporter's Effect: <i>PE assumptions:</i> $\overline{ams}_{is}, \overline{qim}_{is}, \overline{pms}_{irs}, \forall i, \forall r, \forall s$ <i>PE Solution:</i> $(\sigma_i - 1) \cdot ams_{ir} - \sum_s \sum_r ams_{ir} \cdot c_{irs} = \gamma_X \cdot lpi_r$

Equations (1) and (2) illustrate that the trade-augmenting technology variable, ams_{irs} , impacts both the price and quantity of trade. Firstly, improvements in trade facilitation inevitably impact variable costs of trade which has a direct impact on prices. For example, a reduction of customs fees from the implementation of transparent institutional structures directly reduces per unit costs; setting up electronic facilities, such as computerized methods for clearance, reduces paperwork and increases monetary and time efficiencies. Thus in many ways fixed investments at the borders reduce variable costs of trade. The impact on TF comes through ams_{irs} which reduces the

effective price of imports, pms_{irs} , making goods from some region r relatively more attractive. Secondly, TF increases productivity by reducing iceberg-type costs. This is captured by the expansion effect; particularly, ams_{irs} reduces derived demand, suggesting less of qxs_{irs} is required to obtain the same quantity of the composite aggregate import, qim_{is} .

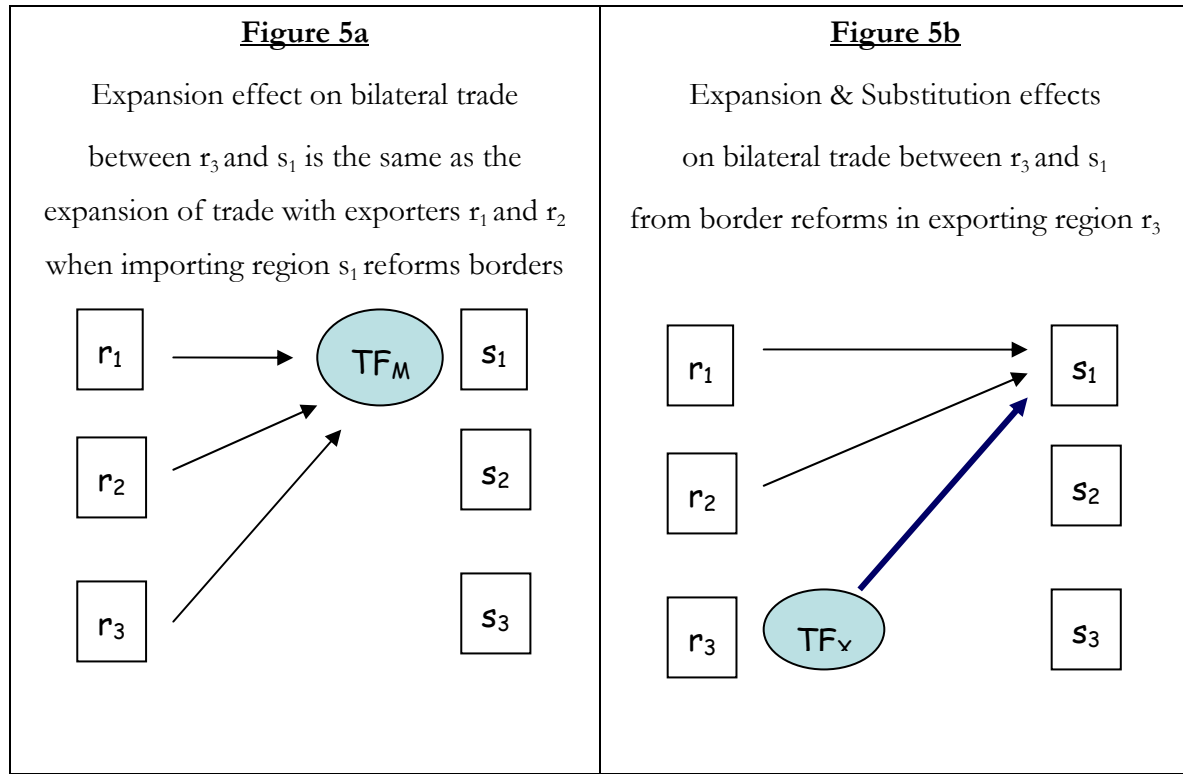
Equations (3a and 3b) illustrate impacts on volume changes in imports and exports from reforms at the respective borders. γ_X and γ_M are the elasticities of technology improvements with respect to changes in the border quality of the exporting and importing regions, *ceteris paribus*. Values for these parameters are obtained from econometric estimates estimated in Mirza (2008). This paper provides a detailed discussion on estimating consistent elasticities of TF with respect to trade using a simultaneous approach. Data used to measure trade and trade barriers are exactly the same as that implemented in the GTAP model.

Equation 4 decomposes the bilateral variable, ams_{irs} , into unilateral components; ams_{is} simulates the effect of improving border logistics of the importer s , while ams_{ir} simulates the effect of improving border logistics of the exporter r . The benefits of this decomposition are twofold. Firstly, the index measuring border quality is unilaterally defined by lpi_s and lpi_r , representing the quality of the border for the importer and the exporter. Defining the technology change variable unilaterally then directly links lpi_s to ams_{is} for importing region s , and same for the exporting region. Secondly, the decomposition simplifies derivations of a PE solution that captures the importer and exporter effects independent of each other.

Let's first consider the link between lpi_s and ams_{is} when there is TF in some importing region s . Let's assume $ams_{ir} = 0$ for simplicity so that the impact of TF on the exporter and importer can be separated. A set of PE restrictions as shown in Table 3 is imposed, where bilateralized prices and quantities are assumed to be fixed. Solving the set of equations simultaneously yields: $ams_{is} = \gamma_{IM} \cdot lpi_s$. Interestingly, the solution suggests that there are no substitution effects from the perspective of the importer. The intuition is that since the importer

undergoes reforms across-the-board, prices of imports from all regions r are affected by ams_{is} in the same way. This means that no region r' becomes more or less competitive than others, and the relative competitiveness among exporters remains unaltered. Hence, the entire effect is driven by the expansion effect which is equivalent to a decrease in the iceberg cost of trade for all exporters as shown in Figure 5a.

Figure 5: Impacts on bilateral trade from exporter and importer reforms



The impact of border quality improvement in the exporting region, lpi_r on ams_{ir} is a little more complex. Figure 5b shows a comparative impact of TF on exporters vs. importers to illustrate the differing impacts. In contrast to the above case, the relative competitiveness of exporters changes when some region r_3 invests at the borders. To keep matters simple let's assume $ams_{is} = 0$, and bilateralized prices and derived demand are assumed to be fixed. While it is not possible to obtain a closed form solution for ams_{ir} , it is possible to derive an equation that endogenously determines its

value. Putting all equations together, we have: $(\sigma_i - 1) \cdot \mathbf{ams}_{ir} - \sum_s \sum_r \mathbf{ams}_{ir} \cdot c_{irs} = \gamma_X \cdot \mathbf{lp}_i$. It is evident from the solution that in this case the substitution effect also matters which implies that the values of $\mathbf{ams}_{ir}$ are affected by the cost share of imports, c_{irs} and the Armington elasticity of substitution, σ_i . The intuition is that when some exporter r_3 undertakes border reforms, imports to region s_1 from r_3 will increase relative to all other regions, r_1 and r_2 , since r_3 can offer goods at a lower price.

3.2.2 Border-Related Capital Investments

Where does funding for trade facilitation come from? Many developing countries obtain foreign aid to assist in trade-related development projects. International and regional organizations channel funds through grant and loan programs to expand market potentials. For instance, the International Trade Center's (ITC, WTO) 'Aid for Trade' program is designed to develop trade-related skills and infrastructure particularly in LDCs. Similarly, country administrations also allocate a portion of the national budget in public expenditure related to trade.

The development of trading facilities is not only limited to public and non-profit organizations, but largely involves the private sector. Often rights are granted to private entities to offer the provision of facilities that enables them to generate flow of revenues in return for the management and maintenance of port facilities. In recent years more concessionaires are being given with the goal to improve efficiency and remove bottlenecks in the quality of facilities and services. Many Chinese ports, including the ports of Dalian, Xiamen, Fuzhou and Guangzhou, maintain strategic alliances with multinational entities such as the APM Terminals, Cosco Pacific and Port of Singapore Authority, to help meet the need for speedy development. To develop Sri Lanka as a maritime hub similar to Singapore and Dubai, the port of Colombo was further modernized in the year 2000 with one-third of costs raised through government budget (USD 350 million) and two-thirds from the private sector (USD 700 million). While privatization is not yet widespread in Africa, there are a few instances. For example, in Mozambique the Maputo Port Development Company has extended port operation responsibilities and development with an initial contract of 15 years. Thus both private and public funds are directed towards strengthening maritime trade.

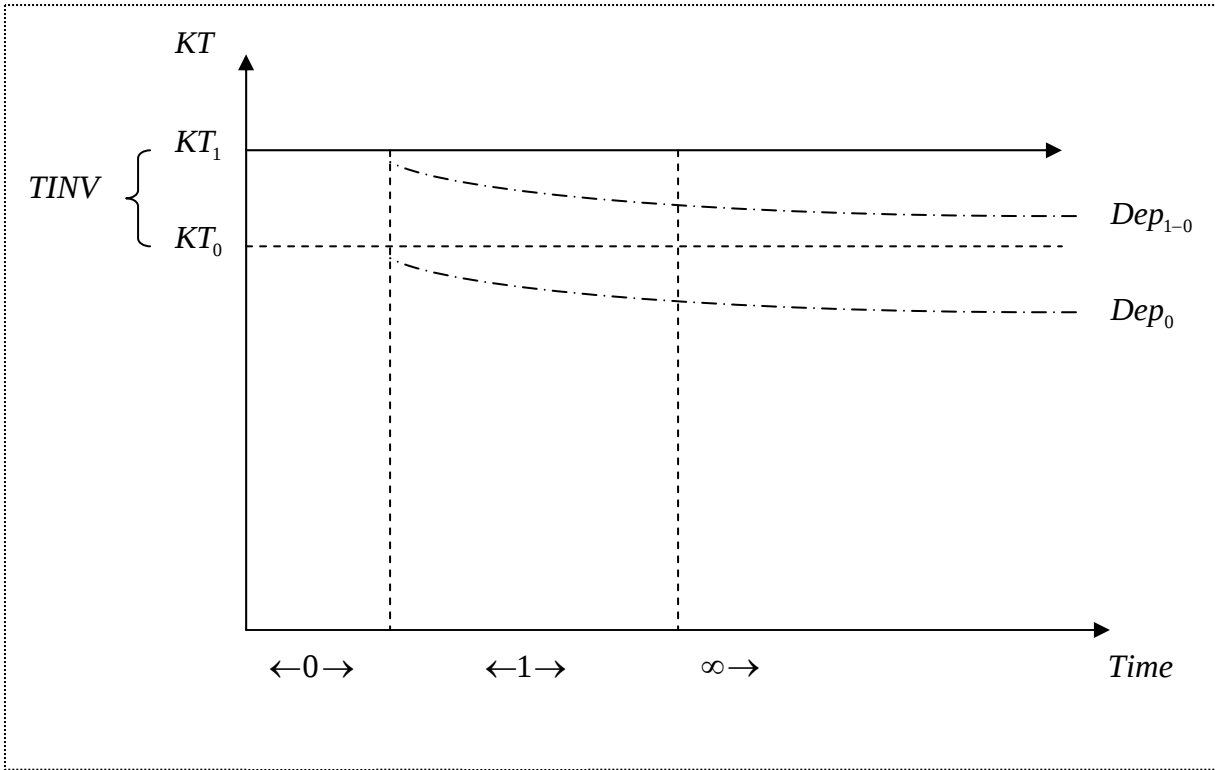
To bring the feature of public and private investments into the GTAP model we channel funds into SSA through the ‘Global Bank’. The global bank in the GTAP model acts as liaison between savings in various regions to investment opportunities in others. This expands provisions for investments in SSA that extend beyond public investments or domestic savings. It allows financing from both the public and private sectors, and domestic and foreign savings. Private investors abroad generate returns in the form of rents generated from providing services that are similar to foreign direct investments.

4 Policy Scenarios

The policy scenario describes a dual experimental setup with two periods. While in Period 0 infrastructure investments take place, in Period 1 benefits are realized. Period 0 characterizes a short run, where economic endowments are assumed to be fixed. The model computes a static equilibrium with a snapshot of the economy at the end of the simulation. One can imagine the length of the simulation in Period 0 to be a time span of several years or enough time to allow the development of port facilities and the reallocation of resources across sectors in response to the changing market forces. Period 1 is described as the steady state long run equilibrium where the endowed capital stock is allowed to expand endogenously.

To fix ideas Figure 6 plots KT over time. In period 0 investments are undertaken such that investments ($TINV$) boosts the trade-related capital stock from KT_0 to KT_1 . All costs associated with investments are fully incurred in this period. No new investments are undertaken in Period 1. However, since the newly-developed capital stock depreciates over time, enough expenditure is undertaken to maintain the new investments (Dep_{1-0}) in Period 1. As Period 1 does not extend to infinity, benefits of infrastructure accrue in the following periods also. To account for this total benefits from reforms are measured by calculating the net present value of benefits reaped in perpetuity.

Figure 6: KT Over Time



4.1 Scenario 1: Investment Costs in the Short Run

4.1.1 A. External Funds

Period 0 describes a short period of investments. As an example, consider a scenario where investments constitute large-scaled development of ports and berths around coastal countries in SSA, which also benefits landlocked countries using ocean shipping. As maritime facilities are strengthened goods no longer have to wait to find available docks resulting in an increased efficiency for loading and unloading shipments. This bumps up the overall perceived quality of border in SSA from 2.44 to 2.46 moving it one-tenth closer to the developing regions of South Asia and Latin America. This corresponds to investments of 24.6 billion USD such that the total value of border-related capital stock increases by 13% to 145 billion USD. The target level of investment is certainly larger than funds annually available at a single aid-providing organization. One of the largest trade reform programs, ‘Aid for Trade’ at the ITC, a joint agency under the WTO & UN, raises about USD 25.4 billion² from bilateral and multilateral donors, a third of which is used primarily or

² ‘Aid for Trade At A Glance, Maintaining Momentum’, 2009 Annual Report, Aid for Trade, ITC, WTO

secondarily on trade-related investments. Most of the fund go to Asia, while Africa and SSA receives the majority. Let's suppose that SSA obtains a fraction of funds from donor organizations and the remaining from private sector both domestic and foreign.

In the remainder of this sub-section we explore the economic impacts of investments in the short run. The first observation is that the diversion of resources into capital investments creates interesting GE effects. Building additional capital stock requires the use of inputs, such as construction services, machinery, and equipment that are constituted in the aggregated manufacturing and services sectors. Together these sectors take 90% of cost shares in capital production. These inputs are in turn produced using fixed endowment resources of the economy that have competing uses. Since the supply of endowments are perfectly inelastic in the short run, as more resources are allocated towards the building of capital goods, less is available to produce other goods and services. This creates crowding out of resources as shown in Table 4. Total output falls by USD 4 billion. Agricultural goods decline by 0.9%, manufacturing goods decline by 2.9%, and textiles and wearing apparel products decline by 4.7%. The only sector that expands is the services sector, most of which is used as inputs in producing capital goods.

Table 4: Changes in Domestic Production

Scenario 1A: Investments in the Short Run using External Funds

	Levels Changes	
	% Changes	(million USD)
Agr	-0.9	-2340
Extr	-1.2	-1360
TexWap	-4.7	-1609
Mnfc	-2.9	-7096
Svces	1.3	8337

As the supply curve for domestic consumer goods shift backwards, prices of commodities rise. At higher prices consumers respond by substituting away from domestic goods, and consuming more foreign goods. However, the total change in consumption of domestic goods is very small; demand for textiles (-1%) and manufacturing goods (-0.8%) decreases, and demand for other goods increase slightly or remains unchanged. We measure the opportunity costs of investments as the foregone utility from lost consumables. In our model the limiting factor for capital production are not financial constraints but endowment constraints that are fixed in the short run. An equivalent variation-based measure of welfare loss is derived from loss of immediate consumption³. Results indicate negligible changes to total consumption, as a result there is no significant welfare loss to the regional household. This scenario depicts an optimistic story since funds for investments are obtained from external sources. Redirection of funding from the regional household in SSA has a very different outcome, as will be explored in an alternative experiment below.

Impacts on commodity and factor prices are substantial in the short run. Table 5 shows impacts on nominal and real returns to factors. Labor market wages increase by 2.03% for unskilled labor and 2.93% for skilled labor. Returns to capital also increases similarly to about 2.11%. Prices of commodities increase, but by a smaller degree, which implies that real income rises and consumers' enjoy better purchasing power. Foreign investments increase demand for limited factors and thereby increase real income. Total GDP increases by 2.07% as a result of greater job creation and increased returns to factors.

Table 5: Changes to Factor Returns

Scenario 1A: Investments in the Short Run using External Funds

	Nominal Price	Real Price
	(% changes)	(% changes)
Unskilled Labor	2.05	0.62
Skilled Labor	2.92	1.47
Capital	2.12	0.68

³ In the tab file this is calculated as: $EVP = [VPAEV/100] * y_{pev}$

Another interesting outcome of designing funding from foreign sources is the large deterioration in trade balances. Imports increase in large proportions such that the terms of trade deteriorate dramatically by USD 21 billion in the short run. The main cause of growing imports is to restore the macroeconomic balance, $X - M = S - I$, a regional constraint imposed in the static model. Since investments increase largely in SSA, and this is largely funded by foreigners, there needs to be complementary adjustments in the current account balance. This, of course, can only happen since the short run is depicted in the static model. In a dynamic setting SSA eventually need to restore positive trade balance by reversing deficits, and generate higher savings from within the region.

4.1.2. Regional Funds

Costs are higher in the instance when SSA must finance investments internally. Here we look at the case where SSA receives no foreign assistance but must generate funds through regional savings. This is equivalent to fixing the ratio of $\overline{S - I}$ to income, such that domestic investments are limited by account of domestic savings. This behavior is implemented by adopting an alternative macroeconomic closure that fixes the ratio of trade balance to income. This closure implies that in contrary to the earlier scenario, the macroeconomic balance can no longer be adjusted through magnifying current account deficits. Instead the trade balance remains more or less fixed, and savings increases in tandem with the increase in infrastructure investment in SSA.

SSA must now save more to be able to fund regional investments. Total savings increases by 67% from 37 billion USD to 61.7 billion USD to fund the 24 billion USD investments on trade facilitation. The large increase in savings crowds out expenditure on nondurable consumer goods and other investments. Table 6 shows changes in private household consumption. Compared to the last scenario opportunity costs of private household consumption are much larger now. Demand for domestic consumption of agriculture decreases by 4.2 billion USD, and that of services decreases by 8.5 billion USD; total domestic consumption decreases by 15.2 billion USD (or 4.2%). Demand for foreign goods also decrease by 3.2 billion USD. This is in remarkable contrast to the former setting where demand for imports rise, and that for domestic goods change negligibly.

Table 6: Changes in Private Consumption*Scenario 1B: Investments in the Short Run using Internal Funds*

	Domestic		Foreign	
	Level Changes		Level Changes	
	(million USD)	% Changes	(million USD)	% Changes
Agr	-4244	-3.1	-1026	-4.4
Extr	-635	-5.5	-19	-5.7
TexWap	-411	-3.7	-322	-4.9
Mnfc	-1408	-4.1	-1184	-5.2
Svces	-8512	-5.0	-721	-5.8

These results suggest that the opportunity costs of investments in terms of foregone consumption are much larger when SSA uses domestic funds. Using equivalent variation-based measures we find that the private household's welfare in SSA falls by a significant USD 18.4 billion. In other words, for every one hundred dollar invested on capital goods private households suffer a welfare loss of seventy-seven dollars in consumer goods.

Since increases in savings squeeze private consumption, and consumers spend less, there is less pressure on producing goods for domestic consumption. This lightens the pressure on resource prices. The average price index for consumables increases by 5.3%, largely driven by additional taxes on consumer goods. In contrast to the last case returns to factors decline, real income falls, and consumers are much worse off. These reflect opportunity costs of consumption to SSA from diverting resources for trade facilitation efforts.

4.2 Scenario 2: First Period Returns

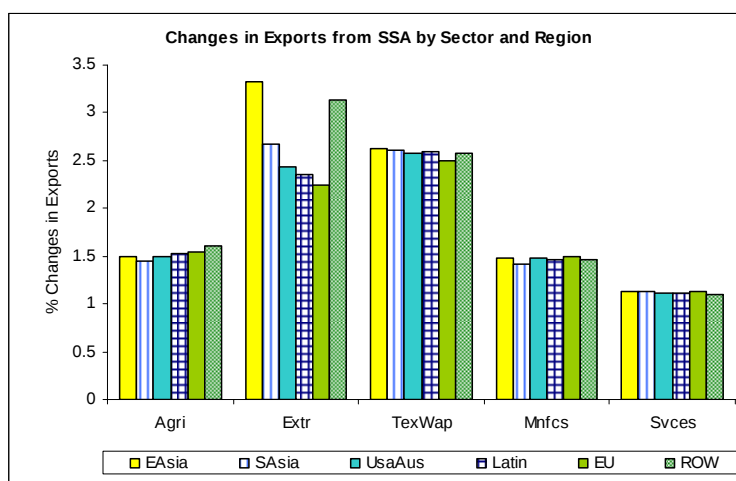
Impacts of trade facilitation efforts are realized in the following period. The new simulation characterizes a unique framework to analyze benefits of trade reforms in SSA. Since reforms have taken place in Period 1, no new efforts are necessary in this period. This set up is established by exogenously shocking the border quality index to attain a target level that corresponds to investment

efforts in the earlier period. This experiment is analogous to a costless technology shock conducted in existing models in the literature. The idea of the dual-experimental set up is to compare benefits accrued from improvements in technology to costs incurred and provide a common platform to compare costs and trade benefits. As mentioned earlier, one of the usefulness of GE analysis is to be able to capture various indirect impacts of trade reforms. To incorporate this into our analysis we compute benefits over steady state capital growth equilibrium (Francois and McDonald, 1996). The steady state equilibrium allows endogenous expansion of non-trade related capital investments that reflect indirect growth opportunities for SSA.

4.2.1 Trade Impacts

This section presents estimates of first-period gains from trade expansions and economic growth opportunities. The first interesting observation is that exports in each sector increases uniformly across importing regions as shown in Figure 7. This is an artifact of the phenomenon that prices at the borders change at the same rate for all regions. Uniform expansion effects suggest trade facilitation reforms are consistent with open regionalism.

Figure 7: Impact on Exports



Relative increases in exports are largest in extraction (Extr) and textiles and wearing apparel (TexWap). Larger increases in extraction are driven by a relatively higher level of substitution across sources of imports, σ_{Extr} , relative to other sectors. SSA also specializes in the production of metals,

minerals and precious stones; for example, more than 80% of Botswana's exports constitutes of diamonds, copper and nickel. As a region SSA holds 13.1% of the value of total global exports of extraction, and certainly much larger shares of diamond and copper. Exports in extraction increases by 2.8% corresponding to USD 1.66 billion.

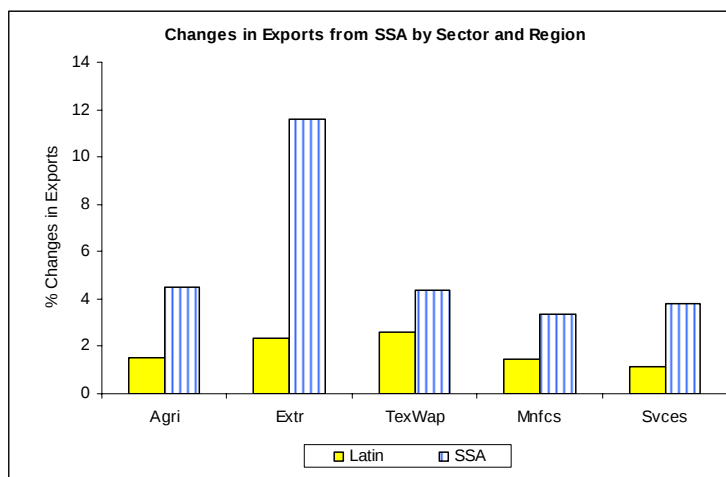
The textiles & wearing apparel (TexWap) is a growing sector in Africa, currently being promoted in the US through the African Growth and Opportunity Act (AGOA) that allows duty-free access of African-manufactured garments and apparel; Africa also enjoys various free trade agreements in TexWap with the EU. Nevertheless, the expiration of the MFA (Multi Fiber Arrangement) in a complete phase-out in 2005 made it difficult for the textiles industries, particular infant industries, to compete with the leading exporters, such as China, Indonesia and India. Access to the global market at lower prices naturally creates better opportunities for SSA to develop these sectors. Export of TexWap increase by 2.6%, primarily driven by substitution away from other regions, due to a decrease in the supply price of exported TexWap from SSA relative to the composite world price change. Unskilled labor and capital are the basic endowments used in producing TexWap; SSA can now export TexWap at lower prices due to a decrease in prices of capital inputs.

Imports also increase in SSA due to a reduction in border costs. Total imports in SSA increase by USD 6.5 billion. Most of this increase, about USD 3.2 billion, comes from increases in manufacturing imports which already constitutes 61% of total imports in SSA. Both lower prices of imports and higher regional income from technology improvements contribute to import expansions. Import increases are slightly more than exports, such that the trade balance deteriorates by USD 337 million.

Impacts on intraregional trade are much larger than bilateral trade with other regions. This partly results from the dual exporter and importer effects. When two countries in SSA, say Kenya and Nigeria, undergo reforms then the impacts on bilateral trade are larger relative to bilateral trade with a non-SSA country that has undertaken no reforms. In addition there are multiplier effects that increase the trade even more. Figure 8 compares intraregional trade with interregional trade using a representative region. For all sectors intraregional trade is twice to three times as large as

interregional trade. Theoretically, intraregional trade is expected to be larger; for example, when one single country in SSA reforms border procedures then the ad-valorem reduction in costs with neighboring countries is larger relative to a distant country, since total iceberg type costs are higher for distant countries. There are some potential for greater economic integration in Africa from trade facilitation reforms.

Figure 8: Intraregional vs. Interregional Trade



4.2.2 Returns to Investments

Trade growth increases welfare in SSA. Some gains in welfare come from direct impacts of trade changes, while others come from various indirect interaction effects. Table 7 decomposes welfare effects into direct and indirect effects. SSA gains about 3.2 billion USD from the availability of lower-prices imports. Gains are particularly large on imports of manufacturing from EU (873 million USD) and East Asia (386 million USD). As export prices decline from SSA, other regions also gain from the available bundle of lower-priced imports. EU being the largest importer of agriculture, extraction and other commodities gains the most (about USD 180 million) from SSA imports. Intraregional trade also contributes to 15% of the total direct gains in welfare.

Table 7: Welfare Gains

EV-based measure of welfare (billion USD)	
Direct Effect	3.2
Total Indirect Effects:	5.2
<i>Allocative Efficiency</i>	1.6
<i>Terms of Trade Effect</i>	1.2
<i>Capital Stock Growth</i>	2.4
Total	8.4

Among indirect effects SSA gains from increases in terms-of-trade (TOT) (15%) and allocative efficiency gains (19%). Positive terms of trade effects come mostly from more competitive export prices relative to world prices. Allocative efficiency gains are driven by changes in the production structure and trade, whereby more efficient sectors expand and less efficient sectors contract. Existing taxes create artificial distortions and move the equilibrium outcome away from the optimal. As the economy moves closer to the optimal, there is Pareto improvement which results in positive welfare effects. Allocative efficiency gains from import tariffs (38%) and production tax (36%) effects are the largest. SSA imposes high import tariffs on agriculture and textiles, with ad valorem equivalents of more than 20% and more than 25% respectively. As trade facilitation increases imports and undoes the impact of existing import tariffs, welfare increases up to 1.6 billion USD.

Direct capital investments transform into various indirect growth of capital stocks in SSA. Non-border related capital investments increase by USD 2.4 billion. These stem from economies of externalities that accrue due to the development of infrastructure. For example, with the development of Europe's largest port, the port of Rotterdam in the Netherlands, an industrial complex grew surrounding the entire area of 10,500 hectares providing auxiliary services and facilities that are interlinked with the supply chain management of tradable goods. Furthermore, beyond the direct impact of infrastructure, the growth of trade opens opportunities for various forward and backward linked industries. Thus infrastructural developments are multiplied into

increased investment opportunities both from foreign and domestic sources that additionally contribute towards economic growth in SSA.

4.3 Understanding the Benefits vs. the Costs

Are net gains from reforms positive in SSA? This section projects costs and benefits explored in the two scenarios into a common scale to estimate net returns to investments. The first dilemma is to assess the full benefits of reforms that extend beyond the first period. In a static framework we only see projections on welfare estimates that are non-cumulative, but investments in fixed infrastructure are expected to generate returns over many periods in the future. This calls to estimate the net present value (NPV) by accumulating the flow of benefits, where benefits are simply measured in terms of the increase in total regional welfare using EV-based measures. A discount value of 12% is chosen to calculate perpetual benefits (this rate is used by the World Bank for calculating NPVs for public projects since 2001). Total welfare gains amount to USD 69.6 billion, which largely exceeds the costs of investments of USD 18.4 billion from self-funding scheme, suggesting a benefit-cost ratio of 3.9%. The large ratio suggests that building trading capacity is largely profitable in SSA.⁴

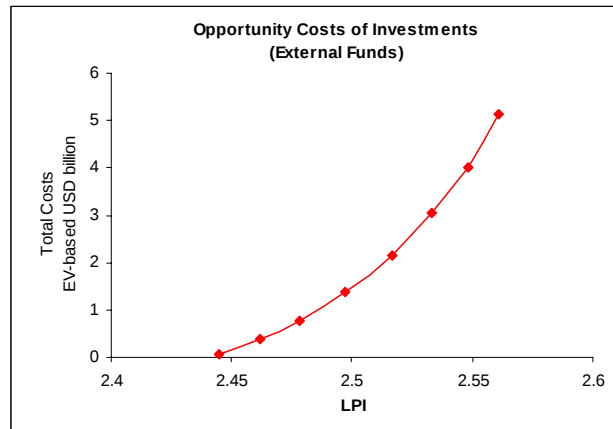
In order to provide a comparative picture we plot total cost and benefit curves for different levels of investments. Costs vary largely in the two scenarios of external versus domestic funding options. Recall that costs of investments are measured in terms of the opportunity costs of foregone consumption. Since the regional households in SSA must forego present consumption in order to redirect limited resources to investments in capital goods, the economic cost to private household's are measured as EV-based welfare losses generated from reduced consumption. Measuring costs as welfare losses then easily compares to EV-based welfare gains from trade reforms. Figure 9 plots costs of reforms to SSA against border quality when there are external funds available. This data is collected by measuring costs at different levels of investments by obtaining several estimates from the model. The upward slope of the curve illustrates that larger investments lead to improved border quality as expected. The convexity of the graph illustrates increasing marginal opportunity costs. As

⁴ At this point it is also worthwhile to mention that this paper does not aim to present a cost-benefit type of assessment or project appraisal as understood in public economics. There is no data on any specific infrastructure project, such as the construction of an airport, mainly due to lack of availability of detailed data, and the level of analysis at a global scale. Instead by providing a complete analysis of economic costs and regional welfare gains, we provide useful insights into regional investment behavior that are predominant in developing countries.

consumers forego more of the consumption bundle, marginal loss of welfare increases quickly. Costs are negligible in this scenario since SSA obtains foreign assistance, and net gains rise by the full scope of total benefits.

Figure 9: Total Cost Curve

Scenario 1A: Investments in the Short Run using External Funds



Figures 10a and 10b plots the cost and benefit curves for the policy experiment where SSA finances own investments. Of course, opportunity costs are much larger in the case of internal funds since the regional household has competing use of resources and income. Figure 11 plots the benefit-cost ratio for different levels of investments, where a decreasing pattern is reflective of increasing marginal costs of reforms. Net gains are maximized for initial investments which declines gradually but still remains high for much larger short term investments.

Figure 10a: Total Cost Curve

Figure 10b: Total Benefit Curve

Scenario 1B: Investments using Internal Funds

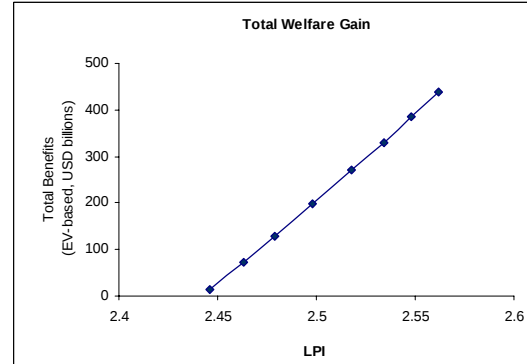
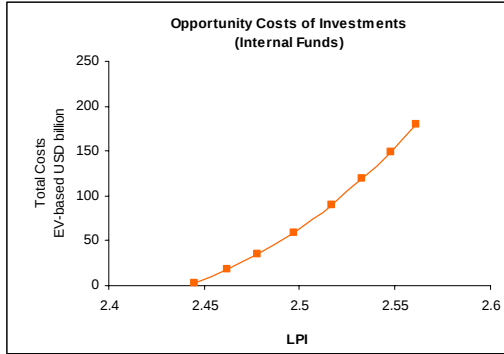
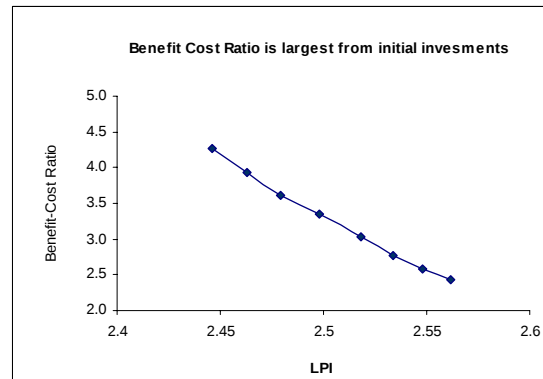


Figure 11: Benefit-Cost Ratio



Returning to the original question in our paper, if facilitation reforms are so large, what leads to smaller investments in SSA? SSA is one of the poorest regions of the world with GDP per capita of USD 878⁵. Approximately 50% of the population in SSA lives below the poverty line or the \$1.25 cutoff⁶. Many Africans living in the lower income countries barely have access to the basic necessities suffering inadequate nutrition, limited access to health care, and increased susceptibility to diseases. With households near subsistence spending 70-80% of income on nutrition for themselves and their family, foregoing present consumption is a far outcry. In the self-finance

⁵ Author's calculation from the GTAP Database v7 using countries included in the particular aggregation of SSA

⁶ World Bank, 2009

scheme SSA must forego 77 dollars worth of consumption goods for every 100 dollars spent on capital goods. This adds up to a total of USD 18.4 billion worth of consumption bundle that must be foregone for project development. This is unlikely to be a feasible current choice for SSA, and in general sheds light onto why poor countries under-invest.

Nevertheless, net gains suggest large profitability from investments. Trade expansions increase factor returns, income, and employment, opening doors for progress in SSA. This call for designing alternative policy plans for developing countries struggling to allocate sufficient funds to such public projects. One possibility is to commercialize logistics facilities to the private sector. As described in Scenario 1A external sources of funds are possible options to be considered. Private sectors, from both home and abroad, may identify profitable investments from strengthening maritime, developing logistics facilities, and border services. Replacement with concessionaires through selection processes, such as bidding, has been largely successful in many countries. For example, Chilean ports have been largely privatized over the last decade, with now more than half of the ports (about 40) being privately owned. The primary interest was to avoid monopolistic market structures and ensure efficient services. Similarly, allowing privatization in Africa is likely to bring newer technology at the border front, increasing competitiveness and broadening the potential for trade. This will allow faster reforms than that facilitated through regional and international grant and loan programs at the present time.

5 Conclusion

While the world has become more integrated with quickly and strongly developing trade relations, Sub-Saharan Africa has little participation (2.1%) in the profound global trading network. A growing literature suggests that a large part of aloofness comes from inadequacies in infrastructure and logistics facilities that bids up border trading costs. A variety of techniques in research find consistent estimates on trade expansions. These papers, however, assume exogenous increases to productivity that is free-of-cost. This only provides a partial analysis of the benefits of reforms without fully understanding the cost story. This paper provides structure to the costs of facilitation reforms that sheds more light on why trade facilitation faltered in Sub-Saharan Africa and other similar developing countries.

The paper designs a framework to analyze impacts of trade facilitation reforms using a many-country, many-sector, general equilibrium framework. It extends the GTAP-based model and database by developing additional data to characterize investments in trading facilities. Taking a step beyond existing papers in CGE it integrates costs of reforms, and naturally overcomes ‘exogenous’ technology improvements, providing a comprehensive analysis of costs and benefits.

Two scenarios are explored for funding schemes of project development in SSA: i) private investments and aid-providing international institutions; and ii) funding from the national budget. Results indicate that returns to initial investments in trading capacity have positive long-term benefits that largely exceed costs, even when SSA self-funds projects. With a benefit-cost ratio of 3.9%, in the case of internal funds, border reforms are largely profitable in terms of trade and economic growth opportunities. Nevertheless, costs of reforms are steep for SSA, a region with low income and high poverty rates. For every hundred dollars invested in capital goods, the regional household must forego 77 dollars in direct consumption. This may be infeasible in a region where large volumes of population live near subsistence level. With limitations to funding policymakers in SSA should consider alternative development schemes, such as commercialization of facilities that may open paths for trading opportunities in SSA.

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Appendix

Tablo Code shows only changes from the Standard GTAP Model (Version 6.2, 2003)

For a detailed description of the model please see Hertel & Tsigas, 1998.

!< Sets >!

```
Set
    TCGD_COMM # TF-related capital goods commodities #
    maximum size 5 read elements from file GTAPSETS header "TCGD";
Set
    BOTH_COMM # Both types of CGDS # = CGDS_COMM union TCGD_COMM;
Set
    PROD_COMM # produced commodities # = TRAD_COMM union BOTH_COMM;
Set
    NSAV_COMM # non-savings commodities # = DEMD_COMM union BOTH_COMM;
```

!< 4-2. Trade Facilitation >!

! TF-Specific Variables!

```
Variable (all,r,REG)
    ktb(r) # beginning-of-period TF-related capital stock in r #;
Variable (all,r,REG)
    kte(r) # end-of-period TF-related capital stock in r #;
Variable (all,r,REG)
    lpi(r) # logistics performance index in r #;
Variable (all,r,REG)
    qtcgds(r) # output of TF-related capital goods sector =
    qo("tcgd",r) #;
Variable (all,r,REG)
    ptcgds(r) # price of TF-related investment goods = ps("tcgd",r) #;
```

! TF-Specific Equations!

```
Equation QTFCAPGDS
# eq'n defines a variable for gross TF-related investments #
(all,r,REG)
    qtcgds(r) = qo("tcgd",r);
```

Equation PTFCAPGDS

```

# eq'n defines the price of tcgd #
(all,r,REG)
    ptcgds(r) = ps("tcgd",r);

Variable (all,r,REG)
    GROWTHKTB(r) # Long run steady state growth path for KTB #;
Equation KTFBEGINNING
# Long run steady state growth path for KTB #
(all,r,REG)
    GROWTHKTB(r) = ktb(r) - qtcgds(r);

Coefficient (ge 0)(all,r,REG)
    VKTB(r) # value of TF-related beginning-of-period capital stock in
r #;
Update (all,r,REG)
    VKTB(r) = ptcgds(r) * ktb(r);
Read
    VKTB from file GTAPDATA header "VKTB";

Coefficient (ge 0)(all,r,REG)
    VTFD(r) # value of TF-related capital depreciation in r
(exogenous) #;
Update (all,r,REG)
    VTFD(r) = ptcgds(r) * ktb(r);
Read
    VTFD from file GTAPDATA header "VTFD";

Coefficient (all,r,REG)
    TINV(r) # regional GROSS TF investment in r (value of "tcgd"
output) #;
Formula (all,r,REG)
    TINV(r) = sum(k,TCGD_COMM, VOA(k,r));

Coefficient (all,r,REG)
    NETFINV(r) # regional NET TF-related investment in region r #;
Formula (all,r,REG)
    NETFINV(r) = sum(k,TCGD_COMM, VOA(k,r)) - VTFD(r);

Coefficient (all,r,REG)
    TFINKTER(r)
    # ratio of gross TF investment to ending TF-related capital stock
in r #;
Formula (all,r,REG)
    TFINKTER(r) = TINV(r) / [VKTB(r) + NETFINV(r)];

Equation KTEND

```

```
# Ending TF-related capital stock equals beginning plus net
investments in TF #
(all,r,REG)
    kte(r) = TFINVKTER(r) * qtcgds(r) + [1.0 - TFINVKTER(r)] * ktb(r);
```

Coefficient (parameter)

LELAS # elasticity of LPI w.r.t. ending TF capital stock #;

Read

LELAS from file GTAPPARM header "LELS";

Coefficient (all,r,REG)

LLPI(r) # Level of logistics performance index in r #;

Read

LLPI from file GTAPDATA header "LPI";

Update (all,r,REG)

LLPI(r) = lpi(r);

Variable (all,r,REG)

vgdp(r) # change in value of GDP #;

Equation VGDP_r

change in value of GDP (HT 70)

(all,r,REG)

```
GDP(r) * vgd(r)
= sum(i,TRAD_COMM, VGA(i,r) * [qg(i,r) + pg(i,r)])
+ sum(i,TRAD_COMM, VPA(i,r) * [qp(i,r) + pp(i,r)])
+ REGINV(r) * [qcgds(r) + pcgds(r)]
+ TINV(r) * [qtcgds(r) + ptcgds(r)]
+ sum(i,TRAD_COMM, sum(s,REG, VXWD(i,r,s) * [qxs(i,r,s) +
pfob(i,r,s)]))
+ sum(m,MARG_COMM, VST(m,r) * [qst(m,r) + pm(m,r)])
- sum(i,TRAD_COMM, sum(s,REG,
    VIWS(i,s,r) * [qxs(i,s,r) + pcif(i,s,r)]));
```

Variable (all,r,REG)

LinkLPIKTE(r) # Linking border-related capital stock (KT) to
border quality (LPI) #;

Equation LPIKTE

Ending TF-related capital stock increases border quality

(all,r,REG)

LinkLPIKTE(r) = lpi(r) - LELAS*kte(r);

!< 4-4. Capital Accumulation based on the theory laid out in GTAP
Technical Paper #7 >!

Coefficient (all,r,REG)

TOTK(r) # total regional net investment #;
Formula (all,r,REG)

$$\text{TOTK}(r) = \text{VKB}(r) + \text{VKTB}(r);$$

Variable (all,i,ENDWC_COMM)(all,r,REG)
EXPAND(i,r) # change in investment levels relative to endowment stock #;
Equation BALDWIN
 # change in investment levels relative to endowment stock #
 (all,i,ENDWC_COMM)(all,r,REG)

$$\text{EXPAND}(i,r) = [\text{VKB}(r) / \text{TOTK}(r)] * \text{qcgds}(r) + [\text{VKTB}(r) / \text{TOTK}(r)] * \text{qtcgds}(r) - \text{qo}(i,r);$$

< 4-5. Global Bank >!

Coefficient (all,r,REG)
TOTNETINV(r) # total regional net investment #;
Formula (all,r,REG)

$$\text{TOTNETINV}(r) = \text{NETINV}(r) + \text{NETFINV}(r);$$

Coefficient
GLOBINV # global expenditures on net investment #;
Formula

$$\text{GLOBINV} = \text{sum}(r, \text{REG}, \text{TOTNETINV}(r));$$

Equation RORGLOBAL
 # either gross investment or expected rate of return in region r (HT 59) #
 (all,r,REG)

$$\begin{aligned} & \text{RORDELTA} * \text{rorg}(r) \\ & + [1 - \text{RORDELTA}] \\ & * [[\text{REGINV}(r) / \text{NETINV}(r)] * \text{qcgds}(r) - [\text{VDEP}(r) / \text{NETINV}(r)] * \text{kb}(r)] \\ & = \text{RORDELTA} * \text{rorg} + [1 - \text{RORDELTA}] * \text{globalcgds} + \text{cgdslack}(r); \end{aligned}$$

!< This equation determines either gross investment or the expected rate of return in each region, depending on the setting for the binary RORDELTA parameter.>!

Equation GLOBALINV
 # either expected global rate of return or global net investment (HT 11) #

$$\begin{aligned} & \text{RORDELTA} * \text{globalcgds} + [1 - \text{RORDELTA}] * \text{rorg} \\ & = \text{RORDELTA} * \text{sum}(r, \text{REG}, [\text{REGINV}(r) / \text{GLOBINV}] * \text{qcgds}(r) + \end{aligned}$$

```

      [TINV(r)/ GLOBINV] * qtcgds(r)
    - [VDEP(r)/ GLOBINV] * kb(r) - [VTFD(r)/ GLOBINV] * ktb(r))
  + [1 - RORDELTA] * sum(r,REG,
      [TOTNETINV(r)/ GLOBINV] * rorc(r));

```

!< This equation computes either the change in global net investment (when RORDELTA = 1), or the change in the expected global rate of return on capital (when RORDELTA = 0). >!

!< 4-6. Price Index of Aggregate Global Composite Capital Goods>!

Variable (all,r,REG)

aggpcgds(r) # composite price index for cgds #;

Equation AGGPRICEINDEX

eqn combines prices of TF and non-TF related cgds

(all,r,REG)

```

aggpcgds(r) = [NETINV(r)/TOTNETINV(r)] * pcgds(r)
              + [NETFINV(r)/TOTNETINV(r)] * ptcgds(r);

```

Equation PRICGDS

eq'n generates a price index for the aggregate global cgds composite (HT 60)

```

pcgds_wld = sum(r,REG, [TOTNETINV(r)/GLOBINV] * aggpcgds(r));

```

!< 4-7. Price of Savings >!

Variable (all,r,REG)

psaveslack(r) # slack variable for the savings price equation #;

Equation SAVEPRICE

savings price

(all,r,REG)

```

psave(r) = aggpcgds(r) + sum(s,REG, [[TOTNETINV(s) - SAVE(s)]/
GLOBINV] * aggpcgds(s)) + psaveslack(r);

```