ESSAYS ON AID AND REGIONAL INTEGRATION IN EAST AFRICA

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ABSTRACT

This thesis tackles issues related to regional integration, trade costs and aid, with empirical work related to the East African Community (EAC). The common thread is the impact of various types of trade costs on the structure and functioning of the economies of EAC member states. The first chapter introduces the literature and chapters 2, 3 and 4 constitute the core of the thesis.

Chapter 2 develops a three-good, two-country duality-based general equilibrium model to investigate the effects of different types of aid and preferential trade on welfare and relative prices. The model is innovative in two ways: (i) a regionally tradable good is introduced, the price of which is determined endogenously, (ii) a regional infrastructure good, bought with aid monies, is brought in which lowers trade costs within the region. Using comparative statics, the properties of the model are explored in terms of the effects of tariff and aid shocks on welfare and relative prices.

Chapter 3 develops a Computable General Equilibrium (CGE) model calibrated on Uganda and Kenya to gauge the importance of chapter 2's results. The regional spill-over is now modeled as regional public capital serving as an input in both countries' production functions. The simulations show how Kenya effectively exports some of the standard aid-induced real exchange rate appreciation to Uganda through a regional trade channel. Distributionally, Kenya's urban and Uganda's rural households win—which corresponds to regional comparative advantage patterns. Abolishing the intra-regional tariff increases welfare in Uganda and reduces it in Kenya, showing the ambiguous welfare results of Customs Unions known since Viner.

Chapter 4 gauges the importance of border effects in Eastern Africa by testing the law-of-one-price (LOP) hypothesis on a consumer price data-set covering 24 goods in 39 cities in 4 countries. Using level regressions a significant border effect is found, whilst distance also plays a big role, both between and within countries. Neither the nominal exchange rate, nor non-tariff barriers (NTBs) reduce the border effect very much, even though both variables are significant. Looking at specific goods, markets for staple foods are the most integrated. As for the impact of the Customs Union between Tanzania, Uganda and Kenya (since 2005), there is a positive integration effect for the Kenya-Uganda border. Finally, Kenya's political crisis at the end of 2007 can be linked to higher departures from the LOP throughout the region and can thus be said to have had clear knock-on effects for the landlocked EAC countries that depend on it as a transit country.

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Contents

Chapter 1

Regional Integration, Trade Costs and the East African Community

1.1 Overview

This thesis tackles issues related to regional integration, trade costs and aid, including empirical work related to the East African Community (EAC). The common thread is the impact of various types of trade costs on the structure and functioning of the economies of EAC member states. This overview section presents a quick tour of the three core chapters (2 to 4) and outlines the key hypotheses that motivate the thesis.

Chapter 2 develops a three-good, two-country duality-based general equilibrium model which allows us to investigate the effects of different types of aid and two different tariffs on welfare and relative prices. This set-up is motivated by the finding in chapter 1 that EAC countries are still heavily aid dependent, whilst making gradual progress with dismantling their trade barriers and integrating their economies more closely. We add value by looking at welfare and real exchange rate movements in a richer general equilibrium environment as compared to analysing preferential trade and aid issues separately. The

model is innovative in two ways: (i) a regionally tradable good is introduced, which allows us to move beyond the tradable / non-tradable good Salter-Swan dichotomy, (ii) a regional infrastructure good, bought with aid monies, is brought in which lowers trade costs within the region. This good is essentially built in one of the two countries making up the preferential trade area and lowers trade costs for the other country through a spill-over effect. Another type of trade cost is linked to the two-tiered tariff structure, which allows analysis of preferential trade. Apart from the aid used for buying the regional infrastructure good, there is also another aid flow used for consumption purposes by the recipient governments (this could be budget support or debt relief).

Chapter 3 develops a Computable General Equilibrium (CGE) model calibrated on Uganda and Kenya to gauge the importance of the theoretical results obtained in chapter 2. Compared to chapter 2, the regional spill-over is modeled differently via regional public capital serving as an input in both countries' production functions. Spending on this good happens exclusively in Kenya. The two-tiered tariff structure is another way of modeling a lowering of regional trade costs. The 123-structure of the model allows us to differentiate between domestic, regional and international sources of production and consumption. This is modeled through nested Constant Elasticity of Substitution and Constant Elasticity of Transformation functions with differing elasticities and is another way of modeling trade costs. Three types of aid use are considered in the simulations: (i) aid supplementing household income, (ii) aid funding national public capital stocks, and (iii) aid funding the regional public capital stock. The simulations start by showing how the movements of the multiple real exchange rates are non-trivial compared to the Salter-Swan set-up. I.e. we need to re-interpret real exchange rates when dealing with inter-dependent countries within a region, as compared to the analysis for a *'stand-alone'* country.

Chapter 4 gauges the importance of border effects in Eastern Africa by testing the law-of-one-price hypothesis on a highly disaggregated consumer price dataset. The data covers 24 goods in 39 cities in 4 countries over the period Jan-2004 to Aug-2008. We look mainly at trade costs for reasons as to why the law-of-one-price might not hold. Hence

we include in the regression analysis variables picking up transport costs (distance), non-tariff barriers, plus a border dummy to see whether price differences between city-pairs within countries exhibit different behaviour from citypairs between countries. We also differentiate the analysis according to good characteristics and look whether the advent of the EAC customs union in 2005 had any impact on price behaviour. Finally, we touch upon landlockedness by analysing the impact of the Kenya 2008 election crisis on prices in the other three landlocked countries in the dataset.

The rest of this chapter now goes on to give very short literature reviews on regional integration, trade costs, regional public goods (all in section 1.2) and the EAC (section 1.3), giving the reader the necessary background information for chapters 2 to 4. Section (1.4) concludes.

1.2 Preferential trade agreements and trade costs

This section is organised as follows: subsection (1.2.1) introduces how economists have usually analysed questions regarding preferential (regional) trade, (1.2.2) discusses recent developments in this literature, (1.2.3) evaluates regional trade agreements in sub-Saharan Africa, (1.2.4) covers North-South preferential trading arrangements, (1.2.5) talks more generally about trade costs and (1.2.6) considers regional public goods provision and the implications of landlockedness for developing countries.

1.2.1 Viner's legacy

This section briefly outlines the main analytical issues related to Preferential Trade Agreements (PTAs)[1]. It is useful to get a clear understanding of what a PTA actually is. Bald-

[1]For more in-depth literature reviews see Baldwin and Venables (1995), Baldwin (1997) or Burfisher et al. (2004). For a focus on Africa, see Yang and Gupta (2005) or UNCTAD (2009) and the discussion in (1.2.3).

win and Venables (1995) distinguish between three types of *'geographically discriminatory (preferential) trade policies'*. These are—ordered by increasing depth of integration:

1. Free Trade Area (FTA). Internal tariffs are reduced, but partner countries set their own tariffs vis-à-vis the rest of the world.
2. Customs Unions (CU). Internal tariffs are reduced, with all partner countries agreeing on a common external tariff governing trade with the rest of the world.
3. Common Market. Adds the free movement of factors of production to the free movement of goods and services between member states.

Analysis of the welfare implications of PTAs goes back to Viner (1950). He used the concepts of trade creation and trade diversion to show that in general welfare effects of preferential trade agreements are ambiguous. To understand Viner's key result, consider a country entering a Customs Union, which aims to reduce intra-regional import tariffs. Trade creation is the displacement of inefficient domestic production by imports from more efficient regional partners. Trade diversion is the displacement of imports from third countries by less efficient (relative to these third-countries) regional partners. The higher post FTA tariffs with respect to goods from third countries, the higher the probability that trade diversion will be significant. World welfare can decrease when trade diversion dominates trade creation, which is in essence an application of the *theory of the second best*—as shown by Lipsey and Lancaster (1956). Viner's trade creation-trade diversion terminology has survived, despite well-documented problems with his framework. Kowalczyk (2000) summarizes these problems:

1. Depending on how trade indifference curves are shaped, a trade-diverting Customs Union can raise welfare.
2. In a world with many goods and many countries, the formation of a CU can raise rather than lower demand for certain imports from the rest of the world due to complementarity between such goods and intra-union trade, or as higher income

of union members raises demand for normal goods[2]. Such effects cannot be categorised according to the Vinerian concepts of trade creation or trade diversion.

3. Determining trade diversion empirically by only looking at trade volumes, which is implied by Viner's analysis, without considering price effects, can lead to erroneous welfare conclusions.

Harrison et al. (1993) describe the problems with the Viner terminology eloquently: *'Though trade creation and trade diversion are good descriptions of the effects of CU formation, indicating the sometimes second-best nature of preferential trading agreements relative to free trade, they do not provide useful measures of the sources of the welfare changes'*. Different authors have suggested various new terminologies, with the welfare decomposition of Kowalczyk (2000) into a *volume-of-trade* and a *terms-of-trade* effect probably the most popular. In subsequent chapters, welfare considerations will form a key component of our analysis, but the Vinerian language will largely be omitted because of these problems with the trade-creation, trade-diversion concepts.

1.2.2 The 'new' regionalism

Apart from welfare considerations, there are other issues which have moved researchers beyond the aforementioned Vinerian analysis. Viner mainly investigated the *static* allocation effects of removing commodity trade barriers, in a perfect competition world. Burfisher et al. (2004) dub Viner's standard analysis the 'old' regionalism, claiming this type of research is *'missing much of the action'*[3]. The 'new' regionalism moves beyond Viner in the following ways.

First, the standard assumptions of the Viner model, such as homogenous goods, perfect competition or constant returns are relaxed. Researchers have built regional trade mod-

[2]Income effects will form an essential part of the general equilibrium analysis of Regional Trade Agreements (RTAs) in chapters 2 and 3.

[3]The same issues are also echoed in more recent work by e.g. Baldwin (2011) who calls this shift away from traditional regionalism *21st century regionalism.*

els that capture issues including differentiated products[4], scale economies[5], international factor mobility, transport costs[6] or market structure & imperfect competition[7].

A good starting point for this literature is Baldwin (1997), who talks about scale and variety effects. Both are related to the increase in market size as a consequence of regional borders being opened. The *scale* effect refers to the improvement in efficiency as firms are less constrained by market size when trying to exploit economies of scale. The *variety* effect implies that integrating a country's economy into a larger market brings about more choice for its consumers, whilst international factor mobility means firms can improve on their optimal input mix. Under standard assumptions, both are welfare increasing. What about transport costs? Despite the improvement of transport links across the globe, it is no secret that sub-Saharan Africa, has particularly poor transport infrastructure—see also subsection (1.3.3) which discusses this in the context of the EAC. As shown by Krugman, transport costs can dramatically alter welfare calculations for regional integration schemes[8].

A second departure from the Vinerian analysis is the explicit incorporation of dynamics. According to World Bank (2004) *'a full welfare analysis of RTAs should also take into account potential dynamic gains'*, with Burfisher et al. (2004) arguing dynamics should include analysis of trade-productivity links and endogenous growth theory. This includes technology and knowledge transfers, especially from developed to developing countries, that increase productivity. The new trade analytics also encompass dynamic comparative advantage and learning-by-doing efficiency gains through increased demand from expanded trade.

The previous arguments can still mostly be linked to (regional) commodity trade. How-

[4]Venables (2000) building on the classic Ricardian trade model with a continuum of goods developed by Dornbusch et al. (1977).
[5]Choi and Yu (1984) or Casella (1996).
[6]Frankel et al. (1995) and Baier and Bergstrand (1997).
[7]Krugman (1991a).
[8]Krugman (1991a) and Krugman (1991b) show that continent-wide FTA's decrease welfare with zero intercontinental transport costs and increase welfare with prohibitive intercontinental transport costs.

ever, the 'deeper' integration that Burfisher et al. (2004) talk about goes further than just commodity trade. Their analysis also incorporates services trade and moves towards political integration alongside economic integration. In the words of World Bank (2004): *'RTAs are often one component of a larger political effort to deepen economic relations with neighbouring countries, trying to overcome institutional as well as policy barriers to trade. Trade agreements usually therefore go beyond slashing tariffs to include measures to reduce trade impediments associated with standards, customs and border crossings, and services regulations—as well as broader rules that improve the overall investment climate'*. These are the so-called 'behind the border' issues and are closely related to trade costs, which are discussed in subsection (1.2.5).

Going beyond the pure tariff story also brings issues like rent-seeking behavior and other political economy considerations to the fore. One issue which has not been addressed very well in the African context is how the spoils of regional integration should be divided, as the EAC history overview in subsection (1.3.1) shows.

However, even when including these 'new' regionalism aspects of regional trade environments, Burfisher et al. (2004)'s conclusion that *'it is impossible to draw strong general conclusions about the desirability of forming an RTA from the perspective either of members or of the rest of the world, from theory alone'* still stands. Hence the need to investigate the record of regional integration efforts, which is what we now turn to.

1.2.3 Preferential trade agreements in Africa: the record so far

Finding an answer as to whether RTAs are welfare increasing is thus fundamentally an empirical question. As this thesis focuses on Eastern Africa, the record of African PTAs is reviewed in this section. Economic (and political) integration has a long history in Africa[9]. African regional organisations have largely been motivated by the desire to pro-

[9]Kouassi (2007) gives a good overview.

mote growth, especially related to creating larger internal markets for small countries[10], increase bargaining power in multilateral negotiations and reduce conflict through regional cooperation.

The African Union sees regional integration within the continent as a 'stepping stone' towards a fully integrated African continent. Intermediate steps are the development of regional communities—as for example outlined by Dr. Maxwell Mkwezalamba, Commissioner for Economic Affairs at the African Union Commission: *'The Regional Economic Communities (RECs) and the AU have a critical role to play in promoting rapid socio-economic development in Africa. This role includes the promotion of regional integration through the enhancement of the competitiveness of African economies by establishing large regional markets, the promotion of intra-Africa trade, harmonizing and coordinating national policies, and the provision of regional infrastructure and regional public goods.'* (Mkwezalamba and Chinyama, 2007)

What is the success rate of African RTAs as measured against these stated objectives? UNECA et al. (2010) find that numerous initiatives and decades of experimentation with integration in Africa have brought no significant improvements to intra-RTA or intra-African trade. UNCTAD (2009) states that *'Regional Initiatives in Africa (..) did not deliver much to uplift the economic conditions of its members nor ensure sustainable growth and liberalisation'*. Yang and Gupta (2005) are equally damning:

- Trade intensity is considerably higher among African countries than between African countries and non-African countries. This is largely due to Africa's marginalization in the world market rather than to sizeable intra-regional trade.
- Econometric evidence on RTAs promoting intra-African trade is mixed. One might tentatively argue that RTAs have had positive but uneven effects on intra-regional

[10] I.e. *accelerate the transformation of their fragmented small economies, expand their markets, widen the region's economic space, and reap the benefits of economies of scale for production and trade* (UNECA et al., 2010, p.10). See also Collier and Venables (2008) who document *the wide range of costs inflicted on African citizens* by the continent's fragmentation compared to for example South Asia.

trade. Over the longer run though, effects are small or insignificant[11].

- RTAs do not seem to have had a significant impact on Africa's export performance in the world market, with little indication that Africa's export competitiveness has a positive relation with the presence of an RTA.
- Africa's poor record in attracting Foreign Direct Investment (FDI) also seems to indicate that RTAs have not significantly improved the region's competitiveness.
- Considering the failure of African RTAs to increase the region's overall trade, it is unlikely that dynamic welfare effects (e.g. from increased competition or learning-by-doing) have been very significant.

As for the non-economic objectives, RTAs have had some success in reducing conflict on the continent, e.g. ECOWAS' role in Sierra Leone. Such evidence is anecdotal however and should not be exaggerated[12]. RTAs can sometimes even be bad for regional cooperation as the collapse of the East African Community in the 1970s shows—see also section (1.3.1).

Overall, it seems that one of the main problems with African RTAs is the *complete non-implementation of agreed trade liberalisation schedules as well as other obligations by members* (UNCTAD, 2009, p.15), caused inter alia by low administrative capacity. Other causes of the poor record given by UNCTAD (2009) include: little private sector support, lack of complementarities between regional partners in goods and factors and lack of viable mechanisms for redistributing benefits and costs.

The recent proliferation in the number of African regional organisations, often with overlapping memberships, has not helped in this respect[13]. According to the IMF this is a

[11] See Elbadawi (1997) for a skeptical assessment or Carrere (2004) for more positive evidence. More recently, Geda and Kebret (2008), using a gravity model, find that regional groupings had insignificant effects on the flow of bilateral trade.

[12] For an interesting discussion on how regional integration can help the rebuilding of fragile states in Africa, see Verdier (2010).

[13] According to World Bank (2004), every African country is member to on average 4 RTAs. Yang and Gupta (2005) find that in early 2005, there were some 30 RTAs in Africa. UNECA et al. (2010) counts 21 RTAs: 14 RECs, 5 EPA's and 2 bilateral agreements. UNCTAD (2009) claims that *today there are more regional organisations in Africa than in any other continent*.

serious obstacle to further integration as it *prevents the elimination of the transaction costs involved in border formalities, including rules of origin* (IMF, 2008, p.59).

Nevertheless, there is some renewed optimism that mistakes from the past can be avoided. The Africa-wide integration process has been helped by the creation of the new-look African Union in 2001 and the New Partnership for African Development, which explicitly mentions support for provision of regional public goods as one of its central goals (NEPAD, 2001, p.20). UNCTAD (2009) cites some recent successes, with the 'new regionalism' apparently catching on in Africa too: *Africa is deepening its regional integration by integrating non-traditional issues such as services, investment and migration in regional programmes linking African countries*.

1.2.4 North-South preferential trade schemes

What about regional trade agreements between African countries and non-African countries? Would welfare results for such RTAs be more positive compared to the intra-African RTAs just reviewed? Venables (2003) develops a model to study how costs and benefits of customs unions are divided between member countries. Countries with a comparative advantage between that of their CU partner and the rest of the world do better than countries with an 'extreme' comparative advantage. Consequently, integration between low income countries tends to lead to divergence of member country incomes, while agreements between high income countries cause convergence. The results of the paper suggest that developing countries are likely to be better served by 'north-south' than by 'south-south' agreements.

World Bank (2004) argues that North-South RTAs with small developing countries yield the biggest benefits for the latter: *'When one partner is much smaller than the other, its participation has virtually no impact on prices, and any incremental exports it sells are a tiny share of the large country's trade flows–so the resulting gains or losses for the larger*

partner are also small'. However, it has also been argued that the recent aggressive pursuit of RTAs by the EU and the US do not always benefit the low-income RTA partner(s). World Bank (2004) is quite critical of these so-called 'hub-and-spoke' agreements. It claims the 'hub' benefits disproportionately because of differing rules of origin, product exclusions, non-trade issues, etc, reflecting the overall unequal negotiating clout.

There is a long history of trade agreements between the EU and Africa, including trade preferences accorded by the EU under the Lomé and Cotonou conventions. However, these trade preferences are to be phased out, as they are not compatible with WTO law. In general under article XXIV of the GATT/WTO, RTAs are not 'compatible' with rules governing multilateral trade if (i) they fail to eliminate barriers on *'substantially all the trade'* among members, and/or if (ii) external tariffs imposed are *higher or more restrictive* compared to the pre-RTA situation. The ACP-EU treaties violate these clauses, and as such a (end-of) 2007 deadline was given by the WTO to make the treaties WTO-compatible. In other words ACP countries have to open their markets in return for access to EU markets.

Economic Partnership Agreements (EPA's) have been the vehicle for realising these changes, with the EU negotiating such agreements originally with four different African regions. As the end-2007 deadline approached, these four groupings, which more often than not had overlapping membership with existing African REC's, fell apart, with the EU ending up initialling interim EPA's with only 17 African countries. The EAC is the only region with more than one country with the same commitments (Stevens et al., 2008, p.xii). In addition, the EAC is the only African region in which all signatory countries have identical tariff reduction schedules. Further, all schedules are based on the EAC's Common External Tariff and none requires a country to start removing any positive tariffs until 2015. The EAC interim-EPA also has the longest transition period, with the full liberalisation schedule to be completed by 2033 (Stevens et al., 2008, p.23). This means that potential revenue losses will be less sharply felt over the short run, with countries given adjustment time to put their public finances in order.

There is no consensus regarding the welfare effects of the EPA's. Cali and te Velde (2006) conclude that *'[under EPAs] trade liberalisation of goods trade is broadly positive though not as large as could be expected from multilateral trade'*, whilst UNECA et al. (2010) quote research from the African Union claiming that European import surges in the wake of the EPA's could displace intra-Africa trade by up to 16%[14].

Research on the EAC-EPA has similarly been inconclusive. Milner et al. (2005) use a partial equilibrium framework to assess welfare effects for Tanzania and Uganda and find that welfare effects will be relatively small, whether positive or negative. Kiringai (2005) argues that a partial equilibrium framework does not pick up more contentious general equilibrium effects on factor incomes and employment. Using a general equilibrium framework, she finds that net economic effects of the EPA are likely to be positive, but negative for some important agricultural products.

The EU also gives the group of Least-Developed Countries (LDC's)[15] duty and quota-free access to the EU market for all their exports. This preference scheme, called the Everything But Arms (EBA) initiative, will keep on running regardless of the EPA process, but is less attractive to LDC's as it is not contractual and thus less predictable. All members of the East African Community, except Kenya, are LDC's. Similar in set-up, the other major preferential trade agreement involving Africa is the African Growth and Opportunity Act (AGOA), through which the US gives African countries preferential access to its domestic market. Collier and Venables (2007) discuss the relative merits of AGOA and EBA, concluding that the former has created larger manufacturing export supply responses than the latter, and link this to more onerous EBA rules of origin.

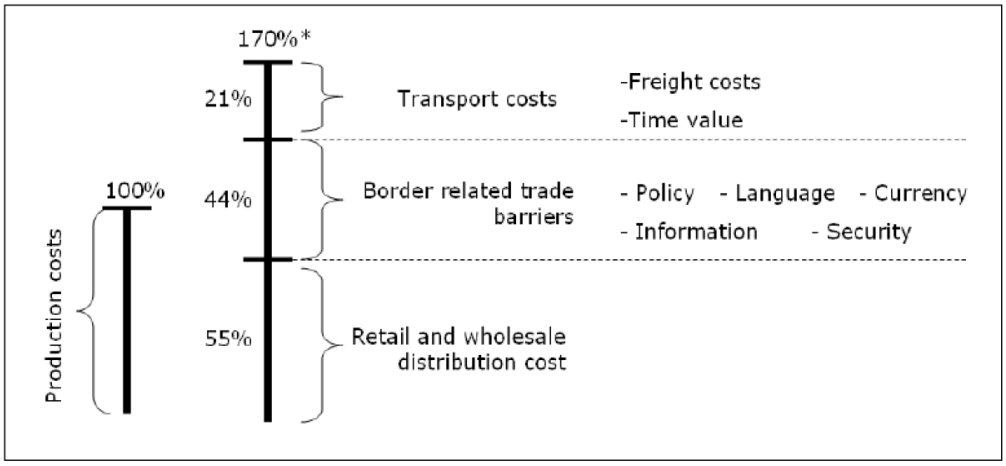
[14]For a more general overview of the pros and cons of the EPA process, see chapter 11 of UNECA et al. (2010).

[15]This is a group of countries defined as such by the UN—see http://www.unohrlls.org/en/ldc/related/62.

1.2.5 Trade costs

Trade costs broadly defined *'include all costs incurred in getting a good to a final user other than the marginal cost of producing the good itself'* (Anderson and Van Wincoop, 2004, p.691). Figure 1.1 gives an estimate of average trade costs for industrialised countries. The headline figure of 170% (ad-valorem equivalent) breaks down into 55% local distribution costs and 74% international trade costs, as *'it is arbitrary to stop counting trade costs once goods cross a border'* (Anderson and Van Wincoop, 2004, p.692)[16]. It is also immediately clear that *tariffs*, which fall under the category *border related trade barriers—policy* in the figure, are just one of many different types of trade costs.

Figure 1.1: Estimates of trade costs in industrialised countries



Source: Portugal-Perez and Wilson (2008) with estimates drawn from Anderson and Van Wincoop (2004).
* The cost components are expressed in ad-valorem equivalent terms: 170%=1.7=1.21*1.44*1.55-1

Portugal-Perez and Wilson (2008) classify trade costs into four broad categories: (i) border-related costs, (ii) transport costs, (iii) costs related to behind-the-border issues, and (iv) costs related to preferential trade agreements. The same authors give compelling evidence, based on the World Bank's Doing Business data, that overall trade costs are higher in sub-Saharan Africa than in other parts of the world[17].

Border-related trade costs are usually split into tariff and non-tariff barriers (NTBs). An-

[16] We will revisit this issue in chapter 4 which focuses on the relative size of domestic and cross-border trade costs in the EAC.
[17] For some summary statistics, see table 8 in UNCTAD (2009).

derson and Van Wincoop (2004) group NTBs into (i) hard barriers (price and quantity measures), (ii) threat measures (antidumping and countervailing duty investigations and measures), (iii) quality measures (standards, licensing requirements, etc), and (iv) embargoes and prohibitions[18].

Behind-the-border issues were already discussed in subsection (1.2.2) as part of the 'new regionalism' agenda, but these are of course also valid for trade more generally. Finally, there are trade costs specifically related to preferential trade. In a free trade area the most obvious costs are related to the administration of often complex rules of origin. For a customs union, additional costs can be incurred because the preferential scheme incentivises producers to make adjustments to the optimal choice of inputs in the production process.

1.2.6 Regional public goods & landlockedness

Together with the aforementioned revival of regional integration schemes in Africa, donors have increasingly looked to help developing countries exploit the benefits of regional public goods, and avoid the repercussions of regional 'bads'. Of course, regional integration efforts in developing countries have always looked at ways to do this, even without external aid. The main example of this has been regional bodies mediating in conflicts between member states, as was mentioned in section (1.2.3).

Ferroni defines international public goods (which include regional public goods) as *'the knowledge, the regimes, and the standards and rules that are required to address cross-border problems or to engender desirable cross-border externalities; the institutions that monitor and enforce the rules and regimes; and the benefits that arise and are shared in-*

[18]Research by UNCTAD shows that NTBs are on the rise in both the developed and developing world. Since 1994, WTO member countries have made good progress in dismantling so-called *core* barriers to trade agreed during the WTO Uruguay Round. These include quantity control measures, finance measures and price control measures. UNCTAD (2005) documents how the use of these core measures decreased dramatically, from 44.7% of all measures in 1994 to 15.2% in 2004. For African countries, this development was even more pronounced. The use of NTBs however, increased from 55.3% in 1994 to 84.8% in 2004.

discriminately among countries' (Ferroni, 2002, p.1). According to a recent World Bank research project on infrastructure *many of Africa's infrastructure assets and natural resources are regional public goods that cut across national frontiers and can be effectively developed and maintained only through international collaboration*, with *regional integration lowering costs across all aspects of infrastructure* (World Bank, 2010b, p.21).

One regional externality which is of major importance in Africa is the amount of countries that are landlocked. In Africa, unlike on other continents, around 1/3 of the population lives in landlocked countries. Collier (2008) argues that this means a very large share of people in Africa are dependent on their neighbours for their economic welfare. He breaks this dependence down as follows :

1. Landlocked countries are dependent upon their coastal neighbours for access to ports, and hence their transport costs will depend on how seriously their coastal neighbours prioritize their interests. In a frequently quoted paper, Limao and Venables (2001) find that transport costs are indeed much higher for landlocked countries (in their model by 50%). However, this average masks sizeable differences between different landlocked countries, and is dependent on expenditures on transport infrastructure in the coastal neighbours.
2. There is compelling evidence that growth spill-overs from neighbours are strong. Hence, *the landlocked have an interest in the economic governance of neighbouring countries since if their neighbours continue to forego opportunities this closes off their own opportunities* (Collier, 2008, p.7).
3. Finally, Collier explains that it takes two to integrate: *the landlocked cannot integrate into a subregional market unless their neighbours implement polices that enable it to happen* (Collier, 2008, p.7).

There is an important regional dimension to the landlockedness issue: *'(..) because many of the African countries are small in population and economic size and/or are landlocked, many competitiveness issues are best addressed at the regional level. For example, it is*

important that the interests of land-locked countries are properly taken into account in motivating reform of ports, customs and transport in the countries that provide access to the global market. (Brenton et al., 2008).

Note that the issues to be addressed are wider than donors or governments providing the regional connectivity *hardware*, like building roads, power stations, etc. Arvis et al. (2010) find that massive investments in infrastructure seem to have had a rather limited impact, claiming that *logistics or trade services efficiency is more important for limiting the cost of being landlocked than investing massively in infrastructure and neglecting the functioning of logistics services.*

In the next two chapters, we will not explicitly model landlockedness, but some conclusions we draw will be relevant for landlocked countries. Also, chapter 4, which investigates the border effect in Eastern Africa, will show how market integration in a region with both coastal and landlocked countries is affected by shocks in the relevant coastal country.

1.3 The East African Community

This section is organised as follows. Subsection (1.3.1) introduces the EAC, (1.3.2) shows how the EAC is doing today on a number of key indicators and (1.3.3) discusses trade costs and infrastructure in the EAC.

1.3.1 A short introduction to the East African Community

Table 1.1 shows some key dates in EAC history, guiding the discussion. Before independence, the area occupied by the current countries of Tanzania, Kenya and Uganda (see map A1 in appendix A), enjoyed a remarkable degree of integration under British

colonial rule, comprising *a customs union with a Common External Tariff (CET) and free trade between the countries, common customs and income tax administrations, common transport and communication services (..), a common university, and a common currency* (Hazlewood, 1982, p.143). Of course, these arrangements were colonial relics and could not be expected to survive independence, especially as Kenya was seen as taking a disproportionate share of the integration cake. The set-up of the East African Community in 1967 thus instituted provisions to counteract Kenya's perceived dominance. Examples of this were the so-called transfer tax, which gave some protection to industries in the two less developed states, the establishment of the East African Development Bank, which was to allocate a disproportionate share of its lending to Tanzania and Uganda, and relocation of some of the Community's common services, so as to reduce the concentration of those in Kenya (Hazlewood, 1982, p.144).

Table 1.1: Key Dates in the Establishment of the East African Community

Date	**Event**
1905	Currency Board set up between Kenya & Uganda
1917	Customs Union established between Kenya & Uganda
1922	Tanganyika joins customs union
1948	High Commission established
1961	Common Services organisation established
1961-1963	Tanganyika, Uganda and Kenya gain independence from Britain
1967	EAC first established with members KEN, UGA and TZA[a]
1977	EAC collapses
Nov 1999	Treaty for establishment of EAC signed (members KEN,UGA, TZA)
Jul 2000	EAC treaty enters into force upon ratification by all 3 members
Mar 2004	Customs Union Protocol signed between KEN, UGA and TZA
Jan 2005	Customs Union between KEN, UGA and TZA established
Jul 2007	Rwanda and Burundi become full members
Nov 2007	EAC Concludes interim EPA with the EU
Nov 2009	Customs Union extended to Rwanda and Burundi
Jul 2009	Common Market Protocol signed by EAC members
Jan 2010	Customs Union enters into force between all 5 states
Jul 2010	Common Market Protocol initiated
ENVISAGED	
2011	EPA Negotiations concluded
2012	Monetary Union
Ultimately, Political Federation of the East African States	

[a] KEN indicates Kenya, TZA indicates Tanzania and UGA indicates Uganda.

However, the EAC project was abandoned in 1977. What were the reasons? First, there was an argument over redistribution. Kenya was seen as taking more than its fair share of integration benefits. This was related mainly to regional manufacturing activities being increasingly concentrated in Kenya. Despite the measures described previously, Tanzania and Uganda felt they were not being appropriately compensated. Second, during the 70's, the three member states took increasingly different development paths. Kenya became more capitalist oriented, whilst Tanzania's Nyerere started experimenting with different forms of socialism. The erratic leadership of Idi Amin in Uganda added to the tensions.

The breaking up of the EAC highlights problems emanating from reversing integration. For Kenya, Mwega and Ndungu'u (2008) document how reduced market size implied reduced demand, which meant that firms had to curtail their activities and suffered from unused capacity. Himbara (1994) shows how multinationals started divesting from Kenya after the EAC collapse.

Similarly, under Belgian colonial rule, Burundi, Rwanda and the Eastern part of today's DRC formed an integrated market. With the advent of independence, these countries instituted tariff and non-tariff barriers, effectively splitting up the market. Nkurunziza and Ngaruko (2008) show how this meant Burundi lost more than half of its external market, with the de-integration process leading to substantially smaller firm size. This process is held up as a key factor in their analysis of slow growth in Burundi over the post-independence period.

The EAC was resurrected by its three original members at the end of the 1990s, with Burundi and Rwanda joining in 2007 (maps A1 and A2 in appendix A). Note that Uganda, Rwanda and Burundi are all landlocked. The discussion about regional public goods and landlockedness (section 1.2.6) is thus very relevant to the EAC. We will come back to this in later chapters. The major overland trade arteries in Eastern Africa are the northern and the central corridors (appendix A, map A3). Currently, regional traffic is concentrated along the better developed northern corridor (World Bank, 2010c).

Using the terminology of section (1.2), we can say that the depth of integration has increased substantially in the last couple of years. As of 2010, the five member states make up a fully fledged customs union. Further, the protocol for a common market was signed by the five heads of state in November 2009, and instituted on the first of July 2010. It should be noted however, that not all impediments to the free flow of labour and capital were removed. Plans are currently being drawn up for a Monetary Union, even though the current timetable as shown in table 1.1 is probably too ambitious.

Table 1.2: Overview economic indicators in EAC

	Burundi		Kenya		Rwanda		Tanzania		Uganda		Total/Average	
	2003	2008	2003	2008	2003	2008	2003	2008	2003	2008	2003	2008
GDP												
GDP (curr. mio US$)	595	1,163	14,904	30,355	1,777	4,457	10,283	20,490	6,337	14,326	33,895	70,791
Agriculture (% GDP)	40%	34%	29%	27%	38%	37%	45%	45%	26%	23%	36%	33%
Industry (% GDP)	19%	20%	18%	19%	13%	14%	17%	18%	24%	26%	18%	20%
Services (% GDP)	41%	46%	53%	54%	49%	48%	38%	37%	49%	52%	46%	47%
GDP per capita (US$)	86	144	438	783	205	458	286	496	236	453	299	541
Other Indicators												
net ODA (% GNI)	40%	44%	4%	5%	19%	19%	17%	12%	16%	12%	19%	18%
Population (mio)	7.0	8.1	34.0	38.8	8.7	9.7	36.9	42.5	26.9	31.7	113.5	130.7
Trade (all % GDP)												
Imports	28	29	30	41	26	31	26	28	26	33	27	33
Exports	8	5	24	27	8	15	20	13	11	16	14	15
C.A.	-4.0	-12.2	-1.3	-6.5	-5.5	-5.7	-1.1	-11.3	-3.1	-5.9	-3.0	-8.3

Source: World Bank World Development Indicators—accessed online on 15 July 2010 at http://data.worldbank.org/.

Table 1.2 gives an overview of the region's socio-economic make-up[19]. In 2008, the EAC region had a population of about 130 million, with a combined GDP of 70 billion USD. The latter more than doubled between 2003 and 2008 (in USD terms), whilst the population increased by some 15 percent. Hence, regional per capita income increased substantially. This masks substantial differences between countries however, as member states find themselves at very different points in their economic development. In 2008, Kenya had the highest GDP per capita of 783 USD, with Burundi coming last with 144 USD per capita. Unsurprisingly, these trends are reversed when looking at aid with post-conflict Burundi receiving 43.9% of its GNI in 2008, with Kenya on 4.5%. There is a slight shift in economic structure between 2003 and 2008 with e.g. Kenya and Uganda reducing their share of agricultural value added in GDP in favour of services and industry.

[19]The tables in this section report data for 2003 and 2008. These two years were chosen to have one year before and one year after the start of the CU in 2005 between Uganda, Kenya and Tanzania. Further, 2008 is the last year for which there is reliable data available, and 2003 is the year for which the Computable General Equilibrium (CGE) model of chapter 3 is calibrated.

Kapstein (2010) shows how this structural shift has been on-going since the mid-80s, especially so in Uganda.

1.3.2 Trade and tariffs in the EAC

Table 1.3 shows direction of trade data for all five EAC member states. Focusing on the three EAC founding members, it is clear that Kenya dominates EAC trade relations, exporting much more than importing from Uganda and Tanzania. It is the only member state to have a positive trade balance within the EAC, even though it still has a significant overall trade deficit. The brunt of the region's trade deficits with the rest of the world is borne by foreign aid (Castro et al., 2004, p.34).

The table shows an increasing trend in all trade flows between 2003 and 2008 for all three original EAC member states. Mugisa et al. (2008) claim that this increase of intra-EAC trade shows the positive effects of the recent integration efforts. As all of these countries posted healthy growth rates in the period under consideration, which was one of strong growth in the world economy, intra-EAC trade growth is to be expected, and should at the very least be compared to growth in trade with other trading partners. For example whereas exports from Kenya to the EAC grew by 56%, exports to the rest of the world grew by 111%. What is more, the increase in regional trade already started during the 90's, with unilateral liberalisation efforts increasing in all countries in the region (Castro et al., 2004). In 2003 for example, Uganda applied preferential COMESA tariffs to intra-EAC imports which did not exceed 6%, whilst Kenya applied a preferential tariff discount of 90% on intra-EAC imports, with a trade-weighted intra-EAC tariff of less than 3% (Stahl, 2005). On top of that, EAC partner states agreed on asymmetrical intra-EAC tariff liberalisation, in the form of a five-year adjustment period between 2005 and 2010, providing Tanzania and Uganda with more time to adjust to the new tariff regime. In conclusion, it is probably more correct to state that the application of the customs union tariff bands from 1st January 2005 onwards has helped increase regional

Table 1.3: Trade flows in EAC member states (all in US$ millons)

	2003	2008	% growth	2003	2008	% growth	Avg 03-08	2008 (EAC source)	
Kenya	**Kenya exporting**			**Kenya importing**			**TB**	**Export**	**Import**
Uganda	404	465	*15*	14	180	*1,220*	352	613	75
Tanzania	192	453	*136*	18	51	*182*	274	424	106
Rwanda	79	167	*111*	0	139	*225,893*	87	130	0
Burundi	36	28	*-24*	0	2	*5,031*	31	50	1
Total EAC	711	1,112	*56*	32	372	*1,072*	743	1,217	183
EU	706	1,519	*115*	911	2,185	*140*	-459	1,294	1,961
Total	2,473	5,206	*111*	3,711	13,379	*260*	-4411	4,987	11,141
Uganda	**Uganda exporting**			**Uganda importing**			**TB**	**Export**	**Import**
Kenya	78	164	*109*	357	511	*43*	-316	165	511
Tanzania	6	30	*420*	11	55	*414*	-5	31	55
Rwanda	21	137	*558*	1	3	*438*	2	137	1
Burundi	10	45	*350*	0	1	*3,459*	0	45	3
Total EAC	115	377	*227*	369	571	*55*	-320	377	571
EU	146	460	*215*	258	878	*240*	96	462	878
Total	534	1,722	*223*	1,375	4,526	*229*	-449	1,724	4,526
Tanzania	**Tanzania exporting**			**Tanzania importing**			**TB**	**Export**	**Import**
Kenya	16	46	*182*	211	498	*136*	-77	252	660
Uganda	10	50	*414*	6	33	*420*	4	59	76
Rwanda	5	49	*892*	0	1	*2,003*	4	22	21
Burundi	17	15	*-8*	0	0	*-69*	0	20	22
Total EAC	48	161	*236*	218	533	*145*	-68	353	779
EU	303	445	*47*	505	1,404	*178*	-237	534	1,858
Total	1,129	2,674	*137*	2,125	7,081	*233*	-863	3,119	6,908
Rwanda	**Rwanda exporting**			**Rwanda importing**			**TB**	**Export**	**Import**
Kenya	0	127	*225,894*	87	184	*111*	-100	31	129
Uganda	0	7	*1,332*	23	166	*624*	-61	1	145
Tanzania	0	1	*2,003*	5	53	*892*	-16	6	26
Burundi	1	6	*833*	2	6	*161*	-2	6	4
Total EAC	1	141	*11,079*	118	409	*248*	-179	43	303
EU	19	93	*387*	92	263	*187*	-104	70	237
Total	151	398	*164*	370	1,146	*210*	-394	201	1,037
Burundi	**Burundi exporting**			**Burundi importing**			**TB**	**Export**	**Import**
Kenya	0.0	1.5	*4,579*	22.5	30.3	*34*	-29	1.6	30.3
Uganda	0.7	1.6	*121*	9.2	34.5	*273*	-19	2.6	34.5
Tanzania	0.0	0.0	*-69*	18.4	16.8	*-8*	-13	0.1	16.8
Rwanda	2.1	3.5	*62*	0.7	3.1	*329*	2	5.0	3.2
Total EAC	2.9	6.6	*124*	50.9	84.7	*67*	-60	9.3	84.8
EU	10.7	14.4	*34*	49.7	123.0	*147*	-78	24.2	116.6
Total	37.5	69.6	*85*	156.8	409.6	*161*	-238	74.3	403.0

Source: The first seven columns are from the IMF's Direction of Trade Statistics (DOTS). Note that partner countries' export and import data are not consistent. The IMF explains: *[..] exports from Country A to B should be equal to imports of Country B from A, after taking into account insurance and freight costs under the generally observed case that Country B imports are valued on a c.i.f. basis. The principal reasons for inconsistent statistics are differences in (i) classification concepts and detail, (ii) time of recording, (iii) valuation, and (iv) coverage, as well as (v) processing errors'*—see www2.imfstatistics.org/DOT/DOTConsi.htm

The last two columns are from EAC (2010), which takes trade data directly from national authorities, which means there are important discrepancies compared to the DOTS. Reasons for this are similar. E.g. *During 2008, Tanzania's total trade with other EAC Partner States increased significantly [..] the increase is largely attributed to improvement in data collection* (EAC, 2010, p.34). Or *Uganda's imports from Rwanda decreased [..] The reduction in imports from Rwanda could also be attributed to improved classification of trade data* (EAC, 2010, p.38).

trade alongside other domestic and regional trade-enhancing initiatives (see below for a discussion on non-tariff barriers).

An important part of the original (i.e. three country) CU negotiations was linked to the setting of the Common External Tariff (CET). The (2010) CET is set to 0% for raw materials, 10% for intermediate goods and 25% for final goods. An accompanying list of sensitive goods allows for exceptions to these rates.

Before the CU came into effect in 2005, Uganda had much lower tariffs vis-à-vis the rest of the world than Tanzania and Kenya. Hence, its average tariffs applied to third countries increased substantially when the CET kicked in in 2010. Stahl (2005) finds that Uganda's trade-weighted average tariff rose by 14%, to 6.7 percentage points, while that of Tanzania fell by 32% to 5.6 percentage points, and Kenya's declined by 66% to 5.9 percentage points. Hence Stahl's claim that *'Uganda's cost of living and production is likely to increase - to the extent that such costs are determined by prices of imported consumer goods and intermediate inputs. In a way, the EAC CET compromise compounds Uganda's disadvantage as a landlocked country, for which the costs of imported products is higher anyway due to the relatively higher transport costs'* (Stahl, 2005, p.17).

The conclusion from Stahl's study is that changes in the CET will most likely be dominating effects on post-CU trade patterns; rather than the intra-EAC tariffs which were much lower to begin with. Hence, *'The creation of the EAC CU [..] will enhance competition in EAC as a whole and tends to reduce consumer prices and production costs. [..] the CET compromise reached is a sacrifice to secure continued high protection of Kenya's relatively more developed industrial sector, which, in turn, provokes significant trade diversion. The CET will act as a medium-term boost to industrial production, mainly in Kenya, but also in EAC as a whole.'* (Stahl, 2005, p.18).

Looking at aggregate trade patterns does not tell us how the composition of trade has changed[20]. IMF (2008) summarizes the main EAC trade flows as follows: *'A few prod-*

[20]For commodity trade, the source that is used throughout the thesis is the UN's COMTRADE database.

uct categories currently dominate intra-EAC trade: Tanzania and Uganda mainly export food to Kenya, while Kenya mostly exports manufactured goods and chemicals to its EAC partners.' Mugisa et al. (2008) find that *intra-EAC trade is increasingly diversifying into more specialized manufactures in all three countries, but more so in Kenya.* Trade in agricultural goods is more pronounced towards Kenya, as Kenya has become a food deficit country in recent years (Govereh et al., 2008, p.8). Even though Tanzania and especially Uganda have made an impressive catch-up effort over the past two decades, Kenya still produces the most advanced goods in the region. Moss et al. (2005), using 2002-2003 firm surveys, show how Kenyan domestic firms are more than twice as productive[21] as Tanzanian companies, with Ugandan firms coming third. The differences are even larger for foreign-owned firms. Kenya-Uganda bilateral trade data will be discussed in more detail in chapter 3, as they are important to the set-up of the CGE.

1.3.3 Trade costs and infrastructure in the EAC

Non-tariff barriers to cross-border trade are important trade costs in EAC member states, as table 1.4 shows. The six indicators reported are collected in the framework of the World Bank's Doing Business initiative. Between 2005 and 2009, progress was made throughout the region on indicators related to *number of documents* and *time*, but less so on the container price. A regional report based on the same dataset shows how if each East African country were to adopt the region's best practice for each Doing Business indicator, it would get 12th place in the Ease of Doing Business rankings (World Bank, 2010a, p.1).

The Protocol for the establishment of the EAC Customs Union shows the member states' appreciation of the importance of removing NTBs to foster regional integration: *Each of the Partner States agrees to remove, with immediate effect, all the existing NTBs to the importation into their respective territories of goods originating in the other Partner*

[21] Productivity measured as value added per worker.

Table 1.4: Overview Doing Business indicators in EAC

	Burundi		Kenya		Rwanda		Tanzania		Uganda	
	2006	2009	2006	2009	2006	2009	2006	2009	2006	2009
Exporting										
Documents[a]	9	9	8	9	14	9	7	5	11	6
Time[b]	47	47	45	29	63	42	30	24	42	39
Cost (container US$)[c]	2,347	2,347	1,955	2,055	3,840	3,275	1,212	1,262	1,050	3,090
Importing										
Documents[a]	10	10	13	8	19	10	13	7	18	8
Time[b]	71	71	62	26	92	42	51	31	67	37
Cost[c]	4,035	4,035	1,995	2,190	4,080	5,070	1,425	1,475	2,945	3,390
World Ranking	N/A	177	N/A	84	N/A	143	N/A	126	N/A	106

Source: IFC Doing Business indicators—accessed 15 July 2010 at www.doingbusiness.org
[a] Number of documents entrepreneurs/traders have to fill out for clearance before they can import or export a good.
[b] Number of days it takes to import or export goods.
[c] Cost measures the fees levied on a 20-foot container in US$. All the fees associated with completing the procedures to export or import the goods are included. These include costs for documents, administrative fees for customs clearance and technical control, customs broker fees, terminal handling charges and inland transport. The cost does not include customs tariffs and duties or costs related to ocean transport. Only official costs are recorded.

States and, thereafter, not to impose any new non-tariff barriers (EAC, 2004, p16).

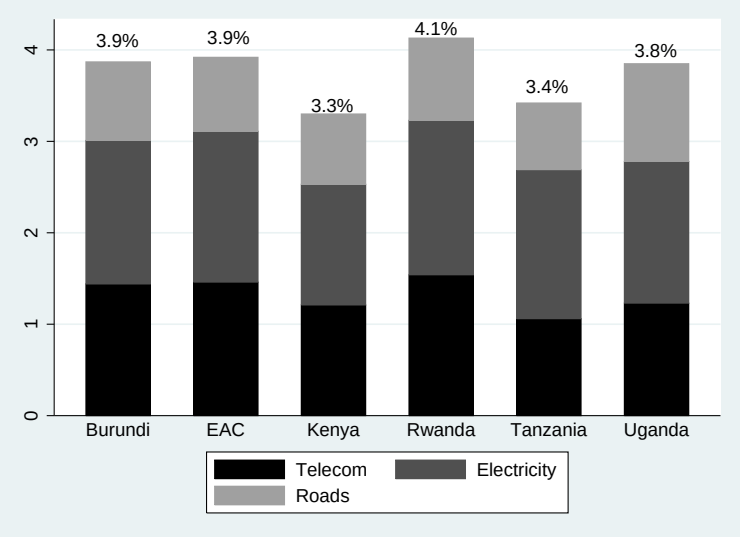
NTBs are well documented for EAC cross-border trade. *NTBs on the formal grains trade include regulations requiring proof of origin, phyto-sanitary certificates, and invoices from vendors, 'required side-payments' to police at road-blocks and border crossings* (World Bank, 2008b, p38). The same report also documents *The Dairy War: Kenya versus Uganda and Tanzania*, which refers to cross-border trading problems between those three countries in the dairy sector. Other research mentions the importance of avoiding delays in the issuance of certificates of origin for traders of perishable products, such as dairy products, fruits and vegetables (Mugisa et al., 2008, p56).

Trade costs are intimately linked to the infrastructure available to bring goods to market, with the most obvious example being the road network, but also increasingly through telecommunications that relay market information and reduce transaction costs[22]. Figure 1.2 gives an estimate of the infrastructure deficit in the EAC relative to the leader in sub-Saharan Africa. The average growth gained for the EAC would fall just short of

[22] See for example the evidence of mobile phones fostering market integration in West Africa (Aker et al., 2010). For a more skeptical reading of the evidence on the transformative qualities of mobile phones in sub-Saharan Africa see Aker and Mbiti (2010).

4%. Telecommunication contribute 1.5%, electricity 1.6% and an expanded road network 0.8%. We refer to World Bank (2010c) for a more detailed description of Eastern Africa's infrastructure.

Figure 1.2: Potential growth improvement in the EAC due to higher infrastructure development[a]



Source: Calderon (2009).
[a] Figures are for Calderon's scenario 1, which simulates growth effects for these countries reaching the infrastructure level of the leader in Africa (Calderon, 2009, p.56).

We take away from this discussion that trade costs are important in Eastern Africa, with the EAC member states suffering from an infrastructure deficit, as does most of the rest of sub-Saharan Africa.

1.4 Conclusion

The first part of this introductory chapter gave a quick overview of the thesis, showing how the impact of various types of trade costs on the structure and functioning of the economies of EAC member states form the thesis' common thread.

The second part explained how the regional trade literature, dominated for a long time by Viner's trade creation-trade diversion concepts, has developed into many sub-literatures. These new directions emphasise new (and more sophisticated) welfare measures, dynam-

ics, non-competitive markets, transport costs, etc. Discussions about RTAs have moved away from considering tariffs as the most important impediments to trade, with 'behind the border issues' captured in the catch-all term 'trade costs' coming to the fore[23].

The third part shows how the EAC was revived at the end of the nineties by the original three member states Uganda, Kenya and Tanzania. Rwanda and Burundi became full members in 2007. The EAC is currently (early 2011) a fully fledged customs union, is gradually moving towards a common market and is aspiring to monetary union. In the world of African regional integration schemes, these are remarkable achievements. Nevertheless, the bloc faces important challenges, including bringing down NTBs, agreeing external trade relations (e.g. further bringing down the CET and concluding the EPA negotiations), and overlapping membership. Kenya is the most advanced country in the region, with the most sophisticated manufacturing/industrial base. It will be crucial that the other countries, which are mostly agriculture based economies, are seen to benefit from the CU too, so as to avoid the mistakes of the earlier attempt at integration in Eastern Africa during the 60s and 70s.

Our regional (two-country) trade theory model in chapter 2 will incorporate trade costs between RTA members through a regional infrastructure spill-over funded by aid. The mechanism in the model is for regional infrastructure investments in one RTA country to have a direct price-reducing impact on a regionally traded good in the other RTA country. This regional infrastructure spill-over will be modeled differently (through differentiated inputs in the countries' production functions) in chapter 3. The CGE model developed there will add dynamics and the increased variety that comes with larger regional markets through the differentiation of goods by source of production. The border effect chapter (chapter 4) will estimate different types of trade costs on the basis of consumer price data.

To make the transition to the next chapter, we reiterate how sub-Saharan Africa is cur-

[23] Stahl (2005) for example, quoting from a NAFCOC/JCCI survey among 79 SME firms operating in Eastern and Southern Africa, argues that tariffs are actually less of a binding constraint to cross-border trade compared to NTBs such as transport, communications, customs procedures, etc. Anderson and Van Wincoop (2004) make the same argument.

rently going through a period marked by a *gradual* move towards deeper regional integration, with the EAC very much at the forefront. This gradualism can be thought of in different ways, as the following examples from this chapter show:

- Within Africa: the EAC gradually removed intra-regional tariffs between 2005 and 2010 and is now a fully-fledged CU with zero intra-regional tariffs. Negotiations towards a grand free trade area across all EAC, COMESA and SADC countries (COMESA-EAC-SADC, 2008) are ongoing. This will most likely involve a gradual reduction of between- and intra-region tariffs.
- Between African and other regions: the EPA's between the EU and African regions are set to have long adjustment periods before reaching the end-goal of zero tariffs. The liberalisation schedule for certain goods in the EAC interim-EPA initialled at the end of 2007 reaches zero only in 2033.
- All types of regional economic integration initiatives which involve African countries also typically involve lists of 'sensitive' products that are excluded from the liberalisation schedules or for which liberalisation is more gradual[24].

[24] It is hard to gauge the effects of these sensitive product lists, with Jean et al. (2011) claiming that the impact on welfare could well be non-negligible, even when the list is quite small.

Chapter 2

Aid & Regional Integration: A Model

2.1 Introduction

Chapter 1 started by giving a short overview of the content of the whole thesis, and went on to give a quick tour of the regional integration and trade cost literature and the East African Community. In chapter 1, we saw how African RTAs, including the EAC, are gradually removing intra-regional barriers to trade. At the same time, most African countries remain heavily aid-dependent and both governments and donors alike have indicated concern about aid-induced *Dutch disease* (IMF, 2005a). It is these two stylised facts that inform the set-up of the general equilibrium model developed in this chapter and the computable general equilibrium model of chapter 3. Both are two-country models loosely based on Uganda and Kenya. The general idea is to look at welfare and relative price effects in a richer general equilibrium environment as compared to analysing regional integration and aid issues separately. A useful summary of the aid and trade shocks to be analysed in both chapters 2 and 3 can be found in table 2.1 at the end of section (2.4).

This chapter links aid-induced real exchange rate movements to regional integration in a duality-based two-country, three-good general equilibrium trade model. The model

is innovative in two ways: (i) it departs from the rigid distinction between tradables and non-tradables by introducing a regionally tradable good, (ii) it brings in a regional infrastructure good that allows trade costs within the region to be lowered. Apart from a common external tariff, the model assumes absence of trade costs for trade with the rest of the world. Using comparative statics, we investigate the effects on welfare and relative prices of (i) lowering the intra-regional tariff (ii) increasing aid used for consumption purposes (iii) increasing aid spent on the regional infrastructure good (iv) transferring consumption aid between the RTA partners and (v) lowering the common external tariff.

The chapter is organised as follows: section (2.2) discusses relevant characteristics of the current aid environment, section (2.3) introduces the aid-induced *Dutch disease* literature in a dependent economy framework, section (2.4) discusses supply-side issues linked to public capital formation and adds the pertinent aspects of RTAs mentioned in chapter 1 to the dependent economy framework, section (2.5) sets the model up, section (2.6) solves the model and analyses what happens when introducing the aforementioned shocks and section (2.7) concludes. *Dutch disease* is typically associated with externalities related to a real exchange rate appreciation. In the model below we do not investigate such externalities as we do not go beyond effects of aid on relative prices.

2.2 The current aid environment

The prospects for large aid increases—on the back of influential reports linked to the Commission for Africa (2005) or the UN Millennium Project (2005)—has largely dissipated in the wake of the financial crisis. Nevertheless, the majority of African countries will still be aid dependent for the foreseeable future, as new donors (China) and a new generation of philanthropists (Bill Gates), step in. Table 1.2 shows aid to be above 5% of GNI in all five EAC countries in 2008.

Aid comes in many different guises, with donors often having a significant say as to what

the aid is to be used for. We consider the following three scenarios: first, aid can be transferred straight to a recipient government—examples of this are debt relief or general budget support (GBS), and we assume most of this aid to be used for consumption. Second, aid can be given for capital projects within a country, like the building of power stations. Third, donors can give aid for delivering regional public goods, taking into account spill-over effects between recipient countries, e.g. helping countries to improve customs procedures or connecting road networks.

We are particularly interested in aid that has a *'regional'* impact. For both geo-strategic and bureaucratic reasons, donors have found it difficult to channel aid to the regional level[1]. Birdsall (2004) calculates that regional public goods only receive 2.0-3.5% of aid flows, whilst *the rates of return to regional investments are likely to be high, especially in Africa*. She calls this the *'Underfunded Regionalism'*. Ravi Kanbur agrees that the division of resources should become *more heavily skewed towards regional institutions* (Kanbur, 2001, p.13-14)[2].

As our theoretical and CGE models involve both aid and trade, it is usefulf to shortly discuss the recent Aid-for-Trade (AfT) initiative[3]. AfT emphasises a catalytic role for aid in facilitating trade. It cuts across the three aforementioned aid types, as the following intervention areas[4] illustrate: (i) Technical Assistance for Trade Policy & Regulations, (ii) Trade Related Infrastructure, (iii) Productive Capacity Building (including trade development), (iv) Trade Related Adjustment, and (v) Other trade related issues. The increasing importance attached to AfT by donors offers opportunities for the financing of regional public goods (te Velde, 2008).

From the above list, *'trade related infrastructure'* relates to physical infrastructure, and

[1] The World Bank for example can only give/lend money to sovereign countries, not to regional bodies, even though it increasingly succeeds in finding ways of financing projects with regional implications.

[2] In recent years, there has been an increase in regional projects, despite the bureaucratic difficulties involved. Examples are the EU's Regional Indicative Programmes or DFID's Southern Africa Regional Plan. For more details see the discussion in te Velde (2008).

[3] For an overview of aid-for-trade programmes in the EAC/COMESA region, see Ancharaz et al. (2010).

[4] Taken from the second AfT Global Review in 2009.

is linked to the second and third aid-use scenario's mentioned earlier. Otherwise, our main interest lies in 'trade related adjustment', which *seeks to help countries with the costs associated with trade liberalisation, such as preference erosion, tariff reductions or declining terms of trade* (Higgins and Prowse, 2010). As most LICs have tax structures that are biased towards trade taxes[5], trade liberalisation often has negative effects on domestic revenues[6]. Most regional integration schemes, including EAC/COMESA, have provisions to compensate countries for such losses, which are mainly funded by aid[7]. Castro et al. (2004) estimate that under the initial 2004 set-up where the EAC comprised only Kenya, Uganda and Tanzania, losses would be around ten percent of pre-CU customs revenue. Aid used for this purpose can be thought of as GBS, even though donor conditionality on what to spend the aid on could be less onerous compared to GBS.

2.3 Aid-induced *Dutch disease*

Whatever purpose aid is supposed to serve, there are well-documented problems in using aid productively. This has been acknowledged by the donor community in the last decade or so, with the result being numerous pledges to improve aid quality, through e.g. the Paris declaration. Even though it is proving hard to change donors' habits (OECD/DAC, 2008), it is fair to say that things are changing, albeit slowly.

Our interest is in the macro-economic effects of aid flows and how to manage these. The main fear is *'that Dutch disease effects of aid will inhibit the development of the tradable goods sector and reduce growth in the recipient economy'* (Adam and Bevan, 2006). *Dutch disease* theory is linked to the small, open economy (SOE) Salter-Swan model in

[5]For evidence on this, see for example World Bank and IMF (2004).

[6]The evidence on this is not entirely conclusive. Such revenue losses can be non-trivial, especially in LICs where structural features might impede governments from raising taxes elsewhere. See Baunsgaard and Keen (2005) and Khatty and Rao (2002) for evidence on those structural impediments, and Agbeyegbe et al. (2006) for a more skeptical view on the links between liberalisation and revenue.

[7]E.g. Burundi and Rwanda received 22 million USD in compensation funds in September 2009 for adopting the EAC common external tariff.

a neo-classical framework of perfect competition and full markets[8]. If at least part of the aid is spent on tradable and non-tradable consumer goods, a decrease in net exports will ensue in order to ensure Balance of Payments equilibrium. Exports decrease because the increase in the demand for non-tradables implies factors of production have to move into that sector (and away from the exportable sector), assuming the price of tradables is fixed. For production factors to move, the price of non-tradables has to go up which causes a real exchange rate (RER) appreciation. On the consumption side, the rise in the price of non-tradables incentivises consumers to shift consumption from non-tradables to imports. This is a standard description of the forces leading an economy back to equilibrium after an exogenous shock, and as such no (government or other) intervention is called for. However, these forces have been labeled as a 'disease' because of concern that positive externalities from the production of tradable goods might be lost as a result of real exchange rate appreciation. Two sorts of externality suggested in the literature are briefly discussed below, although Dutch disease externalities are not modeled in later parts of this thesis.

The first externality is linked to the relative development of the tradables and non-tradables sectors not being neutral to a country's overall growth prospects. This typically takes the form of a positive externality, e.g. learning-by-doing (LBD) in the non-traditional exports sector[9,10]. This is because such exports, particularly manufacturing, are considered to have larger productivity pay-offs, with more traditional commodity exports thought of as problematic to fuel a country's long-run growth in the face of steadily declining terms-of-trade. An appreciating RER will in general hurt the prospects of the manufacturing sector[11]. Exports in general are considered the more likely source of productivity

[8] The main theoretical contributions are Corden and Neary (1982) and Corden (1984) or van Wijnbergen (1986) in the context of the capital inflow taking the form of aid to Africa. For a more substantial literature review on aid-induced *Dutch disease* in LICs, see Adam (2005).

[9] Torvik (2001) however builds a model in which there is LBD in both the tradables and non-tradables' sectors, with the possibility of productivity spill-overs between sectors. He shows that the RER does not need to appreciate in such a framework in response to a foreign exchange inflow.

[10] An alternative to the LBD channel is explored by Melitz (2003). Here an industry's exposure to trade leads to inter-firm reallocations towards more productive firms. The model then goes on to show how the aggregate industry productivity growth generated by the reallocations contributes to a welfare gain.

[11] See for example Bigsten et al. (1999) who give evidence of clear incentive effects of RER movements on export performance in several African countries.

growth as they are assumed to face more pressure to improve their performance from global competitors. As van Wijnbergen (1984) puts it: *'the post World War II success stories in economic development involve without exception countries that promoted their traded goods sector aggressively*[12].

The second externality is linked to whether the aid inflow is permanent or temporary. When the aid is temporary, exporters can experience a slump in foreign exchange receipts which takes them out of business[13]. This *hysteresis* effect implies that temporary aid can have long-run consequences for a country's economic structure. If there are externalities such as LBD in the affected sectors, then this would again have detrimental effects on growth. However, as aid flows are quite unpredictable[14] distinguishing between permanent and transitory aid shocks is not easy. This unpredictability, combined with the inability of most LICs to access international capital markets and the unavailability of domestic substitutes for imported inputs in the production process, can make sudden reversals in aid flows costly[15].

On impact (i.e. when aid funded investments have yet not had time to become productive) an aid increase will always appreciate the RER more compared to a scenario with no aid. The policy choice is whether to save the aid, let the RER appreciate or sterilize—the latter with likely crowding-out effects for credit to the private sector. For example, in a five-country study, IMF (2005a) found that in response to aid surges, Ethiopia and Ghana

[12]The experiences of the East-Asian tigers and China has convinced most commentators of the benefits of an outward-led development path with active export promotion. See for example World Bank (1993) or Kraay (1999). For sub-Saharan Africa, there is mounting evidence that export performance is positively linked to a country's overall growth experience (Ndulu and Ndungu'u, 1997) and, more specifically, that productivity growth is higher in the exports sector through LBD effects—see Bigsten et al. (2004) or Van Biesebroeck (2005). The focus of these papers is mostly manufacturing exports. We are not aware of empirical studies that look for differential LBD effects across sectors, whether intra-manufacturing or more general.

[13]The standard *Dutch disease* model does not allow for credit markets to help smooth over this dip in earnings. This is nevertheless a good representation for LICs, who's financial markets are typically characterised by a lack of depth.

[14]Aid pledges, for example, are known to be a bad predictor for actual aid disbursements. Bulir and Hamann (2005) show how aid is on average pro-cyclical and more volatile than other sources of government revenue.

[15]This discussion is linked to how aid-dependent countries are to be weaned off aid. Exports are one alternative, but increasing exports has proven very difficult for many LICs. In the EAC context, Rwanda has set itself a 2017 target of aid accounting for only 30% of Government spending, rather than the current 50%—see www.economist.com/node/16750119.

saved the extra aid, Uganda sterilized and only Tanzania and Mozambique let the RER appreciate.

2.4 The supply side and the regional dimension

The way aid is used will have a significant impact on the RER path. If it is just consumed away (scenario 1), then, ceteris paribus, the RER will appreciate. Under scenarios 2 and 3 however, aid is invested in the public capital stock, and depending on how quickly these investments become productive, the RER appreciation will be muted. Table 2.1 gives an overview of how shocks and externalities will be addressed and modeled in this chapter (the theory chapter) and the following chapter (which develops the CGE)[16].

What are the likely growth effects of public capital? This is a notoriously difficult research agenda and the literature gives very little direction on how to best model this (Holtz-Eakin and Lovely, 1996). Difficulties are related to reverse causality, non-linearities like network effects and the likely heterogeneous impacts of public capital across countries, regions and sectors (Romp and de Haan, 2007). We follow the production function approach which uses an aggregated Cobb-Douglas production function to estimate the effects of publicly funded infrastructure on growth and productivity:

$$X_t = A_t L_t^{\alpha} K_t^{\beta} G_t^{\gamma} \tag{2.1}$$

with γ the elasticity of output with respect to infrastructure. One can use constant returns to scale, implying that $\alpha + \beta + \gamma = 1$, or one can assume externalities from public infrastructure, as in Adam and Bevan (2006)[17]. As for spill-over effects, there are no papers that explicitly link public infrastructure spill-overs across borders with landlocked regions/countries involved[18].

[16] Hence, some of the symbols will only make sense with the information available in the next chapter.
[17] Parameter values will be discussed in the CGE chapter.
[18] Cohen and Morrison Paul (2004) model cost functions for manufacturing sectors in US states by including

Killick and Foster (2007) are rather skeptical about the possibility of aid addressing supply-side problems: *'..supply side constraints are usually dominant and (..) these are often deep-rooted, unamenable to short-term solutions'*. Adam (2005) comes to the following nuanced conclusion, discussing results from a CGE calibrated for a typical African 'small-open-economy' (SOE):

> *'First, when public infrastructure augments the productivity of private factors, (..) there are potentially large medium-term welfare gains from aid-funded increases in public investment, despite the presence of some short-run Dutch disease effects, and (..) these are compatible with growth in the export sector of the economy. Second, however, when supply side responses to aid are important, RER overshooting may be an important feature of the economy's response to aid. Third, (..) the actual evolution of the economy will depend crucially on the form of public investment, how powerfully (and how quickly) it feeds back onto private production capabilities, and the costs of any short-run contraction of the export sector. Importantly, though, export promotion and growth may be benefited as much, if not more, by public investment geared towards improving the productivity of domestic non-tradable goods production rather than directly towards improving productivity in the export sector'*.

The whole point of infrastructure investments, whether national or regional, is to enable local economies to manage the supply-side response better. The question then becomes how long the infrastructure works take, and how this productivity shock is transmitted to the economy's main (tradable and non-tradable) sectors. Of course, this all depends on the newly installed infrastructure addressing the recipient economy's binding constraints to trade. Castel-Branco and Sulemane (2005) for example argue that in Mozambique, non-price factors such as transport and storage facilities might well be more important

the public capital stock in the state concerned and the public capital stock of neighbouring states. This does not however, specifically address landlocked issues.

than an appreciating RER in limiting the expansion of the exporting sector. Investing aid monies in public infrastructure should then address these binding bottlenecks (and ease pressure on the RER in the process). In the model in this chapter, aid funded infrastructure works have immediate pay-offs in terms of reduced trade costs. In the CGE of the next chapter, the productivity impact comes via increases in the national and regional capital stocks (see also table 2.1), that serve as inputs in the country-specific production functions.

Next, we add regional integration to our framework. In both the theory model and the CGE, we depart from the SOE assumption and assume that regional producers have some pricing power. This implies that we depart from an RER defined as P_N/P_T, and that we now have to trace competitiveness issues at both the regional and the international level.

What else changes? In general, the RER appreciation will be less severe the higher the domestic agents' substitution possibilities between importables and non-tradables. We argue that consumers tastes differ less if they come from neighbouring countries, i.e. consumers substitute more easily between domestic and regional goods than between domestic and international goods. This will have an impact on the regional and the international RERs.

Nkusu (2004) argues there might be imperfect substitutability between domestically produced goods and imported ones, i.e. domestic producers of import substitutes have some market power and are able to raise prices a bit without consumers switching towards imports. Hence P_T rises alongside P_N reducing the appreciating pressure on the RER. We argue that domestic producers might have some market power over regionally tradable goods, but less so over internationally tradable goods. This is related to how we will model the *'regional good'* in the theory model of this chapter and the CGE in the next chapter—see also table 2.1.

On the landlockedness issue, for competitiveness purposes, it might be better that aid is spent on infrastructure projects in the coastal neighbour that unlocks the local market of

the landlocked country to the wider world. This would have the double benefit of not appreciating the landlocked country's RER, whilst reducing its trade costs. Of course, such investments would also help reduce the coastal country's trade costs vis-à-vis the rest of the world. In the model in the next section, the implication of landlockedness that one RTA country has higher trade costs for trade with the rest of the world than its RTA partner, is not explicitly modeled.

Finally, a few papers investigate whether the aforementioned learning-by-doing effects depend on the export destination. As developed country firms in general use more advanced technologies, exports to such countries may be expected to generate more learning opportunities as compared to exports to less developed countries[19]. However, firms could also find it easier to export within a region like the EAC, which in turn helps them move up the value chain, to finally 'graduate' to compete in the global marketplace.

Table 2.1: Shocks and Externalities† in Theory and CGE model

	THEORY MODEL (chapter 2)		CGE MODEL (chapter 3)	
	symbol	externality ?	symbol	externality ?
AID SHOCK - aid used for..				
..consumption	A	NO	$TRNS$ [a]	NO
..national infrastructure	N/A [c]	N/A	KG	Cobb-Douglas ϵ's [b] > 1
..regional infrastructure	G	trade cost spill-over (eq 2.2)	KR	production function (eq 3.4)
TARIFF SHOCK				
intra-regional tariff	τ	NO	tmr	NO
Common External Tariff	t	NO	tmw	NO

† Externalities modeled are infrastructure spill-overs.
[a] Aid is transferred to Households (TRNS) who consume most the windfall, with low and fixed saving rates.
[b] Cobb-Douglas ϵ's = sum of all Cobb-Douglas elasticities.
[c] N/A = Non-Applicable.

[19] Damijan et al. (1998) and Park et al. (2010) have evidence on this for panels of Slovenian and foreign owned Chinese firms respectively. Fernandes and Isgut (2005), using a dataset of Colombian firms, show how learning-by-exporting is more important in industries that deliver a larger percentage of their exports to high-income countries.

2.5 Model set-up and EAC trade patterns

This section analyses regional trade and aid in a two-country trade model, loosely based on Uganda and Kenya[20]. The duality-based general equilibrium model used[21], throws light on two stylised facts fitting most sub-Saharan African countries at the end of the noughties: (i) increasing aid inflows, and (ii) a lowering of intra-regional tariffs. We are interested in the effects of such aid and trade shocks on relative prices and national and regional welfare. In addition to the consequences of changing the region's intra-regional tariffs, we compare the effects of different types of aid spending. We distinguish between aid spent at the national level and aid specifically aimed at reducing trade costs between the regional partners—e.g. through financing infrastructure works like roads. The third topic of interest is how the previous results change when introducing a Common External Tariff (CET) governing trade relations with the rest of the world[22]. In this section we set the model up, whilst section (2.6), which forms the core of the chapter, solves the model and analyses the results.

The key innovation is the introduction of a regional good that is not traded with the rest of the world, and whose price is endogenously determined within the region. The idea is to break the rigid distinction between tradables and non-tradables in a standard Salter-Swan dependent economy macro model. In this way, we model regional producers having some (regional) market power over regionally tradables. For certain goods, this could be related to prohibitive transport costs for trade with the rest of the world, but it could also be linked to (i) inadequate regulation by competition authorities or (ii) imperfect substitutability between regionally produced goods and goods that are imported from the rest of the world, perhaps due to taste differences (Nkusu, 2004).

[20] As explained in previous chapters, Kenya is the EAC's 'hub' economy, whilst Uganda can be considered one of the 'spokes'. Alternatively, one can think of the non-Kenya country in the model as an amalgam of the 4 other EAC countries. In what follows we assume Uganda to be the second country in the model, as the two-country CGE developed in the following chapter will be based on Uganda and Kenya.

[21] The intricacies of this type of model are superbly covered in Dixit and Norman (1980).

[22] This is the only trade cost in the model related to trade with the rest of the world. The differences in such external trade costs between Kenya and Uganda are large, mainly because Uganda has high transit costs through Kenya, as documented by Milner et al. (2000). However, external trade costs are not the focus of the model.

The model has three goods, with consumption and production patterns similar to both countries:

1. An exportable good F, which is not consumed within the region. This is an agricultural good capturing agricultural exports, like food commodities or cash crops, from the region to the rest of the world.
2. A regional good L, that is produced and consumed in both countries, but not traded with the rest of the world[23].
3. An importable good H that is not produced within the region, but is imported from the rest of the world.

It is assumed that Kenya, the regional powerhouse, has a regional comparative advantage in producing the regional good and exports it to Uganda, and its net trade balance vis-à-vis Uganda is thus positive (see previous chapters for empirical evidence on this)[24]. Hence, we will call Kenya the 'exporting country' and Uganda the 'importing country'. This 'regional' good is to be interpreted as a vector comprising all regionally tradables, such as staple foods or low added-value manufacturing goods.

As for trade relations with the rest of the world, it is assumed that the EAC region can sell cash crops like coffee and tea without any problem in the world market at fixed prices. Similarly, it can buy the importable good in world markets at fixed prices. The latter can be thought of as everything that the region does not produce, from high-value added manufactured goods, to intermediate inputs like machinery. The set-up is summarised in table 2.2 below.

Table 2.3 gives more detail on the model's price structure. All variables to do with the exporting country (Kenya) are in capital letters, whilst for the importing country (Uganda), we use small letters. International prices are denoted by an asterisk.

[23]This 'good' can be thought of as the net trade vector between the two countries.

[24]It is possible to extend the model so that the regional good becomes a regional trade vector, but with relative prices for individual regional goods completely endogenous, this will make the model much harder to interpret.

Table 2.2: Patterns of trade

	Uganda	Kenya	RoW
Exportable Good (Food commodities/cash-crops)	X	X	M
Regional Good (staple foods & light manufacturing)	M	X	-
Importable Good (High-value added, machinery,..)	M	M	X

Table 2.3: Overview prices

	Uganda	Kenya	RoW
Exportable Good (Food commodities/cash-crops)	P_F^*	P_F^*	P_F^*
Regional Good (staple foods & light manufacturing)	$p_L = P_L + \tau + \psi(G)$	P_L	-
Importable Good (High-value added, machinery,..)	$p_H = P_H^* + t$	$P_H = P_H^* + t$	P_H^*
Composite Infrastructure Good	-	-	P_G^*

Aid takes two distinct forms: national aid A, divided between importing and exporting country, and regional aid A^{RI} used specifically for investments aimed at reducing trade barriers between the two countries. A^{RI} is used to finance the regional infrastructure good G, which is assumed to be entirely imported and non-fungible such that it does not have an effect on domestic spending patterns. A^{RI} has an *immediate* effect on the price of the regional good. We can think of this as some kind of 'iceberg'-technology, with no rents accruing from this to any domestic agents, i.e. there are no distributional consequences. This could be a technical innovation that lowers transport costs, or more concretely some kind of turnkey project facilitating road transport or border crossings[25]. For accounting purposes, it is assumed that this infrastructure aid is spent by Kenya, but this is not essential to our results[26]. National aid A is in essence budget support, the distribution of which between the two countries is governed by the parameter $0 < \alpha < 1$, such that the exporting country (Kenya) gets αA and the importing country (Uganda) gets $(1 - \alpha)A$.

[25] Whereas there is a trend for more traditional (OECD) donors to move towards budget support, non-traditional donors like China are reported to deliver aid mostly on a turnkey basis: *(Chinese) assistance is largely for energy, telecommunications, and transportation projects. Aid is mostly provided in kind, usually by Chinese companies, and tends to be on a turnkey basis, mostly with Chinese inputs, including labour* (Jacoby, 2007).

[26] Where A^{RI} is spent will matter in the CGE in the next chapter, since the CGE does trace spending effects.

A tariff τ is levied against the regional good L, which will be lowered with the move towards customs union. The price for this good in the exporting country is P_L, whilst for the importing country, it is:

$$p_L = P_L + \tau + \psi(G) \qquad \psi' = \frac{\partial \psi}{\partial G} < 0 \tag{2.2}$$

This equation captures trade costs besides the intra-regional tariff τ through the $\psi(G)$ function, which is an extra wedge between the domestic prices of the two CU member countries. The price of 'L' in the importing country is reduced through the newly constructed infrastructure funded by G, hence ψ's derivative with respect to G is negative. Another tariff t is levied against good H, which is the Common External Tariff (CET) of the CU. The price for the high-skilled manufactured good H is $P_H = p_H = P_H^* + t$. The infrastructure investment is beneficial to the regional good L, but not to the other good produced in both countries (the agricultural good F)[27]. The international price for the agricultural good is P_F^*, which is also the domestic price in both countries.

Next, we introduce trade expenditure functions $\widetilde{E}(.)$ and $\widetilde{e}(.)$ for both countries; first for the exporting, then for the importing country[28]:

$$\widetilde{E}(P_F^*, P_L, P_H; U) = E(P_F^*, P_L, P_H; U) - R(P_F^*, P_L) \tag{2.3}$$

$$\widetilde{e}(P_F^*, p_L, p_H; u) = e(P_F^*, p_L, p_H; u) - r(P_F^*, p_L) \tag{2.4}$$

$E(.)$ and $e(.)$ are household expenditure functions, $R(.)$ and $r(.)$ GNP functions and U and u utility in the respective countries. Hicksian net import demand functions can then be calculated from the trade expenditure functions by taking the first derivative with respect to the price of the good we are interested in. To make it easier to trace through

[27] In other words we assume that all agricultural goods are flown out from either country without using the new infrastructure.

[28] For an exhaustive treatment of the properties and uses of the trade expenditure function, see Neary (1988).

such derivatives, we slightly change notation as follows:

$$P_H^* = T \qquad p_L = q \qquad P_L = Q \tag{2.5}$$

Budget constraints for each of the two RTA countries can be written as follows—where we have used the previous equalities as well as expressions from table 2.3 above:

$$\widetilde{E}\Big(P_F^*, Q, T+t; U\Big) = P_F^* \alpha A + t\widetilde{E}_T\Big(P_F^*, Q, T+t; U\Big) \tag{2.6}$$

$$\widetilde{e}\Big(P_F^*, q, T+t; u\Big) = P_F^*(1-\alpha)A + t\widetilde{e}_T\Big(P_F^*, q, T+t; u\Big) + \tau\widetilde{e}_q\Big(P_F^*, q, T+t; u\Big) \tag{2.7}$$

Subscripts are used to denote a first derivative with respect to price. E.g. $\widetilde{e}_q$ is the first derivative of the importing country's net expenditure function with respect to price q. A positive value of the LHS of either budget constraint implies that the respective country spends more than it receives. The RHS of the equations show how this can be financed: (i) by aid, or (ii) by tariff revenues (international and/or regional). As trade flows from Kenya to Uganda (exporting to importing country), only Uganda's budget constraint shows tariff revenues $\tau\widetilde{e}_q$ from regional trade. For convenience all aid flows are priced in terms of the exportable good F. By using equation (2.2), we can write these expressions as:

$$\widetilde{E}\Big(P_F^*, q-\tau-\psi(G), T+t; U\Big) = P_F^* \alpha A + t\widetilde{E}_T\Big(P_F^*, q-\tau-\psi(G), T+t; U\Big) \tag{2.8}$$

$$\widetilde{e}\Big(P_F^*, q, T+t; u\Big) = P_F^*(1-\alpha)A + t\widetilde{e}_T\Big(P_F^*, q, T+t; u\Big) + \tau\widetilde{e}_q\Big(P_F^*, q, T+t; u\Big) \tag{2.9}$$

The following equation relates expenditure on the regional infrastructure good G to the regional aid flow that pays for it A^{RI}:

$$E^{RI}(P_G^*, G) = P_F^* A^{RI} \tag{2.10}$$

The expenditure function $E^{RI}(.)$ relates increments to the regional infrastructure good to the regional aid flow, which is priced in terms of the internationally exportable good F. As mentioned before, this spending on regional infrastructure is not really part of either of the two national budget constraints (2.8) or (2.9), as all of G is assumed to be imported. Thanks to this equation we can specify the model using either A^{RI} or G. The fourth and final equation of the model is the market clearing condition for the regional good:

$$\widetilde{E}_q\Big(P_F^*, q-\tau-\psi(G), T+t; U\Big) + \widetilde{e}_q\Big(P_F^*, q, T+t; u\Big) = 0 \tag{2.11}$$

We choose the agricultural good F as the numéraire good, and normalise its price to 1. Dividing through the four model equations (2.8), (2.9), (2.10) and (2.11) by the price of the numéraire good $P_F^* = 1$, we get:

$$\widetilde{E}\Big(1, q-\tau-\psi(G), T+t; U\Big) = \alpha A + t\widetilde{E}_T\Big(1, q-\tau-\psi(G), T+t; U\Big) \tag{2.12}$$

$$\widetilde{e}\Big(1, q, T+t; u\Big) = (1-\alpha)A + t\widetilde{e}_T\Big(1, q, T+t; u\Big) + \tau\widetilde{e}_q\Big(1, q, T+t; u\Big) \tag{2.13}$$

$$E^{RI}(P_G^*, G) = A^{RI} \tag{2.14}$$

$$\widetilde{E}_q\Big(1, q-\tau-\psi(G), T+t; U\Big) + \widetilde{e}_q\Big(1, q, T+t; u\Big) = 0 \tag{2.15}$$

This operation reminds us that we are working throughout with relative prices. The model consists of these four equations, and four endogenous variables U, u, G and q, as a function of regional (A^{RI}) and national (A) aid flows, the distribution of national aid between the two countries α, the intra-regional tariff τ, the common external tariff t, and the inverse international terms of trade T. We can however reduce this to a 3x3 system, by using equation (2.14) to solve for G, such that we are left with only three endogenous

variables, U, u and q.

An implicit assumption made in the model is that the pattern of international trade does not change, as we are working with marginal changes throughout. Hence, we do not consider a change in the sourcing of imports due to CU formation[29]. In any case, this 'regional-integration-at-the-margin' set-up is very relevant to the EAC, as the conclusion to chapter 1 made clear. It is also reasonable to assume that the higher the level of aggregation (i.e. talking about low-skilled manufacturing instead of ladies' shoes), the lower the probability of trade reversals.

2.6 Model solutions and analysis

The solution method is to take total differentials of the core equations and perform standard comparative static analysis[30]. However, the algebra involved gets messy quite quickly which is why we make some simplifications. Sub-sections (2.6.1) and (2.6.2) set the Common External Tariff equal to zero with the distribution of national aid between the two countries fixed ($d\alpha = 0$). Instead, we highlight the relative merits of giving aid to regional infrastructure works as opposed to giving aid at the national level to the two countries individually in the form of budget support or debt relief. We also compare the effects of lowering intra-regional tariffs to bringing down trade barriers through regional infrastructure investments. Sub-section (2.6.3) focuses on a transfer of national aid between the two countries ($d\alpha \neq 0$), whilst sub-section (2.6.4) introduces a non-zero common external tariff. Here, we discuss how previous results are to be adapted when $t \neq 0$. Throughout, the focus is on how these exogenous shocks impact on welfare and relative prices. Table 2.4 gives an overview of the assumptions made in the different subsections. Throughout the terms of trade are considered to be constant ($dT = 0$).

[29]This is the same for all papers that have used a duality framework to model customs union, e.g. Wooton (1986).

[30]Again see Dixit and Norman (1980).

Table 2.4: Overview Experiments analysed in section (2.6)

Intra-regional trade liberalisation	Aid transfer between member states	Adding the common external tariff
$dt = 0 = t$ $dT = 0$ $d\alpha = 0$	$dt = 0 = t$ $dT = 0$ $d\alpha \neq 0$	$dt \neq 0 \neq t$ $dT = 0$ $d\alpha = 0$

2.6.1 Aid, regional trade and regional infrastructure

To solve the model, we start by totally differentiating equations (2.12), (2.13), (2.14) and (2.15) to get:

$$\widetilde{E}_q\Big(dq - d\tau - \psi' dG\Big) + \widetilde{E}_U dU = \alpha dA \tag{2.16}$$

$$\widetilde{e}_q dq + \widetilde{e}_u du = (1-\alpha)dA + \widetilde{e}_q d\tau + \tau \widetilde{e}_{qq} dq + \tau \widetilde{e}_{qu} du \tag{2.17}$$

$$E_G^{RI} dG = dA^{RI} \tag{2.18}$$

$$\widetilde{E}_{qq}\Big(dq - d\tau - \psi' dG\Big) + \widetilde{E}_{qU} dU + \widetilde{e}_{qq} dq + \widetilde{e}_{qu} du = 0 \tag{2.19}$$

We have assumed that the world price of the regional infrastructure good P_G^* is fixed. We will use dG instead of dA^{RI} as the exogenous variable dealing with regional aid, with equation (2.18) at the back of our mind. Hence, we really have a 3x3 system, made up of equations (2.12), (2.13) and (2.15); with their differentiated equivalents (2.16), (2.17) and (2.19).

To make things easier to follow, it is useful to introduce the following notation:

$$D_{Q,Y} = \frac{\widetilde{E}_{QU}}{\widetilde{E}_U} > 0 \quad D_{T,Y} = \frac{\widetilde{E}_{TU}}{\widetilde{E}_U} > 0 \quad D_{q,y} = \frac{\widetilde{e}_{qu}}{\widetilde{e}_u} > 0 \quad D_{T,y} = \frac{\widetilde{e}_{Tu}}{\widetilde{e}_u} > 0 \quad S = -\widetilde{E}_{qq} - \widetilde{e}_{qq} > 0 \tag{2.20}$$

The D's are the shares of marginal spending directed towards the two consumed goods, H, the high value-added manufacturing good (with relative price T) and L, the low value-added manufacturing good (with relative price q in the importing and Q in the exporting country). These are pure income effects (Dixit and Norman, 1980, p.62). $D_{Q,Y}$ and $D_{T,Y}$ are the marginal spending shares for the L-good and the H-good in the exporting country. The $D_{..,y}$ expressions are the equivalents for the importing country. Assuming L and H are normal goods, these expressions are positive—i.e. an increase in spending implies an improvement in utility. We further assume that marginal spending shares (i) are equal in the two countries[31], and (ii) are higher for H than for L, as H is high(er) value-added, such that L will have the attributes of a necessity good. In other words, $D_{Q,Y} < 1$, $D_{q,y} < 1$ and $D_{T,..} > 1$. S captures the matrix of derivatives of the compensated excess demand for the regional good L. With standard sloping demand and supply curves, S is positive. As L is only produced and consumed within the region, excess demand for good L in the importing country ($\widetilde{e}_q$) has to equal excess supply in the exporting country ($-\widetilde{E}_q$)—see also equation (2.15). Finally, as neither country produces the H-good, excess demands $\widetilde{E}_T$ and $\widetilde{e}_T$ will be positive.

We can now solve the 3x3 system. This is straightforward (three equations in three unknowns), but rather tedious and hence the algebra is relegated to appendix B. Here, solutions are organised around different propositions, which precede a short proof/discussion.

Equation (2.21) solves our model for dq, or the domestic relative price of the regional good in the importing country, as a function of the exogenous variables:

$$Bdq = (B + \widetilde{e}_{qq})d\tau + [(-\widetilde{E}_{qq} + D_q\widetilde{E}_q)(1 - \tau D_q)\psi']dG + [(1 - \alpha\tau D_q)D_q]dA \quad (2.21)$$

where $B = (\ -\widetilde{E}_{qq}(1 - \tau D_q) - \widetilde{e}_{qq} - (D_q\widetilde{E}_q)\tau D_q)$ is unambiguously positive, as all three of its components are positive. Remember the slopes of excess demand curves $\widetilde{E}_{qq}$ and $\widetilde{e}_{qq}$ are negative, whilst $\widetilde{E}_q$ is also negative. Also, $(1 - \tau D_q) > 0$, as we can choose

[31] I.e. $D_{Q,Y} = D_{q,y}$. We will use use D_q for this variable in what follows.

units for D_q to make this so. We will continue to use B in the remainder of this chapter.

Proposition 1: *A decrease in the intra-regional tariff τ lowers the domestic price of the regionally tradable good in the importing country, relative to the price of the world export good, and increases it in the exporting country. This leads to an increase in regional trade.*

Note first of all that $(B + \widetilde{e}_{qq}) = -\widetilde{E}_{qq}(1 - \tau D_q) - (D_q\widetilde{E}_q)\tau D_q$, and is positive. This leads to the first part of the proposition:

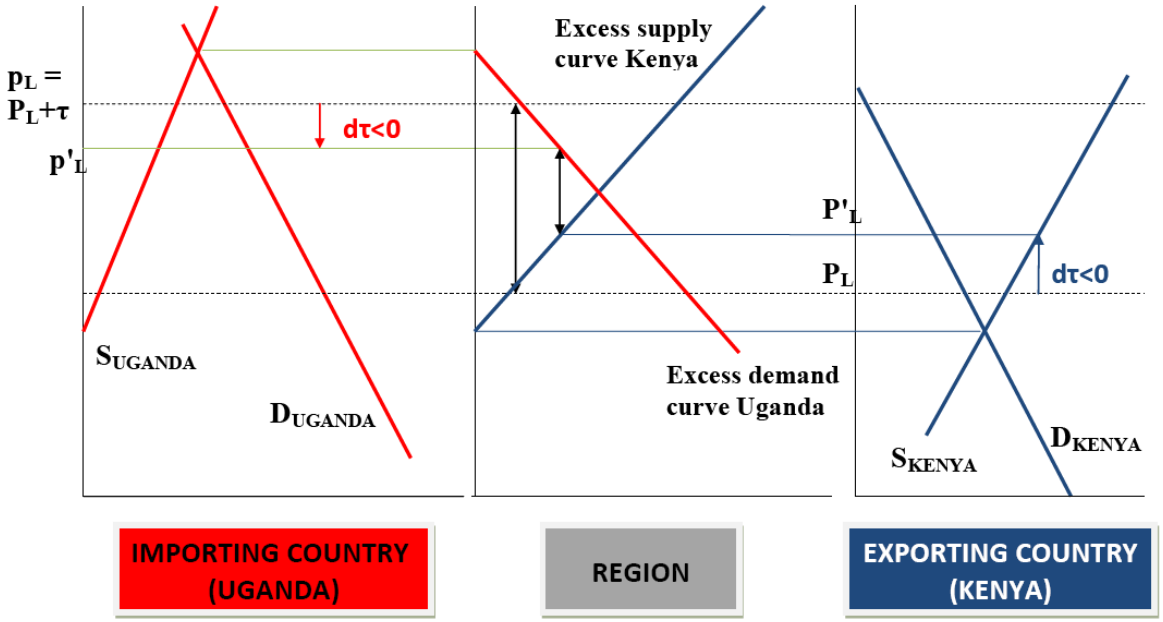
$$\frac{dq}{d\tau} = \frac{B + \widetilde{e}_{qq}}{B} > 0 \tag{2.22}$$

In other words, a lowering of the intra-regional tariff ($d\tau < 0$) implies a lowering of the relative price of the regionally tradable good in the importing country. Figure 2.1 shows this in a partial equilibrium framework. As we can see there the domestic price for the regional good goes down in the importing and up in the exporting country. Indeed, when solving for the domestic price Q of the regional good in the exporting country, the relation between dQ and $d\tau$ can be expressed as:

$$\frac{dQ}{d\tau} = \frac{\widetilde{e}_{QQ}}{-\widetilde{E}_{QQ}(1 - \tau D_Q) - \widetilde{e}_{QQ} - (D_Q\widetilde{E}_Q)\tau D_Q} = \frac{\widetilde{e}_{QQ}}{B} < 0 \tag{2.23}$$

This means that a decrease in τ implies an increase in Q, stimulating production of the regional good in the exporting country. This is the second part of proposition 1. The lowering of q means the production of the agricultural good F will be stimulated in the importing country. From equations (2.22) and (2.23), it is clear that $|\frac{dq}{d\tau}| < 1$ and $|\frac{dQ}{d\tau}| < 1$, which is another way of saying that the total change in τ will be 'divided' between an increase in Q and a decrease in q. Hence, consumption will be stimulated in the importing country and production in the exporting country. This is the standard partial equilibrium analysis result when two large countries (i.e. prices are endogenous) move towards free trade.

Figure 2.1: The effect of reducing τ



From figure 2.1, it is clear that regional trade expands. This implies that the importing country's regional trade balance deteriorates, such that, holding aid constant, its trade balance with the rest of the world will have to improve. I.e. net international exports go up. Unless all of this adjustment comes from a decrease in international imports, this means that factors of production will move from producing the regional good to producing the internationally exportable good. The opposite happens in the exporting country, which sees its regional trade balance improve.

Proposition 2: *An increase in national aid increases the relative price for the regional good in both the importing and exporting country. Under reasonable assumptions, regional trade expands.*

Finally, we look at the influence of national aid on the relative price of the regional good:

$$\frac{dq}{dA} = \frac{(1 - \alpha\tau D_q)D_q}{B} > 0 \tag{2.24}$$

$$\frac{dQ}{dA} = \frac{(1 - \alpha\tau D_Q)D_Q}{B} > 0 \tag{2.25}$$

An increase in national aid increases the relative price of the regional good in both countries through an income effect that is proportional to the marginal share of spending on the regional good D_q. This is the standard aid-induced real exchange rate appreciation result. The adjustment mechanism is as follows. In both countries, demand for the regional good goes up. Assuming upward sloping supply curves, supply will go up across the region. The mobile production factor will have to move to produce the regional good and will need incentives to do that, which will come in the form of higher q and Q. This standard income effect is attenuated by the $(1 - \alpha\tau D_q)$ term, as a positive τ reduces regional trade which is in effect a negative income effect.

What happens to regional trade? With marginal spending shares for both consumption goods assumed equal for both countries, regional trade would be unchanged if demand and supply elasticities are also the same in both countries. However, as we have assumed that the exporting country has a comparative advantage in producing the regional good, it makes sense that the supply-response will be more effective in that country. This means that regional trade expands.

If we add the lowering of τ to the increase in aid, as suggested in the conclusion to chapter 1, then we see that, in terms of the relative price of the regional good, the real exchange rate effect is diluted in the importing and enlarged in the exporting country.

The solutions for du and dU (again see appendix B for details), which are the change in welfare in the importing country and the change in welfare in the exporting country respectively, are:

$$\begin{aligned} B\widetilde{e}_u du = &\Big[\widetilde{E}_q - \tau(\widetilde{E}_{qq} - \widetilde{E}_q D_q)\Big]\widetilde{e}_{qq} d\tau + \\ &\Big[(-\widetilde{E}_{qq} + \widetilde{E}_q D_q)(\widetilde{E}_q + \tau\widetilde{e}_{qq})\Big]\psi' dG + \Big[(1-\alpha)S + (\widetilde{E}_q + \alpha\tau\widetilde{e}_{qq})D_q\Big]dA \end{aligned} \tag{2.26}$$

$$B\widetilde{E}_U dU = \Big[-\widetilde{e}_{qq}\widetilde{E}_q \Big] d\tau + \Big[-\widetilde{E}_q(\widetilde{e}_{qq} + \widetilde{E}_q D_q) \Big] \psi' dG + \Big[-\alpha\widetilde{E}_{qq}(1-\tau D_q) - \alpha\widetilde{e}_{qq} - D_q\widetilde{E}_q \Big] dA \quad (2.27)$$

Proposition 3: *A decrease in the intra-regional tariff or an increase in regional infrastructure spending increases welfare in the exporting country, but not necessarily in the importing country. For the latter the condition for the tariff reduction to increase welfare ($|\widetilde{E}_{qq}| > |\widetilde{E}_q/\tau + \widetilde{E}_q D_q|$) is harder to meet than the condition for regional infrastructure to be welfare increasing ($|\widetilde{E}_{qq}| > |\widetilde{E}_q D_q|$).*

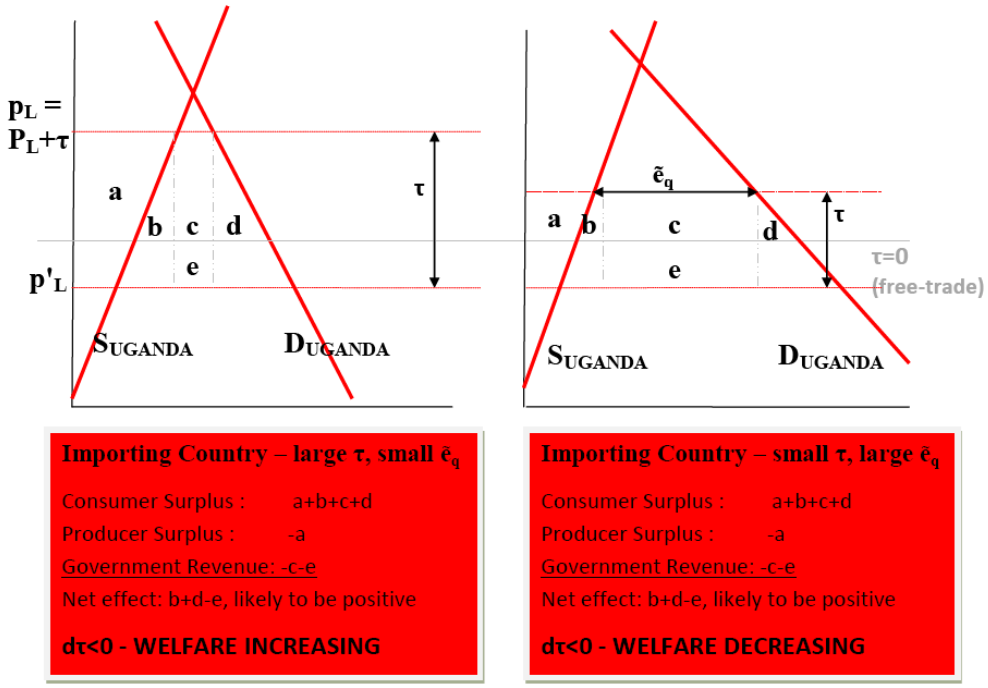
Looking at welfare in the exporting country (equation 2.27), we can immediately see that regional trade liberalisation ($d\tau < 0$) will increase welfare, as the expression multiplying the $d\tau$ term ($-\widetilde{e}_{qq}\widetilde{E}_q$) is negative. The effect of regional infrastructure aid is also unambiguously positive as $-\widetilde{E}_q > 0$, $\widetilde{e}_{qq} < 0$ and $\psi' < 0$.

For the importing country, the term multiplying $d\tau$ is in all likelihood positive. Why? Because the term between large brackets will be dominated by $\widetilde{E}_q < 0$, as we are assuming that τ is not very large (see chapter 1). Taken together with the negativeness of $\widetilde{e}_{qq}$, this gives us a positive overall term. In other words, a reduction in the tariff governing intra-regional trade reduces welfare in the country that is the net importer of the (regionally) tradable good. This is akin to the textbook effect of two large countries, i.e two countries who can influence their bilateral terms of trade, moving towards freer trade. For this not to be the case, τ has to be large and $|\widetilde{E}_{qq}| >> |\widetilde{E}_q D_q|$. Figure 2.2 shows how this effect of regional trade liberalisation on welfare in the importing country depends on the size of $|\widetilde{E}_q|$ and τ. The figure on the left, has a large τ and small $|\widetilde{E}_q|$, and increases welfare, whilst the figure on the right shows the opposite.

The effect of regional infrastructure on the importer's welfare is again ambiguous. If $|\widetilde{E}_{qq}| > |D_q\widetilde{E}_q|$, then welfare increases. The income effect $D_q\widetilde{E}_q$ lowers welfare, and is related to imports—the more regional imports, the lower welfare. The substitution effect $-\widetilde{E}_{qq}$ increases welfare as in the importing country consumption is moved towards the

cheaper regional good. The condition for the tariff reduction to increase welfare is harder to meet than the one for regional infrastructure.

Figure 2.2: Welfare in the importing country when τ decreases



Proposition 4: *Transfer Paradox : An increase in aid given at the national level, which is heavily biased in favour of the exporting country, can reduce welfare in the importing country. The condition for this to happen is* $(1-\alpha)S + (\widetilde{E}_q + \alpha\tau\widetilde{e}_{qq})D_q < 0$

If the term multiplying dA in equation (2.26) is negative, an increase in A reduces welfare in the importing country. This is more likely the higher is α (the share of national aid going to the exporting country), the higher is τ and the higher is trade in the regional good ($\widetilde{E}_q D_q$). Intuitively, an increase in A that is biased towards the exporting country (i.e. α is high), ensures that the increase in demand in that country for the regional good will be larger. Hence, the increase in demand in the importing country will have to be met relatively more by domestic producers which are less good at producing the regional good. The presence of an intra-regional tariff worsens this effect.

Propositions 3 and 4 show how the reaction of welfare in the importing country in the face of three different types of shocks is always ambiguous. Under plausible assumptions, the condition for welfare to go up is the hardest to be met when τ decreases, followed by the condition derived when A increases[32]. The condition linked to the increase in regional infrastructure is the easiest to meet.

Assuming marginal utilities are equal in the two countries ($\widetilde{E}_U = \widetilde{\epsilon}_\upsilon = \widetilde{e}_u$), we can sum equations (2.26) and (2.27), and look at what happens to welfare at the regional level.

$$B\widetilde{\epsilon}_\upsilon dW = \Big[\tau\widetilde{e}_{qq}(\widetilde{E}_q D_q - \widetilde{E}_{qq})\Big]d\tau + \Big[-\widetilde{e}_{qq}\widetilde{E}_q(1-\tau D_q) - \widetilde{E}_{qq}(\widetilde{E}_q + \tau\widetilde{e}_{qq})\Big]\psi' dG + \Big[S(1-\alpha\tau D_q)\Big]dA \quad (2.28)$$

With regional welfare $dW = dU + du$.

Proposition 5: *An increase in regional infrastructure or national aid raises regional welfare. When the intra-regional tariff is lowered however, welfare goes up only if* $|\widetilde{E}_q D_q| < |\widetilde{E}_{qq}|$.

Regional welfare always benefits from regional infrastructure works, as the term multiplying ψ' is always negative and ψ' itself is also negative. Regional integration ($d\tau < 0$) improves regional welfare only if $|\widetilde{E}_q D_q| < |\widetilde{E}_{qq}|$. This is a less harsh condition than for the importing country's welfare to go up (which is logical, as the exporting country's welfare is always going up when τ is lowered—see higher). It is notable that the regional infrastructure has larger welfare gains than the intra-regional liberalisation in this model. An increase in national aid A always increases regional welfare. This increase is attenuated by the presence of τ.

[32] We can see this by writing the condition for the importing country's welfare to go up when national aid A increases as: $|\widetilde{E}_{qq}| > |\widetilde{e}_{qq} + \frac{-\widetilde{E}_q D_q - \alpha\tau\widetilde{e}_{qq}D_q}{1-\alpha}|$

2.6.2 Comparing national aid to regional aid

Next, we want to see what happens if there is a shift in donor funding from national aid A to regional aid A^{RI}, with the total amount of aid Z staying constant. Writing this budget constraint ($dZ = 0$) as a function of change in the two types of aid, we get:

$$dZ = dA + dA^{RI} = 0 \tag{2.29}$$

Using equation (2.18) to substitute for dA^{RI}:

$$dA = -E_G^{RI} dG \tag{2.30}$$

In what follows, we assume without loss of generality that $E_G^{RI} = 1$, such that equation (2.30) becomes $dA = -dG$. Note that we are keeping the shares of national aid going to the individual countries α (to the exporting country and $1 - \alpha$ (to the importing country) constant. We are interested under what circumstances aid given for regional infrastructure works is better in welfare terms than aid given at the national level.

Proposition 6: *If the productivity of regional infrastructure is high enough, then there exist values for α that make welfare go up in both exporting and importing countries when switching from national to regional aid. An increase in regional welfare is more likely at higher values of α because the importing country suffers relatively more from the switch towards regional aid.*

For a proof of proposition 6, we look at the dG and dA terms in equations (2.26), (2.27) and (2.28). Thus, if the following three equalities hold:

$$(-\widetilde{E}_{qq} + \widetilde{E}_q D_q)(\widetilde{E}_q + \tau \widetilde{e}_{qq})\psi' = (1 - \alpha)S + (\widetilde{E}_q + \alpha\tau\widetilde{e}_{qq})D_q \tag{2.31}$$

$$-\widetilde{E}_q(\widetilde{e}_{qq} + \widetilde{E}_q D_q)\psi' = -\alpha\widetilde{E}_{qq}(1 - \tau D_q) - \alpha\widetilde{e}_{qq} - D_q\widetilde{E}_q \tag{2.32}$$

$$\Big(- \widetilde{e}_{qq}\widetilde{E}_q(1-\tau D_q) - \widetilde{E}_{qq}(\widetilde{E}_q + \tau\widetilde{e}_{qq})\Big)\psi' = S(1-\alpha\tau D_q) \tag{2.33}$$

then for all three areas (importing country, exporting country, total region), aid directed towards regional infrastructure has an equal (marginal) impact on welfare as aid given at the national level.

We are interested in the interaction of ψ' with α to gauge for which values of ψ' and α the switch from national aid to regional aid has a *positive* marginal impact on welfare. Consider the following experiment. First, isolate ψ' from (2.31) and (2.32) and set these respective ψ's equal to each other—we call this value ψ'^*:

$$\psi'^* = \frac{(1-\alpha)S + (\widetilde{E}_q + \alpha\tau\widetilde{e}_{qq})D_q}{(-\widetilde{E}_{qq} + \widetilde{E}_q D_q)(\widetilde{E}_q + \tau\widetilde{e}_{qq})} = \frac{\alpha\widetilde{E}_{qq}(1-\tau D_q) + \alpha\widetilde{e}_{qq} + \widetilde{E}_q D_q}{\widetilde{E}_q(\widetilde{e}_{qq} + \widetilde{E}_q D_q)} \tag{2.34}$$

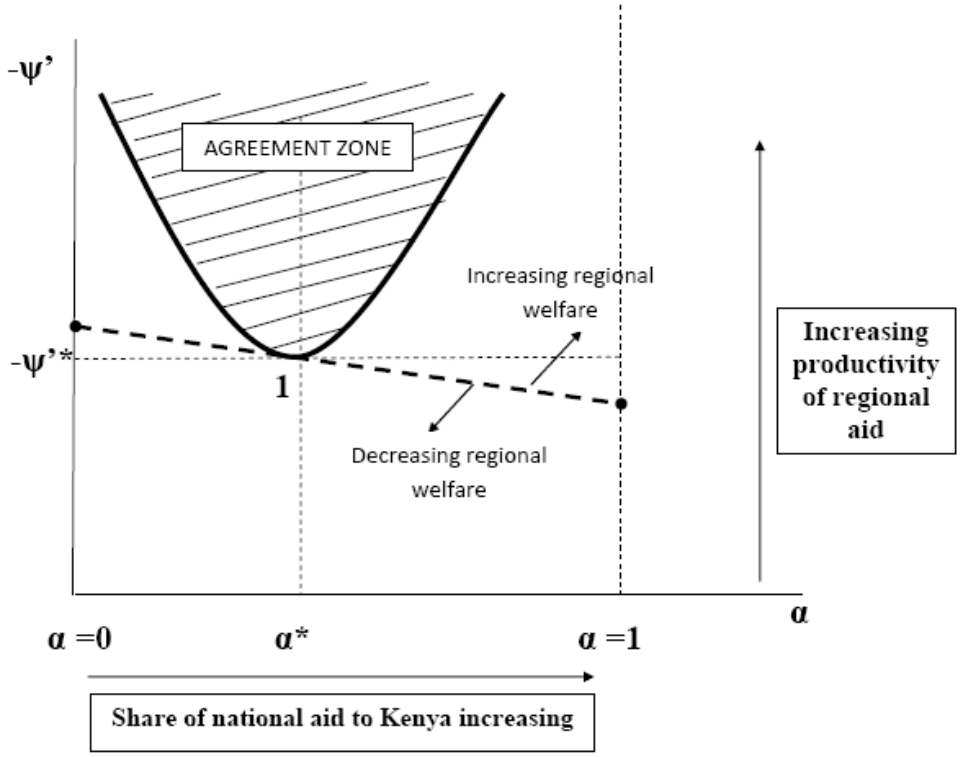
We back out the value for α that is coherent with the value of ψ'^* we just found. We call this α^*. At (α^*, ψ'^*), the marginal contributions to welfare of dA and dG are the same in both countries. This point is depicted as point 1 in figure 2.3[33]. The 'agreement zone' (hatched area) includes those combinations of ψ' and α for which welfare goes up in both countries after switching from national aid A to regional aid G. How do we interpret this 'agreement' zone? When productivity of regional infrastructure ($-\psi'$) is low, then there are no combinations of α and $-\psi'$ that increase welfare when making that switch (area south of point 1). When α is high (most national aid goes to the exporting country), then taking away national aid in favour of regional aid will disproportionately hit Kenya, so only at very high productivity levels will welfare in the exporting country go up. A similar reasoning can be applied to the importing country[34].

Of course, within the agreement zone, regional welfare goes up. There are cases outside the agreement zone however, where welfare benefit in one country will be higher than the welfare loss of the aid switch in the other country. Hence regional welfare goes up

[33] We are disregarding the possibility of endogenous changes to supply and demand slopes as a response to changes in α and ψ'. I.e. not for all demand or supply curve specifications is the (α, ψ')-space stable. E.g. it will be stable for a linear demand curve, but not for an iso-elastic one.

[34] Another way of thinking about this, is that neither country will agree to switch from A to G if their share of A is very high and α is kept constant, i.e. when α is very high or very low.

Figure 2.3: National vs. Regional aid—part I



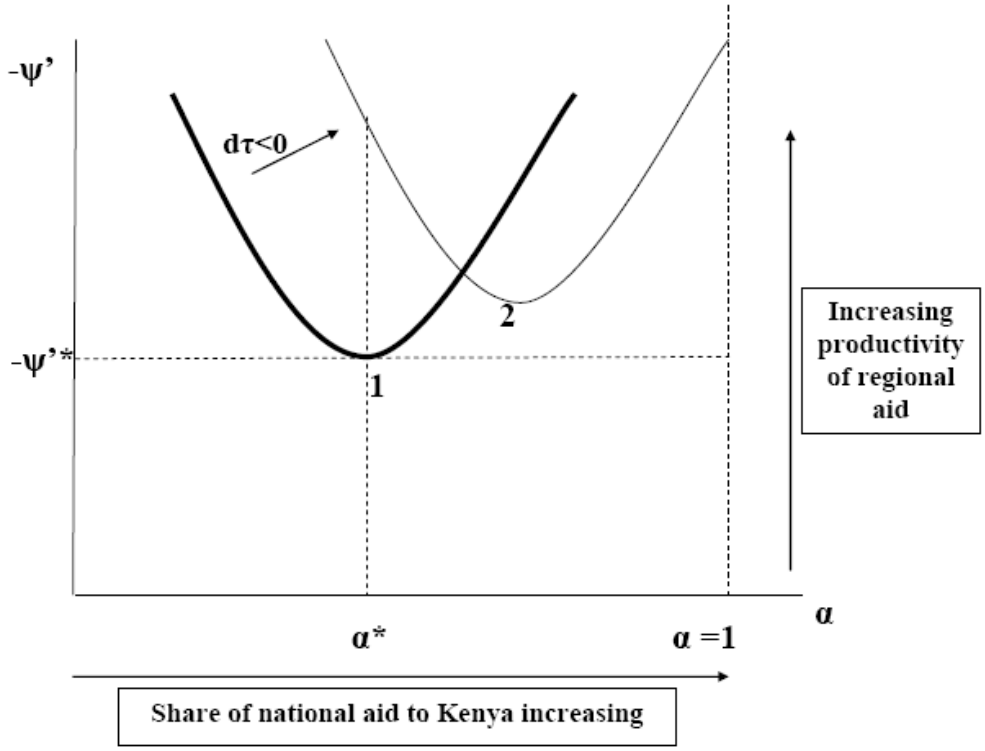
for (α, ψ') combinations above the dashed line and goes down below it. This line is negatively sloped as it will be easier to increase regional welfare at higher values of α because the importing country suffers relatively more from the switch in aid type, as it loses tariff revenue (as now no aid is spent on regional imports).

Proposition 7: *When regional trade is liberalised, it becomes harder to fulfill the conditions for welfare to go up in both countries when switching from national to regional aid, as the productivity of regional infrastructure needs to be relatively higher. As the liberalisation implies that the importing country is losing tariff revenue, satisfying the condition for the shift towards regional aid to be welfare increasing is harder for the importing country.*

Figure 2.4 depicts what happens when τ is lowered. Overall, the productivity increase instigated by the regional infrastructure works needs to be higher to convince the regional partners to switch to regional aid. This shows how trade liberalisation is partly substi-

tutable for regional infrastructure works (recall the regional good's price equation 2.2). Also, it becomes harder to satisfy the condition that welfare in the importing country goes up, as that country loses tariff revenue.

Figure 2.4: National vs. Regional aid—part II



In this model, the net exporter of the regional good takes a disproportionate advantage in welfare terms both from intra-regional trade opening up and from the regional-infrastructure aid. This is because both shocks make regional trade go up, which favours the exporting country. In the discussion regarding proposition 1 we related this to trade diversion (to the detriment of the importing country) and trade creation (to the benefit of the exporting country) effects. Even though for the region as a whole, welfare is still likely to go up in the face of these type of shocks, it does bring us to the question of the relative 'winner' of these shocks compensating the 'loser'.

2.6.3 Transfer between RTA members

This subsection looks at a transfer from exporting to importing country through a lowering of the α parameter. This could be part of a re-distribution of gains from regional integration, or it could be a unilateral decision from donors, perhaps because of the exporting country's governance deteriorating relative to the importing country.

Proposition 8: *A transfer of national aid from exporting to importing country ($d\alpha < 0$) increases welfare in the importing country, and lowers welfare in the exporting country. It also increases regional welfare, but that effect is likely to be small.*

Relaxing the assumption that $d\alpha = 0$ means that we again totally differentiate equations (2.12), (2.13) and (2.15), and solve the model as was shown in appendix B. As we are only interested here in the links between α, which is the share of national aid going to the exporting country, and welfare, this leads to[35]:

$$\frac{du}{d\alpha} = \frac{(-S + \tau D_q \widetilde{e}_{qq})A}{B\widetilde{e}_u} < 0 \tag{2.35}$$

$$\frac{dU}{d\alpha} = \frac{(S + \tau D_q \widetilde{E}_{qq})A}{B\widetilde{E}_U} > 0 \tag{2.36}$$

$$\frac{dW}{d\alpha} = \frac{(-\tau D_q S)A}{B\widetilde{\epsilon}_u} < 0 \tag{2.37}$$

Unsurprisingly, a decrease in α leads to welfare gains in the importing and welfare losses in the exporting country. It also leads to an improvement in the region's welfare, but only if $\tau > 0$. A decrease in α decreases spending on the regional good in the exporting country, and increases it in the importing country. If $\tau = 0$, these two effects cancel out. With a positive τ however, the importer's welfare gains are larger than the exporter's losses.

[35]Note that equation (2.37) is the sum of equations (2.35) and (2.36), with $dW = du + dU$, $\widetilde{E}_u = \widetilde{e}_u = \widetilde{\epsilon}_u$ and $S = -\widetilde{E}_{qq} - \widetilde{e}_{qq}$, similar to the discussion regarding the derivation of proposition four.

This is because in the former, producers of the regional good gain from tariff protection, but consumers do not lose too much as the loss of purchasing power in the exporting country means there is a deflationary pressure on the price of the regional good (remember from figure 2.1 how the local prices of the regional good are interconnected)[36].

Proposition 9: *If the regional good's marginal spending share is higher in the importing country ($D_{q,y} > D_{Q,Y}$), a transfer from the exporting to the importing country of national aid ($d\alpha < 0$) increases the relative price of the regional good in both countries.*

Next, we look at the impact of α on relative prices when marginal spending shares $D_{Q,Y}$ and $D_{q,y}$ are allowed to differ by country. Totally differentiating equations (2.12), (2.13) and (2.15) and solving for dq, we get:

$$\Big[-S - D_{Q,Y}\widetilde{E}_q + \frac{D_{q,y}(\widetilde{E}_q + \tau\widetilde{E}_{qq})}{1-\tau D_{q,y}}\Big]dq = -\Big[\alpha D_{Q,Y} + (1-\alpha)\frac{D_{q,y}}{1-\tau D_{q,y}}\Big]dA + \Big[-D_{Q,Y} + \frac{D_{q,y}}{1-\tau D_{q,y}}\Big]Ad\alpha + \Big[\widetilde{E}_{qq} - D_{Q,Y}\widetilde{E}_q + \frac{D_{q,y}\widetilde{E}_q}{1-\tau D_{q,y}}\Big]d\tau + \Big[\widetilde{E}_{qq} - D_{Q,Y}\widetilde{E}_q\Big]\psi' dG \tag{2.38}$$

Unfortunately, the sign of the term multiplying dq on the left-hand side is not straightforward. $(-S)$ is negative, $(-D_{q,Y}\widetilde{E}_q)$ is positive, and the third part is again negative (assuming L is a normal good in both countries)[37]. It is assumed for this section that this term in its totality is negative. This will be the case unless the marginal spending share for the L-good is substantially higher in the exporting than the importing country ($D_{Q,Y} >> D_{q,y}$). This is unlikely as it would mean that the exporting country, which we think of as slightly richer, has a higher marginal spending share for the good that resembles more a necessity[38].

[36] Note the difference with proposition 4 (where we found that an increase in A could decrease welfare in the importing country at high *levels* of α) and proposition 6 (where we found it would be easier to increase regional welfare at high *levels* of α when switching from national to regional aid.). Here we are looking at changes in α with A constant.

[37] Remember the relative price for L is q in the importing and Q in the exporting country.

[38] Or in the words of section (2.6.1): *marginal spending shares are assumed to be higher for H than for L (..) H is high(er) value added, such that L will have the attributes of a necessity good.* The assumptions can be written more simply as: $D_{Q,Y} < D_{q,y} < 1 < D_{T,y} < D_{T,Y}$.

A transfer from exporting to importing country implies $d\alpha < 0$. If $D_{Q,Y} < D_{q,y}$ and $\tau = 0$, then q and Q increase via an income effect. This is reminiscent of Samuelson (1952)'s *crucial marginal income propensities*, which determine the effect of a transfer on the terms of trade (ToT) of two trading partners. Here the relative price of the regional good is akin to regional ToT[39]. Production in both countries is stimulated as total demand for the regional good goes up. I.e. demand in the importing country goes up more than demand in the exporting country falls. Hence, regional trade expands. The trade balance of the importing country deteriorates by the amount of the transfer, and vice versa for the exporting country[40]. If $\tau > 0$, the difference between the importer and exporter's marginal spending shares for the regional good will have to be higher for this result to go through.

2.6.4 Re-introducing the Common External Tariff

The introduction of a non-zero Common External Tariff (CET) increases the complexity of the model, implying that it becomes much harder to obtain clear-cut results as in the previous sub-sections. Hence this sub-section points out what to be aware of in an intuitive way when allowing for a non-zero common external tariff instead of rigorously proving propositions. It thus shows the limits of the above modeling approach, and paves the way for the development of the Computable General Equilibrium model in the next chapter.

The good which is subject to the CET is H (relative price T), which is traded with the rest of the world and is not produced within the region. A non-zero CET will make it more expensive to consume H, relative to the regionally tradable L (relative prices q and Q). Across the region, the increased demand for L will shift the mobile factor of

[39] Not to be confused with T which is the international terms of trade—see equations (2.5).

[40] As there is only one good whose price is determined within the model, it is not possible to replicate the result of Fluckiger (1987), who shows that *a unilateral transfer might create an overall ToT deterioration in a world where two countries form a CU (..) This result might appear if the paying country experiences a ToT deterioration and if the transfer made between the CU partners generates a change in the imports composition which is sufficiently important to worsen the ToT of the receiving country.*

production into the L-sector, and away from the F-sector. How much of the increased production will happen in either country will depend on bilateral trade relations, aid flows and deeper structural factors such as elasticities of demand and supply, and marginal spending shares. Note that the lower is t, the closer our results will be to those of the previous sub-sections. In general, we assume t to be relatively small, as it is an aggregate tariff rate across imports from the rest of the world[41]. When $t \neq 0$, totally differentiating equations (2.12), (2.13), and (2.15), gets us:

$$\begin{aligned}\widetilde{E}_q(dq - d\tau - \psi' dG) + \widetilde{E}_U dU = \alpha dA + \\ t\widetilde{E}_{Tq}(dq - d\tau - \psi' dG) + t\widetilde{E}_{TU} dU + t\widetilde{E}_{TT} dt\end{aligned} \tag{2.39}$$

$$\begin{aligned}\widetilde{e}_q dq + \widetilde{e}_u du = (1-\alpha)dA + t\widetilde{e}_{Tq} dq + t\widetilde{e}_{Tu} du + \\ \widetilde{e}_q d\tau + \tau\widetilde{e}_{qq} dq + \tau\widetilde{e}_{qu} du + t\widetilde{e}_{TT} dt + \tau\widetilde{e}_{qT} dt\end{aligned} \tag{2.40}$$

$$\begin{aligned}\widetilde{E}_{qq}\Big(dq - d\tau - \psi' dG\Big) + \widetilde{E}_{qT} dt + \\ \widetilde{E}_{qU} dU + \widetilde{e}_{qq} dq + \widetilde{e}_{qT} dt + \widetilde{e}_{qu} du = 0\end{aligned} \tag{2.41}$$

In what follows, we will use the following simplifications:

$$\begin{aligned}\Gamma = 1 - tD_T > 0 \qquad \gamma = 1 - tD_T - \tau D_q > 0 \qquad \widetilde{\epsilon}_{qT} = \widetilde{E}_{qT} + \widetilde{e}_{qT} > 0 \\ \Lambda = \widetilde{E}_q - t\widetilde{E}_{qT} < 0 \qquad \lambda = \widetilde{e}_q - t\widetilde{e}_{qT} - \tau\widetilde{e}_{qq} > 0\end{aligned} \tag{2.42}$$

In signing these expressions, it was assumed that D_T is not much larger than one, such that $tD_T < 1$, and that H and L are substitutes. We can then re-write the three core equations (2.39), (2.40) and (2.41) more simply:

$$\Lambda dq + \Gamma\widetilde{E}_U dU = \Lambda d\tau + \Lambda\psi' dG + \alpha dA + t\widetilde{E}_{TT} dt \tag{2.43}$$

[41] In the CGE in the next chapter, CET's will not be larger than 14%.

$$\lambda dq + \gamma \widetilde{e}_u du = (1-\alpha)dA + \widetilde{e}_q d\tau + (t\widetilde{e}_{TT} + \tau \widetilde{e}_{qT})dt \tag{2.44}$$

$$-Sdq + D_q \widetilde{E}_U dU + D_q \widetilde{e}_u du = \widetilde{E}_{qq} d\tau + \widetilde{E}_{qq} \psi' dG - \widetilde{\epsilon}_{qT} dt \tag{2.45}$$

As before, we focus on: (i) the effect of the CET on the relative price of the regional good, including how proposition 1 changes, (ii) the effect of the CET on regional welfare.

The solution for dq is:

$$\begin{aligned} -\Big[S + \Lambda \frac{D_q}{\Gamma} + \lambda \frac{D_q}{\gamma}\Big] dq = \Big[\widetilde{E}_{qq} - \Lambda \frac{D_q}{\Gamma} + \widetilde{E}_q \frac{D_q}{\gamma}\Big] d\tau + \\ \Big[(\widetilde{E}_{qq} - \Lambda \frac{D_q}{\Gamma})\psi'\Big] dG - \Big[\frac{\alpha D_q}{\Gamma} + \frac{(1-\alpha)D_q}{\gamma}\Big] dA + \\ \Big[- \widetilde{\epsilon}_{qT} - \frac{D_q t \widetilde{E}_{TT}}{\Gamma} - \frac{D_q (t\widetilde{e}_{TT} + \tau \widetilde{e}_{qT})}{\gamma}\Big] dt \end{aligned} \tag{2.46}$$

Keeping A, t and G constant, to focus on the relation between q and τ, we write:

$$\frac{dq}{d\tau} = \frac{\widetilde{E}_{qq} - D_q\Big(\frac{\widetilde{E}_q - t\widetilde{E}_{Tq}}{\Gamma}\Big) + D_q \frac{\widetilde{E}_q}{\gamma}}{\widetilde{E}_{qq} + \widetilde{e}_{qq} - D_q\Big(\frac{\widetilde{E}_q - t\widetilde{E}_{Tq}}{\Gamma}\Big) - D_q\Big(\frac{\widetilde{e}_q - t\widetilde{e}_{Tq} - \tau\widetilde{e}_{qq}}{\gamma}\Big)} \tag{2.47}$$

and:

$$\frac{dQ}{d\tau} = \frac{-\widetilde{e}_{QQ} - D_Q \frac{\Big(t\widetilde{e}_{TQ} + \tau \widetilde{e}_{QQ}\Big)}{\gamma}}{\widetilde{E}_{QQ} + \widetilde{e}_{QQ} - D_Q\Big(\frac{\widetilde{E}_Q - t\widetilde{E}_{TQ}}{\Gamma}\Big) - D_Q\Big(\frac{\widetilde{e}_Q - t\widetilde{e}_{TQ} - \tau\widetilde{e}_{QQ}}{\gamma}\Big)} \tag{2.48}$$

In most cases, both numerator and denominator of the RHS of (2.47) will be negative such that the whole expression will be positive. The numerator of (2.48) will be positive and the denominator negative, such that (2.48) will be negative. This is the same result as in sub-section (2.6.1), i.e. regional liberalisation decreases the relative price of L in the importing country, and increases it in the exporting country.

Compared to that previous sub-section, the $t\widetilde{E}_{Tq}$ and $t\widetilde{e}_{Tq}$ terms are new and could possibly overturn this result. The presence of $t > 0$ makes it relatively more expensive to

consume H, and if, as we assume, the substitution elasticity $t\widetilde{E}_{Tq}$ is positive, consumption in the region will move away from H towards L. As L is only produced within the region, the mobile production factor will move towards the L sector. Higher q and Q *relative* to the $t = 0$ case, will provide the incentive for this to happen. If τ is lowered, and $\widetilde{E}_{Tq}$ is high enough, translating into a demand surge in the exporting country for L, then q might go up to incite production of L in the importing country. As for the exporting country, in most cases equation (2.48) will be negative, but large substitution terms are able to overturn this result. In other words, the results found in proposition 1 can be overturned if substitution elasticities are large enough.

We do not know the direction of the effect of t itself on dq without making any further assumptions. We already saw that we do not know the sign of the term multiplying dq without putting more structure onto the model, and the same goes for the term multiplying dt. What are the adjustment mechanisms when the CET goes up ($dt > 0$), assuming that the term multiplying dq is negative? The first part of the term multiplying dt ($-\widetilde{\epsilon}_{qT}$) implies that higher substitution possibilities between the two consumer goods lead to more consumption of L. As L is only produced within the region, the mobile production factor has to move to increase production in that sector, which will increase q. The second part ($-tD_q\widetilde{E}_{TT}/\Gamma$) and the first bit of the third part ($-tD_q\widetilde{e}_{TT}/\gamma$) are (negative) income effects, the size of which will depend on demand elasticities in the H-sector. These two terms will decrease q. The last term ($-\tau D_q\widetilde{e}_{qT}/\gamma$) shows how a positive $\tau > 0$ increases production of L in the importing country as that country now has to produce more of L as it becomes harder to import it from the exporting country. This part increases q, and will be higher if the importing country can easily substitute for consumption between H and L (i.e. $\widetilde{\epsilon}_{qT}$ is large).

Next, we turn to welfare considerations. The solutions for welfare in the importing (du) and exporting (dU) countries can be written as follows—these are the equivalents of

equations (2.26) and (2.27) from previous sections:

$$\Big[D_q - \frac{\gamma}{\lambda}(-S - \frac{D_q\Lambda}{\Gamma})\Big]\widetilde{e}_u du = \Big[(\widetilde{E}_{qq} - \frac{D_q\Lambda}{\Gamma})\psi'\Big]dG - \Big[\frac{\alpha D_q}{\Gamma} + \frac{(1-\alpha)D_q}{\gamma}(-S - \frac{D_q\Lambda}{\Gamma})\Big]dA + \Big[\widetilde{E}_{qq} - \frac{D_q\Lambda}{\Gamma} + \frac{\widetilde{E}_q}{\lambda}(-S - \frac{D_q\Lambda}{\Gamma})\Big]d\tau + \Big[-\widetilde{\epsilon}_{qT} - \frac{D_q t\widetilde{E}_{TT}}{\Gamma} - (-S - \frac{D_q\Lambda}{\Gamma})(\frac{t\widetilde{e}_{TT} + \tau\widetilde{e}_{Tq}}{\lambda})\Big]dt \tag{2.49}$$

and:

$$\Big[D_q - \frac{\Gamma}{\Lambda}(-S - \frac{D_q\lambda}{\gamma})\Big]\widetilde{E}_U dU = \Big[(\widetilde{E}_{qq} + S + \frac{D_q\lambda}{\gamma})\psi'\Big]dG - \Big[\frac{(1-\alpha)D_q}{\gamma} + \frac{\alpha}{\Lambda}(-S - \frac{D_q\lambda}{\gamma})\Big]dA + \Big[-\widetilde{e}_{qq} - \frac{D_q(t\widetilde{e}_{qT} + \tau\widetilde{e}_{qq})}{\gamma}\Big]d\tau + \Big[-\widetilde{\epsilon}_{qT} - \frac{D_q(t\widetilde{e}_{TT} + \tau\widetilde{e}_{Tq})}{\gamma} + (S + \frac{D_q\lambda}{\gamma})\frac{t\widetilde{E}_{TT}}{\Lambda}\Big]dt \tag{2.50}$$

We are interested in how regional welfare changes as a consequence of a change in the CET. In other words, we keep τ and G constant (so we can get rid of the $d\tau$ and dG terms above). We simplify the two above equations by making sure both expressions are put on common denominators ($\lambda\Gamma$ for importing and $\Lambda\gamma$ for the exporting country), to get the following expressions for the link between national welfare and the CET:

$$[\lambda\Gamma D_q + \gamma S\Gamma + \gamma\Lambda D_q]\widetilde{e}_u du = [-\widetilde{\epsilon}_{qT}\lambda\Gamma - D_q t\widetilde{E}_{TT}\lambda + (S\Gamma + \Lambda D_q)(t\widetilde{e}_{TT} + \tau\widetilde{e}_{Tq})]dt \tag{2.51}$$

$$[\lambda\Gamma D_q + \gamma S\Gamma + \gamma\Lambda D_q]\widetilde{E}_U dU = [-\widetilde{\epsilon}_{qT}\Lambda\gamma - D_q(t\widetilde{e}_{TT} + \tau\widetilde{e}_{Tq})\Lambda + (S\Lambda + \lambda D_q)t\widetilde{E}_{TT}]dt \tag{2.52}$$

Again, we assume marginal utility is the same in both countries ($\widetilde{E}_U = \widetilde{\epsilon}_\upsilon = \widetilde{e}_u$). Sum-

ming the two previous expressions gets us an expression for regional welfare dW:

$$[\lambda\Gamma D_q + \gamma S\Gamma + \gamma\Lambda D_q]\widetilde{\epsilon}_\upsilon = \Big[-\widetilde{\epsilon}_{qT}(\lambda\Gamma + \gamma\Lambda) + S\Gamma(t\widetilde{e}_{TT} + \tau\widetilde{e}_{Tq}) + S\Lambda t\widetilde{E}_{TT}\Big]dt \tag{2.53}$$

We do not know the sign of either the LHS or the RHS of this expression without putting more structure on the model, which implies that the region's move towards trade liberalisation vis-à-vis the rest of the world is not necessarily welfare improving. The possibility that welfare might be reduced by lowering the common external tariff may seem to contradict the standard theory of gains of trade. However, as in section (1.2) second best theory applies, because the model has distortions related to the intra-regional tariff $\tau \neq 0$ and the infrastructure spill-over.

2.7 Conclusion

Two stylised facts regarding Low Income Countries in sub-Saharan Africa motivate the development of a duality based general equilibrium trade model in this chapter : (i) African RTAs are gradually removing trade barriers, and (ii) African countries remain heavily aid dependent. Such trade and aid shocks can have significant welfare and relative price implications depending on how the aid is used and the structural aspects of the economies involved.

We started the chapter with an overview of the *Dutch disease,* public capital effectiveness and regional integration literature. We studied these topics by using the angle of externalities. *Dutch disease* only becomes an issue when one thinks that the development of certain sectors is more important than others for growth, e.g. through learning-by-doing effects in manufacturing. Public investments in transport infrastructure or power stations can equally be considered as an externality as they increase the productivity of private factors. Our main modeling interest lies with how public investments in a Customs Union

member state can have spill-over effects on productivity in a neighbouring member state. We modeled this externality through aid-funded infrastructure that lowers regional trade costs through exerting downward pressure on the price of a regionally tradable good. In the next CGE chapter, the externality is modeled via the production function—see table 2.1 and the discussion in section (3.2) of the next chapter. In neither of these two chapters do we explicitly model Dutch disease related externalities like learning-by-doing.

The inclusion of a regionally tradable good that is not traded with the rest of the world, is the main innovation of our model, allowing us to move away from the Salter-Swan tradable / non-tradable good dichotomy. The productivity spill-over is modeled onto this regional good and our focus is on this good's relative price, with the price of an internationally exportable good used as the numéraire. The third good in the three-good model is an internationally importable good. In the main analysis, we make abstraction from the common external tariff. When trade costs are lowered, whether through a lowering of the intra-regional tariff or through regional infrastructure works, the regional good's relative price goes up in the exporting country, and goes down in the importing country. Regional trade is boosted, with the regional trade balance deteriorating for the importing country and improving for the exporting country. With aid constant, net international exports have to go up in the importing country.

An increase in aid given at the national level increases relative price of the regional goods in both countries.

One robust welfare result is that the importing country does not necessarily gain from intra-regional trade liberalisation, from regional infrastructure works or from an increase in national aid (like budget support). We then analysed what parameters determine whether both countries would agree to a move from national aid to regional aid. First, regional infrastructure investments need to be productive enough, second, national aid should be relatively evenly spread across the regional partners, and third, welfare gains from moving to regional infrastructure works are lower when intra-regional tariffs are

lowered simultaneously. We did not find results that point to a transfer paradox when aid is shifted between member states, whilst the introduction of the common external tariff increases the model's complexity, making it harder to derive clear-cut results.

The idea in this chapter was to shed some light on the qualitative implications of the interaction among the main variables of a stylised trade model involving aid, trade costs and preferential trade. For more quantitative detail and specific parameterizations we now turn to the development of a Computable General Equilibrium (CGE) model[42].

[42]Implications for further research are discussed in the conclusion to chapter 3.

Chapter 3

Aid & Regional Integration: A Computable General Equilibrium Model

3.1 Introduction

Chapter 2 showed how introducing preferential trade and regional spill-overs from public investments into a duality-based general equilibrium trade model substantially increases the model's complexity, making the analysis much harder. Also, there has been some skepticism surrounding theoretical work on regional integration, as a lot of the results the literature arrives at hinge on specific assumptions (Abrego et al., 2006). Responding to these two issues, this chapter develops a two-country Computable General Equilibrium (CGE) model allowing for a richer set of relations between economic actors and more possibilities regarding the types of exogenous shocks that can be analysed. The recursive dynamic CGE developed here is made up of six sectors, and can be thought of as a two-country extension of the Adam and Bevan (2006) paper, even though we do not explicitly address *Dutch disease* related externalities like learning-by-doing.

Compared to the previous chapter, we model the supply-side in much more detail, introducing regional spill-overs via the two countries' production functions. The CGE simulations experiment with changing aid, public investment and tariff variables. We look at the effects on welfare, relative prices and trade quantities, with a specific interest in how results from the standard regional integration and dependent economy (Salter-Swan) literature might need to be adjusted in this richer framework.

The chapter's structure is as follows. After this introduction, section (3.2) introduces the CGE and details the link with the theory chapter. Only the most important equations are discussed here, with a full listing of equations and variables relegated to appendix C. Section (3.3) discusses the data used in calibrating the model for Uganda and Kenya, section (3.4) analyses the main simulations, section (3.5) performs some sensitivity analysis and section (3.6) concludes.

3.2 Developing the CGE model

To assess the impact of trade and aid shocks on the EAC region, we build a two-country CGE based on single country CGEs developed by IFPRI. The Social Accounting Matrices (SAMs) used are based on Kiringai et al. (2006) for Kenya (base-year 2003) and by Dorosh and El-Said (2004) for Uganda (base-year 1999). The model is recursive dynamic and runs over the period 2003-2013. This means that the model is solved for a series of equilibria with economic agents optimising their behaviour within each period. The between-period component is governed by adaptive expectations, with the model updated to reflect changes in the capital stock[1]. The CGE set-up is fairly standard and is well described in e.g. Devarajan et al. (1994). Table 3.1 below depicts a highly aggregated SAM for one country[2], where the rows 'pay' the columns. For example Households

[1]This means temporary shocks will not have much impact as we are not looking at a fully *inter-temporally* optimised CGE. Thus, the aid shock should be interpreted as a reduction in debt stock, which translates into a permanent lowering of debt service over the CGE horizon. This implies we will not look at transitory vs. permanent aid shocks in the simulations.

[2]For presentational purposes, intra-regional trade flows are subsumed in the RoW account in table 3.1.

spend (trace the HoH column) their money on 'HoH consumption', pay taxes to Government and save.

The model is completely real with nominal exchange rates not playing any role, except as unit of account. As such it is possible to convert all variables from the Ugandan SAM from Ugandan Shillings (USh) into Kenyan Shillings (KSh). In the simulations below, all results are reported in KSh. The main characteristics of our two-country CGE are:

- Six Sectors: Food, Cash Crops, Low-skilled Manufacturing, High-skilled Manufacturing, Private Services and Public Services. The last two are entirely non-tradable, whilst Cash Crops are entirely produced for the world market.
- Firms are not explicitly modeled.
- Two Household Types: Rural and Urban.
- Three Factors of Production: Land, Labour and Capital.
- Two Labour Types: Unskilled and Skilled. Both are assumed to be fully employed with flexible wages. The food sector only employs unskilled labour. 10% of the labour force is assumed to be skilled in both countries.
- Three Types of Capital: (i) Sector-specific capital and public capital destined for (ii) national infrastructure works and (iii) regional infrastructure works. Sector-specific capital profit rates are equalised at 20% for the five private sectors.
- There are no sales taxes. Direct taxes on land, capital and labour are flat for both countries and set at 7.5% in Uganda and 10% in Kenya, reflecting different stages of monetization and economic development.
- All aid goes straight to Government.
- Transaction costs are set to zero, as are inventories.
- There are tariffs on imports, but no export subsidies.
- In the baseline case, we assume a depreciation rate of 6.25%.

Comparing the consumption/production patterns outlined in the first bullet point above with the set-up of table 2.2, we see a 1-1 correspondence between the exportable good

Table 3.1: Stylised Social Accounting Matrix (SAM) for one country

Stylised Social Accounting Matrix		EXPENDITURES							
		Activities	**Commodities**	**Factors**	**HoH**	**Gov't**	**Investment**	**RoW**	**Total**
R	**Activities**		Marketed Outputs						**Activity Income**
E	**Commodities**	Intermediate Inputs			HoH Consumption	Gov't Consumption	I, change in stocks	Exports	**Absorption**
C	**Factors**	Value Added							**Factor Income**
E	**Households**			Factor Payments to HoH		Gov't Transfers to HoH		Remittances	**HoH Income**
I	**Government**		Import Tariffs		Direct HoH Taxes			Aid	**Gov't Income**
P	**Savings**				HoH Savings	Gov't Savings			**Total Savings**
T	**RoW**		Imports						**Forex Outflow**
S	**Total**	**Activity Expenditures**	**Total Supply**	**Factor Expenditures**	**HoH Expenditures**	**Gov't Expenditures**	**Investment**	**Forex Inflow**	

Source: Adapted from Kiringai et al. (2006).

and the cash-crop sector. Further in the CGE, the regional good becomes a two-way tradable (*'Food'* from Uganda to Kenya, *'L-Manuf'* from Kenya to Uganda), whilst in the theory chapter we only had exports from Kenya to Uganda. The CGE *'H-Manuf'* sector corresponds to the theoretical H-sector. Finally, the theory model did not have any purely non-tradables, like private or public services, the final two sectors of the CGE.

We now introduce the innovations to the standard CGE model developed by Devarajan et al. (1994). Trade relations are governed by nested Constant Elasticity of Substitution functions on the demand side and Constant Elasticity of Transformation functions on the supply side, where domestic, regional and foreign goods are distinguished by their origins[3]. On the supply side, the first 'nesting' level is between local goods and exports to the rest of the world, whilst the second level disaggregates 'local' into domestic sales and regional exports. These relations are shown in equations (C.6)-(C.7) and (C.22)-(C.25) in appendix C. A similar set up is developed for the demand side.

The regional good is only consumed and produced within the region, which means we are not strictly in a 'small-open-economy' world where producers and consumers are price-takers in all foreign markets. The following two equations show how this is modeled, with $PMR_{rm,r}$ the domestic price of the regional good in sector rm in the importing country r and $PER_{rx,rr}$ the domestic price of the regional good in sector rx in the exporting country rr. $tmr_{rm,r}$ is the tariff imposed on regional trade by the importing country. Equation (3.2) then shows how quantities of intra-regional imports in one CU member state have to equal intra-regional exports in the other.

$$PMR_{rm,r} = PER_{rx,rr} * (1 + tmr_{rm,r}) \tag{3.1}$$

$$MR_{rm,r} = ER_{rx,rr} \tag{3.2}$$

The production function is Cobb Douglas in land (LAND), composite labour (CL) and

[3]See Decaluwé et al. (2004) for a similar set-up for regional trade analysis in the UEMOA region.

the sector-specific capital stock (KP), with $\lambda n_{i,r} + \lambda l_{i,r} + \lambda k_{i,r} = 1$:

$$X_{i,ken} = AP_{i,ken} * (LAND_{i,ken}^{\lambda n_{i,ken}} CL_{i,ken}^{\lambda l_{i,ken}} KP_{i,ken}^{\lambda k_{i,ken}}) * KG_{ken}^{\lambda kg_{i,ken}} * KR_{ken}^{\lambda kr_{i,ken}} \quad (3.3)$$

$$X_{i,uga} = AP_{i,uga} * (LAND_{i,uga}^{\lambda n_{i,uga}} CL_{i,uga}^{\lambda l_{i,uga}} KP_{i,uga}^{\lambda k_{i,uga}}) * KG_{uga}^{\lambda kg_{i,uga}} * KR_{ken}^{\lambda kr_{i,uga}} \quad (3.4)$$

The national public capital stock for infrastructure KG does not have a sectoral subscript, but its effect can differ across sectors through the parameter $\lambda kg_{i,r}$. Compared to Adam and Bevan (2006), we add a regional public capital stock for infrastructure KR. In an accounting sense, the latter is listed in Kenya's SAM, even though it figures in both Uganda's and Kenya's production function. Like this, we introduce the spill-over effect of Kenyan infrastructure to unlock the economic potential of Uganda. Hence, constant returns prevail in the private factors of production, but increasing returns are possible in the presence of the two types of public infrastructure capital.

In the theory chapter, the aid-funded infrastructure impacted on the tradability of the regional good via downward pressure on its price in the importing country, Uganda (see also table 2.1). Here the externality is modeled in the production function and is not limited to one sector. The way of modeling through the production function is more general, and allows us also to look at spending effects, apart from the downward pressure on prices.

Households receive income through employment of their factors of production, labour, land and capital. Rural households possess all the factors of production employed for production of the agricultural goods (food and cash crops), whilst urban households possess the factors to produce the other four goods. Households then pay direct taxes, with their disposable income ($YD_{hh,r}$) allocated across consumption goods according to a linear expenditure system (LES), derived from a Stone-Geary utility function:

$$CD_{ic,hh,r} * PQ_{ic,r} = \left[\frac{PQ_{ic,r}^{1-\sigma c_r} * CLES_{ic,hh,r}^{\sigma c_r}}{\sum_{jc} PQ_{jc,r}^{1-\sigma c_r} * CLES_{jc,hh,r}^{\sigma c_r}} * \right.$$

$$\Big((1 - MPS_{hh,r})YD_{hh,r} - \sum_{jc} PQ_{jc,r} * CBASE_{jc,hh,r}\Big)\Big] + \Big[CBASE_{ic,hh,r} * PQ_{ic,r}\Big] \quad (3.5)$$

with $CD_{ic,hh,r}$ final consumption of non-public good ic by household type hh in country r, $CLES$ the marginal budget shares (see section C.1.3 of appendix C for a definition), PQ the price of the consumption goods, MPS the marginal propensity to save, and $CBASE$ subsistence consumption (set to zero in the baseline case).

The model is recursive dynamic, with periods linked through updating rules for factors of production labour and capital. A typical updating rule (this one for capital), looks like[4]:

$$KP_{i,r}^{t+1} = KP_{i,r}^{t} * (1 - DEPR_{i,r}) + DK_{i,r}^{t} \quad (3.6)$$

The CGE model is driven by a neo-classical closure rule in which total private investment is constrained by total savings net of exogenous public investment. Household saving propensities are exogenously given. This fixed savings rates imply that there is full crowding out between public and private investment. The model is run in the GAMS software with the model maximising final household consumption:

$$WELFARE_{r,hh} = \left[\sum_{ic} CLES_{ic,hh,r} * (CD_{ic,hh,r} - CBASE_{ic,hh,r})^{\frac{\sigma c_r - 1}{\sigma c_r}}\right]^{\frac{\sigma c_r}{\sigma c_r - 1}} \quad (3.7)$$

For national welfare, the above equation is weighted by population shares. For regional welfare, we sum both countries' national welfare. For an overall welfare measure across time, we multiply (3.7) by a discount factor $\overline{\beta}$—set to 0.95 or 0.99 :

$$Discounted\ Welfare_{r,hh} = \sum_{t=1}^{10} \overline{\beta}^{t-1} * (WELFARE_{r,hh})_t \quad (3.8)$$

Discounted total national welfare and regional welfare can then again be calculated as before.

[4]For the other updating rules, involving other types of capital and labour growth, see appendix C.

3.3 Data and calibration issues

3.3.1 Macro SAMs

Table 3.2 gives an overview of both countries' so-called 'macro' SAMs, where we put numbers on the stylised SAM presented in table 3.1. For comparison purposes, both

Table 3.2: Kenya and Uganda Macro SAMs (KSh bn)

KENYA	**Acts.**	**Comms.**	**Facts.**	**HoHs**	**Gov't**	**Inv**	**RoW**	**Total**
Activities	-	1,957	-	-	-	-	-	1,957
Commodities	1,030	-	-	754	114	165	205	2,268
Factors	927	-	-	-	-	-	-	927
HoH	-	-	927	-	-	-	42	970
Gov't	-	34	-	93	-	-	29	156
Investment	-	276	-	123	42	-	-	441
RoW	-	-	-	-	-	-	-	-
Total	1,957	2,268	927	970	156	165	276	6,719
UGANDA	**Acts.**	**Comms.**	**Facts.**	**HoHs**	**Gov't**	**Inv**	**RoW**	**Total**
Activities	-	841	-	-	-	-	-	841
Commodities	391	-	-	378	68	63	69	969
Factors	450	-	-	-	-	-	-	450
HoH	-	-	450	-	-	-	13	463
Gov't	-	7	-	34	-	-	39	80
Investment	-	-	-	51	12	-	-	63
RoW	-	121	-	-	-	-	-	121
Total	841	969	450	463	80	63	121	2987

Source: own calculations.

SAMs are presented in billion Kenyan Shilling. We can see for example how the Kenyan economy is about twice the size of the Ugandan economy, or that more aid goes to Uganda (39 bn KSh) than to Kenya (29 bn KSh). Table 3.3 shows how the 50 sectors of the IFPRI Kenya SAM and the 26 sectors of the Uganda SAM are aggregated into six sectors for our own CGE model.

Table 3.3: Sector mapping

Own SAM	IFPRI 2003 Kenya SAM		IFPRI 1999 Uganda SAM
FOOD	Maize	Others crops	Maize
	Wheat, Rice	Beef	Sorghum/Millet
	Barley	Dairy	Cassava, Matooke
	Other cereals	Poultry	Sweet Potatoes
	Roots/tubers	Sheep/goat/lamb-slaughter	Horticulture
	Pulses/oil seeds	Other livestock	Other agriculture
	Fruits	Fishing	Livestock
	Vegetables	Forestry	Forestry, Fishing
CASH CROPS	Coffee, Tea	Cotton	Coffee
	Cut flowers	Sugarcane	Other Cash crops
AGRIBUSINESS and LIGHT MANUFACTURES	Meat/dairy	Other manuf. food	Meat/dairy processing
	Grain milling	Textile/clothing	Coffee processing
	Sugar/bakery/confect.	Leather/footwear	Grain milling
	Beverages/tobacco	Printing/publishing	Other beverages
			Textiles and leather
INDUSTRY and HEAVY MANUFACTURES	Mining	Metals/machines	Manufacturing
	Wood and paper	Non-metallic products	Fertilizers
	Petroleum	Other manufactures	Petroleum/chemicals
	Chemicals		
SERVICES	Water	Transport	Construction
	Electricity	Communication	Commerce
	Construction	Finance	Transport
	Trade	Real estate	Private services
	Hotels	Other services	Utilities
PUBLIC SECTOR	Adminsitration	Education, Health	Public services

Source: Kiringai et al. (2006) for Kenya, Dorosh and El-Said (2004) for Uganda.

3.3.2 Trade data in the CGE

Trade patterns in the four tradable sectors are shown in tables 3.4 (Kenya) and 3.5 (Uganda). There are only two sectors in which regional goods are traded, with Uganda importing low-skilled manufacturing goods from Kenya and food going the other way. Cash crops are only produced for export to the rest of the world, and are not consumed in the region. This is a 'stylized' representation of regional and international trade relations involving Uganda and Kenya.

Uganda is close to being food self-sufficient (Gollin and Rogerson, 2010). The 2005 Uganda IFPRI SAM corroborates this by reporting agricultural imports to be less than 1% of GDP (Dorosh and Thurlow, 2009, p.11). Chapter 1 showed Kenya to be the manufacturing hub of the EAC, with a food deficit (Govereh et al., 2008). In 2003,

Kenya sourced only 2.3% of its world imports from within EAC, of which about two thirds came from Uganda (Stahl, 2005). This is much lower than the 8.7% mentioned in table 3.4. It is likely however, that a lot of informal trade on the Kenya-Uganda border is not reported in official statistics. The Ugandan informal cross border trade survey for example estimates non-recorded exports from Uganda to Kenya to be around 44.2 million USD in 2005 and 63.9 million USD in 2006, the bulk of which were agricultural products (Bank of Uganda and UBOS, 2007, p.vii). This brings us closer to the figures shown in the tables below. As for Kenyan exports to Uganda, Stahl (2005) states that *'Uganda sources a significant 26.8% of its world imports from within EAC, 97% of which are from Kenya'*. This is close to the figure of 28.7% reported in table 3.5.

Table 3.4: Overview Kenya trade patterns

KENYA	**IMPORTS**						**EXPORTS**			
(KSh bn)	from UGA			from RoW			to UGA		from RoW	
	Volume	%	Tariff	Volume	%	Tariff	Volume	%	Volume	%
Food	27.0	8.7%	3.50%	32.2	10.4%	13.30%				
Cash Crops									129.2	63.1%
L-Manuf				125.2	40.4%	13.30%	39.0	19.0%	36.5	17.8%
H-Manuf				125.2	40.4%	13.30%				
Total	27.0	8.7%		282.6	91.3%		39.0	19.0%	165.7	81.0%

Source: Stahl (2005) and own calculations.

Table 3.5: Overview Uganda trade patterns

UGANDA	**IMPORTS**						**EXPORTS**			
(KSh bn)	from KEN			from RoW			to KEN		from RoW	
	Volume	%	Tariff	Volume	%	Tariff	Volume	%	Volume	%
Food							27.0	39.0%	11.6	16.8%
Cash Crops									30.6	44.2%
L-Manuf	39.0	28.7%	3.50%	16.1	11.8%	6.73%				
H-Manuf				80.8	59.5%	6.75%				
Total	39.0	28.7%		96.9	71.3%		27.0	39.0%	42.3	61.0%

Source: Stahl (2005) and own calculations.

Intra-regional tariffs were set at 3.5% in both Uganda and Kenya, as pre-CU tariffs in the EAC were actually quite low—see section (1.3.2). Uganda had also substantially reduced tariffs unilaterally at the end of the 90's. Hence Uganda has much lower third-country tariffs, with an average of around 6.5% as opposed to Kenya's 13.3% [5].

[5]These are averages, and hide some large differences between goods. E.g. Kenya had a 35% tariff on wheat in 2003, as it was on the so-called sensitive list of products, which implies that tariffs applied to third countries are not bound by the agreed 25% CET rate on finished goods—see Stahl (2005).

Tariff revenue in Uganda is 9% of total government revenue in our own SAM, but is more than 30% in the 1999 IFPRI SAM. Two factors explain this discrepancy: (i) we compare 1999 with 2003, and tariffs were lowered substantially over the 1999-2003 period; (ii) the 30% number includes import taxes other than tariffs, such as excise duties[6]. For Kenya, tariff revenue as a percentage of total government revenue was 22% in our own SAM, but just below 10% for the IFPRI 2003 SAM. This is because our own SAM does not have any indirect taxes, which make up the bulk of Kenya's Government revenues[7].

3.3.3 Household expenditure shares

Table 3.6 shows household expenditure shares in Uganda and Kenya, with food consumed relatively more in Uganda than in Kenya. This is because Uganda is in general poorer, and also because it has a larger rural population which produces more food for own consumption. Richer Kenya spends twice as much on services, but slightly less than Uganda on manufactured goods, even though Kenyan households still spend 30% more on manufactured goods in absolute terms.

Table 3.6: Household expenditure shares

	UGANDA			**KENYA**		
	Rural	Urban	**Total**	Rural	Urban	**Total**
Food	15.6%	23.8%	**39.4%**	10.0%	18.2%	**28.2%**
Cash Crops	0.0%	0.0%	**0.0%**	0.0%	0.0%	**0.0%**
L-Manufacturing	9.6%	13.1%	**22.7%**	7.2%	17.0%	**24.2%**
H-Manufacturing	4.8%	13.0%	**17.8%**	1.3%	7.3%	**8.6%**
Private Services	7.9%	12.2%	**20.1%**	10.4%	28.6%	**39.0%**
Total	**37.9%**	**62.1%**	**100.0%**	**28.8%**	**71.2%**	**100.0%**
Population share	67.4%	32.6%	**100.0%**	47.0%	53.0%	**100.0%**

Source: Own calculations.

[6]Uganda levied excise duties of 10% on selected imports until 1 January 2005 (Stahl, 2005, p.3).

[7]This is less so in Uganda, as that country's business sector is much less advanced and corporate taxes are consequently much lower.

3.3.4 Key elasticities in the CGE

Production function elasticities related to capital (λk), land (λn) and labour (λl) sum to one and figure in first order conditions, hence we can fully determine the value of these through the calibration exercise. Table 3.7 shows the baseline values for key elasticities which cannot be calculated from the calibration. As our CGE can be thought of as a two-country extension of the Adam and Bevan (2006) CGE which was itself based on Uganda, we compare our baseline with the elasticity values used in that paper.

Table 3.7: Baseline values for key elasticities

Sector	λkg^a	λkr^b Kenya	λkr^b Uganda	$\sigma 1, \sigma 3^c$	$\sigma 2, \sigma 4^c$	σc^d	σl^e
Food	0.175	0.15	0.10	0.50	0.80		
Cash Crops	0.175	0.15	0.10	0.50	0.80		
L-Manufacturing	0.175	0.15	0.10	0.50	0.80		
H-Manufacturing	0.175	0.15	0.10	0.50	0.80		
Private Services	0.175	0.15	0.00	0.50	0.80		
Public Services	0.175	0.15	0.00	0.50	0.80		
Not sector-specific						0.5	0.5

[a] Elasticity governing national infrastructure capital stock, see equations (3.3) and (3.4).
[b] Elasticity governing regional infrastructure capital stock, see equations (3.3) and (3.4).
[c] $\sigma 1$ and $\sigma 2$ are constant elasticities of transformation, see equations (C.22), (C.23), (C.24) and (C.25). $\sigma 3$ and $\sigma 4$ are constant elasticities of substitution, see equations (C.28), (C.29), (C.30) and (C.31).
[d] Elasticity governing final consumption, see equation (3.5).
[e] Labour aggregator elasticity, see equations (C.19) and (C.20).

We put values of 0.175 on the elasticities governing the productivity of the national infrastructure public capital stock (the λkg_i's). This is similar to the research cited in Romp and de Haan (2007). Note that those papers only report one type of public capital. As we include two types of public capital (λkr estimates are discussed below), the overall elasticity governing total public capital is higher than what is estimated in the literature. The estimates quoted in Romp and de Haan (2007) however, mainly come from industrialised countries, where investments in public capital have lower returns compared to the potential of LICs like Uganda and Kenya[8].

There is no research that can guide us on the elasticity governing the regional infrastruc-

[8] Briceno-Garmendia and Shkaratan (2011) for example calculate that raising Kenya's infrastructure endowment to that of Africa's middle income countries *'could boost annual growth by more than three percentage points per capita'*, while during the noughties *'poor roads proved to be a drag on growth'*.

ture capital stock. We set the λkr_i's equal to 0.15 for all sectors in Kenya, effectively treating the KR_{ken} capital stock as another type of public capital. The spill-over is really about Uganda, where we put the λkr_i's equal to zero for the two sectors that are completely non-tradable. We reason that for these sectors, possible increases in the productivity of private factors solely come through the λkg_i's. For the four tradable sectors, values are lower than in Kenya and set at 0.10.

Elasticities of substitution and transformation ($\sigma 1$, $\sigma 2$, $\sigma 3$ and $\sigma 4$), are set equal across sectors in the baseline run. For substitution possibilities in the Constant Elasticity of Substitution and Constant Elasticity of Transformation equations, we assume that domestic products are more easily substitutable with regional products than with international goods, hence $\sigma 1 < \sigma 2$ and $\sigma 3 < \sigma 4$. Values chosen are quite conservative, and all are smaller than 1. The values for similar elasticities in the Uganda IFPRI 1999 SAM (Dorosh and El-Said, 2004) range from 1.5 (Constant Elasticity of Substitution for industrial goods and services) to 3.0 (Constant Elasticity of Transformation and Constant Elasticity of Substitution for agricultural goods). However, these are for much more disaggregated goods, for which higher substitution possibilities between domestic, regional and international sourcing make more sense. E.g. maize will probably be quite similar whether it is imported from the other side of the world or produced domestically. However, if the substitution is between *'food'* and *'public services'*, then one can imagine substitution possibilities to be lower[9].

The substitution elasticity for consumption σc is set at 0.5—similar to Adam and Bevan (2006) and (consumption) subsistence shares are set to zero in the baseline run. Finally, the elasticity governing substitution possibilities between skilled and unskilled labour, σl, is set at 0.5—this is the low-end in one of the experiments of Adam and Bevan (2006).

[9]Note that for the case of the UEMOA Customs Union, Dissou (2002) also uses higher Constant Elasticities of Transformation and Substitution (between 1.5 and 2.0) even though his 'economy' is only made up of 8 sectors, i.e. similar to our SAM.

3.3.5 Details of the Kenyan SAM

The base year for the Kenyan SAM is 2003, which is also the base year for our calibration. Table 3.8 compares 2003 macro variables from National Accounts and Balance of Payments (BoP) data, with the IFPRI SAM and with our own constructed SAM. Overall, our own SAM is closer to the national accounts/BoP data than the IFPRI SAM. The exceptions are government final expenditure which stands at only 12% of GDP in our SAM, but at around 20% for the other two data sources and imports and exports which are lower in our SAM (as % of GDP), even though the BoP deficit is quite similar. The contributions of the different sectors to GDP (bottom 3 rows) looks curiously 'off' in the IMF data. It is not entirely clear why the percentage for services is so high, also compared to the data reported in chapter 1 (table 1.2)[10]. From this data-comparison exercise we remember that a highly aggregated CGE model always entails some trade-offs, but that the major macroeconomic variables from our SAM are close to official data.

The IFPRI SAM which forms the basis of our own SAM, is disaggregated into ten different types of rural household and ten different types of urban households. We aggregated these into just one type of rural and one type of urban household. Further, the IFPRI SAM uses three types of labour: skilled, semi-skilled and unskilled. Again, we retain two categories: skilled and unskilled, with the latter an aggregation of IFPRI's semi-skilled and unskilled. The relative size of infrastructure investment (both national and regional) was inspired by the Adam and Bevan (2006) SAM that was itself loosely based on Uganda. Hence, private investment is 74%, public sectoral investment 7% and national plus regional infrastructure investment is 18% of total investment—similar to the aforementioned paper. The regional infrastructure capital stock is slightly less than the sum of the two national (Uganda+Kenya) infrastructure capital stocks.

Data from the 1998/99 Kenyan labour force survey was used to deduce sectoral employ-

[10]We note that other figures from table 1.2 are not always consistent with table 3.8. We put this down to the difference in sources and different classifications. However, numbers within each table are consistently from the same source (with some exceptions as per the notes to table 3.8).

Table 3.8: Kenya SAM comparison

KENYA	'03 Nat. Accts., BoP		own '03 SAM		IFPRI '03 SAM	
	Ksh bn	% GDP [a]	Ksh bn	% GDP [a]	Ksh bn	% GDP [a]
Final Consumption Expenditure (a)	1,001	103.3%	869	93.7%	1,048	107.3%
Private Sector	805	83.1%	754	81.4%	848	86.9%
General Government	195	20.2%	114	12.3%	199	20.4%
Gross Capital Formation (b)	141	14.6%	147	15.8%	214	21.9%
Fixed Capital Formation	137	14.1%	147	15.8%	197	20.1%
General Government [b]	22	2.3%	24	2.6%		
Private Sector	115	11.8%	123	13.2%		
Change in Inventories	5	0.5%	0	0.0%	17	1.8%
Gross Domestic Expenditure (a+b)	1,142	117.9%	1,015	109.5%	1,262	129.2%
Balance of Trade	-50	-5.2%	-72	-7.7%	-136	-13.9%
Exports	272	28.1%	205	22.1%	281	28.8%
Imports	322	33.2%	276	29.8%	417	42.7%
Aid	38	3.9%	29	3.2%	6	0.6%
Remittances	39	4.1%	42	4.6%	101	10.4%
Net indirect taxes	123	12.7%	0	0.0%	111	11.4%
GDP at factor cost	**968**	**100%**	**927**	**100%**	**977**	**100%**
Labour			481	51.9%	430	44.1%
Land			54	5.8%	47	4.8%
Capital			392	42.3%	499	51.1%
GDP at market prices	**1,092**	**100%**	**927**	**100%**	**1,088**	**100%**
Primary	154	14.1%	264	28.4%	276	25.40%
Secondary	188	17.2%	177	19.1%	175	16.10%
Tertiary	750	68.7%	487	52.5%	636	58.50%

Source: National Accounts and Balance of Payments data taken from IMF (2009), except for GDP disaggregation by sector, aid and remittances for which the source is World Development Indicators. IFPRI SAM data taken from Kiringai et al. (2006).

[a] Percentage of GDP at factor cost.

[b] Does not include regional infrastructure related capital in own SAM.

ment[11]. According to this survey, total labour force participation was 10.5 million in 1999. Allowing for annual population growth of 2.6%[12], we get to a total active workforce of 11.6 million in 2003. The same survey has 42.1% of the working population engaged in small-scale farming or working as pastoralists. We use this percentage to come up with a figure for unskilled workers in the food sector. 31.6% of the working population was engaged in the informal sector which is used as the number of unskilled workers in the private services sector. Employment in the other sectors is then calculated according to sectoral employment numbers published annually by the Government of Kenya Statistical Abstract and Economic Surveys, as reported in IMF (2009)[13].

[11] Available from www.knbs.go.ke

[12] This number was taken from the World Bank's World Development Indicators database.

[13] These are a mixture of extrapolations from the labour force survey and business surveys, but only report employment in the formal sector.

3.3.6 Details of the Ugandan SAM

The base year for the Uganda IFPRI SAM is 1999, whilst our own SAM needs to be calibrated for 2003. We decided against using the cross-entropy method suggested by Robinson et al. (2001)[14] for updating the Ugandan SAM as such an exercise would only yield relatively small benefits because of the high level of aggregation. To increase our understanding of the structure and development of the Ugandan economy, we use another Uganda SAM developed by Dorosh and Thurlow (2009) with baseline year 2005 instead. We use this data to update and cross-check some variables to make sure that the major macro variables in our own SAM are close to official 2003 data.

Table 3.9: Uganda SAM comparison

UGANDA	'03 Nat. Accts., BoP		own '03 SAM		IFPRI '05	IFPRI '99
	USh bn	% GDP [a]	USh bn	% GDP [a]	% GDP [b]	% GDP [a]
Final Consumption Expenditure (a)	11,031	101.5%	11,143	99.1%	75.3%	108.5%
Private Sector	9,232	84.9%	9,453	84.1%	60.9%	96.2%
General Government	1,799	16.5%	1,690	15.0%	14.4%	12.3%
Gross Capital Formation (b)	2,453	22.6%	1,580	14.0%	22.6%	
General Government	553	5.1%	300	2.7%		
Private Sector	1,900	17.5%	1,280	11.4%		
Gross Domestic Expenditure (a+b)	13,484	124.0%	12,723	113.1%	97.9%	
Balance of Trade	-1,625	-14.9%	-1,304	-11.6%	-12.4%	-18.3%
Exports	1,463	13.5%	1,732	15.4%	14.1%	12.8%
Imports	3,088	28.4%	3,036	27.0%	26.5%	31.1%
Aid	1,867	17.2%	973	8.7%		6.1%
Remittances	560	5.1%	330	2.9%		7.4%
Net indirect taxes	988	9.1%	0	0.0%		3.3%
GDP at factor cost	**10,871**	**100.0%**	**11,246**	**100%**	**100%**	**100%**
Labour			5,800	51.6%	40.0%	53.8%
Land			1,350	12.0%	18.4%	22.6%
Capital			4,096	36.4%	41.5%	23.7%
GDP at market prices	**11,859**	**100%**	**11,246**	**100%**	**100%**	**100%**
Primary	3,837	32.4%	4,050	36.0%	31.1%	44.3%
Secondary	2,513	21.2%	2,916	25.9%	24.0%	21.1%
Tertiary	5,509	46.5%	4,280	38.1%	44.9%	34.6%

Source: National Accounts and Balance of Payments data taken from IMF (2005b) (fiscal year 2002/2003), except for aid and remittances for which the source is World Development Indicators. IFPRI 1999 SAM data taken from Dorosh and El-Said (2004), and IFPRI 2005 SAM data taken from Dorosh and Thurlow (2009).

[a] As percentage of GDP at factor cost.

[b] As percentage of GDP at market prices.

[14] The problem in estimating a social accounting matrix (SAM) for a recent year is to find an efficient and cost-effective way to incorporate and reconcile information from a variety of sources, including data from prior years. Based on information theory, these authors present a flexible cross entropy approach to estimating a consistent SAM starting from inconsistent data estimated with error.

Table 3.9 compares macro variables from these different sources[15]. The last two columns only give percentages, as it does not make sense to compare nominal values from different years. Our own SAM is close to the national accounts/BoP data. Exceptions are foreign capital flows (aid and remittances) which are lower in the own SAM, gross capital formation (also lower), and the balance of trade (less negative). Comparing our own SAM with the IFPRI SAMs for 1999 and 2005 (last two columns) is reassuring in the sense that these are not too far apart either.

The 1999 IFPRI SAM is disaggregated into nine different household types: two urban (poor and non-poor), and seven agricultural (six according to agricultural regions, and one for non-farm households). We aggregate these respective households into one urban and one rural household type. IFPRI labour categories used are the same as for our own SAM, i.e. skilled and unskilled labour. The relative size of national infrastructure investment is similar to the Adam and Bevan (2006) SAM.

The 1999 IFPRI Uganda SAM documentation does not provide employment data. Data from the 2002/03 Labour force survey was used for the sectoral breakdown of employment numbers[16]. For that year, the total active number of employed persons was slightly higher than 9.2 million. Employment in the agricultural sector was 67.4% of this total, jobs in manufacturing were at 9.3%, services at 17.8% and the public sector at 5.4%. This break-down is quite similar to Dorosh and Thurlow (2009), except for the agricultural sector which is slightly lower in the labour force survey. Wages are highest for the skilled workers in the public sector, and lowest for the workers in the food sector.

[15]The two IFPRI SAMs have the same author. Hence, it is most likely that the base data from which the SAMs are sourced, are very similar. A comparison of the last two columns of table 3.9 however, reveals that these SAMs diverge substantially. This shows how SAMs can differ markedly when trying to answer different economic questions, even when the underlying data is quite similar.

[16]See table 3.3, p15 in Ugandan Bureau of Statistics (2003).

3.4 Simulations

Table 3.10 summarises the 11 simulations analysed in this section, using the CGE model outlined previously and linking the simulations to the theoretical propositions from the previous chapter (column two). The table can be disaggregated into three parts. Simulations $AID1 - AID3$ consider an increase in aid to the region as a whole of 100 million USD without regional trade liberalisation. This 'donor envelope' is distributed across the region and used in different ways. It funds either a transfer from government to household income (HoH's), or to national (DKG) or regional (DKR) public capital.

Table 3.10: Overview simulations (All in millions of KSh or % deviation from baseline [a])

Simulation no.	Chapter 2 Proposition	Aid to.. Ken	Uga	..HoH's Ken	Uga	..DKG Ken	Uga	..DKR Ken [b]	τ [c]	t [c] (CET)
Aid increase is 100 mio USD or 7500 mio KSh										
AID1	2, 5	+ 3220 +11.0%	+ 4280 +11.0%	+ 3220 (+)	+ 4280 (+)				BL [d]	BL
AID2		+ 3220 +11.0%	+ 4280 +11.0%			+ 3220 +26.8%	+ 4280 +53.5%		BL	BL
AID3	3, 5	+ 7500 +25.6%						+ 7500 +41.7%	BL	BL
$tmr_{i,r} = 0$ **+ Aid increase of 2310 mio KSh to compensate loss of tariff revenue**										
CORE0	1, 3, 5	+ 945 +3.2%	+ 1365 +3.5%						0%	BL
$tmr_{i,r} = 0$ **+ Aid increase of 7500 mio KSh + 2310 mio KSh to compensate loss of tariff revenue**										
CORE1	1, 2, 3, 5	+ 4165 +14.2%	+ 5645 +14.5%	+ 3220 (+)	+ 4280 (+)				0%	BL
CORE2		+ 4165 +14.2%	+ 5645 +14.5%			+ 3220 +26.8%	+ 4280 +53.5%		0%	BL
CORE3	1, 3, 5	+ 8445 +28.8%	+ 1365 +3.5%					+ 7500 +41.7%	0%	BL
EXTENSIONS: redistributing aid, transferring aid, changing the CET										
EXT1	4, 6, 7	+ 1445 +4.9%	+ 8365 +21.5%	+ 500 (+)	+ 7000 (+)				0%	BL
EXT2	8	- 3220 -11.0%	+ 3220 +8.3%	- 3220 (-)	+ 3220 (+)				0%	BL
EXT3									0%	10%
EXT4		+ 7500 +25.6%						+ 7500 +41.7%	0%	10%

[a] Except for tariffs, which are quoted in levels instead of deviations from the baseline. As all transfers to households are set to zero in the baseline, we cannot use a percentage change for aid supplementing household income. Instead we use (+) to indicate an increase.
[b] DKR is non-zero in Kenya only.
[c] Changes to the intra-regional tariff tmr and the common external tariff tmw are similar in both countries.
[d] BL = Baseline.

The next four simulations set the intra-regional tariff $tmr_{i,r}$ equal to zero. Compared to the AID-simulations, the aid increases shown in table 3.10 are slightly higher, as aid also makes up for lost tariff revenue[17]. In $CORE0$ this is the only thing that happens, whilst the three other $CORE$ simulations replicate the three AID simulations, but now with $tmr_{i,r} = 0$. As the names indicate, this forms the core of our analysis, where we look at both the aid and the intra-regional tariff shock simultaneously.

Simulations $EXT1 - EXT4$ are extensions to the core simulations, with $tmr_{i,r} = 0$. These simulations mimic the discussion in the previous (theory) chapter. $EXT1$ changes the share of aid going to each country, with the total increase in aid to the region remaining the same—the equivalent of changing α in the previous chapter. $EXT2$ considers a transfer of aid from Kenyan to Ugandan households and $EXT3$ and $EXT4$ look at what happens when the CET is changed, as in section (2.6.4) of chapter 2.

Subsections (3.4.1) to (3.4.3) analyse these simulations, following the disaggregation schedule from table 3.10, with the figures and tables on the next pages serving as our guide. Figure 3.1 shows discounted welfare (from equation 3.8) by country in terms of deviations from the baseline. Figure 3.2 shows the evolution of GDP. Tables 3.11 and 3.12 show the simulations' effects in terms of welfare, macro variables, balance of trade, quantities and prices. Results are reported in % change between the baseline (period t=1) and the impact result (t=2), and cumulative changes up to years six and ten.

The prices reported at the bottom of table 3.12 deserve some more discussion. With regional prices determined endogenously, there is no clear-cut equivalent of the P_N/P_T real exchange rate from the standard dependent economy model. Instead, we report the following relative prices for the goods that are regionally traded:

$$\frac{PMR_{i,r}}{PD_{i,r}} \quad , \quad \frac{PER_{i,r}}{PD_{i,r}} \quad , \quad \frac{PEW_{i,r}}{PER_{i,r}} \tag{3.9}$$

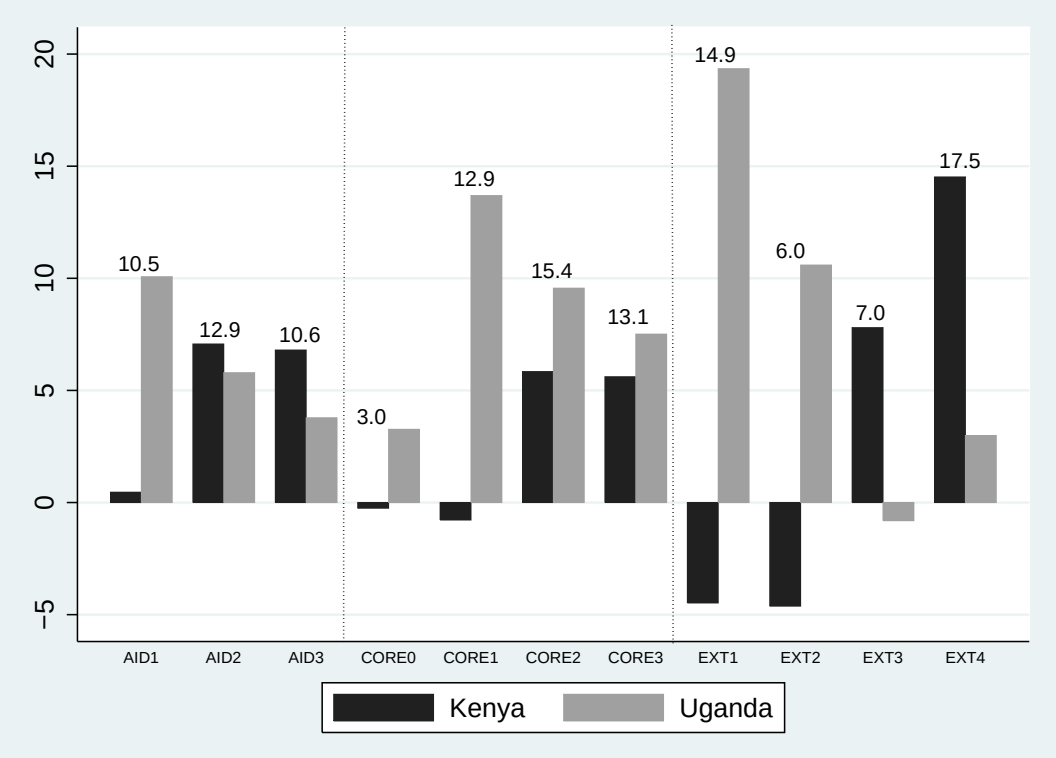
[17] This would fall under the aid header of *'trade related adjustment'* (see section 2.2). It implies that government revenue GR stays constant after government has transferred aid monies according to the specifications in the simulations.

The first two relative prices are about the competitiveness of country r within the region. The third relative price, together with the export weighted RER in equation (3.10) below, informs us about country r's competitiveness' position vis-à-vis the rest of the world.

$$EWRER_r = \frac{\sum_i \frac{PEW_{i,r}}{PD_{i,r}} * EW_{i,r}}{\sum_i EW_{i,r}} \tag{3.10}$$

The way the regional infrastructure spill-over is modeled is not exactly the same as in chapter 2. In chapter 2 an increase in G builds regional infrastructure and directly decreases the price of the regional good in the importing country through the ψ-function. Here in the relevant simulations, aid increases the regional public capital stock KR, with the elasticity $\lambda kr_{i,r}$ determining its productivity alongside other inputs and total factor productivity $AP_{i,r}$ (equations 3.3 and 3.4). Simulations regarding the increase of the national capital stock do not have an equivalent in chapter 2. These are included as they form a logical link to Adam and Bevan (2006).

Figure 3.1: Welfare measures for all 11 simulations (discounted deviations from baseline)



Note: Discounted welfare calculated as in equation (3.8), with $\overline{\beta} = 0.95$ and multiplied by 10^7. To sum rural and urban welfare results within countries, population shares from table 3.6 are used. The numbers shown above the bars are the sum of Uganda and Kenya, i.e. a regional welfare measure.

Figure 3.2: GDP evolution by country (all 11 simulations)

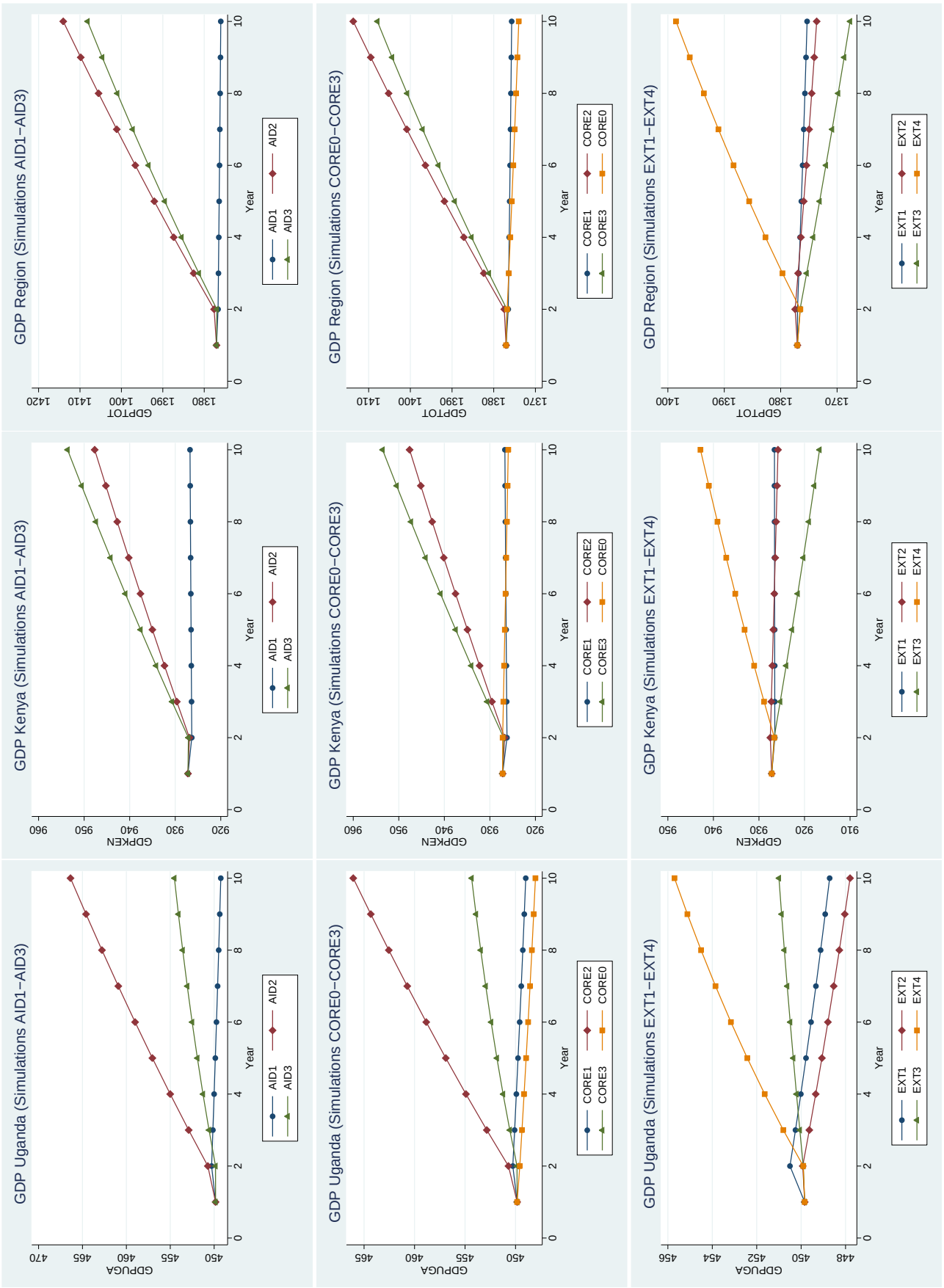


Table 3.11: CGE Simulations: Welfare and macro variables

All % change[a]		AID1		AID2		AID3		CORE0		CORE1		CORE2		CORE3		EXT1		EXT2		EXT3		EXT4	
		KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA
DETAILS OF EXPERIMENTS																							
Aid to..		11.0	11.0	11.0	11.0	25.6	0	3.2	3.5	14.2	14.5	14.2	14.5	28.8	3.5	4.93	21.5	-11.0	+8.3			25.6	0
..HoH		(+)	(+)							(+)	(+)					(+)	(+)	(-)	(+)				
..DKG				26.8	53.5							26.8	53.5										
..DKR						41.7	0							41.7	0							41.7	0
τ (%)		3.5	3.5	3.5	3.5	3.5	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t (%)		13.3	6.75	13.3	6.75	13.3	6.75			13.3	6.75	13.3	6.75	13.3	6.75	13.3	6.75	13.3	6.75	10.0	10.0	10.0	10.0
WELFARE (discounted deviations from baseline [b])																							
$\overline{\beta} = 0.95$	Total	0.46	10.07	7.07	5.79	6.80	3.78	-0.25	3.52	-0.78	13.69	5.84	9.56	5.61	7.51	-4.48	19.35	-4.62	10.59	7.80	-0.81	14.52	2.99
	urban	4.21	4.24	10.96	11.89	13.97	3.28	0.68	-1.83	6.43	4.63	13.20	12.27	16.14	3.80	4.08	7.27	-2.17	1.53	2.00	-1.06	15.94	2.22
	rural	-3.77	12.94	2.68	2.78	-1.28	4.03	-1.31	6.15	-8.91	18.16	-2.47	8.23	-6.26	9.34	-14.13	25.30	-7.38	15.05	14.34	-0.69	12.91	3.38
$\overline{\beta} = 0.99$	Total	0.58	12.22	9.876	7.93	9.881	4.91	-0.40	4.19	-0.92	16.63	8.37	12.52	8.43	9.45	-5.45	23.49	-5.75	12.77	8.81	-0.99	18.59	3.95
	urban	5.13	5.13	13.98	14.96	17.72	4.28	0.80	-2.28	7.84	5.60	16.71	15.41	20.37	4.91	4.97	8.79	-2.70	1.80	2.22	-1.28	19.90	3.01
	rural	-4.55	15.71	5.25	4.47	1.04	5.22	-1.74	7.37	-10.80	22.06	-1.02	11.10	-5.03	11.69	-17.21	30.73	-9.19	18.17	16.24	-0.85	17.11	4.42
MACRO																							
Real	to t=2	-0.09	0.10	-0.03	0.20	-0.01	0.00	0.00	-0.06	-0.10	0.10	-0.05	0.19	-0.02	0.00	-0.07	0.15	0.03	0.02	-0.06	0.01	-0.06	0.01
GDP	to t=6	-0.07	-0.02	1.13	2.04	1.48	0.59	-0.07	-0.24	-0.08	-0.06	1.12	2.00	1.47	0.57	-0.07	-0.06	-0.06	-0.23	-0.62	0.15	0.86	0.74
	to t=10	-0.05	-0.13	2.21	3.67	2.85	1.04	-0.13	-0.40	-0.05	-0.19	2.20	3.61	2.84	1.00	-0.06	-0.25	-0.15	-0.45	-1.13	0.26	1.69	1.30
Output	to t=10	0.00	-0.13	2.35	3.81	3.01	1.05	-0.13	-0.43	0.04	-0.19	2.38	3.74	3.03	1.01	0.02	-0.25	-0.15	-0.47	-1.23	0.28	1.75	1.33
FOO	to t=10	0.17	-0.09	2.12	3.60	2.68	1.53	-0.13	-0.25	0.18	-0.07	2.13	3.62	2.68	1.57	0.11	-0.13	-0.22	-0.31	-0.92	0.23	1.74	1.76
CCR	to t=10	-1.99	-3.20	1.14	3.24	1.57	1.23	-0.28	-0.66	-2.75	-4.09	0.37	2.31	0.82	0.30	-2.16	-5.70	0.43	-2.64	-0.67	0.28	0.91	1.50
LMA	to t=10	0.28	0.09	2.83	4.65	3.13	1.00	0.03	-0.62	0.59	-0.06	3.15	4.48	3.44	0.87	0.73	-0.04	0.19	-0.55	-1.18	0.23	1.91	1.22
HMA	to t=10	-0.02	-0.20	2.68	4.01	3.62	1.11	-0.21	-0.52	-0.01	-0.26	2.68	3.94	3.62	1.07	-0.08	-0.33	-0.29	-0.57	-1.96	0.56	1.60	1.67
SER	to t=10	0.18	0.23	2.64	4.55	3.49	0.88	-0.15	-0.51	0.25	0.28	2.72	4.59	3.56	0.96	0.12	0.44	-0.31	-0.28	-1.34	0.31	2.11	1.20
PUB	to t=10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	to t=2	0.24	-1.45	-0.10	-2.57	-0.31	-0.27	-0.69	-2.17	0.28	-1.77	-0.07	-2.95	-0.28	-0.51	0.07	-2.45	-0.94	-2.97	-5.66	1.58	-5.89	1.30
Private	to t=6	0.27	-1.61	2.34	1.73	2.83	0.04	-0.81	-2.41	0.31	-1.97	2.38	1.31	2.85	-0.24	0.07	-2.73	-1.10	-3.30	-6.56	1.74	-3.78	1.78
Investment	to t=10	0.30	-1.76	4.55	5.23	5.61	0.30	-0.92	-2.62	0.35	-2.14	4.59	4.77	5.62	-0.01	0.08	-2.98	-1.25	-3.60	-7.40	1.88	-2.01	2.19
	to t=2	1.10	4.14	1.11	3.84	1.68	0.37	0.02	-0.26	1.45	5.09	1.47	4.77	2.02	1.32	1.04	7.36	-0.47	2.33	-1.19	0.90	0.47	1.28
PK(private	to t=6	1.08	4.26	0.92	2.42	1.37	0.65	0.06	-0.13	1.43	5.24	1.26	3.35	1.71	1.63	1.04	7.58	-0.41	2.53	-0.77	0.66	0.59	1.32
sectors)	to t=10	1.07	4.37	0.63	1.25	0.95	0.91	0.10	-0.01	1.42	5.38	0.97	2.18	1.28	1.91	1.03	7.77	-0.35	2.70	-0.38	0.45	0.56	1.37
	to t=2	1.09	4.16	1.11	4.03	1.69	0.41	0.02	-0.40	1.45	5.00	1.47	4.85	2.04	1.26	1.03	7.25	-0.47	2.17	-1.19	0.69	0.48	1.11
PK(pub)	to t=6	1.08	4.28	0.92	2.61	1.38	0.65	0.06	-0.26	1.43	5.15	1.27	3.43	1.72	1.52	1.03	7.46	-0.41	2.37	-0.77	0.49	0.60	1.14
	at t=10	1.06	4.38	0.63	1.43	0.95	0.85	0.11	-0.14	1.41	5.28	0.97	2.25	1.28	1.75	1.02	7.65	-0.36	2.55	-0.37	0.31	0.58	1.18
Gov't	to t=2	3.01	7.92	3.05	7.54	6.22	0.20	-0.54	-1.65	3.35	8.59	3.39	8.20	6.56	0.94	1.30	13.39	-2.97	3.96	-5.83	1.86	0.30	2.06
Revenue	to t=6	3.01	7.93	3.85	7.64	7.18	0.63	-0.58	-1.68	3.36	8.61	4.19	8.28	7.51	1.37	1.29	13.41	-3.01	3.93	-6.00	1.74	1.02	2.40
	to t=10	3.02	7.94	4.53	7.81	7.99	1.01	-0.61	-1.70	3.36	8.63	4.87	8.43	8.31	1.76	1.29	13.43	-3.06	3.91	-6.15	1.63	1.59	2.68

[a] Except for tariff changes, which are quoted in levels instead of deviations from the baseline. As all transfers to households are set to zero in the baseline, we cannot use a percentage change for aid supplementing household income. Instead we use (+) to indicate an increase, and (-) for a decrease, which is always equivalent in value to the increase/decrease in aid in the respective country.

[b] Discounted welfare calculated as in equation (3.8), multiplied by 10^7. To sum rural and urban welfare results within countries, population shares from table 3.6 are used.

Table 3.12: CGE Simulations: Balance of payments and prices

All % change[a]		AID1		AID2		AID3		CORE0		CORE1		CORE2		CORE3		EXT1		EXT2		EXT3		EXT4	
		KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA	KEN	UGA
BALANCE OF TRADE																							
	t=1	-7.73	-11.6	-7.73	-11.6	-7.73	-11.6	-7.73	-11.6	-7.73	-11.59	-7.73	-11.59	-7.73	-11.59	-7.73	-11.59	-7.73	-11.6	-7.73	-11.6	-7.73	-11.6
BoT	t=6	-7.97	-11.9	-7.90	-12.0	-8.29	-11.4	-7.73	-11.6	-8.03	-11.99	-7.96	-12.10	-8.35	-11.55	-7.78	-12.21	-7.42	-11.9	-7.75	-11.5	-8.31	-11.4
(%GDP)	t=10	-7.97	-11.9	-7.84	-12.0	-8.22	-11.4	-7.73	-11.6	-8.03	-11.98	-7.90	-12.08	-8.28	-11.46	-7.78	-12.20	-7.42	-11.9	-7.76	-11.6	-8.25	-11.3
Total	to t=2	-0.48	-0.78	-0.40	-0.69	-1.84	0.49	0.42	1.19	-0.16	0.24	-0.09	0.32	-1.53	1.47	0.77	-0.73	1.52	0.01	1.11	1.04	-0.71	1.54
Exports	to t=6	-0.46	-0.89	1.07	1.33	0.06	1.50	0.35	1.01	-0.14	0.11	1.39	2.31	0.37	2.48	0.78	-0.91	1.42	-0.24	0.56	1.07	0.64	2.59
(Value)	to t=10	-0.43	-0.98	2.39	3.12	1.71	2.30	0.28	0.84	-0.11	0.01	2.71	4.07	2.03	3.27	0.79	-1.06	1.34	-0.46	0.05	1.09	1.77	3.42
Total	to t=2	0.81	3.08	0.87	3.13	1.35	0.28	0.31	0.68	1.38	4.78	1.44	4.83	1.92	1.96	1.09	6.47	-0.04	2.65	0.82	0.59	2.19	0.88
Imports	to t=6	0.83	3.02	1.96	4.28	2.75	0.86	0.26	0.57	1.41	4.71	2.54	5.96	3.33	2.54	1.10	6.37	-0.11	2.51	0.41	0.61	3.19	1.48
(Value)	to t=10	0.84	2.97	2.93	5.30	3.98	1.31	0.21	0.48	1.43	4.65	3.52	6.97	4.56	2.99	1.11	6.28	-0.18	2.39	0.03	0.62	4.02	1.95
EXPORTS AND IMPORTS (QUANTITIES)																							
Exports	to t=2	-1.70	-2.75	-1.70	-2.22	-2.41	-0.24	-0.09	-0.12	-2.30	-3.57	-2.30	-3.04	-2.99	-1.10	-1.73	-4.98	0.59	-1.86	0.54	-0.43	-1.85	-0.68
to RoW	to t=6	-1.66	-2.96	-0.05	0.70	-0.16	0.63	-0.17	-0.42	-2.25	-3.82	-0.64	-0.18	-0.73	-0.27	-1.71	-5.33	0.49	-2.26	-0.16	-0.07	-0.30	0.56
(quantity)	to t=10	-1.63	-3.15	1.43	3.27	1.83	1.24	-0.23	-0.67	-2.21	-4.05	0.85	2.34	1.26	0.30	-1.69	-5.63	0.40	-2.61	-0.81	0.26	1.01	1.48
Exports	to t=2	1.57	-1.41	1.80	-0.94	-0.48	0.49	1.20	1.20	3.28	-0.56	3.51	-0.07	1.23	1.34	4.60	-1.91	2.78	-0.46	1.87	1.08	1.39	1.56
to Reg.	to t=6	1.57	-1.54	2.95	1.23	0.74	1.55	1.10	1.02	3.29	-0.72	4.68	2.07	2.47	2.37	4.59	-2.14	2.64	-0.72	1.32	1.12	2.08	2.67
(quantity)	to t=10	1.58	-1.65	4.08	3.07	1.91	2.36	1.01	0.87	3.30	-0.87	5.82	3.89	3.66	3.15	4.57	-2.35	2.52	-0.94	0.81	1.15	2.75	3.52
Imports	to t=2	0.65	2.31	0.77	2.20	1.32	0.13	-0.01	-0.22	0.86	2.84	0.99	2.72	1.53	0.68	0.57	4.13	-0.36	1.32	0.55	-0.80	1.88	-0.66
RoW	to t=6	0.66	2.24	1.92	3.55	2.74	0.80	-0.07	-0.34	0.88	2.75	2.14	4.05	2.96	1.35	0.57	4.01	-0.44	1.15	0.15	-0.81	2.91	-0.01
(quantity)	to t=10	0.67	2.18	2.94	4.76	3.98	1.35	-0.12	-0.45	0.89	2.68	3.16	5.24	4.19	1.89	0.57	3.90	-0.51	1.00	-0.22	-0.83	3.76	0.52
Imports	to t=2	-1.41	1.57	-0.94	1.80	0.49	-0.48	1.20	1.20	-0.56	3.28	-0.07	3.51	1.34	1.23	-1.91	4.60	-0.46	2.78	1.08	1.87	1.56	1.39
Reg.	to t=6	-1.54	1.57	1.23	2.95	1.55	0.74	1.02	1.10	-0.72	3.29	2.07	4.68	2.37	2.47	-2.14	4.59	-0.72	2.64	1.12	1.32	2.67	2.08
(quantity)	to t=10	-1.65	1.58	3.07	4.08	2.36	1.91	0.87	1.01	-0.87	3.30	3.89	5.82	3.15	3.66	-2.35	4.57	-0.94	2.52	1.15	0.81	3.52	2.75
PRICES																							
	to t=2	1.96	-1.48	1.17	-1.33	-0.76	0.68	-1.48	-1.74	0.86	-3.64	0.08	-3.49	-1.80	-1.54	2.56	-4.99	0.52	-3.37	-1.14	-2.48	-1.87	-1.82
PMR /	to t=6	2.15	-1.67	-0.17	-0.20	-0.25	-0.17	-1.35	-1.89	1.11	-3.86	-1.20	-2.41	-1.25	-2.40	2.87	-5.25	0.73	-3.56	-1.87	-1.57	-2.10	-1.75
PD	to t=10	2.33	-1.83	-1.15	0.68	0.39	-1.12	-1.23	-2.01	1.33	-4.05	-2.12	-1.58	-0.57	-3.35	3.16	-5.48	0.92	-3.73	-2.55	-0.73	-2.15	-1.85
	to t=2	1.82	-2.43	1.98	-1.41	-1.03	0.65	1.45	1.54	3.84	-1.42	4.00	-0.39	0.97	1.65	5.56	-3.50	3.49	-1.07	2.69	1.46	1.63	2.10
PER /	to t=6	1.80	-2.43	1.83	-1.00	-1.45	0.93	1.43	1.56	3.82	-1.42	3.83	0.02	0.54	1.92	5.53	-3.50	3.47	-1.07	2.83	1.38	1.34	2.30
PD	to t=10	1.78	-2.43	1.72	-0.74	-1.80	1.16	1.42	1.57	3.79	-1.42	3.70	0.29	0.19	2.14	5.51	-3.52	3.46	-1.06	2.95	1.31	1.10	2.46
	to t=2	-3.00	-3.63	-3.14	-2.61	-1.06	-1.12	-1.35	-1.99	-5.16	-6.35	-5.29	-5.36	-3.29	-3.94	-6.12	-7.39	-2.57	-3.30	-1.60	-2.19	-2.64	-3.28
PEW /	to t=6	-2.96	-3.81	-2.71	-1.05	-0.22	-1.28	-1.38	-2.14	-5.11	-6.58	-4.85	-3.89	-2.46	-4.13	-6.08	-7.69	-2.62	-3.53	-2.21	-1.68	-2.43	-2.94
PER	to t=10	-2.92	-3.98	-2.23	0.19	0.66	-1.55	-1.42	-2.28	-5.07	-6.79	-4.35	-2.72	-1.59	-4.43	-6.06	-7.95	-2.67	-3.74	-2.77	-1.21	-2.13	-2.75
	to t=2	-0.28	-1.65	-0.27	-1.10	-0.47	-0.13	0.02	-0.13	-0.34	-2.12	-0.34	-1.58	-0.53	-0.65	-0.20	-2.94	0.18	-1.20	0.23	-0.21	-0.24	-0.34
EWRER	to t=6	-0.27	-1.70	-0.21	-0.56	-0.37	-0.10	0.01	-0.17	-0.33	-2.18	-0.27	-1.07	-0.43	-0.63	-0.20	-3.02	0.17	-1.26	0.12	-0.09	-0.25	-0.19
	to t=10	-0.27	-1.74	-0.12	-0.15	-0.26	-0.11	0.00	-0.20	-0.33	-2.24	-0.18	-0.67	-0.31	-0.66	-0.20	-3.09	0.15	-1.31	0.02	0.02	-0.23	-0.10

[a] Except for the balance of trade (BoT) variable which is quoted in % of GDP.

3.4.1 Simulations with aid increases

Simulations $AID1-AID3$ all involve an increase in total aid to the region of 100 million USD or 7.5 billion Kenyan Shillings. This is equivalent to an increase of 11% in each of Uganda and Kenya, or an increase of 25.6% from Kenya's initial aid allocation if everything is given to Kenya.

The three bars on the left of figure 3.1 show how regional welfare goes up in all three AID simulations—as predicted by proposition five of chapter 2. The largest increase comes from using the aid for adding to the national public capital stock ($AID2$), followed by $AID3$ and $AID1$. If we increase the discount factor from 0.95 to 0.99 (see the welfare section in table 3.11), then $AID3$ leaves $AID1$ much more behind. The higher the discount factor of course, the more weight we put on investment relative to consumption as the former has relatively higher pay-offs in later years. This is also evident when looking at GDP (top right graph in figure 3.2), with the investments related to $AID2$ and $AID3$ paying off in higher growth relative to $AID1$, which actually ends up with lower GDP by year ten.

Looking at aggregate regional welfare masks the distributional consequences of our experiments. From figure 3.1 we see that Uganda gains most from a direct income transfer to households ($AID1$), but that in GDP terms it gains most from investing into its national public capital stock ($AID2$, see top left graph of figure 3.2). Kenya gains most in welfare terms from $AID2$, but only if the discount factor is not too high. Indeed, if we increase $\overline{\beta}$ to 0.99, $AID3$ comes out on top (see again the welfare section in table 3.11, with 9.786 < 9.881). Logically, in growth terms, $AID3$ also comes out on top in Kenya (see top middle graph in figure 3.2).

In general, postponing consumption in favour of investment can be seen as a political time-consistency issue, i.e. even though politicians know that welfare will be higher in the future, it takes time for investments to come on-stream and welfare benefits to

materialise. In the CGE set-up here, investments made in period t become 'productive' (i.e. have pay-offs in terms of growth) in period t+1. In the theory chapter the regional infrastructure investment pay-off was immediate, whilst Adam and Bevan (2006) use lags before investments come on-stream.

Looking at the simulations individually, in $AID1$ the increase in aid going straight to household incomes increases household spending on the five final private consumption goods according to marginal spending shares and increases private savings. In response domestic prices PD rise and the export weighted real exchange rate $EWRER$ (see equation 3.10) appreciates in both countries (see the price section at the bottom of table 3.12). However, unlike in the dependent economy model, this is not the end of the story, as part of the adjustment falls on increases of regional prices PMR and PER—as predicted by proposition two in the theory chapter. The increase in these prices relative to exogenously determined international prices (PEW/PER goes down), together with the evolution in $EWRER$ ensures that for the region as a whole, competitiveness vis-à-vis the rest of the world deteriorates unambiguously.

Within the union, Kenya effectively *exports* some of its aid-induced real exchange rate appreciation to Uganda as its domestic prices go up less than its regional prices, with the opposite happening in Uganda. This is because Uganda exports food within the region, which has a much higher consumption share compared to Kenya (see table 3.6). Hence the aid inflow causes domestic demand for food to go up more in Uganda than in Kenya. In contrast, consumption shares for low-end manufactures, which is what Kenya specialises in, are much more similar between the two countries. These effects make regionally traded quantities go down in the food sector and go up in the low-end manufactures sector (see *'exports and imports (quantities)'* section in table 3.12).

For $AID2$ and $AID3$ prices increase on impact (t=2), but then decline when investments come on-stream. As the public investments address supply-side issues and thus increase output, $AID2$ and $AID3$ imply less loss of competitiveness vis-à-vis the rest of the

world, as the bottom two variables reported in table 3.12 show less appreciation compared to $AID1$. In both simulations, we also see that, relatively to $AID1$, Uganda claws back some of its regional competitiveness losses. In $AID2$, this can be seen from $\frac{PMR_{foo,ken}}{PD_{foo,ken}}$ depreciating on impact, but appreciating by year ten, whilst $\frac{PER_{foo,uga}}{PD_{foo,uga}}$ appreciates much less compared to $AID1$. A similar reasoning can be applied to the LMA sector and to simulation $AID3$ in general (see price section in table 3.12).

For the region as a whole, there is little difference between $AID2$ and $AID3$ in terms of growth rates (see the top right graph in figure 3.2), with growth higher for Uganda under the former, and higher for Kenya under the latter. This is mainly because the increase of the total public capital stock ($DKG+DKR$) is higher for Kenya under $AID3$ (26.8% vs. 41.7%), and higher for Uganda under $AID2$ (+53.5% vs 0%)[18]. The regional investment spill-over does not overturn these expected results.

Rural households in Uganda and urban households in Kenya are the winners in $AID1$, as these household types profit from the higher prices in the sectors they specialise in as producers. Discounted welfare even goes down in absolute terms for Kenyan rural households as they see their real disposable income $\frac{Y_{rur,ken}}{CPI_{rur,ken}}$ go down. These relative welfare rankings also apply to $AID3$, except for $AID2$ where it is Uganda's urban households that see higher welfare increases.

3.4.2 Intra-regional trade liberalisation

$CORE0$ simulates regional trade liberalisation by bringing down all $tmr_{i,r}$'s to zero. Figure 3.1 shows how in discounted welfare terms Uganda gains, whilst Kenya loses, giving evidence to the ambiguous welfare outcomes of customs unions (see also proposition five in chapter 2). As predicted in the first proposition of chapter 2, prices of regional importables go down and prices of regional exportables go up, as is evident from the price

[18] See table 3.10.

section in table 3.12 with PMR/PD decreasing and PER/PD increasing. As regional trade expands, producers of regionally tradables gain, i.e. Kenyan urban households and Ugandan rural households. Exports to the rest of the world suffer in both countries as resources are moved towards regionally tradables. Indeed, if we look at total output, the cash crops sector is the biggest loser.

Recalling the discussion about the relative benefits of regional vs. international exports in the last paragraph of section 2.4 (chapter 2), if LBD effects are higher for international exports, then preferential liberalisation in a region like the EAC might not be such a good idea.

$CORE1 - CORE3$ add regional trade liberalisation to simulations $AID1 - AID3$. The size of the aid flow is slightly larger however, as we compensate for the lost tariff revenue (see table 3.10)[19]. As expected, we again see that regional trade is stimulated, with regional exports and imports larger for the $CORE$ simulations compared to their AID counterparts, and exports to the rest of the world lower (see the *'exports and imports (quantities)'* section in table 3.12).

The relevant section of figure 3.1 demonstrates that discounted regional welfare goes up for all three simulations relative to $AID1 - AID3$ and that distributionally Uganda wins and Kenya loses. We see a transfer paradox appearing in simulation $CORE1$ where Kenya's welfare falls relative to the baseline. The main reason for this is the added benefits for the large Ugandan rural population, who now get higher prices for the food they produced. The flip side of this is that rural Kenyan households massively lose out as they have to import some of their food from Uganda. Finally, note that the relative welfare ranking between the three simulations is the same as for $AID1 - AID3$, both at the regional and the national level.

In growth-terms however, the $CORE$ experiments all score *worse* compared to the AID

[19]The losses in tariff revenue were calculated from the baseline trade numbers, as reported in tables 3.4 and 3.5.

simulations, even though the differences are minimal (see the real GDP section in table 3.11). Simulating only regional trade liberalisation (as in $CORE0$) has negative growth effects. The differences in growth rates between the AID and $CORE$ simulations are thus directly attributable to adding intra-regional liberalisation to the mix. Regional importable prices are lower compared to the AID simulations (PMR/PD down in relative terms) and prices for regionally exportables are higher (PER/PD higher in relative terms)—as expected.

It is interesting also to see how investing in the regional capital stock gives Uganda only a 1% increase in GDP after ten years (see $CORE3$), which is not enough to induce an increase in private investment. This is a consequence of Uganda's savings rate being very low[20], but it also shows that public investment might well be very important for the growth path of a LIC over the medium term.

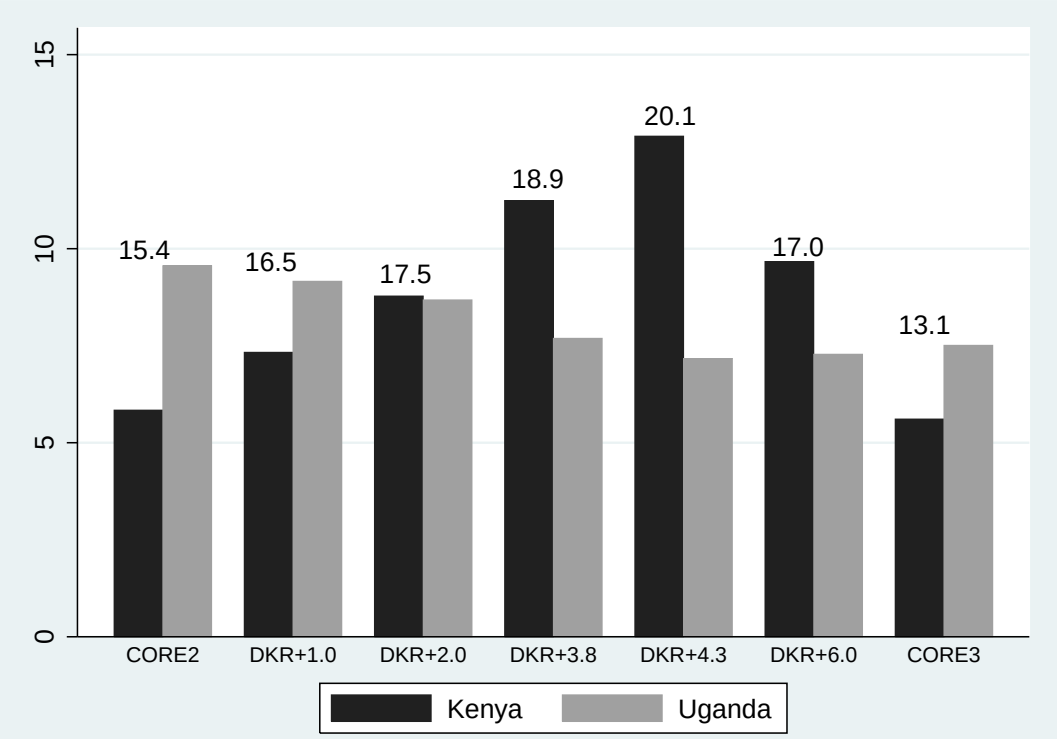
We end this subsection by looking at what happens in welfare terms when we shift the use of aid between DKG and DKR, as shown in figure 3.3 and the accompanying table. There are seven simulations, with the utmost left one equal to $CORE2$ and the utmost right one equal to $CORE3$ [21]. As shown in the table, the five in-between simulations gradually increase DKR, first to the detriment of DKG_{uga} and then in the last two simulations, once DKG_{uga} has reached zero, to the detriment of DKG_{ken}. The total aid flow stays constant throughout at KSh million 9810.

The highest regional welfare gains are made in the fifth simulation where DKG_{uga} is zero and DKG_{ken} still at its initial value. In those first five simulations, Kenyan welfare goes up steadily, each time overcompensating the Ugandan welfare losses. This is because the loss in DKR_{UGA} is compensated through the increase in DKR in both countries, as DKR figures in the production functions of both Uganda and Kenya. When we increase DKR to the detriment of DKG_{ken} as in the final two simulations, Ugandan welfare

[20] Remember also that the CGE is set up such that savings rates are fixed.

[21] For all seven simulations, there are no impediments to regional trade, but the results do not change materially if there is a positive intra-regional tariff. Note that the five in-between simulations are not reported in the earlier figures and tables of this section.

Figure 3.3: Comparing welfare between national and regional infrastructure investments



Simulation	DKR	DKG_{ken}	DKG_{uga}	AID_{ken}	AID_{uga}	Total AID
CORE2	0	+3220	+4280	+4165	+5645	9810
DKR+1.0	+1000	+3220	+3280	+5165	+4645	9810
DKR+2.0	+2000	+3220	+2280	+6165	+3645	9810
DKR+3.8	+3750	+3220	+530	+7915	+1895	9810
DKR+4.3	+4280	+3220	0	+8445	+1365	9810
DKR+6.0	+6000	+1500	0	+8445	+1365	9810
CORE3	+7500	0	0	+8445	+1365	9810

Notes: Discounted welfare calculated as in equation (3.8), multiplied by 10^7 with $\overline{\beta} = 0.95$. To sum rural and urban welfare results within countries, population shares from table 3.6 are used. The numbers shown above the bars are the sum of Uganda and Kenya, i.e. a regional welfare measure. Aid flows include compensation for lost tariff revenue.

goes up, with Kenyan welfare now falling rapidly. The idea here is to get a feel for the trade-off between using aid for national or regional public investments.

Even though simulation five maximises regional welfare, political economy-wise it will be hard to convince Uganda to part with its current aid programme in favour of more regional public investment as that would reduce its own national welfare[22]. Even though the correspondence is not perfect, we could say that in terms of figure 2.3 (chapter 2), we are not in the *'agreement zone'*. Note also that for certain configurations it is the coastal

[22] And effective redistribution mechanisms have proven to be elusive in regional integration history—see the EAC history discussion in section (1.3.1).

country (Kenya) that derives more benefits from regional public investments. This is not so strange of course as KR is also still an input into Kenya's production function.

3.4.3 Extensions

All four simulations in this section include regional trade liberalisation. $EXT1$ increases the share of aid going to Uganda, with the total aid flow kept constant at 7.5 bn KSh. This is the equivalent of changing α in the previous chapter. All the aid is transferred to households. Going back to figure 3.1, this simulation is the CGE equivalent of proposition four in chapter 2, as Uganda's welfare increases substantially whilst Kenya's welfare decreases[23].

$EXT2$ considers a transfer of aid from Kenyan to Ugandan households, as in proposition eight of chapter 2. There are no surprises here, with Kenyan welfare going down and Ugandan welfare going up, and regional welfare as a whole going up as well[24]. It is interesting to see how Kenyan welfare is reduced in similar fashion in $EXT1$ and $EXT2$. However, the distributional make-up is very different, with Kenyan urban households' welfare actually going up under $EXT1$, as the huge increase in income in Uganda means regional exports from Kenya to Uganda increase by twice as much as in $EXT2$. Kenyan rural households however lose much more under $EXT1$ than under $EXT2$ (see welfare section in table 3.11).

$EXT3$ looks at what happens when the common external tariff t is set at 10% together with regional trade liberalisation and without considering any aid increases. This is close to what is currently happening in the EAC (see subsection (1.3.2) in chapter 1), and implies that Uganda's tariff vis-à-vis the rest of the world increases and Kenya's decreases. Standard gains from trade apply here, with Kenya better and Uganda worse off compared

[23] If we reverse the experiment, i.e. bias the aid flow in favour of Kenya, then there is a large welfare gain for Kenya and a small one for Uganda.

[24] If we consider an aid transfer from Ugandan to Kenyan households, we get a similar result, with Kenyan welfare up, Uganda welfare down and regional welfare up.

to both $CORE0$ and the baseline (see figure 3.1). Regional welfare is also larger compared to $CORE0$. Regional trade only expands in the food sector, but not for low-end manufactures. The big winners are Kenyan rural households.

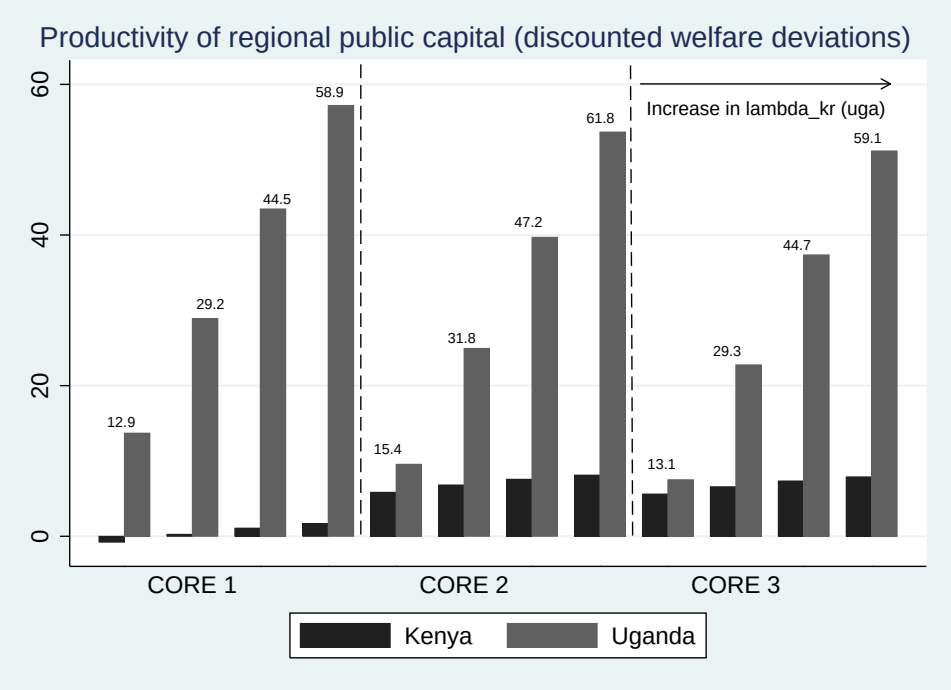
Simulation $EXT4$ adds to $EXT3$ an aid increase worth KSh 7.5 billion to fund an expansion of regional public capital KR. This simulation reaches the highest regional welfare of all 11 simulations and increases the welfare of all four household types in the model. The only other simulation from figure 3.1 that achieves this is $AID2$. In growth terms however, $EXT4$ fails to match the AID and $CORE$ simulations that use aid to fund public investments.

3.5 Sensitivity Analysis

In this final section, we perform sensitivity analysis by changing some of the parameter values from the baseline scenario. Figure 3.4 shows 12 simulations divided up into three groups linked to the $CORE1-CORE3$ simulations. From left to right $\lambda kr_{i,uga}$ increases by 0.005 increments, starting from its baseline value of 0.10. We do this only for the tradable sectors, with the $\lambda kr_{i,uga}$'s kept at zero for private and public services sectors.

The bars most to the left of each of the three groups are equal to the respective $CORE$ simulations from previous sections. Besides the obvious fact that welfare increases with $\lambda kr_{i,uga}$, we want to show here that small increases in the key λ parameters governing public capital have quite a dramatic impact on welfare. Interesting is also that Kenya's welfare increases along the way, getting across the point that your neighbour's growth, through increased demand for your tradables, acts like a positive externality.

Figure 3.4: Welfare implications of increasing productivity of regional capital in Uganda



Notes: Discounted welfare calculated as in equation (3.8), multiplied by 10^7 with $\overline{\beta} = 0.95$. To sum rural and urban welfare results within countries, population shares from table 3.6 are used. The numbers shown above the bars are the sum of Uganda and Kenya, i.e. a regional welfare measure.

3.6 Conclusion

This chapter developed a stylized two-country recursive dynamic Computable General Equilibrium model based on the theoretical model developed in chapter 2. The CGE allows us to put much more structure on the economies of the two Customs Union member states, whilst conserving the innovations from the theoretical model. Hence we again have a regional good, which is now made up of two-way trade; Kenya importing food from Uganda and low-end manufactures going the other way. The regional spill-over is modeled through a regional public capital stock that is maintained by Kenya, but which is also an input into Uganda's production function. We further introduce a national capital stock which produces a within-country externality by augmenting the productivity of private factors of production.

The first three sections of the chapter detail the data and calibration issues, with section (3.4) performing the actual analysis of simulations linked to changes in key aid, trade and

public capital variables. The three main simulations involve aid increases that are used to (i) supplement household income, (ii) increase the national public capital stock and (iii) increase the regional public capital stock. The trade experiments are related to lowering the intra-regional tariff and/or increasing the Common External Tariff from its baseline level.

Using increased aid flows to supplement household income isolates aid's spending effect and gives us the two-country equivalent of a real exchange rate appreciation (and the potentially ensuing *Dutch disease*). The region as a whole still experiences a deterioration in its competitiveness situation vis-à-vis the rest of the world, but our regional trade set-up complicates the standard dependent economy picture. Within the union, Kenya effectively exports some of its RER appreciation as its domestic prices go up less than its regional prices, with the opposite happening in Uganda. When using aid to invest in public capital stocks, the loss of competitiveness vis-à-vis the rest of the world is muted, as is the regional RER appreciation that Kenya exports to Uganda. The simulation involving aid going to national public capital stocks sees the highest welfare gains, followed by aid augmenting the regional public capital stock, with aid-used-for-consumption coming last. Distributionally, it is mainly Kenya's urban and Uganda's rural households that win—which corresponds to regional comparative advantage patterns.

Abolishing the intra-regional tariff increases welfare in Uganda and reduces it in Kenya, showing the ambiguous welfare results of Customs Unions known since Viner. Regional trade expands and producers of regionally tradables gain, whilst exports to the rest of the world take a hit. When we add the three aforementioned aid shocks to the mix, we see that adding regional trade liberalisation increases regional welfare. For the aid-used-for-consumption experiment, we even see a transfer paradox appearing with the increase in aid to Kenya more than offset by the negative welfare effect of the regional trade liberalisation. When the CET is set at 10%, which implies an increase for Uganda and a decrease for Kenya, welfare rises in the latter and falls in the former. Regional welfare is larger as compared to the *stand-alone* regional trade liberalisation simulation.

The final section of this chapter shows how sensitive our results are to estimates of key parameters governing the productivity of the different types of public capital. Unfortunately, these are also the parameters for which we have the least information available, as was already noted in the literature review in section (2.4). This is an obvious area for future research. Other directions for future research could include introducing CGE simulations linked to TFP (including spill-overs) and/or looking at the effect of LBD in different sectors, for example in internationally exportables vs. regionally exportables.

The next and final chapter of the thesis estimates trade costs empirically for the EAC by looking at consumer prices in cities across the region. As such, it looks at how integrated markets are across the region and links this to regional trade patterns. It does not immediately touch upon spill-overs, even though the impact on the wider region of the Kenyan election crisis of 2007 is briefly commented upon.

Chapter 4

Market Integration and Border Effects in Eastern Africa

4.1 Introduction

In this final chapter, we gauge the importance of border effects in Eastern Africa, essentially by testing the Law of One Price (LOP) hypothesis and looking for the reasons behind LOP violations. The violation of LOP across borders is one of the most enduring stylised facts in the international pricing literature. Obstfeld and Rogoff (2000) list this border effect among one of the six remaining puzzles of international macroeconomics. Clearly, when similar goods do not sell for the same price in geographically separated markets, trade is impaired, with standard welfare losses. Anderson and Van Wincoop (2002) argue that current policy-related trade costs are often worth more than 10% of national income. For people in low-income countries, this can be the difference between life and death. One famous example is the famine in Ethiopia during the 80s: *'Interregional trade in Ethiopia during famine years of the 1980s was impaired by government trade restrictions. As a result, famine in one region was able to coexist with a reasonable balance of food supply and demand in other regions'* (Webb and von Braun, 1994, p47).

In this instance, markets were not integrated as prices did not perform their normal allocative tasks, with deadly welfare losses as a consequence. It also shows that trade and price signals can be distorted within countries. Further, from an economic theory and modeling perspective, most international macro-models rely on LOP holding in some way. Insight into the determinants of violations to LOP should then give access to better modeling tools.

To test the LOP, we put together a highly disaggregated consumer price data set, covering 39 cities in four out of five of the member countries of the East African Community (EAC)—see the maps in appendix A for an overview. These prices are collected as part of the standard inflation (CPI) measurement process in these countries. As the CPI includes different goods in different countries, we selected 24 goods which are comparable and representative for consumer patterns in the region. Hence, we try and bridge the good-specific literature emanating from developing countries[1], which mostly focuses on micro/market structural issues, with the developed country literature, which uses highly disaggregated price data to learn about macro-issues such as border effects, trade patterns and exchange rate regimes[2]. This work is also the first in the cross-section border effect literature based on price data that uses data for Non-Tariff Barriers in the regression analysis. Equally, it is the first paper that tries to measure border effects in an African context, using *more* than a handful of (typically) food-related goods.

Our price dataset covers the period 2004-2008, which should allow for some CU effect of increased integration, especially between Uganda and Kenya. We investigate one other external 'event' that might have a bearing on market integration: the Kenya election of December 2007 and the ensuing violence in the first months of 2008. As Kenya is a transit country for many goods into landlocked Uganda, Rwanda and Burundi (see map A3 for the main transport corridors in the region), markets in these countries were severely disrupted. Otherwise, we do not assume any structural breaks or other major

[1] See Fackler and Goodwin (2001) for an overview of that literature or Rashid and Minot (2010) for a focus on Africa.

[2] See Broda and Weinstein (2008) for a recent contribution.

upheavals during the 2004-2008 time period in these four countries.

The chapter is structured as follows. After this introduction, section (4.2) introduces a framework that will help us set up our LOP/PPP testing strategy. It includes a derivation of the main empirical specification employed in the price-based border effect literature, pioneered by Engel and Rogers (1996). Section (4.3) introduces the East African data set, with section (4.4) giving summary statistics of the main variables to be used in the regression analysis of section (4.5). Section (4.6) concludes.

4.2 The law of one price, trade costs and the border effect: introduction to the literature

In this section, a theoretical framework is set out linking the Law of One Price (LOP), Purchasing Power Parity (PPP) and trade costs. Section (4.2.1) defines these concepts, section (4.2.2) looks at possible reasons as to why PPP/LOP might not hold and section (4.2.3) relates these theoretical insights to empirical specifications in the price-based border effect literature. Section (4.2.4) reviews the results from this literature, while section (4.2.5) concludes. Throughout, we borrow freely from Broda and Weinstein (2008) (mainly section 4.2.1) and from Gorodnichenko and Tesar (2005) (mainly section 4.2.3).

4.2.1 Absolute and relative PPP/LOP and aggregation issues

Purchasing Power Parity (PPP) states that, once converted to a common currency, price levels should be equal across countries. The underlying mechanism is that if goods market arbitrage manages to enforce parity in prices across a sufficient range of goods (the law-of-one-price or LOP), then one should also see high correlation in aggregate price levels. The concept of *Absolute LOP* thus refers to the price of identical goods being the

same across locations when denominated in a common currency:

$$P_{uct} = E_{cc't} P_{uc't} \tag{4.1}$$

with P_{uct} the price of good u in city c at time t, $P_{uc't}$ the price of the same good in a different city c' and $E_{cc't}$, the nominal exchange rate, which equals one when both cities are in the same country. When testing whether (4.1) holds, researchers often have to work with data from different country sources. It is likely then that these countries do not define goods in exactly the same way. Hence, a lot of tests are actually based on a slightly different version of (4.1):

$$P_{uct} = E_{cc't} P_{u'c't} \tag{4.2}$$

If this equation holds, *Approximate Absolute LOP* holds, with u and u' belonging to a similar product category but not identical[3]. When performing tests using different goods, i.e. using equation (4.2) instead of (4.1), we are faced with a problem of unobserved heterogeneity. I.e. we are unable to distinguish whether markets are really not integrated, or whether non-integration could be attributed to the fact that we are actually not comparing like with like.

An alternative way of testing the LOP is by looking at the co-movement of prices. We call this *relative LOP*. This means looking at first differences of log price levels, and testing whether prices tend to remain a constant level apart. We can write this in the following way:

$$\Delta p_{uct} = \Delta e_{cc't} + \Delta p_{uc't} \tag{4.3}$$

where lower case letters describe the logs of upper-case variables. The *Approximate* version of this LOP equation can be derived in the same way as equation (4.2).

[3] A recent paper mentions that in the US most product groups (e.g. eggs) are comprised of over 200 different Universal Product Categories (UPC's or barcodes). For eggs for example, there are 2275 different barcodes (Broda and Weinstein, 2008, p10).

What are the implications of using price indices rather than good level prices? Or, using the definitions from Rogoff (1996), testing for PPP instead of LOP? *Absolute PPP* can be derived by weighting equation (4.1)—with expenditure weights typically calculated from household surveys—summing and taking logs:

$$ln\Big(\sum_{u\in I_c} w_{uc}P_{uct}\Big) = lnE_{cc't} + ln\Big(\sum_{u\in I_c} w_{uc}P_{uc't}\Big) \tag{4.4}$$

In the previous expression the P's refer to price indices, i.e. prices have been normalised by dividing through by a reference price before summing. Obviously, assuming *Absolute LOP* holds, *Absolute PPP* will only hold if the same weights are used across locations—excluding some freak occurrence, where weights and price indices would behave in such a way as to cancel out any differences in weights used in the aggregation process[4].

4.2.2 Deviations from the PPP/LOP hypothesis

From a theoretical perspective, the breakdown of PPP/LOP, both within and across countries, can have many origins. Researchers have found it useful to make a distinction between 'real' and 'nominal' sources of this breakdown[5]. A short overview of these explanations is given below, also mentioning the main papers tackling these issues. Section (4.2.4) discusses the literature in more detail. 'Real' sources include:

1. **Transportation Costs**, often proxied by distance between regions or cities, are associated with moving goods from one region to another.
2. **Trade Barriers**, such as tariffs and quotas. Engel and Rogers (1998) look at the Canada-US free trade agreement that came into effect in January 1990[6], whilst Rogers and Smith (2001) explore the effect of the NAFTA agreement.

[4]Similarly to the LOP exposition, we could also construct PPP equivalents to the other approximate and relative versions of the LOP discussed above.

[5]For a more in-depth discussion of these issues, see Engel and Rogers (2001), Rogers and Smith (2001), Beck and Weber (2003) or Cecchetti et al. (2002).

[6]They split their sample in 2, reflecting when the US-Canada Free Trade Agreement came into effect, and find a reduction in the border effect since 1994.

3. **Non-tariff Barriers**, like bureaucracy related red-tape. According to the World Bank's Doing Business Surveys[7], this channel could be quite important in sub-Saharan Africa.
4. **Influence of non-traded goods on the general price level**. Intuitively, one would expect arbitrage-type pressures to be smaller for non-tradable goods. Crucini and Shintani (2008), exploiting the time series dimension of micro-price data, find some evidence for this, but the results from papers working in the Engel-Rogers border effect tradition are largely inconclusive (see also section 4.2.4, most notably the papers with a † in table 4.1). Of course this is not a 'root cause' for departures from the LOP benchmark. It is the characteristics of goods in terms of transport costs, tariffs and NTBs that make a good non-tradable, with tradability being a matter of degree rather than purely dichotomous. Still, it is instructive to keep in mind that we should not really expect the LOP to hold for 'goods' such as haircuts.
5. **The existence of non-traded inputs**, like marketing and distribution services that are part of final goods prices. One of the reasons that researchers have not been able to come up with conclusive evidence related to the previous source of PPP/LOP breakdown could be that a substantial amount of non-traded inputs go into certain traded goods. A famous paper by Sanyal and Jones (1982) model all retail (consumer) goods as a composite of traded and non-traded inputs. Final goods are then all essentially non-tradable, due to costs associated with retail/distribution/marketing-type services[8].
6. **Imperfect Competition**. There is a large literature arguing that we should not expect equality of prices across different locations because producers set different prices, for example because they have local monopoly power in segmented markets (pricing to market).

[7] see e.g. World Bank (2008a)

[8] One could argue that retail costs have gone down substantially with the advent of online shopping, but even there, one still needs some kind of distribution network to physically deliver final goods. This is obviously less relevant for developing countries where online retailing is almost non-existent.

The main 'nominal' cause of the PPP/LOP breakdown is related to the nominal exchange rate. Floating exchange rates, combined with sticky prices can incite producers selling abroad to set prices in the currency of the (foreign) consumer rather than their own. This is called incomplete exchange rate pass through or Local Currency Pricing (LCP). If LCP applies, changes in the nominal exchange rate do not affect goods prices in the local market. Feenstra and Kendall (1997) find evidence for this in explaining deviations from LOP and most border effect studies find this channel to be an important determinant of observed price dispersion (see table 4.1). Intuitively, fixing exchange rates between countries would thus entail welfare gains, as deviations to the LOP would be minimised. However, *overall* welfare does not increase necessarily, as the *inefficiency (and hence the welfare loss) is due to price stickiness, and the choice of exchange rate regime does not necessarily alter that* (Engel and Rogers, 2001, p32)[9]. Other welfare issues to be considered are the standard loss of monetary policy autonomy under fixed exchange rates and the ease of relative price adjustment under floating exchange rates. Devereux and Engel (1998) contrast these welfare trade offs with the 'real' causes of the failure of the LOP, which can be interpreted unequivocally as deadweight welfare losses.

4.2.3 Deriving reduced form regression specifications

In this section, the PPP/LOP framework set out in section (4.2.1) is linked to an empirically testable specification. From equation (4.1), we define the real exchange rate for good u at time t:

$$Q_{ucc't} = \frac{P_{uct}}{E_{cc't} * P_{uc't}} \tag{4.5}$$

If absolute LOP holds, then equation (4.1) holds, and expression (4.5) is equal to one. We now link these city-pair real exchange rates to their determinants, to end up with reduced form regressions that we can estimate[10]. Note that we exploit the cross-section hetero-

[9]Devereux and Engel (1998) show how the underlying sticky prices inefficiency makes fixed exchange rates increase the variance of average world consumption.

[10]This section gives some examples of papers using such reduced form specifications. For a full discussion of the border effect literature, the reader is referred to section (4.2.4).

geneity of the data (the good and location dimensions) rather than the time dimension.

Allowing for trade costs and differences in currency between locations, we define $T_{ucc't}$ as the ad valorem cost of trade between locations c and $c^{'}$ per unit of good u. Then the LOP effectively boils down to defining the following 'band of inaction':

$$\frac{1}{T_{ucc't}} \leq Q_{ucc't} \leq T_{ucc't} \tag{4.6}$$

Equation (4.6) implies that the price difference between our two locations cannot be higher than the cost of trading. Note that the cost of trade here is defined as everything that would make equation (4.5) not hold, i.e. all the reasons given in the previous subsection for the LOP breakdown are subsumed into the T-term. Using the assumption of iceberg trade costs[11] is that $q_{ucc't}$ is uniformly distributed across the band of inaction $[-t_{ucc't}\ ,\ t_{ucc't}]$[12]. Trade costs at time t could then be specified as:

$t_{ucc't}$= f(distance, border, tariffs, NTBs, E, trade costs specific to c or $c^{'}$)

NTBs are Non-Tariff Barriers and E is (as before) the nominal exchange rate. How can this be related to the real exchange rate? The simplest way, equivalent to testing an absolute version of the LOP, is assuming that $p_{uct} - e_{ucc't} - p_{uc't} = f(t_{ucc't})$, with the deviation of the real exchange rate from unity revealing the size of the trade costs. A possible log-linear regression specification reflecting this is:

$$\left| ln\Big[\frac{P_{uct}}{E_{cc't} * P_{uc't}}\Big] \right| = \beta_0 + \beta_1\, ln\, d_{ucc'} + \beta_2\, B_{ucc'} + \beta_3\, TARIFF_{ucc't} + \beta_4\, NTB_{ucc't} + \beta_5\, ln\, E_{cc't} + \sum_{k=1}^{m} \gamma_k D_k + \epsilon_{ucc't} \tag{4.7}$$

This captures long-run deviations from the LOP, allowing for the different reasons as to why LOP might not hold, which were outlined in the previous section. The unit of

[11] There are other specifications possible, and the iceberg assumption has come under some criticism recently. The log-linear specification is inaccurate if a large fraction of trade costs is per-unit and not ad-valorem. There is some evidence that distance-related transport costs are mainly per-unit. For an overview see Anderson and Van Wincoop (2004).

[12] Again, lower-case letters indicate logs.

observation is city-pairs, with $ln\, d_{ucc'}$ the log of the distance between locations c and $c^{'}$ and $B_{ucc'}$ a dummy variable which takes the value of one if locations c and $c^{'}$ are in different countries and zero otherwise. When we speak in what follows about a border effect being present, it means this variable is significant[13]. The D_k's are m city dummies which take on a value of one for D_c and $D_{c'}$ and a value of zero for all other locations. This is to pick up any city fixed effects. $\epsilon_{ucc't}$ is the error term. This is our central estimation equation, to which we will return at several points in the paper. Examples of papers using this levels-specification are Broda and Weinstein (2008) and Engel et al. (2005) for the US-Canada border, Grafe et al. (2008) for five central Asian countries, and Aker et al. (2010) for the Niger-Nigerian border.

Zooming in on the exchange rate effect, if $\beta_5 = 0$, then there is full pass-through of the nominal to the real exchange rate. This is easier to see if we slightly re-arrange equation (4.7):

$$\left| ln\Big[\frac{P_{uct}}{P_{uc't}}\Big] \right| = \beta_0 + \beta_1\, ln\, d_{ucc'} + \beta_2\, B_{ucc'} + \beta_3\, TARIFF_{ucc't} + \beta_4\, NTB_{ucc't} + (1+\beta_5)\, ln\, E_{cc't} + \sum_{k=1}^{m} \gamma_k D_k + \epsilon_{ucc't} \tag{4.8}$$

Alternatively, one can use the first difference of the real exchange rates to test a relative version of the LOP. As Engel et al. (2005) point out, this is equivalent to testing deviations from the LOP in the short run:

$$\Delta q_{ucc't} = \eta_0 + \eta_1\, ln\, d_{ucc'} + \eta_2\, B_{ucc'} + \eta_3\, \Delta TARIFF_{ucc'} + \eta_4\, \Delta NTB_{ucc'} + \eta_5\, \Delta ln\, E_{ucc'} + \sum_{k=1}^{m} \gamma_k D_k + \epsilon_{ucc't} \tag{4.9}$$

The dependent variable is the first difference of $q_{ucc't} = ln\Big[\frac{P_{uct}}{E_{cc't} * P_{uc't}}\Big]$. Engel et al. (2005) is the only paper we know of that reports both level and first difference results.

[13]The distance and border variables are considered time invariant. This might be less than obvious in times or places where borders change (see e.g. the papers by Morshed (2003) or Morshed (2007)) or where road-quality measures are incorporated into the distance measure.

Note that (4.9) is not equivalent to the short-run (error-correction) version of (4.7), as the time invariant distance variable and the border dummy are retained. For the former specification, distance plays a role in how prices are moving together, i.e. the hypothesis is that geographically closer cities will see their prices move in a similar direction. Specification (4.7) measures how distance impacts on the *levels* of relative prices, and is thus a straight test for absolute LOP.

This brings us to the standard specification used in the price-based border effect literature, which was pioneered by Engel and Rogers (1996). They use the standard deviation of equation (4.9) as their dependent variable[14]:

$$st.\ dev.\ (\Delta q_{ucc't}) = \lambda_0 + \lambda_1\ ln\ d_{ucc'} + \lambda_2\ B_{ucc'} + \sum_{k=1}^{m} \gamma_k D_k + \epsilon_{ucc't} \tag{4.10}$$

Gorodnichenko and Tesar (2005) give two reasons as to why Engel & Rogers (ER) construct the LHS variable like this. First, taking the standard deviation implies that the dependent variable becomes scale invariant, i.e. it does not matter in which units the components that make up $q_{ucc't}$ are measured, whilst E($q_{ucc't}$) does not have to be zero. This transformation is necessary because Engel & Rogers work with price indices and not with good-level prices[15]. Second, ER use the standard deviation of the *first difference* of real exchange rates. The reason for this is that CPI indices are persistent, which could bias border effect estimates by confounding price shocks with price movements related to prices moving gradually back to their equilibrium. If the real exchange rates follow a random walk, then this confusion would be eliminated by differencing[16]. In general, using indices like the CPI would only permit to investigate short-run deviations to the LOP anyway, as the normalization involved makes a levels regression meaningless.

How to interpret the dependent variable in the Engel-Rogers tradition? The idea of taking

[14] We have left out variables for tariff and non-tariff barriers and nominal exchange rate variation, as most studies in this vein do not include these.

[15] As price indices are *normalised* averages of prices for different goods.

[16] Gorodnichenko and Tesar (2005) call this the persistence effect. See pages 9-12 of their paper for an in-depth treatment.

the standard deviation of the first difference is that in highly integrated markets, there is a tendency of relative prices to move towards a constant value, with deviations small and transitory, which together imply low standard deviations. However, it is not easy to interpret the implications of the size of the coefficients on the RHS-variables. Another problem is over how long a time period the standard deviation should be taken, and what the effects are of using different frequencies. If the time dimension is collapsed into one single metric, enough time periods should be included to make sure the series reflect the economies' underlying fundamentals and not some transitory shocks. Inclusion of too many periods however might well mask important structural changes in these economies. In the literature following the Engel-Rogers paper, researchers have mostly taken the standard deviation over the longest time period available in their data. Similarly, the frequency of the data is often dictated by data availability, with Engel and Rogers (1996) working with two-monthly differences, Engel et al. (2005) with yearly data and Aker et al. (2010) with monthly data, to name but a few.

What are the implications of this for our own work on East Africa? First of all, our data set does have good-level prices, whilst persistence is, at least for some of the goods we will be analysing, quite low. Hence, there is no immediate reason for us to emulate the Engel-Rogers specification. Instead we will use our monthly price data to estimate an equation like (4.7), which will give us more intuitive results regarding departures from the LOP and its main determinants. Some reflections on the time series properties of the time-varying variables in equation (4.7) are given in section (4.4.4) which introduces the nominal exchange rate data.

4.2.4 An overview of the border effect literature

Even though we are not exactly following the Engel-Rogers (ER) set-up, we are still very much working within the ER-tradition as we try to understand departures from the law-of-one price through exploiting cross-sectional heterogeneity in price data. This is

in contrast to the more 'mature' literature that focuses on the time series dimension to uncover whether LOP/PPP holds and looks at convergence dynamics[17]. Research on developing countries has focused more on using micro-price data to investigate how integrated commodity markets are across and within countries. In general, this research deals with a small number of heavily traded goods (mainly staples), zooming in on commodity micro-market structure in the country under consideration. Methodologically, this is again very much time series based analysis. Fackler and Goodwin (2001) give a good overview of this literature, with Rashid and Minot (2010) focusing on Africa. Related research looks at the transmission of international price shocks to commodities to the local market(s)—e.g. Conforti (2004) for basic food commodities. Results from this literature with relevance to Eastern Africa are compared to our own estimation results in section 4.5. The current chapter thus bridges the PPP macro time series oriented research with the more crop-specific work.

This section starts by summarizing the results emanating from the Engel-Rogers literature, including a discussion of distance equivalents. After that, we look at some studies that have used the levels-specification equation (4.7).

ER estimate equation (4.10) on a sample of US and Canadian cities. They find a significant border effect (i.e. λ_2 is significant at the 1% level), whilst physical distance also plays an important role in explaining price dispersion. The coefficients on these variables translate into crossing the border adding the equivalent of 75,000 miles to the average standard deviation of prices between city pairs (see below for the way in which this is calculated). Data-wise, they use bi-monthly prices from city-specific Consumer Price indices (CPI's) disaggregated into 14 good categories. These categories encompass a vast number of different individual goods, with different weights attached to them in each country. Essentially, ER test for what we could call approximate relative PPP, with

[17]The standard reference for PPP-research for industrialised countries is Rogoff (1996), with Broda and Weinstein (2008) a more recent contribution using micro-price data.

a dependent variable like:

$$st.\ dev.\Big[\Delta q_{ucc't}\Big] = st.dev\left[\frac{\Delta ln\Big(\sum_{u\in I_c} w_{uc}P_{uct}\Big)}{\Delta lnE_{cc't} + \Delta ln\Big(\sum_{u\in I'_c} w_{uc'}P_{uc't}\Big)}\right] \tag{4.11}$$

Engel and Rogers' 1996 paper started a small research industry on border effects based on price data. Table 4.1 gives a summary of some of the papers that essentially use equation (4.10) to estimate the importance of the border. Most of these papers, mainly dictated by data availability concerns and comparability to the original Engel-Rogers paper, work on the US-Canada border. Exceptions are Engel and Rogers (2001) and Beck and Weber (2003) who investigate the border effect across European cities. Examples of border effect research involving Asian countries are Parsley and Wei (2001) for the Japan-US border and Baba (2007) for the Japan-Korea border. Applications with respect to developing countries are few and far between, with the exceptions of the papers by Morshed on the India-Bangladesh-Pakistani borders and Grafe et al. (2008) for Central Asia. Do we expect larger or smaller border effects for developing countries? On the one hand, transport costs and information problems related to transmitting price signals across space will be higher in developing countries, and NTBs are also higher. On the other hand, goods in developed countries are probably more complex and diversified compared to the more homogenous food items that form the larger part of household consumption in low-income countries.

Almost all papers listed in table 4.1 find the border effect to be significant and substantial (i.e. large distance equivalents). Column six indicates that the original Engel-Rogers US-Canada border distance equivalent of 75,000 miles is at the lower end of estimates[18], with Parsley and Wei (1996)'s preferred specification throwing up a whopping 43,000 trillion km. Distance equivalents for developing countries could only be calculated for the Grafe et al. (2008) paper and seem to be on the lower end of the estimation spectrum.

How are distance equivalents calculated? From the regression equation (4.7) we retain

[18]The exception is the Rogers and Smith (2001) paper who reports a distance equivalent of only 71 miles.

Table 4.1: Overview of border effect studies

Unless otherwise indicated, the dependent variable is of the form $st.dev.\left(ln\left[\frac{P_{uct}}{E_{cc't}*P_{uc't}}\right] - ln\left[\frac{P_{uc,t-1}}{E_{cc',t-1}*P_{uc',t-1}}\right]\right)$ - see also equation (4.10) above.						
Authors	**Countries (Cities)**	**Aggregation**	**Frequency**	**Border Effect?**	**Distance Equivalent ‡**	**Other Explaining Variables**
1. Engel and Rogers (1996)[a,b]	US (14) - Canada (9)	CPI sub-indices (14 for each country)	Monthly (Jun 78-Dec 94)	Yes	75,000 miles	ln Distance*, relative wage variability, nominal xr variability*
2. Engel and Rogers (1998)	US (14) - Canada (10 provinces)	CPI sub-indices (14 for each country)	Monthly (Sep 78-Dec 97)	Yes	$3.6 * 10^7$ miles	ln Distance*, relative wage variability, nominal xr variability*
3. Engel and Rogers (2001)	55 cities in 11 European countries	CPI indices	Monthly (Mar 81-Jul 97)	Yes	N/A	Distance*, Distance squared*, nominal xr variability*, language
4. Parsley and Wei (2001)[c]	US (48) - Japan (48)	27 (tradable) Commodity-level goods (27)	Quarterly (76:1-97:4)	Yes	$6.5 * 10^{12}$ miles	ln Distance*, unit costs of transport and insurance*, nominal xr variability*, relative wage variability
5. Rogers and Smith (2001)	US (14) - Canada (10) - Mexico (14)	CPI indices	Monthly (Jan 80-Dec 97)	Yes	71 miles	ln Distance*, nominal xr variability*, relative hourly manufacturing wage
6. Morshed (2003)[a] †	India (19) - Bangladesh (5)	CPI (sub-)indices (food and clothing)	Annual (1974-1995)	Yes	N/A	ln Distance*, nominal xr variability*, relative wage variability*
7. Beck and Weber (2003)[b,d]	81 cities in 7 European countries	CPI (sub-)indices	Monthly (Jan 91-Dec 02)	Yes	$1.1*10^6$ km	ln Distance*, nominal xr variability*
8. Baba (2007) †	Japan (47) - Korea (36)	192 consumer goods (from CPI data)	Monthly (Jan 99-Dec 01)	Yes	$1.5 * 10^{10}$ km	ln Distance*
9. Morshed (2007)[a] †	Pakistan (5) - Bangladesh (5)	Actual prices of 10 consumer goods	Annual (1950-1970 and 1975-1993)	Yes	N/A	Independence
10. Horvath et al. (2008)[a,e] †	Hungary (20) - Slovakia (36)	Actual prices of 20 consumer goods	Monthly (May 97-Dec 01)	Yes	$9.6 * 10^{18}$ km	ln Distance, language, nominal xr variability, country heterogeneity
11. Grafe et al. (2008) – part I [a,e,f] †	33 regions in 3 Central Asian countries	CPI (sub-)indices (food and non-food)	Monthly (Jan 99-Dec 03)	Yes	238,221 km	ln Distance, nominal xr variability*, country heterogeneity

‡ N/A means Non-Applicable and implies the basic specification found in the respective paper is not conform (4.10), such that (4.12) could not be calculated.

* Implies that the variable is statistically significant in the regression analysis (usually at 5% level).

† Implies that the paper runs regressions depending on the characteristics of the goods (e.g. tradables, non-tradables, perishables, services, etc).

[a] The dependent variable was re-calculated relative to city-specific CPI's to check whether nominal xr variability has an impact on the Border Effect.

[b] An alternative dependent variable used is the two-period ahead in-sample forecast error of each relative price series (forecast based on AR(6) model).

[c] Good-specific fixed effects are removed from the dependent variable by regressing q_{ij} on individual good dummies and using residuals in the main specification. As an alternative dependent variable, the inter-quartile range between the 75th and the 25th quartiles in the empirical distribution of all price differences between a given city-pair is also used.

[d] An alternative dependent variable used is the spread between the 10th and the 90th percentile of the distribution of 2m changes in the relative price between 2 locations.

[e] Testing for the country heterogeneity effect is done through running regression equation (11) from Gorodnichenko and Tesar (2005).

[f] The three countries in part I are Kazakhstan, Kyrgyz Rep. and Uzbekistan.

that the distance coefficient is β_1 and the border dummy coefficient is β_2. Say x_{ER} is the equivalent of the added distance induced by the border. Using the coefficients on distance and the border dummy, this is the same as saying that $\beta_1 \, ln \, x_{ER} = \beta_2$, or:

$$x_{ER} = exp\Big(\frac{\beta_2}{\beta_1}\Big) \tag{4.12}$$

The problem with this metric is that it is essentially unitless, i.e. the distance equivalent is the same whether distance is measured in km or in miles, which is obviously not a desirable trait. Parsley and Wei (2001) develop an alternative measure based on how much extra distance one needs to add to the average distance between the two countries to generate as much price dispersion as we actually observe internationally. More specifically, their distance equivalent x_{PW} solves: $\beta_1 ln(\overline{distance} + x_{PW}) = \beta_1 + \beta_2 * ln(\overline{distance})$, with $\overline{distance}$ the average distance between cities that are in different countries. Rearranging, we get:

$$x_{PW} = \overline{distance} * exp(\frac{\beta_2}{\beta_1} - 1) = \overline{distance} * (x_{ER} * e^{-1}) \tag{4.13}$$

Parsley and Wei (2001) show that the size of the border effect varies quite dramatically with the way this distance equivalents are calculated—as can be seen from the way the two metrics are related. As not all authors in the papers cited in table 4.1 give enough details to calculate this metric, the Engel-Rogers distance equivalent is still reported there. Note that if one is interested in changes to the border effect over time, for example because of exogenous shocks like a move to a customs union, the distance equivalent measure might not be very interesting. This is because measures aimed at closer integration would typically affect both the distance and the border coefficients.

As can be seen from the last column of table 4.1, authors have tried to isolate the pure border effect in different ways. In general, the log distance between two cities has been very significant in regressions following equation (4.10). In almost all of the papers cited in table 4.1 however, a border effect is present even with a significant distance coefficient

(i.e. in specification (4.10) both λ_1 and λ_2 are significant). In general, authors have taken these results and then added other variables to see whether the border dummy reduced the distance equivalent and/or became insignificant.

In contrast to 'distance', nominal exchange rate variability does help 'isolate' the Border Effect, i.e. when exchange rate variability is introduced in the regression analysis, λ_2 goes down (e.g. Rogers and Smith (2001), Beck and Weber (2003)). However, the Border coefficient, though reduced in absolute size, does remain significant in most papers[19], even when the nominal exchange rate is allowed for[20]. In some papers, wage variability is introduced as a regressor to proxy for non-tradable inputs. It is mostly not significant, and it does not reduce the size of the border effect coefficient. Methodologically, some authors have used different measures of price dispersion as their dependent variable. The footnotes to the table give more details, with the main conclusion being that the main message in these papers does not change.

Morshed (2007) uses a natural experiment to isolate the border effect by looking at price differentials before and after the independence of Bangladesh. Interestingly, he finds a border effect both before and after the partition. This is a timely reminder that forces

[19] But not in Gorodnichenko and Tesar (2005) who find that the border effect disappears when controlling for persistence and nominal exchange rate effects.

[20] How is nominal exchange rate variability included in the regression analysis? In papers that analyse more than two countries, it is possible to include a regressor that captures this. However, in the two-country case, this is not possible, as it would make this variable perfectly collinear with the Border Effect dummy. Of course, when border dummies are introduced for every single border in the dataset, the collinearity problem resurfaces, even with more than two countries being analysed — see Engel and Rogers (2001) for a discussion. As a way out of this, some researchers (see again the footnote to the table for details), divide the prices used to calculate the price dispersion measure above by city-specific price indices to 'strip' the dependent variable from any nominal influence—effectively making it a real variable. The dependent variable now becomes:

$$st.\ dev.\left[ln\frac{\left(P_{uct}/\overline{P_{ct}}\right)}{\left(E_{cc't}*P_{uc't}\right)/\left(E_{cc't}*\overline{P_{c't}}\right)}-ln\frac{\left(P_{uct-1}/\overline{P_{ct-1}}\right)}{\left(E_{cc't-1}*P_{uc't-1}\right)/\left(E_{cc't-1}*\overline{P_{c't-1}}\right)}\right] \quad (4.14)$$

$\overline{P_{ct}}$ is the price index for city c and $\overline{P_{c't}}$ is the price index for city $c^{'}$. Obviously, the E's can be taken out, which leaves us with a nominal exchange rate free measure. However, (Engel and Rogers, 1996, p1121) find the series $(P_{uct}/\overline{P_{ct}})/(P_{uc't})/(\overline{P_{c't}})$ to be stationary, which would mean that (4.14) is over-differenced. As a way around this, Engel & Rogers use a filtered measure of prices rather than the two-month difference—see also the note indicated by ^{b} in table 4.1. It is likely that this is the case for similar series in other countries too. As our data set spans four countries, we do not use this measure in the empirical part of the paper, as it also becomes quite hard to interpret coefficients.

affecting between-country LOP deviations are not the only reason why markets are not integrated. Indeed, some of the reasons LOP/PPP deviations mentioned in section (4.2.2) influence both within country and between country market integration.

Moving to BE research using level-specifications, Aker et al. (2010) fail to find significant border effects between Niger and Nigeria when looking at price behaviour of millet and cowpeas[21]. They do however find border-type effects between ethnic regions within Niger. Other variables that enter their regression framework include urban status, which reduces LOP deviations, a drought dummy (inconclusive), and cellphone coverage which again reduces departures from the LOP benchmark. The cross-section part of the Broda-Weinstein paper, after allowing for aggregation bias[22], also fails to detect a significant border effect[23]. The final section of the paper by Grafe et al. (2008) analyses price levels for 31 goods in Kyrgyz Republic, Tajikistan and Uzbekistan, relating relative prices in levels to geographical distance and a cost of living index. They only report that results are non-robust, and thus inconclusive as to the importance of a possible border effect. The only level-specification paper that does find a significant border effect is Engel et al. (2005). In this paper distance equivalents are 7.5 billion miles for the level regression, and almost 20 million miles for the difference regression, even though the border adds only 7% to LOP deviations. These authors also include population as a variable, as larger cities tend to have higher prices, and local sales taxes, which could drive a wedge between prices in different locations. The former is found to be significant, the latter not.

The cross-section border-effect literature thus tries to capture most of the reasons for LOP/PPP violations mentioned in section (4.2.2) in variables then used in regression analysis. The exceptions are arguably tariff measures and non-tariff barriers. What are the reasons for this? It is strange that tariff rates have not been included for border effect

[21] It is not possible to calculate distance equivalents as Aker et al. (2010) do not specify how their 'Transport Cost' variable is linked to distance. If one would calculate the distance equivalent using their transport cost variable, it would be around one to two miles.

[22] The biases identified in equations (4.2) and (4.4)

[23] Acknowledging these aggregation problems, more recent papers investigating the border effect have increasingly used price data at the good level—see column three in table 4.1 for those papers using the ER-specification.

research in OECD-countries. It is probably more understandable for developing countries, as time varying, good-specific tariff rates are hard to come by in these countries. As for Non-Tariff Barriers, these are probably less important for most of the ongoing research that focuses on the USA-Canada border and EU countries[24]. NTBs are very important however in a developing country context, and we have already discussed examples for Eastern Africa in section (1.3.3). We will come back to both tariff and NTBs when we discuss regression results in section (4.5).

4.2.5 Conclusion

In this section we derived a reduced form regression specification that we can use to estimate the border effect, and we reviewed the empirical border effect literature. The main issues to remember from this section are the following:

- Using non-comparable goods and different aggregation methods can bias how we estimate and interpret border effects (as per the analysis in Broda and Weinstein (2008)). Section (4.3.2) below shows how these issues will be dealt with in our East African data set.
- We linked 'real' and 'nominal' reasons for the breakdown of LOP/PPP to variables to be used in the regression analysis. These variables will be introduced in the datasection of this paper (section 4.3).
- The border-effect literature following the Engel-Rogers specification shows very large border effects and distance equivalents, the (few) papers using level-specifications, however, do *not* come up with significant border effects.
- Considering the data we have at our disposal, we decided on a real exchange rate levels regression as the most insightful estimation strategy—see equation (4.7) from section (4.2.3). This measures long-run deviations to the LOP.

[24] Chen (2004) finds evidence that NTBs are not important in explaining the border effect in the EU using a gravity model.

4.3 Consumer price data in eastern Africa

This part introduces the EAC consumer price data set. Section (4.3.1) gives an overview of the data availability by country, while section (4.3.2) discusses how the 24 common goods on which the empirical part of the paper is based were chosen, including an assessment of how comparable these goods are across countries. Section (4.3.3) concludes. Appendix D explains how missing observations were dealt with.

4.3.1 Overview of the price data

Table 4.2 gives an overview of the coverage of the CPI data sets collected over the Summer of 2008 at different national statistics offices. Data covers 39 cities in four out of five of the EAC member countries[25]—see the maps in appendix A. Monthly time series are available from October 1997 (Uganda and Kenya), January 2003 (Burundi) and January 2004 (Rwanda). All series run until August 2008, except for Rwanda where the series end in July 2008. This means the datasets have 55 months (Jan-04 to Jul-08) in common.

The number of goods for which data is available ranges from 216 in Kenya to 557 in Burundi. These numbers are slightly deceptive however, because (i) not all items are available in all cities, with more remote cities reporting sometimes less than half of the goods for which price data is available in the respective capital city, (ii) some datasets (notably the Burundi one) contain missing values[26], and (iii) for Kenya, there are actual price quotes available, below the so-called 'elementary aggregates' level (see box 1 for an explanation of elementary aggregates). Hence, we can disaggregate the Kenyan elementary aggregates into more finely defined items, which means that at least for Kenya, we have slightly more goods to work with than the 216 quoted.

[25] It was not possible to obtain similar data for Tanzania, despite a visit to the National Bureau of Statistics in Dar Es Salaam and numerous follow-up efforts.

[26] Note that in the CPI overview table (table 4.2) 'Missing Observations' refers to incomplete series, i.e. series per good-city that have less than 55 observations, but more than zero observations.

Table 4.2: CPI Country Overview†

	Burundi	**Kenya**	**Rwanda**	**Uganda**
Cities	7 (Bujumbura, Cibitoke, Gitega, Muyinga, Ngozi, Rumonge, Ruyigi)	13 (Nairobi, Mombasa, Kilifi, Malindi, Meru, Nyeri, Nakuru, Garissa, Kisii, Kisumu, Kakamega, Kitale, Kabarnet)	12 (Kigali, Butare, Gisenyi, Ruhengeri, Kibungo, Gikongoro, Cyangugu, Gitarama, Kibuye, Kabuga, Byumba, Umutara)	7 (Kampala, Masaka, Mbarara, Jinja, Mbale, Gulu, Arua)
Areas[a]	N/A	15 (10 in Nairobi, 3 in Mombasa, 2 in Nakuru)	N/A	N/A
Income Groups	1	3 (Nairobi has 3 types of income group)	1	2 (Kampala has a low-income and a high-income index)
Items in Consumer Basket (min-max)[b]	557	216 (98 - 200)	413 (211 - 386)	243 (208 - 223)
Items for which price quotes not collected monthly	N/A	N/A	N/A	Rent, Health & Medical goods, Education, Centrally Administered Prices
Data available 'below' elementary aggregates?	Only for Bujumbura-index (weekly prices available which are then aggregated into monthly averages)	Yes, on average 3 individual price quotes available per item in every of the 25 areas	No	No
Source of Weights	unknown	1993-1994 Urban Household Budget Survey	2001 Household Living Conditions Survey (French acronym EICV)	Uganda National Household Survey 2005/2006
Weights available per city?	No (only weighting scheme available is for Bujumbura-index)	Only for Nairobi Low Income, Nairobi Middle/Upper Income and 'Rest-of-Kenya'	yes (with different weights attached depending on whether goods are locally sourced or imported)	Yes
Observations missing?[c]	Yes	No	Yes	No
Period Available	Jan 2003 - Aug 2008	Jan 1997 - Aug 2008	Jan 2004 - Jul 2008	Jan 1997 - Aug 2008
Frequency	Monthly	Monthly	Monthly	Monthly

† For more information on CPI data collection and calculations: for Burundi, see ISTEEBU (2007); for Kenya, see Kenya National Bureau of Statistics (2002); for Rwanda, see National Institute of Statistics Rwanda (2007) and for Uganda, see Ugandan Bureau of Statistics (2006).

[a] In some Kenyan cities, different price indices are constructed for different city areas.

[b] This is the total number of items. It might be that not all cities have all items in their respective baskets, with the most 'developed' cities (typically capital cities), having the most items — i.e. being the most diversified. In brackets are listed those cities with the minimum and maximum number of items for which price series are available in that country. These statistics are not reported for Burundi as it constructs only a CPI index for Bujumbura and data coverage is very patchy.

[c] Missing observations ≈ Good-city time series that have less than 55 observations, but more than zero observations.

BURUNDI. The *Institut de Statistiques et d'Etudes Economiques du Burundi* (ISTEEBU) is responsible for the collection of Consumer Price Data in Burundi. Inflation is reported on a monthly basis, but takes into account only consumer prices gathered in the capital city of Bujumbura. Next to this Bujumbura-index, ISTEEBU also collects prices in six other cities (ISTEEBU, 2007). This is done using a slightly different methodology and for comparison purposes, prices for Bujumbura are also collected using this (latter) methodology. The Burundi data suffers from quite a lot of missing observations. Appendix D outlines a strategy for dealing with this. Because the price data collected for the Bujumbura index has better coverage, those prices are used for Bujumbura. Even though the collection method is slightly different, correlations between the two Bujumbura series is high. Amongst the 24 common goods retained (see section 4.3.2), there are two goods, 'milk' and 'maize grains', that do not appear in the Bujumbura Index. For these items, prices from the other (non-CPI) Bujumbura series were used.

KENYA. The Kenyan National Bureau for Statistics (KNBS) is the institution responsible for Kenyan inflation statistics. Every month, KNBS enumerators collect prices for a basket of consumer goods in 13 cities across Kenya in order to calculate the Consumer Price Index. In the larger cities of Nairobi, Mombasa and Nakuru, there are several areas in which these prices are collected. In Nairobi for example there are 10 separate areas, covering different income groups and geographical locations. For every item in the consumer price basket, on average three price quotes are gathered every month, and aggregated up into elementary aggregates (see box 1). A total of 216 elementary aggregates are collected every month, with 67 items common to the 25 areas in the data set. Kenya is the only country in our sample for which we have actual price quotes, i.e. we can go a level below the 'elementary aggregates'. This means that for some of the 24 goods retained for the analysis (see the next section), we can drill down one level to make certain goods are more comparable with the goods definitions in the other three countries and within Kenya itself. This is done for the following four 'elementary aggregates':

Elementary Aggregate		Replaced by
1. Soda	$\Rightarrow$	Fanta
2. Beer	$\Rightarrow$	Tusker Beer
3. Cigarettes	$\Rightarrow$	Sportsman Cigarettes
4. Petrol	$\Rightarrow$	Petrol - Super

As is explained in more detail in the following sections, the Nairobi high-income groups (which cover three areas in Nairobi) are not retained for the final analysis, leaving us with 22 areas (in 13 cities) to work with.

Box 1: CPI calculations

It is instructive to reflect shortly on the way statistical offices calculate Consumer Price indices (CPIs). A good reference is the ILO CPI manual (ILO, 2004). A country's overall Consumer Price Index is the result of aggregating prices of different goods into one index. Sometimes goods prices are also aggregated over different cities. The evolution over time of the country-wide index is then used as a summary statistic of the country's inflation path. In the aggregation process, weights are used to make sure goods that are consumed more often are counted more heavily in the index. These weights are typically expenditure weights calculated from national household surveys. In such surveys, however, expenditures/consumption are only recorded for categories of goods. For example, a household would report how much beer it consumes, but not the exact brand of beer. The lowest level in the aggregation chain for which expenditure weights from household surveys are available, are called 'elementary aggregates'. As the name indicates, these are already averages (aggregates) of real price quotes. Thus, CPI statisticians average up prices to the level of these 'elementary aggregates', using geometric or arithmetic means, and then use weights to construct the higher levels of the aggregation chain, and ultimately the country-wide CPI.

RWANDA. The National Institute of Statistics of Rwanda (NISR), which is responsible for the CPI in Rwanda, collects monthly price data in 12 different cities. The data for Ruhengeri and Byumba were found to be very incomplete for the goods we are interested in, and were dropped, i.e. no effort was made to recover some data through imputing, as is done for some of the other series (see appendix D). Expenditure weights are city-specific, but are collected one level above the aggregation level that is used in the other countries of our sample. This means weights are given at the level of milk instead of one level below (i.e. fresh milk, or powder milk, etc). To get to the 'elementary aggregate', a geometric mean is taken from the prices of the latter products. Implicitly, this means that these items get the same weighting within their elementary aggregate. Price quotes for a total of 413 items are collected every month, with 105 items common to the 10 retained cities. The city with the most items covered is Kigali City (386) and the lowest number is for the city of Umutara (211).

UGANDA. Similar to Rwanda, Uganda calculates its CPI indices through city-specific expenditure weights, taken from the Uganda National Household Survey. In total, there are seven cities for which data is available. However, because price quotes have only started to be collected recently for Arua, this city is not included in the analysis. There are two series for Kampala, with the Kampala High-Income series only begun a couple of years ago. Hence, the series included in the analysis is the low income one. Price quotes for a total of 243 items are collected every month, with 187 items common to our six cities. Kampala Low/Middle Income series has the most goods (223) and Gulu the least (208). Price data is available only at the 'elementary aggregates' level. For averaging up to the elementary levels, arithmetic averaging is used.

4.3.2 Comparability of goods across four EAC countries

Table 4.3 shows the 24 goods from the data set retained for the analysis in the remainder of this chapter. These goods were chosen according to the following criteria:

- Data availability across countries (only 'domestique' is not available in all countries).
- Data availability across cities (goods should have complete series across most cities within countries). For Rwanda and Burundi, an imputation method was used to complete data for some good-city-month series (see appendix D).
- Comparability of goods across countries (easiest for food items, much harder for almost all other goods).
- Low persistence of the series. This is particularly a problem for small manufactured goods such as matches, batteries, etc. It is also an issue for services such as doctor fees, education fees, etc. The latter are less surprising as such fees are often set by the public sector[27].

The literature review of section 4.2.4 already mentioned that Broda and Weinstein (2008) find a bias in border effect estimates when non-similar goods are compared. Using good-specific prices instead of aggregate indexes is probably even more important to avoid bias in developing countries, as the latter mostly have more unequal income distributions and therefore more heterogeneity in consumption (Fielding, 2009, p112). As table 4.3 shows, this comparability problem will probably be lower for staple foods and fruits & vegetables than for goods in the 'Other' category. Indeed for the first two categories, the original names of the staple foods look very similar. However, for other items the correspondence is less than perfect, e.g. 'beer' is actually Primus beer in Burundi and Rwanda, Tusker in Kenya, whilst there are no details beyond the label 'Brewed bottled Beers' in Uganda.

To start with, we deal with this by omitting high-income price series in Kenya (three areas located in Nairobi) and Uganda (Kampala high-income), as this makes the goods more comparable. Why? At the lower ends of the income distribution, product diversification is normally less pronounced, as good attributes such as packaging, shop location, etc.

[27] A further discussion on time series properties and persistence of the real exchange rates can be found in section (4.4.4)

Table 4.3: Matching 24 Goods Across 4 Countries - Data Availability per Country[a,b]

Common name	C[c]	BURUNDI		KENYA		RWANDA		UGANDA	
		Original Name (unit)	C	Original Name (unit)	C	Original Name (unit)	C	Original Name (unit)	C
STAPLES (5)									
RICE	44	Rice - White (1 kg)	7	Rice (1 kg)	22	Rice - local (1 kg)	9	Rice (1 kg)	6
MAIZE FLOUR	43	Maize Flour (1 kg)	7	Maize Flour (2 kg)	22	Maize Flour (1 kg)	8	Maize Flour (2 kg)	6
MAIZE GRAINS	35	Dry Maize Grains (1 kg)	5	Maize Grains (1 kg)	22	Dry Maize Grains (1 kg)	7	Maize Grains (1 kg)	1
POTATOES	45	Potatoes - local (1 kg)	7	Potatoes - local (1 kg)	22	Potatoes - local (1 kg)	10	Irish Potatoes (1 kg)	6
SWEET POTATOES	43	Sweet Potatoes (1 kg)	7	Sweet Potatoes (1 kg)	20	Sweet Potatoes (1 kg)	10	Sweet Potatoes (1 kg)	6
FRUITS and VEGETABLES (7)									
ORANGES	38	Oranges (1 kg)	5	Oranges (1 kg)	22	Oranges - local (1 kg)	5	Oranges (1 kg)	6
ONIONS	45	Onions (1 kg)	7	Onions (1 kg)	22	Onions - Red (1 kg)	10	Onions - Big (1 kg)	6
CABBAGES	43	Cabbage - white (1 kg)	7	Cabbages (1 kg)	22	Cabbage - white (1 kg)	8	Cabbages (1 kg)	6
BANANA RIPE	45	Ripe Bananas - Ibigurube (1 kg)	7	Banana Ripe (1 kg)	22	Ripe Bananas - Kamara (1 kg)	10	Banana Bogoya (1 kg)	6
BANANA COOKING	45	Green Bananas (1 kg)	7	Banana Cooking (1 kg)	22	Bananas Cooking - local (1 kg)	10	Banana Ndizi (1 kg)	6
TOMATOES	45	Tomatoes (1 kg)	7	Tomatoes (1 kg)	22	Tomatoes - Fresh (1 kg)	10	Tomatoes - Big (1 kg)	6
CARROTS	44	Carrots (1 kg)	6	Carrots (1 kg)	22	Carrots (1 kg)	10	Carrots (1 kg)	6
OTHER FOOD ITEMS (6)									
SUGAR	45	Sugar - local (1 kg)	7	Sugar - local (1 kg)	22	Sugar - imported (1 kg)	10	Sugar - brown(1 kg)	6
SALT	45	Kitchen Salt - imported (1 kg)	7	Table Salt (500 gr)	22	Table Salt - imported (1 kg)	10	Salt (500 gr)	6
EGGS	45	Eggs - Fresh (unit)	7	Eggs (unit)	22	Eggs - Fresh (unit)	10	Eggs (2 units)	6
MARGARINE	42	Blue Band from Kenya (250 gr)	7	Blue Band (500 gr)	22	Blue Band (500 gr)	7	Margarine (500 gr)	6
FISH NOT FRESH	35	Dry Ndagara - local (1 kg)	7	Fish Non Fresh (1 kg)	15	Ndagara - imported (1 kg)	7	Fish - Dried Tilapia (1 kg)	6
MILK	41	Milk - non-pasteurized (1 l)	7	Milk - Fresh Packed (0.5 l)	21	Milk - Fresh Packed (1l)	7	Milk - Fresh (1 l)	6
OTHER (6)									
BEER	43	Primus (72 cl)	7	Tusker (500 ml)	20	Primus (72 cl)	10	Brewed bottled beers (0.5 l)	6
SODA	45	FANTA (30 cl)	7	FANTA (30 cl)	22	Fanta citron (30 cl)	10	Bottled Soda (30 cl)	6
CIGARETTES	43	Supermatch - local (20 units)	7	Sportsman (1 packet)	21	SM (1 packet)	9	Cigarettes (1 packet)	6
CHARCOAL	44	Charcoal (1 kg)	7	Charcoal (1 kg)	21	Charcoal (1 kg)	10	Charcoal (sack/kg)	6
DOMESTIQUE	31	Cost of a domestic helper in the popular quarter	7	Maid (per month)	15	House Worker	9	N/A	0
PETROL	34	Petrol (1 l)	7	Petrol - Super (1 l)	15	Petrol - Super (1 l)	6	Petrol (1 l)	6

[a] Names of goods from the Burundi and Rwanda CPI baskets are translated from French.
[b] When countries employ different units, prices are recalculated to the unit that is most common.
[c] C stands for number of cities that report price data for the respective good.

Table 4.4: Weights in the CPI basket of the 24 retained goods (all in percentages)[a]

Good Groupings	Burundi	Kenya[b]	Rwanda	Uganda	Average	KEN High Income[c]	UGA High Income[d]
Staples	7.5	10.3	8.6	6.0	8.1	4.3	2.8
Fruits & Vegetables	4.9	4.2	4.6	1.9	3.9	2.8	1.2
Other Food Items	4.7	12.7	5.3	6.6	7.3	7.9	3.8
Other	10.9	4.4	6.9	7.7	7.5	2.4	6.2
% of total CPI basket	**28.0**	**31.6**	**25.4**	**22.2**	**26.8**	**17.4**	**14.0**
food items as % of CPI food basket	**42.8**	**35.4**	**45.3**	**47.0**	**41.1**	**48.4**	**42.9**

[a] These are % taken from a total CPI basket summing to 100.
[b] Average of Nairobi Low-Income basket and non-Nairobi basket.
[c] Nairobi High Income basket.
[d] Kampala High Income basket.

have less impact on pricing. E.g. shopping for even quite basic goods like staple foods, in a supermarket like Nakumatt, makes quite a big difference price-wise as compared to buying from market stalls. For luxury goods, this effect will be even more pronounced[28].

Another way of showing that higher income groups have more diversified consumption patterns is by looking at their consumption baskets. In Kenya for example, the lowest number of items for which price quotes are available is in arguably the poorest area (the Kibera-slum in Nairobi), whilst the highest is for Mombasa city centre. Furthermore, the penultimate row of table 4.4, which has the weights attached to consumption goods in the respective countries' CPI baskets, shows that our 24 goods account for a lower percentage of the total CPI basket in the high-income series compared to the low income series.

How representative are these goods? Is there a case for saying that conclusions reached from analysing the 24 retained items, can be generalised to how integrated these economies are at a macro-level? The diet within the EAC across countries is quite similar, i.e. tastes are not so different, with more similarity found for poorer households. Table 4.4 has some evidence on this, with 23 out of 24 goods consumed in all four countries, making

[28] A nice example from the Kampala high-income series sums up both the high-income claim and the fact that items in the 'other' category will be less comparable. The 'elementary aggregate' shown in the data set for the item 'wine' in July 2008 is 24,800 Ugandan Shillings. Unpacking this number, it is effectively an arithmetic average of the prices of 8 different wines, staggered across four different shops in Kampala, with a standard deviation of just under 8,000 USh. The type of shop where these price quotes were gathered varied substantially: from a top-class hotel to an Uchumi supermarket, whilst the quality of the wine was also substantially different across the eight quoted prices.

up on average 27% of the (low-income) total CPI basket. The 18 food items make up on average 41% of the CPI food basket (for the low-income groups).

Further, we are not only interested in the share of consumption in national CPI baskets, but also in how much these goods are traded. A quote from a recent study on Non-Tariff Barriers indicates that we are capturing most of the heavily traded goods in the region: *Food and live animals as a group continue to dominate the formal intra-EAC trade of almost all EAC members, except the exports of Kenya (..). The two other important groups - especially for the new EAC members - are beverages and tobacco, and inedible crude materials* (World Bank, 2008b, p.iv). Anecdotal evidence on informal trade also shows the majority of the 24 goods to be heavily traded across borders (Bank of Uganda and UBOS, 2007)[29].

4.3.3 Conclusion

This part of the paper presented the characteristics of the consumer price dataset and reflected on the possible problems that might surface when conducting our border-effect regression analysis. The findings can be summarised as follows:

- 24 Goods were retained across the four countries.
- We are confident that the goods in the 'staples' and 'fruits & vegetables' categories are comparable across countries. We need to be more careful with the other two good categories. In order to make series more comparable, we excluded all the 'high-income' price series, as product characteristics become more diversified (and thus less comparable) in wealthier areas and for luxury goods.
- The chosen goods are representative of consumption patterns in all four countries, with food items representing on average 41% of CPI baskets. Furthermore, there is good evidence that most of the 24 goods are traded across borders in the region.

[29] We assume that informal trade does not affect price patterns, as it is reasonable to assume that competition makes sure that prices between formally and informally traded goods cannot be very substantial.

4.4 Exploring the data

This section provides a preliminary analysis of the data that will be used in the border effect regression analysis of section 4.5. In turn, data on prices, distance, doing business indicators (non-tariff barriers) and the nominal exchange rate are presented, whilst some regression estimates for the impact of different distance measures on prices are also included.

4.4.1 Prices

Table 4.5 shows summary statistics of the absolute value of the log of good real exchange rates, which is the dependent variable in the subsequent regression analysis, across country-pairs, good groupings and time. A zero implies the LOP hypothesis holds perfectly, with higher values showing larger deviations from the LOP. The average mean for within-country city-pairs is 0.243. This implies that the absolute value of the natural log of the relative price (expressed in the same currency) is $e^{0.243}$ or 1.275. I.e. 27.5% higher than the LOP benchmark. For the highest between-country pair (Burundi-Kenya) this rises to 66% ($e^{0.509}$). Are these large numbers? Grafe et al. (2008) cite very similar numbers, with the departure from LOP for their set of 31 goods in the 30-50% range. Aker et al. (2010) report slightly smaller numbers for the Niger/Nigeria border, but they only report price differentials within five km of the border (see their Figures 1 and 2), and still report peaks of more than 0.4.

If price differentials are a function of trade costs, as was asserted in section (4.2.3), we can compare with some of the estimates on trade costs in general. As mentioned in chapter 1, Anderson and Van Wincoop (2004) come up with an estimate of 170% for the tax equivalent of trade costs: 21% transportation costs, 44% border-related trade barriers and 55% retail and wholesale distribution costs. Hence, the means in our data-set do not seem to be out of line with these previous estimates, even though for certain outlier

Table 4.5: Overview good real exchange rates by country pair and good-category[a]

	Obs	Mean	St.dev.	Max-Min	Mean (pre-2008)[d]	Mean (2008)[d]
WITHIN-COUNTRY	**367,675**	**0.243**	**0.281**	**2.59**	**0.241**	**0.256**
By Country-pair (avg. distance)						
BUR-BUR (138 km)[b]	26,180	0.253	0.257	1.82	0.254	0.250
KEN-KEN (392 km)	276,155	0.246	0.293	2.59	0.244	0.264
RWA-RWA (163 km)	47,190	0.226	0.237	2.08	0.226	0.223
UGA-UGA (317 km)	18,150	0.221	0.244	1.45	0.219	0.235
By good category[c]						
Staple Food	79,365	0.231	0.248	1.87	0.229	0.245
Fruits and Vegetables	116,325	0.396	0.327	2.59	0.395	0.397
Other Food items	90,915	0.142	0.197	2.20	0.140	0.155
Other	81,070	0.149	0.221	1.64	0.145	0.179
BETWEEN-COUNTRY	**779,790**	**0.443**	**0.379**	**3.28**	**0.436**	**0.492**
By Country-pair (avg distance)						
BUR-KEN (1575 km)	186,450	0.509	0.411	3.10	0.499	0.589
BUR-UGA (912 km)	50,105	0.425	0.339	2.28	0.424	0.436
KEN-RWA (1323 km)	244,420	0.467	0.401	3.28	0.455	0.549
BUR-RWA (302 km)	79,750	0.363	0.310	2.37	0.363	0.364
KEN-UGA (792 km)	154,000	0.391	0.341	2.47	0.390	0.392
RWA-UGA (658 km)	65,065	0.405	0.348	2.48	0.400	0.442
By good category[c]						
Staple Food	159,170	0.401	0.412	3.10	0.387	0.498
Fruits and Vegetables	241,835	0.528	0.405	3.28	0.519	0.589
Other Food items	197,615	0.372	0.295	2.20	0.371	0.383
Other	181,170	0.445	0.373	2.23	0.441	0.479

[a] The dependent variable is the absolute value of the log of good real exchange rates, see the LHS of equation (4.7). The statistics shown are the mean, standard deviation, and the difference between the maximum and the minimum of the series, averaged over time and across country-pairs or good categories (as indicated).
[b] In brackets is the average distance between cities for the respective country-pair, in km.
[c] For the composition of these groups, i.e. which items belong to which group, see table 4.3.
[d] When the figure in this column is underlined, it implies the means of the respective real exchange rates before and after 2008 are significantly different at the 1% level (through performing a standard t-test).

citypair-good combinations, goods in one city can fetch a multiple of the price of the same good in another city.

We can see that both the mean and the standard deviation of city-pairs from the same country are substantially lower compared to city-pairs from different countries. Within the latter category the mean and the standard deviation are higher for countries that do not share a border, with the two countries furthest apart geographically (Burundi and Kenya) having the highest deviations from the LOP. Further, the means for between-country city-pairs are higher for all 4 good categories. The last two columns show means before and after the Kenyan election crisis, where we are looking for any knock-on effect

of the crisis for the wider (landlocked) region. For city-pairs involving a Kenyan city, mean real exchange rates are on average 12% higher in 2008 compared to the 2004-2007 period. For most other country-pairings, the 2008 means are also higher.

The means for good categories 'Other Food items' and 'Other' show relatively large differences between within-country and between-country means, which points to the existence of a border effect. This difference is smaller for the 'fruits & vegetables' category, even though the mean for the latter is higher. Remember that these are unconditional means, so it might be for example that once we control for distance, the (conditional) mean for 'fruits & vegetables', which are mostly perishable goods, is lower than for the final two groups. To distance we now turn.

4.4.2 Distance

The maps in appendix A give the reader a feel for distances between countries and cities. Distances are all measured in kilometers. Also, the first column of table 4.5 shows the average distance between two cities by country-pair. We experiment with four different distance measures[30]. The first distance measure is the log of the great circle distance between two cities ('ln Straight')[31]. The second metric is road distance ('ln Road') which calculates the road distance between two cities[32]. Road distance follows the Northern Corridor roads as shown in map A3 in appendix A. For both these measures, we set distances within Kenyan cities equal to zero—remember that we use prices in seven areas in Nairobi, three in Mombasa and two in Nakuru. Measures three and four (variable names 'ln Straight KEN' and 'ln Road KEN') are linked to the previous straight distance and road distance variables respectively, but now with distances within Kenyan cities different from zero. All these within-city distances are calculated as straight lines; with

[30] In each case, we take logs to reflect the consensus that the relationship between distance and price dispersion is concave.

[31] In developing this metric, we used the googlemaps distance measurement tool. See http://googlesystem.blogspot.com/2007/09/measuring-distances-in-google-maps.html

[32] From the East Africa Road Map by Freytag and Berndt.

the distances between these three cities and all other cities in the sample the same as for measures one and two. All these distance measures are highly correlated, with correlation coefficients between all possible pairs higher than 0.95 and significant at the 0.1 % level. These various metrics will be used for assessing the robustness of the regression analysis of section (4.5).

4.4.3 Non-tariff barriers

One of the innovations in this paper is that the regression analysis includes some variables that capture non-tariff barriers (NTBs). To this end, the three indicators linked to the *Trading Across Borders* chapter of the World Bank's Doing Business database were used. Table 1.4 in chapter 1 shows how between 2006 and 2009, most of these indicators improved in EAC member states. The exceptions are Kenya for exporting and Burundi, where the evolution was flat.

The drawbacks of these indicators for our purposes are two-fold: (i) data is only available from 2005 onwards[33], and (ii) the data is yearly and not monthly. In the regression analysis we use an index-type variable constructed out of the three variables. In a first step, indices are constructed for each of the three variables individually, with Burundi-2005 the benchmark (i.e. the value of each indicator is set at 100 for Burundi-2005). After this, the indices for two different countries are added to get values per country-pair—or are doubled if cities are part of the same country.

4.4.4 Nominal exchange rates

All prices are converted into US Dollars, using monthly averages of local currency/USD nominal exchange rates from the IMF's International Finance Statistics (IFS). The log of

[33]Technically, these indicators are only available from 2006. However, the time at which these indicators are collected are often more than half a year before that. Hence, the data points we construct bring the years 1 year forward.

these averages is used as the nominal exchange rate regressor.

When estimating an equation like (4.8), we want time-varying variables, on the LHS (good real exchange rates) and RHS (nominal exchange rate) to be of similar orders of integration[34] for the regression results to make sense. We do not propose exhaustive unit root testing[35], but instead give some arguments as to why we think this is not a major problem in the proposed estimation strategy.

First, there is only one time-varying variable on the RHS of equation (4.7), i.e. time series issues have ramifications only for the regression specifications including the nominal exchange rate (see section (4.5.5) for a discussion of the regression results related to the nominal exchange rate variable). Second, as we essentially try to capture the cross-section variation, we have included monthly time dummies in all regression specifications to try to deal with time-specific heterogeneity. Third, one of the criteria for selecting the 24 retained goods was their persistence characteristics—see also section (4.3.2). Time series of food prices for example, are in general less persistent and thus less likely to contain unit roots.

Even if we would perform unit root tests, we anticipate most of these to be inconclusive, for two reasons: (i) testing good real exchange rates for a unit root is in itself a test for market integration. Hence, we expect LOP to hold for some goods and city-pairs but not for others, probably depending on good and city characteristics. (ii) Methodologically, *unit root tests are now well known to have very low power, and to be unable to distinguish between random-walk behaviour and very slow mean-reversion in the PPP-consistent level of the real exchange rate* (Caporale and Gil-Alana, 2010, p10). Hence, as our time series is quite short, we do not expect meaningful results to emerge from the unit root tests. We conclude that for the real exchange rate, some units within the different possible panel dimensions (city-pairs and goods), will probably exhibit unit root behaviour, but

[34] As we only have annual data for our Doing Business variable, we interpret it more like a dummy variable.
[35] We could of course subject the LHS of equation (4.8) to a battery of unit root and co-integration tests, which would be an alternative for testing for market integration, using the time dimension of the data-set.

that this will not constitute a major problem for drawing conclusions across our data-set.

When testing the nominal exchange rate for unit roots, using the Dickey Fuller Generalised Least Squares (DFGLS) univariate testing procedure[36], we found four out of six of the bilateral exchange rates contain a unit root, with only the KEN-UGA and RWA-UGA country-pairs rejecting the unit root null. When deploying panel unit root tests, we get conflicting messages, as predicted by Caporale and Gil-Alana (2010) cited above. Using the Pesaran (Pesaran, 2007) or Fischer (Maddala and Wu, 1999) tests, the null of a unit root cannot be rejected, whereas when we run the Hadri test (Hadri, 2000), we cannot reject the null of stationarity. Even though nominal exchange rates are mostly thought to be I(1), there are authors who find long memories in nominal exchange rates (see e.g. Gil-Alana (2003) or Caporale and Gil-Alana (2010)). In the African context, Odedokun (2000) finds a non-trivial number of nominal bilateral USD exchange rates to be stationary. We conclude that some bilateral exchange rates in our data will exhibit I(1) behaviour, but that this will not play too important a role. Remember that we are trying to learn LOP and PPP lessons at the aggregate level by exploiting a lot of micro price data. Hence, we will always have to make some difficult methodological choices, as we cannot model all the individual goods and city-pairs—unlike the crop-specific work.

4.5 The border effect - regression analysis

We start this section with a last look at the data, comparing kernel densities between country-pairs (4.5.1), before border effect regressions are run in (4.5.2). We also look at whether different goods have a differential impact on border effect estimations (4.5.4), and what the effects are of the introduction of the Customs Union in the EAC (4.5.3). Finally, we discuss the effect of the nominal exchange rate and pass-through (4.5.5).

[36] As proposed by Elliott et al. (1996).

4.5.1 Dealing with country heterogeneity

One of the main criticisms leveled at the Engel-Rogers literature is that most papers fail to accommodate for the so-called country heterogeneity effect: *If relative price variability across locations within the same country differs systematically country-by-country, the border effect measured by a regression comparing within-country and cross-country price dispersion will be confounded by the divergence between two countries' internal price distributions* (Gorodnichenko and Tesar, 2009, p220).

Appendix E.1 shows how non-parametric kernel distributions fit our data, and whether city-pair relative prices exhibit different distributions conditional on which country-pair they belong to. Figure E.1.1 shows how within-country price distributions are very similar, with the Rwanda and Kenya distributions almost impossible to distinguish from each other. This eases our worries regarding the country heterogeneity effect. Figures E.1.2 and E.1.3 hint at the presence of border effects. Figure E.1.2 suggests distributions for country-pairs that share one border are slightly different from the Rwanda internal distribution (other within-country densities not shown), whilst Figure E.1.3 indicates that departures from those internal distributions might even be larger for country-pairs that are more than one border away.

4.5.2 The border effect: pooled regression

Considering our data availability, our preferred regression specification looks like this:

$$\left| ln\Big[\frac{P_{uct}}{E_{cc't} * P_{uc't}}\Big] \right| = \theta_0 + \theta_1\, ln\, d_{ucc'} + \theta_2\, B_{ucc'} + \theta_3\, NTB_{ucc't} + \theta_4\, ln\, E_{ucc't} + \sum_{k=2}^{45} \gamma_k D_k + \sum_{m=2}^{55} \zeta_m D_m + \sum_{p=2}^{24} \xi_p D_p + \epsilon_{ucc't} \tag{4.15}$$

Compared to equation (4.7), we do not have reliable data on tariffs, and we have added dummy variables for the different time periods and for goods. This level-specification is

is closest to the theory we want to test, which is the long-run border effect and the related effects of customs union and exchange rate pass-through. Standard errors reported below are clustered by city-pair. The underlying hypothesis for this choice is that there is a high probability that errors are not independent within the city-pairs dimension, mainly because we suspect persistence to be important in the time series dimension, as the time-span we are working with is relatively short.

To account for the 'Country Heterogeneity Effect' discussed in the previous section, we follow Gorodnichenko and Tesar (2005) who suggest using dummies for city-pairs that are both in the same country. We cannot include both a border-dummy and dummies for all four countries, as that would imply perfect collinearity. So which one of the four country dummies should be dropped? The same authors make a case for a conservative approach (i.e. which would make the border effect as small as possible) by choosing the country which has the lowest difference between within-country and between-country city-pairs' price variation. In our case this is Rwanda (calculated from table 4.5), hence regressions are run without a 'Rwanda-Rwanda' dummy variable. Further, we construct the 'Dummy Incremental' variable variable to capture the hypothesis that crossing more than 1 border should add to the border effect—kind of a double border effect. A value of one indicates no borders crossed, a two indicates one border crossing (i.e. BUR-RWA, RWA-UGA and UGA-KEN city-pairs), a three two borders (BUR-UGA and RWA-KEN city-pairs) and a four three borders (BUR-KEN city-pairs)[37].

Table 4.6 reports results from six regression specifications: (i) with distance and the border dummy as regressors, (ii) with the incremental dummy instead of the border dummy, (iii) with six bilateral dummies to capture bilateral border effects[38], (iv) specification one with the nominal exchange rate added, (v) specification one with doing business indica-

[37]This metric is predicated on the fact that imports into Burundi from the rest of the world mainly come through the so-called northern corridor, i.e. via Kenya and not via Tanzania. Of course, for certain staples and fruits and vegetables that are locally grown, one cannot exclude Tanzania-Burundi trade, but the point is that pass-through from Kenya to Burundi will rather happen via Uganda and Rwanda than via Tanzania (Central Corridor)—see also map A3 in annex A. It is also possible that price signals are well transmitted from Kenya to Burundi, without actual trade taking place.

[38]Note that we cannot include the nominal exchange rate in such a regression as this would be perfectly collinear with the bilateral dummies.

Table 4.6: Border effect pooled regressions

ALL GOODS (24 items)

VARIABLES	Specific. 1	Specific. 2	Specific. 3	Specific. 4	Specific. 5	Specific. 6	Sp.3 w/o 2008
ln Road KEN	0.0286***	0.0189***	0.0170***	0.0251***	0.0291***	0.0255***	0.0176***
	(0.00312)	(0.00345)	(0.00351)	(0.00315)	(0.00306)	(0.00309)	(0.00353)
Border dummy	0.136***			0.186***	0.148***	0.199***	
	(0.00953)			(0.00983)	(0.000966)	(0.00996)	
Dummy Incremental		0.0775***					
		(0.00480)					
Burundi-Kenya dummy			0.240***				0.221***
			(0.0211)				(0.0202)
Burundi-Rwanda dummy			0.111***				0.110***
			(0.00968)				(0.00912)
Burundi-Uganda dummy			0.167***				0.165***
			(0.0126)				(0.0122)
Kenya-Rwanda dummy			0.217***				0.198***
			(0.0156)				(0.0151)
Kenya-Uganda dummy			0.158***				0.153***
			(0.0156)				(0.0151)
Rwanda-Uganda dummy			0.168***				0.162***
			(0.00906)				0.00888
Nominal Exchange Rate				0.0202***		0.0206***	
				(0.00214)		(0)	
Doing Business					0.000168***	0.000150***	
					(0)	(0)	
Observations	1,147,465	1,147,465	1,147,465	1,147,465	897,109	897,109	1,001,424
R-squared	0.316	0.317	0.319	0.317	0.318	0.319	0.311
Dist. Eq. 1 (total)	116			1,653	162	2,450	
Dist. Eq. 2 (total)	292 km			4,159 km	407km	6,165 km	
Dist. Eq. 1 (Bur-Ken)			1,352,746				284.025
Dist. Eq. 2 (Bur-Ken)			3,663,685 km				769,235 km
Dist. Eq. 1 (Bur-Rwa)			685				518
Dist. Eq. 2 (Bur-Rwa)			1,439 km				1,088 km
Dist. Eq. 1 (Bur-Uga)			18,463				11,790
Dist. Eq. 2 (Bur-Uga)			46,293 km				29,561 km
Dist. Eq. 1 (Ken-Rwa)			349,656				76,880
Dist. Eq. 2 (Ken-Rwa)			924,558 km				203,285 km
Dist. Eq. 1 (Ken-Uga)			10,874				5,962
Dist. Eq. 2 (Ken-Uga)			26,700 km				14,640 km
Dist. Eq. 1 (Rwa-Uga)			19,582				9,942
Dist. Eq. 2 (Rwa-Uga)			46,746 km				23,735 km

Notes: Dependent variable is the absolute value of the log of good relative prices (=LHS of equation 4.15). All regressions are run with a constant, 23 good dummies ('rice' being dropped), 44 city dummies ('Bujumbura' is dropped), 54 month-dummies ('Jan-04' dropped), except for the regressions involving Doing Business indicators for which we do not have data for 2004, and 3 country-specific dummies ('Rwanda-Rwanda' dummy dropped). p-values in parentheses are clustered by city-pair. Significance levels are: *** p<0.01, ** p<0.05, * p<0.1

Dist. Eq. stands for Distance Equivalent. The correct expressions are [$x = exp(\beta_2/\beta_1)$] for Distance Equivalent 1 and [$x = \overline{distance} * exp(\beta_2/\beta_1 - 1)$] for Distance Equivalent 2—see also section 4.2.4.

tor added, (vi) specification one with both exchange rate and doing business indicators. Distance equivalents, explained in section (4.2.4), are reported in the lower half of the table. The number of observations for the first four specifications are 1,147,465 covering 20,863 citypair-good combinations, each for 55 months[39].

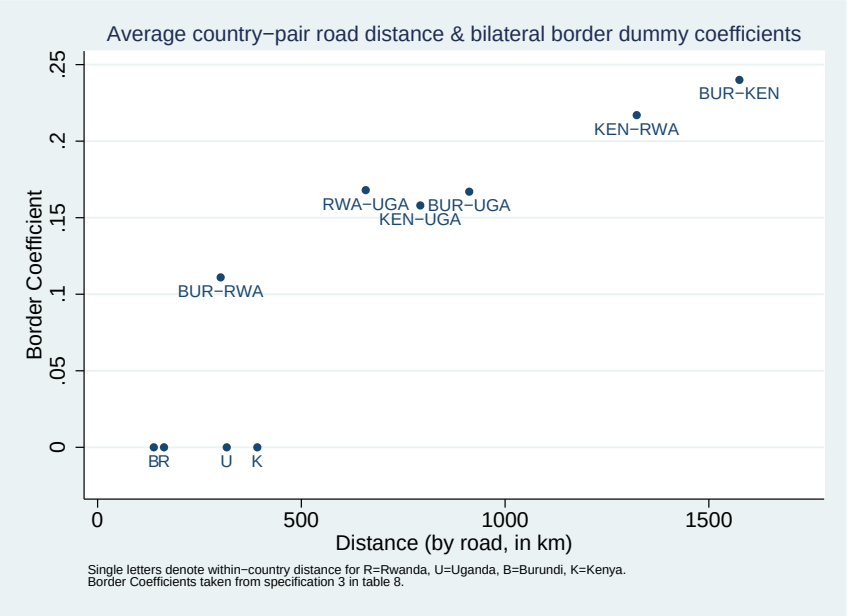
Specification one shows both distance and the border dummy to be highly significant. A distance of 100 km between two cities counts for departures of around 13% from the LOP benchmark[40]. The border dummy is positive and highly significant, moving prices more than 13% away from the LOP hypothesis. This is higher than the 7% estimated by Engel et al. (2005) for the US-Canada border, and higher than the 2-3% found by Aker et al. (2010) for the Niger-Nigeria border. We see that the 'cost' (in terms of departures from LOP) of distance is lower than the 21% transport cost estimate of Anderson and Van Wincoop (2002). Similarly, their estimate of border-related trade barriers (44%) is substantially higher than our border-dummy coefficient. Alternative measures for the border dummy (specifications two and three) similarly show that countries that are further apart have higher deviations from the LOP. Specification three for example shows prices being moved away from the LOP equilibrium by 24% for Burundi-Kenya city-pairs, but only by 11% for Burundi-Rwanda pairs. Figure 4.1 shows how these coefficients are related to distance. The further away two countries are, the higher is their border dummy coefficient. The four observations near the origin depict average distances within our four countries, for which the border coefficients are zero. Note that distance is measured in km, whilst the border effect relates to the log of real exchange rates. Hence, the linear relationship depicted understates the extent to which for example Kenya and Burundian city-pairs are disconnected. This figure is also consistent with the low figures in the aggregate trade volumes between Rwanda/Burundi and Kenya from table 1.3.

Distance equivalents are quite low (with the exception of specification three) compared to similar estimates from the Engel-Rogers tradition, but are similar to the findings of the

[39]Not all cities have data for all goods. Table 4.3 gives an overview of which goods are missing for which cities. If there were no missing data our dataset would span 24 (goods) * 55 (months) * (45*44/2) (number of city-pairs) = 1,306,800 observations.

[40]Calculated as $0.0286 * ln(100)$.

Figure 4.1: Distance and bilateral border coefficients



previously discussed papers using level-specifications like us. One interpretation of this is that good markets are integrated in the long-run, but that short-run deviations, which is what the ER-standard deviation approach picks up, are significant.

Can we 'explain' the border dummy and distance equivalents by adding the nominal exchange rate or measures for non-tariff barriers? The answer is no. The nominal exchange rate is highly significant and thus explains departures from the LOP, but it does not reduce the border effect coefficient, nor does it reduce the distance equivalents. In both specifications including the exchange rate (four and six), the coefficient is very close to zero, implying a high pass-through from foreign to domestic prices. The NTB variable is also highly significant, but again reduces neither the size nor the significance of the border dummy. The inclusion of these variables also does not increase the performance of the regression in terms of R^2. The pass-through effect is taken up in more detail in section (4.5.5) below.

How robust are these results? First, returning to the country heterogeneity effect, none of our conclusions changes when using a different combination of benchmark dummies, with the exception of using 'Burundi-Burundi' as the benchmark. In that case, we see the border coefficient actually decrease between specification one and four and between

one and six. The size of this change is small, such that this does not warrant a revision of the conclusions reached so far, especially as Burundi is arguably the most 'peripheral' of our four countries[41]. Second, results changed neither quantitatively nor qualitatively, when using any of the three other distance measures discussed in section (4.4.2) instead of 'ln Road KEN'. Third, we ran regressions with a time trend instead of the 54 time dummies, again without noticeable effects. In specification 1, the time trend was found to be positive and significant, but very small (0.00058). Fourth, we did a robustness check regarding the goods included in the regression, where we ran 24 regressions with one good deleted every time—again, this did not change any of the above conclusions. Finally, as the final two specifications do not have data for 2004, we ran the four other regressions without 2004. Results are barely different, with both the distance coefficient and the border dummy slightly larger compared to the baseline case.

4.5.3 A customs union effect? Border effects & the time dimension

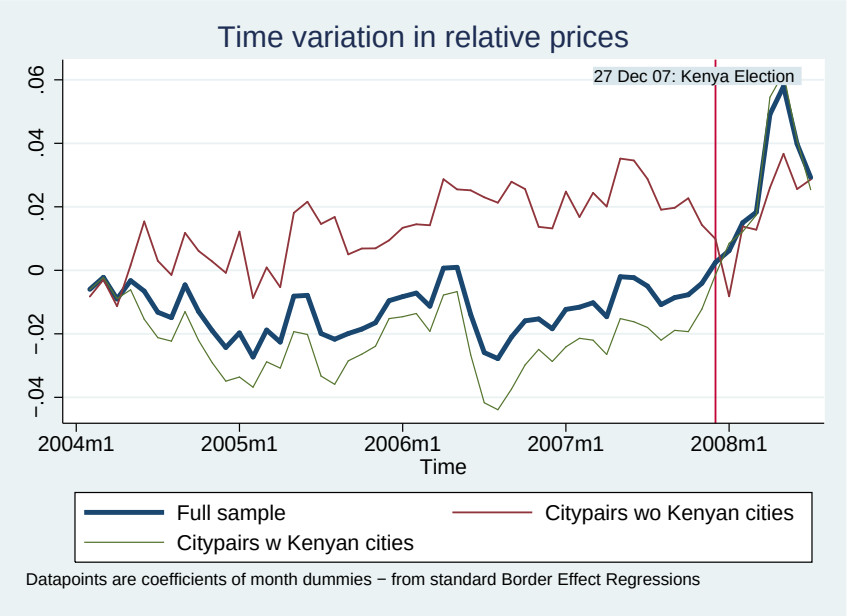
To make a start on gauging the effect of the 2008 Kenya election crisis, the last column of table 4.6 shows results for regression specification three, leaving out 2008 data. Even though all bilateral border coefficients are lower when we leave out 2008, the size of this decrease does not entice us to change much of our conclusions, with countries that are further apart still reporting the highest border effects. This is as we expect, i.e. the Kenya crisis increases the border effect[42].

The time dimension of the regression analysis is depicted in figure 4.2, which shows the time dummy coefficients from a regression based on equation (4.15)—specification six from table 4.6. We can interpret the datapoints as month-specific shocks that influence departures from the LOP but are not explained by any of the other explanatory variables.

[41] Burundi only shares a border with Rwanda and was for much of the time of the dataset still embroiled in civil war and its aftermath.

[42] As for the other 5 specifications (not reported), the border effect coefficient again goes down in all specifications compared to the baseline, on average by around 6%. However, as the distance coefficients also go down slightly, the impact on the distance equivalents is negligible.

Figure 4.2: Relative prices and the time dimension



The thick line shows the time dummy coefficients for a regression with all city-pairs in the data set included. It shows a clear increase in the size of LOP-deviations in the last year or so of the data set (roughly August-07 to April-08), with a sharp reduction in the summer of 2008. This is yet another way of showing the impact of the Kenyan elections, with the series only truly moving into 'outlier' territory from January 2008 onwards. As Kenya is a transit country for the transport of many goods into Uganda, Rwanda and Burundi, markets in those 3 countries were severely disrupted. This story holds up well when we add a graph that has time dummy coefficients for a regression which includes city-pairs of those three countries only. This graph only starts going up at the very time of the Kenyan elections. The sharp decrease at the end of our dataset coincides with a return to normalcy in Kenya[43].

With the help of table 4.7, we analyse the possible effect of the EAC Customs Union in two ways. First, we run regressions in the spirit of equation (4.15) for 2004 and then for 2007. Looking at effects by year removes possible seasonal effects. Next, we construct

[43] An alternative explanation is the world food crisis. For this to be an explanation of the pattern we are seeing, this phenomenon would need to have a differential impact on markets in different cities, which seems plausible. According to the FAO's Cereals Price Index (see www.fao.org/worldfoodsituation/FoodPricesIndex/en/), food prices starting increasing in the last quarter of 2006, accelerated in the second half of 2007, and reached a peak around May 2008, which sits well with our graphs.

Table 4.7: Looking for customs union impact

	TOTAL SAMPLE			KENYA-UGANDA citypairs only		
VARIABLES	**2004**	**2007**	**2004-2007**	**2004**	**2007**	**2004-2007**
ln Road KEN	0.0269***	0.0256***	0.0327***	0.0220***	0.0195***	0.0219***
	(0.00348)	(0.00328)	(0.00306)	(0.00329)	(0.00312)	(0.00290)
Border Dummy	0.0937***	0.136***		0.147***	0.120***	
	(0.0100)	(0.0103)		(0.0173)	(0.0176)	
Border-trend			0.00157***			-0.000242**
			(0.000122)			(0.000119)
Observations	250,356	250,356	1,001,424	97,812	97,812	391,248
R-squared	0.323	0.320	0.306	0.351	0.355	0.341
Dist. Eq. 1	33	203		798	709	
Dist. Eq. 2	82 km	510 km		1,959 km	4,733 km	

Notes: The notes to table 4.6 are still valid, with the exception that good and city-pair dummies are only used when the relevant cities/goods actually enter the regressions.

an interaction term between the border dummy and a time trend, which we call 'border-trend' and check whether this has a positive sign over the period 2004-2007. Because of the '2008' effect, I omit the seven months for which we have data in 2008.

Results seem to contradict what we would expect from the EAC Customs Union. Comparing coefficients for 2004 with 2007, the border effect coefficient goes up, with distance equivalents increasing. Similarly, the border-trend variable, estimated over the sample period 2004-2007 is positive and significant, suggesting the border effect has gotten stronger. Of course, the Customs Union agreement of 2005 was only between Uganda, Kenya and Tanzania. Hence, the final three columns of table 4.7 show estimates for the Kenya-Uganda country-pair only. Here, we do see a CU effect, with both the distance coefficient and the border coefficient diminishing between 2004 and 2007. We can expect the former also to go down with the Customs Union, as such agreements often give new impetus to cross-country infrastructure works for example. As both distance and border dummy coefficients are going down, the CU-effect does not show up in the distance equivalents. Furthermore, the border-trend variable is significant and negative, implying a reduced effect of the border over the 2004-2007 period, again what we would expect from deeper integration.

4.5.4 Border effect regressions across the four good categories

Table 4.8 shows results from running regression specifications one, four and six from table 4.6 for the four good categories. Strikingly, the border dummy is significant in all 12 regressions reported. In terms of model performance, the 'other goods' category regressions have the highest R^2, followed by the 'staples' category, which still has more than double the R^2 of the 'fruits & vegetables' category.

Looking at specification one, we can see that for food items (first three categories), the border dummy increases departures from the LOP benchmark by some 10%. This goes up to 25% for the 'other good' category. Distance drives less of a wedge between prices in different locations for 'staples' compared to the other categories, which is an indication that staple goods are more easily traded across the region. One reason is that staples are a very important part of people's diets across the region, as was shown in table 4.4, and that markets for these goods are 'deep'[44]. Because of their prominence in household food consumption, some of these staples have been subjected to market interventions, like food aid and/or government subsidies[45]. Distance could then play less of a role in far-off areas, if these areas get relatively higher subsidies or more food aid. Such interventions are much less common for fruits or vegetables. Another reason for the relatively higher distance coefficient for the latter compared to staples is that they are perishable. So, even though regional trade in 'fruits & vegetables' is well-documented[46], according to this estimation, these goods have less integrated markets compared to staple foods both across (border dummy coefficient) and within (distance coefficient) countries.

[44] von Cramon-Taubadel et al. (2009), exploiting more the time series dimension of the data, find maize markets to be well integrated between Ugandan and Kenyan cities, but less so with Tanzania. Distance has a significant effect on the strength of the price transmission within the EAC region. Another study by the University of Michigan similarly find the maize markets in Eastern and Southern African well integrated, even though Govereh et al. (2008) and Haggblade et al. (2008) claim that further regional integration and cooperation would help improve market functioning.

[45] Even though the countries we study proclaim a policy of non-intervention and market-driven price determination, this is not always implemented uniformly. See for example the Kenya and Uganda country chapters in Anderson and Masters (2009). For the maize market in Kenya, Govereh et al. (2008) find that *Kenyan maize policy in recent decades has involved supporting high prices for farmers through high government procurement prices*.

[46] See for example Bank of Uganda and UBOS (2007) for informal trade related to Uganda's borders.

Table 4.8: Border effect regressions for good categories

	STAPLE FOOD (5 items)			**FRUITS & VEGETABLES (7 items)**		
VARIABLES	Specific. 1	Specific. 4	Specific. 6	Specific. 1	Specific. 4	Specific. 6
ln Road KEN	0.0148***	0.0154***	0.0163***	0.0360***	0.0309***	0.0306***
	(0.00456)	(0.00465)	(0.00457)	(0.00601)	(0.00617)	(0.00608)
Border Dummy	0.101***	0.0923***	0.0879***	0.0804***	0.153***	0.208***
	(0.0138)	(0.0151)	(0.0211)	(0.0182)	(0.0204)	(0.0262)
Nominal Exchange Rate		-0.00355	-0.00443		0.0307***	0.0316***
		(0.00276)	(0.00279)		(0.00451)	(0.00452)
Doing Business			0.000122			-0.00103***
			(0.000272)			(0.000242)
Observations	238,535	238,535	186,491	358,160	358,160	280,016
R-squared	0.442	0.442	0.445	0.194	0.197	0.199
Dist. Eq. 1	920	401	220	9	141	896
Dist. Eq. 2	2,316 km	1,009 km	553 km	23 km	356 km	2,254 km

	OTHER FOOD (6 items)			**OTHER GOODS (6 items)**		
VARIABLES	Specific. 1	Specific. 4	Specific. 6	Specific. 1	Specific. 4	Specific. 6
ln Road KEN	0.0242***	0.0197***	0.0195***	0.0376***	0.0327***	0.0343***
	(0.00268)	(0.00259)	(0.00261)	(0.00360)	(0.00344)	(0.00357)
Border Dummy	0.109***	0.171***	0.0655***	0.252***	0.317***	0.310***
	(0.0110)	(0.0132)	(0.0186)	(0.0159)	(0.0154)	(0.0192)
Nominal Exchange Rate		0.0261***	0.0262***		0.0254***	0.0275***
		(0.00296)	(0.00303)		(0.00271)	(0.00287)
Doing Business			0.00203***			0.00112***
			(0.000179)			(0.000210)
Observations	288,530	288,530	225,578	262,240	262,240	205,024
R-squared	0.342	0.346	0.340	0.448	0.451	0.460
Dist. Eq. 1	90	5,885	29	814	16,223	8,416
Dist. Eq. 2	228 km	14,813 km	72 km	2,049 km	40,833 km	21,183 km

Notes: The notes to table 4.6 are still valid, with the exception that good dummies are only used when the relevant goods actually enter the above regressions. The dependent variable is still the absolute value of the log of good relative prices (=LHS of equation 4.15).

Neither the nominal exchange rate, nor the doing business indicator seems to have much of an impact on the border effect—similar to the pooled regression. Interestingly, neither of these two indicators is even significant in the staples regression. This points to very high pass-through of the nominal exchange rate, and NTBs not playing a large role when it comes to trading these goods across borders. This is in line with our discussion of NTBs in section 1.3.3, where the NTBs seemed to be concentrated in non-staple food sectors. The exchange rate result sits rather well with the Engel (1993) finding for industrialised countries that for most goods there are significant deviations from the LOP at the consumer level, with the exception of 'pure' commodities (as opposed to more complex consumer products)[47].

All this points to well-integrated and well-functioning regional markets for staples. We corroborate this by running regression specifications one and four for the five individual goods making up the 'staples' category (results not reported here). We find that the border dummy is not significantly different from zero for sweet potatoes and maize flour and negatively significant for maize grains. These results confirm the evidence gathered in the recent crop-based work on the regional maize market in Eastern and Southern Africa[48].

The category 'other goods' has the highest border effects, which fits well with our prior that these goods are less traded across borders. However, if we run regressions for the goods in this category separately, we can see that this effect is mainly due to 'domestique' (household services), and 'charcoal', which has the highest border coefficient of all goods. For the latter, this is probably related to repeated production and export bans and other policy interventions in EAC countries to combat deforestation and other charcoal-related environmental damage[49]. The results for the other goods in this category, like

[47] It reasonable to assume that staples are more like a 'pure' commodity than the goods in the other categories. Engel and Rogers (2001) find evidence for this hypothesis in a dataset spanning 11 European countries.

[48] See the references mentioned in footnote 44 in this chapter.

[49] For Kenya, see e.g. ban on moving charcoal from Turkana (http://allafrica.com/stories/200605110704.html), whilst in Rwanda charcoal trade is linked to rebel activity in the DRC which the Government is cracking down on (http://allafrica.com/stories/200708201143.html).

cigarettes, petrol, beer and soda are similar to those for the food items. This is not unsurprising in the light of more anecdotal evidence on trade flows for these goods in the region (see section (4.3.2) for a reference). The high border dummy coefficient for the 'other goods' category translates into high distance equivalents. For the other three categories, distance equivalents are much lower however and in line with the pooled regression results. Note that the very low results for this indicator for 'fruits & vegetables' is more due to the high distance coefficient, rather than a low border coefficient.

4.5.5 The nominal exchange rate and pass-through

The four papers mentioned above that use the level-specification to look at border effects do not use the nominal exchange rate when trying to explain long-run departures from the LOP. The ER-literature typically adds the standard deviation of the first difference of the log nominal exchange rate as a regressor to equation (4.10). Engel and Rogers (2001) for example look at European cities and find their nominal exchange rate variation coefficient to be close to one. This implies that the nominal exchange rate tracks the real exchange rate quite closely, or:

$$st.\,dev.\left(ln\,\frac{P_{uct}}{E_{cc't}*P_{uc't}}-ln\,\frac{P_{uct-1}}{E_{cc't-1}*P_{uc't-1}}\right)\simeq st.\,dev.\,(ln\,E_{cc't}-ln\,E_{cc't-1}) \quad (4.16)$$

ER interpret this as evidence for local currency pricing with sticky prices, with the nominal exchange rate inclusion reducing the border effect. Importantly, the ER-set up does not allow for isolating the $E_{cc't}$ term on the right hand side (RHS) as we do in equation (4.8), because we cannot take the $E_{cc't}$ term out of a standard deviation expression easily. In the ER context, standard deviations of the first differences of real and nominal exchange rates moving together does not need to imply sticky prices, as expression (4.16) makes clear. Indeed, all we need is for the non-exchange rate component of the real exchange rate to remain constant, which could happen for a number of reasons, only one of

Table 4.9: The role of the nominal exchange rate

VARIABLES	Specific. A	Specific. B	Specific. C
ln Road KEN	0.0251***	0.0169***	0.0171***
	(0.00315)	(0.00351)	(0.00343)
Border Dummy	0.186***	0.153***	0.271***
	(0.00983)	(0.0543)	(0.0583)
Nominal Exchange Rate (overall)	0.0202***		
	(0.00214)		
Nominal Exchange Rate (BUR-KEN)		0.276***	0.334***
		(0.0194)	(0.0221)
Nominal Exchange Rate (BUR-RWA)		0.0474	-0.0652
		(0.0426)	(0.0413)
Nominal Exchange Rate (BUR-UGA)		0.0828**	0.0236
		(0.0357)	(0.0367)
Nominal Exchange Rate (KEN-RWA)		-0.319***	-0.380***
		(0.0213)	(0.0234)
Nominal Exchange Rate (KEN-UGA)		-0.145***	-0.216***
		(0.0150)	(0.0165)
Nominal Exchange Rate (RWA-UGA)		0.0985**	0.100**
		(0.0388)	(0.0443)
Doing Business			0.000142***
			(0)
Observations	1,147,465	1,147,465	897,109
R-squared	0.317	0.320	0.322

Notes: The notes to table 4.6 are still valid.

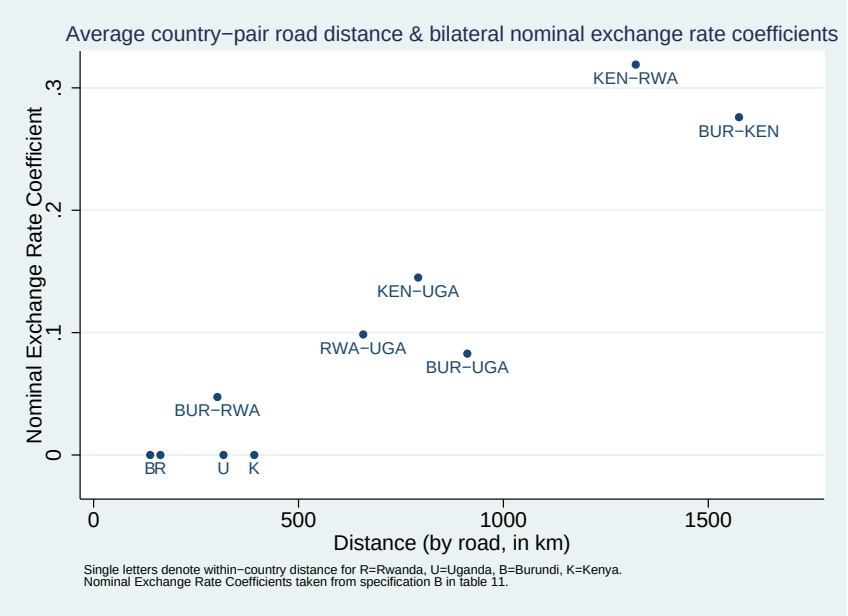
these being sticky prices[50]. I.e. it is not necessary for the individual components of the LHS of (4.16) to exhibit high persistence (which is what sticky prices mean) to have high correlations between nominal and real exchange rate dispersion.

In our own levels-specification, if θ_4 from equation (4.15) is zero, then this implies that the LOP hypothesis holds perfectly (conditional on no other sources of LOP violations). Hence, our own result from section 4.5.2, which showed the coefficient on the nominal exchange rate to be 0.02 implies a high pass-through from foreign to domestic prices. This result is reproduced in the first column of table 4.9. This result sits well with the Engel-Rogers finding that border dummy coefficient not being reduced by including the nominal exchange rate as a regressor. In other words, we do not find much evidence of local currency pricing in our Eastern Africa price data.

The second column in table 4.9 allows for different nominal exchange rate effects by

[50]One such possibility would be prices being very flexible both abroad and domestically, and tracking each other one-for-one; the very opposite of sticky prices!

Figure 4.3: Distance and bilateral nominal exchange rate coefficients



country pair. Figure 4.3 shows graphically the positive relation between distance and the nominal exchange rate pass-through coefficient. Unsurprisingly, the highest coefficients are for the bilateral pairs geographically furthest from each other, notably Kenya-Burundi and Kenya-Rwanda. These coefficients are quite high (around 0.3), much higher than the 0.02 of the aggregate coefficient. The Burundi-Rwanda coefficient is not significantly different from zero at the 10% level, whilst the Uganda-Rwanda one is not significantly different from zero at the 1% level. For these two country-pairs, it seems pass-through is very high. Similarly, the coefficient for the Burundi-Uganda pair is not significant at the 1% level. These findings corroborate the conventional wisdom that passthrough is relatively rapid and complete in countries that are small and/or less developed (Frankel et al., 2005, p1) and is counter-evidence for the claim by the same authors that the pass-through recently has decreased in developing countries.

4.6 Conclusion

This chapter investigated the behaviour of consumer prices across Eastern Africa between 2003 and 2008, a period in which, through the start of the Customs Union, market inte-

gration was supposed to be accelerating. Using level regressions to test the law-of-one price hypothesis, we find that the border effect is significant, with distance equivalents ranging from 300 to 6,000 km. This is much lower than in the papers using the Engel-Rogers regression specifications, but in line with the (few) papers using real exchange rate level regressions (as we do). We also find that cities that are in countries that do not share a border show higher departures from LOP compared to cities in adjacent countries. Distance plays a big role, both between and within countries. Surprisingly, neither the nominal exchange rate, nor Non-Tariff Barriers seem to reduce the border effect very much, even though they are both significant variables in the regression analysis. One reason for the latter might be that NTBs are not well measured. Looking at specific goods, we corroborate earlier findings that markets for staple foods are well integrated. We finally research whether the start of the customs union between Tanzania, Uganda and Kenya has shown a reduction in the deviations to the LOP. We find that there is a positive effect for the Kenya-Uganda border, but that the benefits in terms of price co-movements have not extended to Rwanda or Burundi. Further, the Kenya crisis of early 2008 can clearly be linked to higher departures from the LOP throughout the region.

This chapter is part of a larger research agenda regarding the behaviour of consumer prices in Eastern Africa. Little is known about the real and nominal aspects of good-city-time series like the ones researched in this paper for developing countries. Our finding that a border dummy plays a significant role in explaining real exchange rates, shows more work needs to be done in this field. Particularly interesting for future work would be to test alternative specifications to our log-linear framework and look at whether a linear specification capturing per-unit transport costs would be a better fit. Another promising avenue for future research seems to be to understand what drives the time variation in the price data (see figure 4.2 and the discussion in section 4.5.3), and especially the 2008 developments, involving the international food price shock and the Kenyan crisis. It would also be interesting to take a closer look at what factors drive the divergence and convergence between relative price series and nominal exchange rates. We have hinted that the nominal exchange rate pass-through is high in the region, which lends credibility

to the characterisation of these developing countries as small open economies. The fact that the pass-through was found to be lower for city-pairs that include a Kenyan city strengthens this hypothesis, as Kenya is the largest economy in the region. These issues will come increasingly to the fore with the prospect of Monetary Union. In that respect it will be crucial for EAC member states to improve on the comparability of inflation statistics, which will allow more systematic research on pricing in the region.

This chapter has analysed whether different types of trade costs, like distance, borders, NTBs or the exchange rate, explain departures from the law of one price benchmark for consumer prices in 36 cities in eastern Africa. Hence, we have assessed empirically the trade costs we assumed existed in chapters two and three. Through our 'incremental' dummy variable, which measures the impact on prices of crossing more than one border, and the analysis of the Kenyan crisis, we also touched on the importance (in terms of trade costs) of countries in the region being landlocked.

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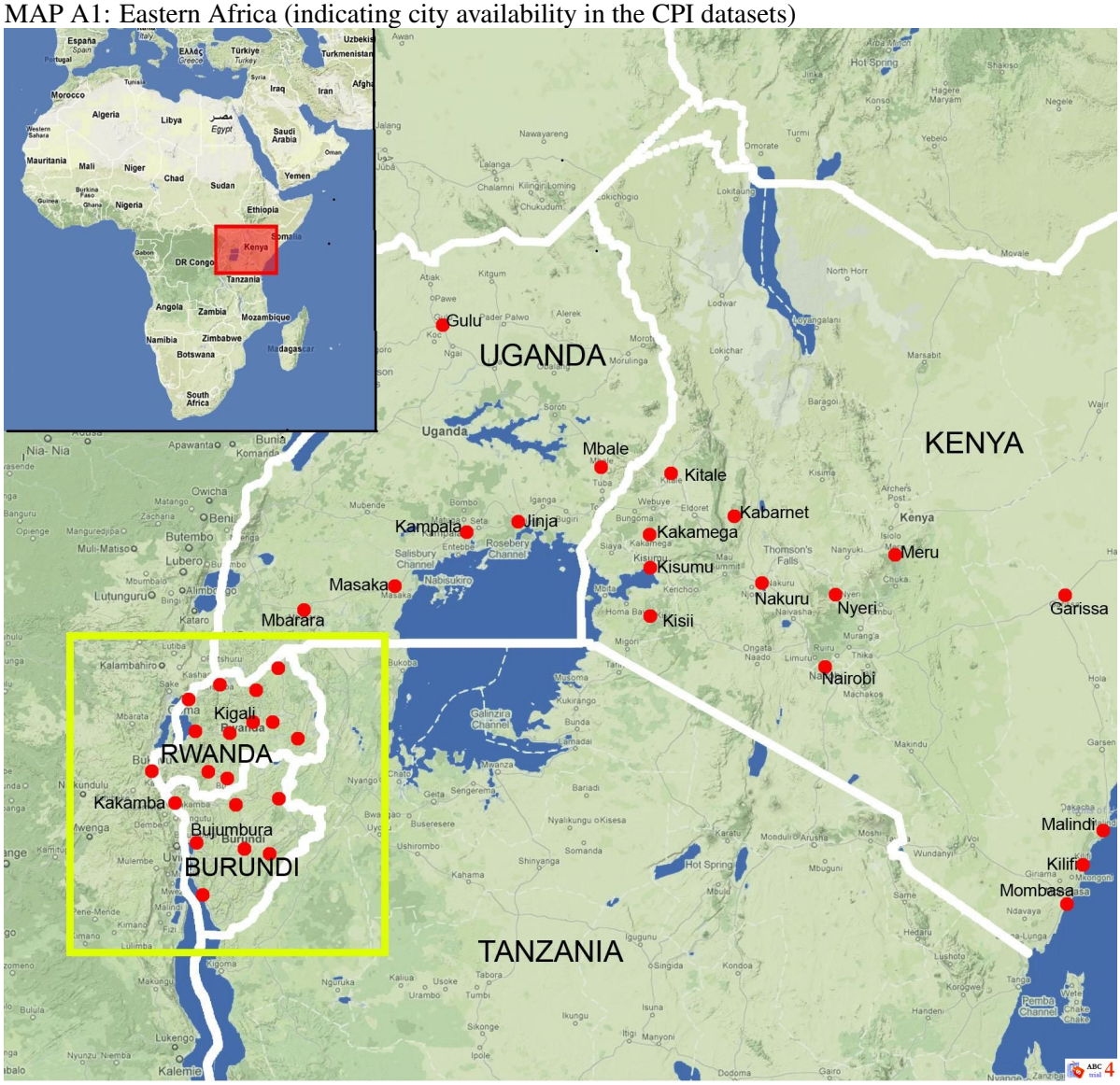
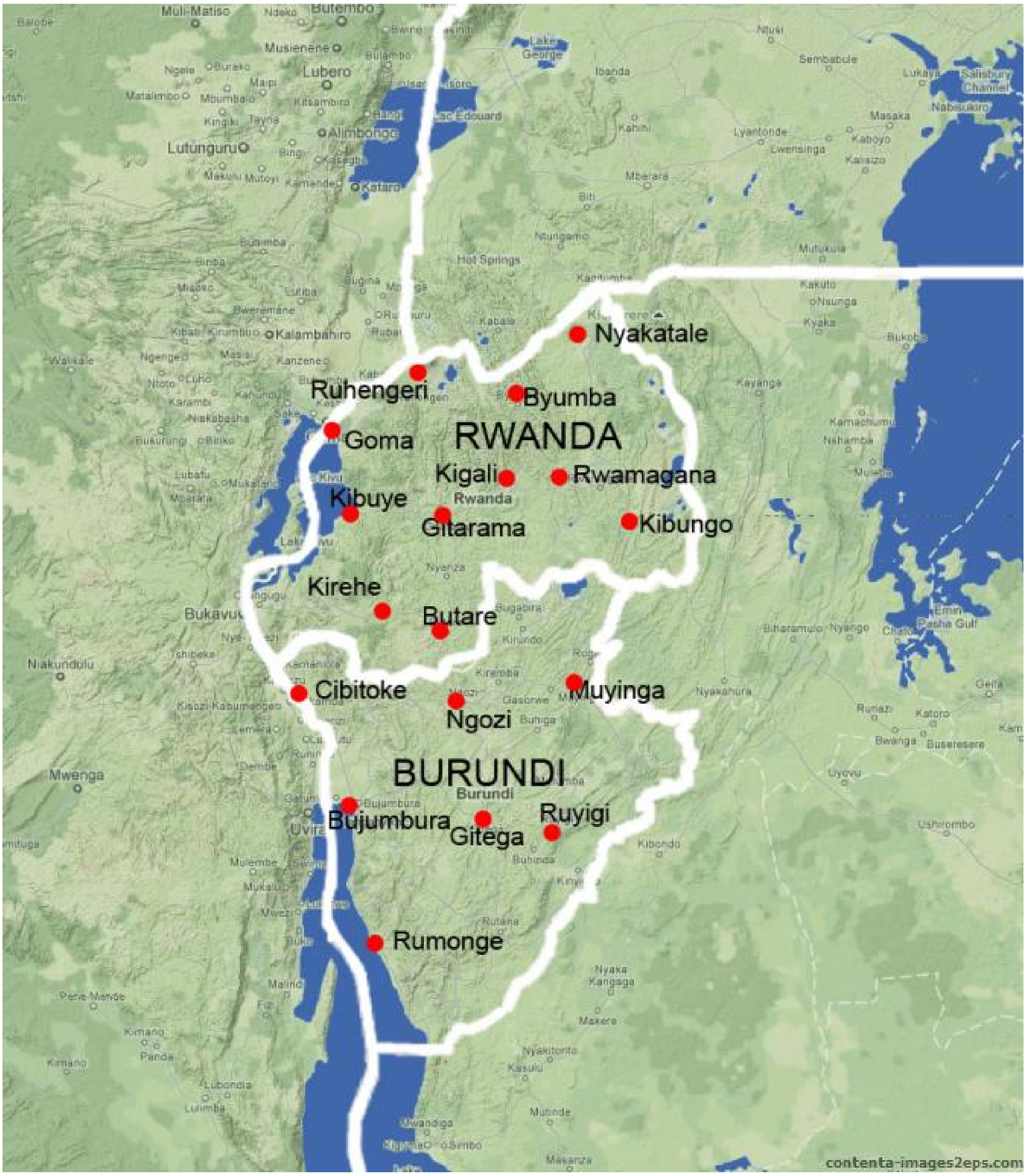
Appendix A

Maps

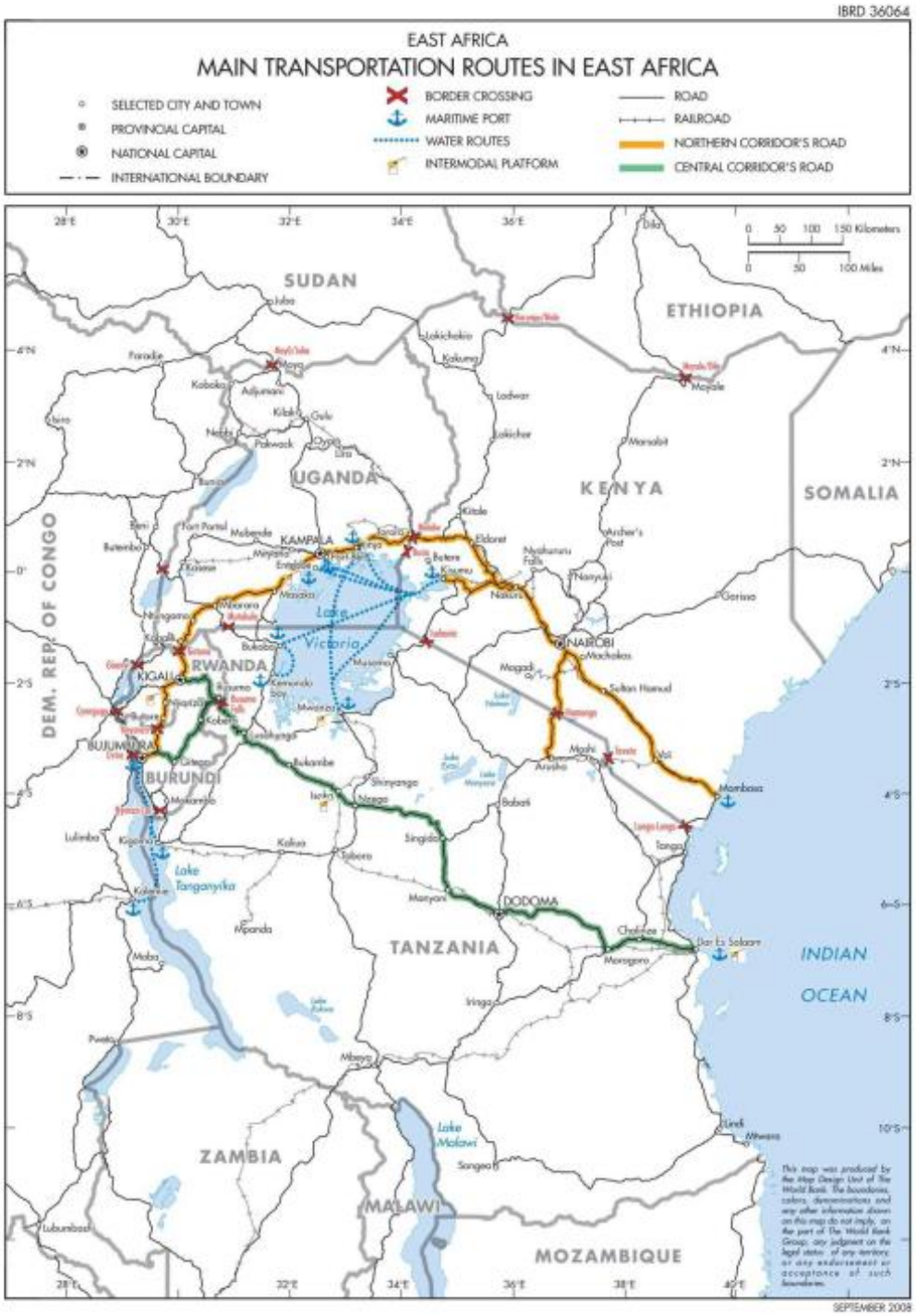
MAP A1: Eastern Africa (indicating city availability in the CPI datasets)



MAP A2: Rwanda and Burundi (indicating city availability in the CPI datasets)



MAP A3: Northern and Central Corridors



Appendix B

Solving for dq, dU and du

The three main model equations (2.16), (2.17) and (2.19) can be written more simply as follows:

$$\widetilde{E}_q dq + \widetilde{E}_U dU = \alpha dA + \widetilde{E}_q d\tau + \widetilde{E}_q \psi' dG \tag{B.1}$$

$$(-\widetilde{E}_q - \tau \widetilde{e}_{qq}) dq + (1 - \tau D_q)\widetilde{e}_u du = (1-\alpha) dA - \widetilde{E}_q d\tau \tag{B.2}$$

$$-S dq + D_q \widetilde{E}_U dU + D_q \widetilde{e}_u du = \widetilde{E}_{qq} d\tau + \widetilde{E}_{qq} \psi' dG \tag{B.3}$$

We start by solving for the **relative price** dq. Isolating dU from equation (B.1) and du from (B.2), and substituting these into (B.3), we get:

$$\begin{aligned} -S dq + D_q \widetilde{E}_U \Big[\frac{-\widetilde{E}_q dq + \widetilde{E}_q d\tau + \alpha dA + \widetilde{E}_q \psi' dG}{\widetilde{E}_U} \Big] + \\ D_q \widetilde{e}_u \Big[\frac{(\widetilde{E}_q + \tau \widetilde{e}_{qq}) dq + (1-\alpha) dA - \widetilde{E}_q d\tau}{(1 - \tau D_q)\widetilde{e}_u} \Big] = \widetilde{E}_{qq} d\tau + \widetilde{E}_{qq} \psi' dG \end{aligned} \tag{B.4}$$

Collecting terms:

$$\Big[-S - D_q\widetilde{E}_q + \frac{D_q(\widetilde{E}_q + \tau\widetilde{e}_{qq})}{1-\tau D_q}\Big]dq = \Big[\widetilde{E}_{qq} - D_q\widetilde{E}_q + \frac{D_q\widetilde{E}_q}{1-\tau D_q}\Big]d\tau + \Big[(\widetilde{E}_{qq} - D_q\widetilde{E}_q)\psi'\Big]dG - \Big[\alpha D_q + \frac{(1-\alpha)D_q}{1-\tau D_q}\Big]dA \quad \text{(B.5)}$$

Using the definition of S, remembering that $\widetilde{e}_q = -\widetilde{E}_q$ and multiplying both LHS and RHS by $1-\tau D_q$, this simplifies to equation (2.21) in the main text.

Next, we look at welfare at the national level, i.e. solving out for du and dU. Starting with **welfare in the importing country, Uganda** (du), we first isolate dU from equation (B.1), and substitute it into equation (B.3), to get:

$$-Sdq + D_q\Big[\alpha dA + \widetilde{E}_q d\tau + \widetilde{E}_q\psi' dG - \widetilde{E}_q dq\Big] + D_q\widetilde{e}_u du = \widetilde{E}_{qq}d\tau + \widetilde{E}_{qq}\psi' dG \quad \text{(B.6)}$$

Collecting terms gets us:

$$\begin{aligned}&(-S - \widetilde{E}_q D_q)dq + D_q\widetilde{e}_u du = \\ &\quad (\widetilde{E}_{qq} - \widetilde{E}_q D_q)d\tau + [(\widetilde{E}_{qq} - \widetilde{E}_q D_q)\psi']dG - (\alpha D_q)dA \quad \text{(B.7)}\end{aligned}$$

We now isolate dq from equation (B.2), and substitute into expression (B.7):

$$\begin{aligned}&(-S - \widetilde{E}_q D_q)\Big[\frac{-(1-\alpha)dA + \widetilde{E}_q d\tau + (1-\tau D_q)\widetilde{e}_u du}{\widetilde{E}_q + \tau\widetilde{e}_{qq}}\Big] + D_q\widetilde{e}_u du = \\ &\quad (\widetilde{E}_{qq} - \widetilde{E}_q D_q)d\tau + [(\widetilde{E}_{qq} - \widetilde{E}_q D_q)\psi']dG - (\alpha D_q)dA \quad \text{(B.8)}\end{aligned}$$

Collecting terms, we get:

$$\Big[D_q + \frac{(-S - \widetilde{E}_q D_q)(1-\tau D_q)}{\widetilde{E}_q + \tau\widetilde{e}_{qq}}\Big]\widetilde{e}_u du = \Big[\widetilde{E}_{qq} - \widetilde{E}_q D_q + \Big(\frac{S + \widetilde{E}_q D_q}{\widetilde{E}_q + \tau\widetilde{e}_{qq}}\Big)\widetilde{E}_q\Big]d\tau + \Big[(\widetilde{E}_{qq} - \widetilde{E}_q D_q)\psi'\Big]dG - \Big[\alpha D_q + (1-\alpha)\Big(\frac{S + \widetilde{E}_q D_q}{\widetilde{E}_q + \tau\widetilde{e}_{qq}}\Big)\Big]dA \quad \text{(B.9)}$$

And finally, we multiply through by $-\widetilde{E}_q - \tau\widetilde{e}_{qq}$, to get equation (2.26) in the main text.

What about **welfare in the exporting country, Kenya** (the dU term)? we first isolate du from equation (B.2), and substitute it into equation (B.3), to get:

$$-Sdq + D_q\widetilde{E}_U dU + \frac{D_q}{1-\tau D_q}\Big[(1-\alpha)dA - \widetilde{E}_q d\tau + (\widetilde{E}_q + \tau\widetilde{e}_{qq})dq\Big] = \widetilde{E}_{qq}d\tau + \widetilde{E}_{qq}\psi' dG \quad \text{(B.10)}$$

Collecting terms, gets us:

$$\Big[-S + D_q\frac{(\widetilde{E}_q + \tau\widetilde{e}_{qq})}{1-\tau D_q}\Big]dq + D_q\widetilde{E}_U dU = \Big[\widetilde{E}_{qq} + \frac{\widetilde{E}_q D_q}{1-\tau D_q}\Big]d\tau + \Big[\widetilde{E}_{qq}\psi'\Big]dG - \Big[\frac{(1-\alpha)D_q}{1-\tau D_q}\Big]dA \quad \text{(B.11)}$$

We now isolate dq from equation (B.1), and substitute into expression (B.11):

$$\Big[-S + D_q\frac{(\widetilde{E}_q + \tau\widetilde{e}_{qq})}{1-\tau D_q}\Big]\Big[\frac{\alpha dA + \widetilde{E}_q d\tau + \widetilde{E}_q\psi' dG - \widetilde{E}_U dU}{\widetilde{E}_q}\Big] + D_q\widetilde{E}_U dU = \Big[\widetilde{E}_{qq} + \frac{\widetilde{E}_q D_q}{1-\tau D_q}\Big]d\tau + \Big[\widetilde{E}_{qq}\psi'\Big]dG - \Big[\frac{(1-\alpha)D_q}{1-\tau D_q}\Big]dA \quad \text{(B.12)}$$

And collecting terms:

$$\Big[D_q + \frac{S}{\widetilde{E}_q} - \frac{D_q(\widetilde{E}_q + \tau\widetilde{e}_{qq})}{\widetilde{E}_q(1-\tau D_q)}\Big]\widetilde{E}_U dU = \Big[\widetilde{E}_{qq} + \frac{\widetilde{E}_q D_q}{1-\tau D_q} + S - D_q\frac{\widetilde{E}_q + \tau\widetilde{e}_{qq}}{1-\tau D_q}\Big]d\tau + \Big[\Big(\widetilde{E}_{qq} + S - D_q\frac{\widetilde{E}_q + \tau\widetilde{e}_{qq}}{1-\tau D_q}\Big)\psi'\Big]dG - \Big[\frac{(1-\alpha)D_q}{1-\tau D_q} - \frac{\alpha}{\widetilde{E}_q}\Big(S - D_q\frac{\widetilde{E}_q + \tau\widetilde{e}_{qq}}{1-\tau D_q}\Big)\Big]dA \quad \text{(B.13)}$$

Finally, to get equation (2.27), we multiply through by $\widetilde{E}_q(1-\tau D_q)$.

Appendix C

Equation and variable list for the CGE

C.1 List of model equations

C.1.1 Price block

We start with the price equations for internationally tradable goods. Throughout we are using only one exchange rate, which is the exchange rate of Kenyan shillings per USD. Hence, the use of EXR_{ken}. This is a consequence of only looking at the real side of the economy, with exchange rates only playing a conversion role[1].

$$PMW_{im,r} = pwmw_{im,r} * (1 + tmw_{im,r}) * EXR_{ken} \tag{C.1}$$

$$PEW_{ix,r} = pwew_{ix,r} * EXR_{ken} \tag{C.2}$$

[1]Note that world prices $pwmw$ and $pwew$, which are in USD need to be the same in both countries, as these world prices are considered fixed. This equality will be used in the calibration. In the equations below, a country subscript is nevertheless included as this will be needed in GAMS to make sure dimensions within the equation are not conflicting.

As for the goods only tradable within the region, prices are fully endogenously determined within the model, with rr indicating a different country than country[2] r:

$$PMR_{rm,r} = PER_{rx,rr} * (1 + tmr_{rm,r}) \tag{C.3}$$

We can write the following accounting identities as the equivalents of cost functions, as Constant Elasticity of Substitution and Transformation aggregation functions are linearly homogenous and the first order conditions (FOC's) will be incorporated in the import demand and export supply functions below. The following four equations give us expressions for the price of the level one and two Constant Elasticity of Substitution composite goods, and the price of level one and two Constant Elasticity of Transformation composite good.

$$PQ_{ic,r} = \frac{(PQL_{ic,r} * QL_{ic,r}) + (PMW_{ic,r} * MW_{ic,r})}{Q_{ic,r}} \tag{C.4}$$

$$PQL_{ic,r} = \frac{(PD_{ic,r} * D_{ic,r}) + (PMR_{ic,r} * MR_{ic,r})}{QL_{ic,r}} \tag{C.5}$$

$$PX_{i,r} = \frac{(PXL_{i,r} * XL_{i,r}) + (PEW_{i,r} * EW_{i,r})}{X_{i,r}} \tag{C.6}$$

$$PXL_{i,r} = \frac{(PD_{i,r} * D_{i,r}) + (PER_{i,r} * ER_{i,r})}{XL_{i,r}} \tag{C.7}$$

Next, we look at the labour market. The composite labour price is:

$$PL_{i,r} = \frac{\sum_{lc} wdist_{i,lc,r} * LS_{i,lc,r} * WA_{lc,r}}{CL_{i,r}} \tag{C.8}$$

For the next two prices, we need the capital composition matrix $IMAT_{ij,r}$ and the input-output matrix $IO_{ij,r}$ to calculate value added prices and capital good prices.

$$PVA_{i,r} = PX_{i,r} - \sum_{j} IO_{ji,r} * PQ_{j,r} \tag{C.9}$$

$$PK_{i,r} = \sum_{jp} PQ_{jp,r} * IMAT_{jp,i,r} \tag{C.10}$$

[2]No need here for adapting to a common exchange rate, as at this stage we already have converted all prices into Kenyan Shilling.

The final three prices in this section are definitions for the GDP deflator, the Producer Price Index (PPI) and the Consumer Price Index (CPI)[3].

$$PGDP_r = GDPVA_r / RGDP_r \tag{C.11}$$

$$PPI_r = \sum_i WP_{i,r} * PX_{i,r} \tag{C.12}$$

$$CPI_r = \sum_i WC_{i,r} * PQ_{i,r} \tag{C.13}$$

C.1.2 Output and factor demands

The production function is Cobb Douglas in land (LAND), labour (CL) and capital (KP). The national public capital stock for infrastructure KG does not have a sectoral subscript, but its effect can differ across sectors through the parameter $\lambda kg_{i,r}$. Same for the regional public capital stock for infrastructure KR. In an accounting sense, the latter is listed in Kenya's SAM, even though it figures in both Uganda's and Kenya's production function.

$$X_{i,ken} = AP_{i,ken} * (LAND_{i,ken}^{\lambda n_{i,ken}} CL_{i,ken}^{\lambda l_{i,ken}} KP_{i,ken}^{\lambda k_{i,ken}}) * KG_{ken}^{\lambda kg_{i,ken}} * KR_{ken}^{\lambda kr_{i,ken}} \tag{C.14}$$

$$X_{i,uga} = AP_{i,uga} * (LAND_{i,uga}^{\lambda n_{i,uga}} CL_{i,uga}^{\lambda l_{i,uga}} KP_{i,uga}^{\lambda k_{i,uga}}) * KG_{uga}^{\lambda kg_{i,uga}} * KR_{ken}^{\lambda kr_{i,uga}} \tag{C.15}$$

The first order conditions for factor markets:

$$CL_{i,r} * PL_{i,r} = \lambda l_{i,r} * X_{i,r} * PVA_{i,r} \tag{C.16}$$

$$RS_{i,r} = \lambda n_{i,r} * X_{i,r} * PVA_{i,r} \tag{C.17}$$

[3]The weights for the PPI_r and CPI_r are defined as follows: $WP_{i,r} = \frac{X_{i,r}}{\sum_j X_{j,r}}$ and $WC_{i,r} = \frac{\sum_{hh} CD_{i,hh,r}}{CDMTOT_r}$, with $CDMTOT_r$ total household consumption.

$$RK_{i,r} = (X_{i,r} * PVA_{i,r}) - RS_{i,r} - (PL_{i,r} * CL_{i,r}) \tag{C.18}$$

Next, we have the labour composite good (aggregator) and accompanying first order condition. Because the food sector does not employ skilled labour, the following two equations are for all sectors but food. Equation (C.21) then determines $CL_{foo,r}$

$$CL_{inf,r} = B_{inf,r}\Big[\omega_{inf,r}(LS_{inf,unsk,r})^{\frac{\sigma l_{inf,r}-1}{\sigma l_{inf,r}}} + (1-\omega_{inf,r})(LS_{inf,sk,r})^{\frac{\sigma l_{inf,r}-1}{\sigma l_{inf,r}}}\Big]^{\frac{\sigma l_{inf,r}}{\sigma l_{inf,r}-1}} \tag{C.19}$$

$$\frac{LS_{inf,unsk,r}}{LS_{inf,sk,r}} = \left[\frac{\omega_{inf,r} * wdist_{inf,sk,r} * WA_{sk,r}}{(1-\omega_{inf,r}) * wdist_{inf,unsk,r} * WA_{unsk,r}}\right]^{\sigma l_{inf,r}} \tag{C.20}$$

$$CL_{foo,r} = \sum_{lc} LS_{lc,foo,r} \tag{C.21}$$

Supply equations (first and second level Constant Elasticity of Transformation composite goods + first order conditions)

$$X_{ix,r} = AT1_{ix,r}\Big[\alpha_{ix,r}(XL_{ix,r})^{\frac{1+\sigma 1_{ix,r}}{\sigma 1_{ix,r}}} + (1-\alpha_{ix,r})(EW_{ix,r})^{\frac{1+\sigma 1_{ix,r}}{\sigma 1_{ix,r}}}\Big]^{\frac{\sigma 1_{ix,r}}{1+\sigma 1_{ix,r}}} \tag{C.22}$$

$$\frac{EW_{ix,r}}{XL_{ix,r}} = \left[\frac{PEW_{ix,r}\alpha_{ix,r}}{PXL_{ix,r}(1-\alpha_{ix,r})}\right]^{\sigma 1_{ix,r}} \tag{C.23}$$

$$XL_{rx,r} = AT2_{rx,r}\Big[\beta_{rx,r}(D_{rx,r})^{\frac{1+\sigma 2_{rx,r}}{\sigma 2_{rx,r}}} + (1-\beta_{rx,r})(ER_{rx,r})^{\frac{1+\sigma 2_{rx,r}}{\sigma 2_{rx,r}}}\Big]^{\frac{\sigma 2_{rx,r}}{1+\sigma 2_{rx,r}}} \tag{C.24}$$

$$\frac{ER_{rx,r}}{D_{rx,r}} = \left[\frac{PER_{rx,r}\beta_{rx,r}}{PD_{rx,r}(1-\beta_{rx,r})}\right]^{\sigma 2_{rx,r}} \tag{C.25}$$

For the non-exportable sectors—internationally, respectively regionally, we get:

$$X_{nix,r} = XL_{nix,r} \tag{C.26}$$

$$XL_{nrx,r} = D_{nrx,r} \tag{C.27}$$

Demand equations (first and second level Constant Elasticity of Substitution composite goods + first order conditions)

$$Q_{im,r} = AC1_{im,r}\Big[\gamma_{im,r}(QL_{im,r})^{\frac{\sigma 3_{im,r}-1}{\sigma 3_{im,r}}} + (1-\gamma_{im,r})(MW_{im,r})^{\frac{\sigma 3_{im,r}-1}{\sigma 3_{im,r}}}\Big]^{\frac{\sigma 3_{im,r}}{\sigma 3_{im,r}-1}} \tag{C.28}$$

$$\frac{MW_{im,r}}{QL_{im,r}} = \left[\frac{PQL_{im,r}(1-\gamma_{im,r})}{PMW_{im,r}\gamma_{im,r}}\right]^{\sigma 3_{im,r}} \tag{C.29}$$

$$QL_{rm,r} = AC2_{rm,r}\Big[\delta_{rm,r}(D_{rm,r})^{\frac{\sigma 4_{rm,r}-1}{\sigma 4_{rm,r}}} + (1-\delta_{rm,r})(MR_{rm,r})^{\frac{\sigma 4_{rm,r}-1}{\sigma 4_{rm,r}}}\Big]^{\frac{\sigma 4_{rm,r}}{\sigma 4_{rm,r}-1}} \tag{C.30}$$

$$\frac{MR_{rm,r}}{D_{rm,r}} = \left[\frac{PD_{rm,r}(1-\delta_{rm,r})}{PMR_{rm,r}\delta_{rm,r}}\right]^{\sigma 4_{rm,r}} \tag{C.31}$$

For the non-importable sectors—internationally, respectively regionally:

$$Q_{nim,r} = QL_{nim,r} \tag{C.32}$$

$$QL_{nrm,r} = D_{nrm,r} \tag{C.33}$$

And finally production of goods produced and consumed by the government sector:

$$X_{pub,r} = GD_{pub,r} \tag{C.34}$$

C.1.3 Demand and income block

Intermediate goods demand:

$$ND_{i,r} = \sum_{j} IO_{ij,r} * X_{j,r} \tag{C.35}$$

Demand is governed by an LES/CES (Linear Expenditure System) and there are no indirect taxes:

$$CD_{ic,hh,r} * PQ_{ic,r} = \left[\frac{PQ_{ic,r}^{1-\sigma c_r} * CLES_{ic,hh,r}^{\sigma c_r}}{\sum_{jc} PQ_{jc,r}^{1-\sigma c_r} * CLES_{jc,hh,r}^{\sigma c_r}} * \Big((1-MPS_{hh,r})YD_{hh,r} - \sum_{jc} PQ_{jc,r} * CBASE_{jc,hh,r}\Big)\right] + \Big[CBASE_{ic,hh,r} * PQ_{ic,r}\Big] \tag{C.36}$$

The marginal budget share $CLES$ in the linear expenditure system is:

$$CLES_{ic,hh,r} = PQ_{ic,r} * \left[\frac{CD_{ic,hh,r} - CBASE_{ic,hh,r}}{CDMTOT_r - \sum_{jc} PQ_{jc,r} * CBASE_{jc,hh,r}}\right]^{\frac{1}{\sigma c_r}}$$

GDP at factor cost (measured at value added) and real GDP at factor cost are defined as follows:

$$GDPVA_r = \sum_i (PVA_{i,r} * X_{i,r}) \tag{C.37}$$

$$RGDP_r = \sum_i (X_{i,r} - ND_{i,r}) \tag{C.38}$$

Household income for the two household types (rural, urban) are:

$$Y_{rur,r} = \sum_{ir} PVA_{ir,r} * X_{ir,r} \tag{C.39}$$

$$Y_{urb,r} = \sum_{iu} PVA_{iu,r} * X_{iu,r} \tag{C.40}$$

Disposable income is made up of remittances, transfers from Government and household income that is taxed at 10% in Kenya and 7.5% percent in Uganda (all three factors of production are taxed at the same rate—regardless of household type):

$$YD_{hh,r} = Y_{hh,r}(1 - DTAX_{hh,r}) + (EXR_{ken} * RMIT_{hh,r}) + TRNS_{hh,r} \tag{C.41}$$

Profit rates on capital by sector are calculated as:

$$RE_{ip,r} = \frac{RK_{ip,r}}{PK_{ip,r} * KP_{ip,r}} \tag{C.42}$$

The next four equations define Government Consumption, Government Revenue and two components of government revenue (tariffs and direct taxes).

$$GDTOT_r = \Big[PVA_{pub,r} + (\sum_{jp} IO_{jp,pub,r} * PQ_{jp,r})\Big] * GD_{pub,r} + \sum_{hh} TRNS_{hh,r} \tag{C.43}$$

$$GR_r = TARIFF_r + \sum_{hh} DIRTAX_{hh,r} + (AID_r * EXR_{ken}) \tag{C.44}$$

$$TARIFF_r = \sum_i \frac{tmw_{i,r} * MW_{i,r} * PMW_{i,r}}{1 + tmw_{i,r}} + \sum_i \frac{tmr_{i,r} * MR_{i,r} * PMR_{i,r}}{1 + tmr_{i,r}} \tag{C.45}$$

$$DIRTAX_{hh,r} = Y_{hh_r} * DTAX_{hh,r} \tag{C.46}$$

$$TRNSTOT_r = \sum_{hh} TRNS_{hh,r} \tag{C.47}$$

C.1.4 Saving-Investment block

We have household savings, government savings, total savings equations:

$$HHSAV_{hh,r} = MPS_{hh,r} * YD_{hh,r} \tag{C.48}$$

$$GOVSAV_r = GR_r - GDTOT_r \tag{C.49}$$

$$SAVING_r = GOVSAV_r + \sum_{hh} HHSAV_{hh,r} \tag{C.50}$$

The next three equations describe capital formation. The first equation calculates the shares of the private capital stock going to each sector. The second equation determines capital formation in the private sector ($DK_{ip,r}$=investment by destination). Note that all three public capital types are given exogenously, i.e. $PK_{pub,r}$, DKG_r and DKR_r are all determined outside the model. The third equation in effect translates investment by destination to investment by origin by using the capital composition matrices $IMAT_{ij,r}$ and $IMATP_{ij,r}$.

$$KI_{ip,r} = \frac{KP_{ip,r}}{\sum_{jp} KP_{jp,r}} \tag{C.51}$$

$$PK_{ip,r} * DK_{ip,r} = KI_{ip,r} * \Big[SAVING_r - PK_{pub,r} * (DK_{pub,r} + DKG_r + DKR_r)\Big] \tag{C.52}$$

$$ID_{ip,r} = \sum_{j} IMAT_{ip,j,r} DK_{j,r} + IMATP_{ip,infrnat,r} * DKG_r + IMATP_{ip,infrreg,r} * DKR_r \tag{C.53}$$

C.1.5 Market clearing and closure

Demand of goods equals supply of goods:

$$Q_{i,r} = \sum_{hh} CD_{i,hh,r} + ND_{i,r} + ID_{i,r} + GD_{i,r} \tag{C.54}$$

Labour market equilibrium:

$$LSTOT_{lc,r} = \sum_{i} LS_{i,lc,r} \tag{C.55}$$

Regional Market equilibrium:

$$MR_{rm,r} = ER_{rx,rr} \tag{C.56}$$

Balance of Payments:

$$\sum_{i} \Big[MW_{i,r} * pwmw_{i,r} - EW_{i,r} * pwew_{i,r} \Big] - AID_r - \sum_{hh} RMIT_{hh,r} = \sum_{i} \frac{ER_{i,r} * PER_{i,r}}{EXR_{ken}} - \sum_{i} \frac{MR_{i,r} * PMR_{i,r}}{(1 + tmr_{i,r}) * EXR_{ken}} \tag{C.57}$$

To maximise welfare at the national level, we maximise:

$$OBJE = \sum_{r} \sum_{hh} HW_{hh,r} * \left[\sum_{ic} CLES_{ic,hh,r} * (CD_{ic,hh,r} - CBASE_{ic,hh,r})^{\frac{\sigma c_r - 1}{\sigma c_r}} \right]^{\frac{\sigma c_r}{\sigma c_r - 1}} \tag{C.58}$$

However, to maximise welfare at the regional level, we disaggregate the previous equation:

$$OBJIND_r = \sum_{hh} HW_{hh,r} * \left[\sum_{ic} CLES_{ic,hh,r} * (CD_{ic,hh,r} - CBASE_{ic,hh,r})^{\frac{\sigma c_r - 1}{\sigma c_r}} \right]^{\frac{\sigma c_r}{\sigma c_r - 1}} \tag{C.59}$$

Welfare in each country for each type of household

$$WELFARE_{r,hh} = \left[\sum_{ic} CLES_{ic,hh,r} * (CD_{ic,hh,r} - CBASE_{ic,hh,r})^{\frac{\sigma c_r - 1}{\sigma c_r}} \right]^{\frac{\sigma c_r}{\sigma c_r - 1}} \tag{C.60}$$

The discounted version of the previous metric can be written down as:

$$Discounted\ \ Welfare_{r,hh} = \sum_{t=1}^{10} \overline{\beta}^{t-1} * (WELFARE_{r,hh})_t \tag{C.61}$$

C.1.6 Updating variables

The previous subsections in this appendix all dealt with within-period optimization of economic agents. How are periods linked? The two main variables that play a role here are population growth and capital accumulation:

$$KP_{i,r}^{t+1} = KP_{i,r}^{t} * (1 - DEPR_{i,r}) + DK_{i,r}^{t} \tag{C.62}$$

$$KG_r^{t+1} = KG_r^t * (1 - DEPR_r) + DKG_r^t \tag{C.63}$$

$$KR_r^{t+1} = KR_r^t * (1 - DEPR_r) + DKR_r^t \tag{C.64}$$

$$LSTOT_{lc,r}^{t+1} = LSTOT_{lc,r}^t * (1 + LABGROW_{lc,r}^t) \tag{C.65}$$

C.1.7 Calculated variables

Import and export weighted world RER:

$$MWRER_r = \frac{\sum_i \frac{PMW_{i,r}}{PD_{i,r}} * MW_{i,r}}{\sum_i MW_{i,r}} \tag{C.66}$$

$$EWRER_r = \frac{\sum_i \frac{PEW_{i,r}}{PD_{i,r}} * EW_{i,r}}{\sum_i EW_{i,r}} \tag{C.67}$$

C.2 Subscripts

1. i,j=sectors (FOO, CRO, LMA, HMA, SER, PUB)
2. ip,jp=private sectors (FOO, CCR, LMA, HMA, SER)
3. iu=urban sectors (LMA, HMA, SER, PUB)
4. ir=rural sectors (FOO, CCR)
5. inf=non-food sectors (CCR, LMA, HMA, SER, PUB)
6. ic=consumption sectors (FOO, LMA, HMA, SER)
7. ix=Internationally Exportables
8. rx=Regionally Exportables
9. im=Internationally Importables
10. rm=Regionally Importables

11. nix=Non-Exportables Internationally
12. nrx=Non-Exportables Regionally
13. nim=Non-Importables Internationally
14. nrm=Non-Importables Regionally

Other subscripts refer to countries (r=KEN, UGA), labour categories (lc=SK, UNSK), household types (HH=urban, rural) and public infrastructure sectors (PINFR=INFRNAT, INFRREG).

C.3 List of variables and parameters

C.3.1 Endogenous variables

PRICES

1. $PMW_{i,r}$ = Domestic price of imports from RoW in sector i
2. $PEW_{i,r}$ = Domestic price of exports to RoW in sector i
3. $PMR_{i,r}$ = Domestic price of imports in sector i from region
4. $PER_{i,r}$ = Domestic price of exports in sector i to region
5. $PQ_{i,r}$ = Price of the level 1 Constant Elasticity of Substitution Composite good in sector i
6. $PQL_{i,r}$ = Price of the level 2 Constant Elasticity of Substitution Composite good in sector i
7. $PD_{i,r}$ = Price of domestic good in sector i
8. $PX_{i,r}$ = Price of domestic output (level 1 Constant Elasticity of Transformation composite good) sector i
9. $PXL_{i,r}$ = Price of level 2 Constant Elasticity of Transformation composite good in sector i

10. $PL_{i,r}$ = Price of Composite labour for sector i
11. $PVA_{i,r}$ = Value Added price
12. $PK_{i,r}$ = capital price (by destination)
13. PPI_r = Producer Price Index
14. CPI_r = Consumer Price Index
15. $PGDP_r$ = GDP deflator

QUANTITIES

1. $Q_{i,r}$ = Level 1 Constant Elasticity of Substitution composite good in sector i (absorption)
2. $QL_{i,r}$ = Level 2 Constant Elasticity of Substitution composite good in sector i
3. $D_{i,r}$ = Domestic good in sector i
4. $X_{i,r}$ = Domestic output (level 1 Constant Elasticity of Transformation Composite good) in sector i
5. $XL_{i,r}$ = Level 2 Constant Elasticity of Transformation composite good in sector i
6. $EW_{i,r}$ = Exports to RoW in sector i
7. $ER_{i,r}$ = Exports in sector i to region
8. $MW_{i,r}$ = Imports from RoW in sector i
9. $MR_{i,r}$ = Imports in sector i from region
10. $CL_{i,r}$ = Composite labour for sector i
11. WA_{lc} = Average (nominal) wage rate for labour category lc
12. $LS_{i,lc}$ = labour supply in sector i for labour category lc
13. $RS_{i,r}$ = Rent on land in agricultural sectors (food and cash-crops)
14. $RK_{i,r}$ = Rent on capital for sector i

DEMAND AND INCOME

1. $ND_{i,r}$ = Intermediate goods demand
2. $CD_{i,hh,r}$ = household (final) consumption by household type hh in sector i
3. $GDPVA_r$ = GDP at factor cost measured by value added
4. $RGDP_r$ = Real GDP at factor cost
5. $YD_{hh,r}$ = Disposable income for household type hh
6. $Y_{hh,r}$ = household income for household type hh
7. $RE_{ip,r}$ = Rental rate of capital for sector i (only private sectors)
8. GR_r = Government Revenue
9. $GDTOT_r$ = Total government consumption
10. $TARIFF_r$=Total Tariff Revenue
11. $DIRTAX_{hh,r}$=Direct Taxes for HoH type HH
12. $TRNS_{hh,r}$ = Transfer to HoH of type HH (from gov't)
13. $TRNSTOT_r$ = Total transfers to all HoH in country r (from gov't)

SAVING AND INVESTMENT

1. $SAVING_r$ = Total Saving
2. $GOVSAV_r$ = Government Saving
3. $HHSAV_{hh,r}$ = Savings of household type hh
4. $KI_{ip,r}$ = Shares of capital stock (only for private sectors)
5. $DK_{i,r}$ = Investment demand (by destination), except for national (DKG) and regional (DKR) investment
6. $ID_{i,r}$ = Investment demand by sector of origin i

7. $HW_{hh,r}$ = Household weights

8. $OBJE$ = Objective maximization variable

C.3.2 Exogenous variables

PRICES AND QUANTITIES

1. $pwmw_{i,r}$ = world price of imports from the rest of the world

2. $pwew_{i,r}$ = world price of exports to the RoW

3. $tmw_{i,r}$ = tariff rate for imports from rest of the world in sector i

4. $tmr_{i,r}$ = tariff rate for imports from the region in sector i

5. EXR_r = Nominal Exchange Rate (home currency per USD)

6. $LSTOT_{lc,r}$ = total labour supply for labour category lc

7. $LAND_{i,r}$ = Land by sector i

8. $KP_{i,r}$ = Capital stocks by sector i

9. KG_i = Public Capital Stock for national infrastructure works

10. KR_i = Public Capital Stock for regional infrastructure works

DEMAND AND INCOME

1. $GD_{i,r}$ = Final demand for government consumption for i goods

2. $CBASE_{i,hh,r}$ = Subsistence Consumption for i-goods from HoH type HH

3. $MPS_{hh,r}$ = Marginal Propensity to Save for household of type HH

4. $DTAX_{hh,r}$ = Direct Tax Rate for HoH type HH

5. $RMIT_{hh,r}$ = Remittances to household type HH in USD

6. AID_r = Foreign Savings (all accruing to Government) in USD

SAVING, INVESTMENT AND OTHER VARIABLES

1. DKG_r = Total national public investment to infrastructure
2. DKR_r = Total regional public investment to infrastructure
3. $IO_{i,j,r}$ = input-output matrix
4. $CLES_{ic,hh,r}$ = auxiliary parameter to calculate CD
5. $IMAT_{i,j,r}$ = Coefficients of the capital composition matrix
6. $IMATP_{i,pinfr,r}$= Coefficients of the capital composition of public infrastructure capital
7. $WP_{i,r}$ = Weights to calculate PPI
8. $WC_{i,r}$ = Weights to calculate CPI

C.3.3 Parameters

1. $wdist_{i,lc,r}$=Parameter measures labor market distortion in sector i for labour category lc
2. $B_{i,r}$=Parameter for labour aggregation equation for sector i
3. $\omega_{i,r}$ = share parameter governing substitutability between skilled and unskilled labour for sector i
4. $\sigma l_{i,r}$ = elasticity governing substitutability between skilled and unskilled labour
5. $\lambda l_{i,r}$ = Production function share parameter for labour in sector i
6. $\lambda k_{i,r}$ = Production function share parameter for capital in sector i
7. $\lambda n_{i,r}$ = Production function share parameter for land in sector i
8. $\lambda kg_{i,r}$ = Production function share parameter for (national) public capital stock in sector i
9. $\lambda kr_{i,r}$ = Production function share parameter for (regional) public capital stock in sector i

10. $\sigma 1_{i,r}$ = Constant Elasticity of Transformation between exports to RoW and regional composite good

11. $\sigma 2_{i,r}$ = Constant Elasticity of Transformation between exports to the region and domestic good

12. $\sigma 3_{i,r}$ = Constant Elasticity of Substitution between imports from RoW and regional composite good

13. $\sigma 4_{i,r}$ = Constant Elasticity of Substitution between imports from the region and domestic good

14. $AP_{i,r}$ = Production function shift parameter for sector i

15. $AT1_{i,r}$ = Constant Elasticity of Transformation Function shift parameter (level 1)

16. $AT2_{i,r}$ = Constant Elasticity of Transformation Function shift parameter (level 2)

17. $AC1_{i,r}$ = Constant Elasticity of Substitution Function shift parameter (level 1)

18. $AC2_{i,r}$ = Constant Elasticity of Substitution Function shift parameter (level 2)

19. $\alpha_{i,r}$ = Constant Elasticity of Transformation level 1 function share parameter for sector i

20. $\beta_{i,r}$ = Constant Elasticity of Transformation level 2 function share parameter for sector i

21. $\gamma_{i,r}$ = Constant Elasticity of Substitution level 1 function share parameter for sector i

22. $\delta_{i,r}$ = Constant Elasticity of Substitution level 2 function share parameter for sector i

23. σc_r = elasticity of substitution (consumption)

24. $\overline{\beta}$ = discount factor in the social welfare function

Appendix D

Dealing with missing observations in Rwanda and Burundi

For the 24 goods retained, the raw price data from Rwanda and Burundi are not balanced panels. The two figures below give an overview of the missing data by good and by city. For each city, reading the graphs from top to bottom gives you the months in which price data is available (white) or missing (grey). For 'milk' in 'Gitarama' (see the Rwanda graph) for example, we see that there are some missing observations in the beginning and at the end of the 55 months of data. For Burundi, most good-city pairs have some missing data, which is mainly due to data missing for entire month-city pairs (e.g. the city of Ngozi for March 2006). In Rwanda, missingness is more related to certain goods, such as oranges, a good which has no observations in five cities.

Most social scientists, when confronted with missing data, use list-wise deletion, which effectively means throwing away potentially valuable observations. Researchers have tried to mend this problem by writing algorithms that calculate 'best guesses' for the missing data-points. We use Amelia II, a sophisticated imputation algorithm, based on the EMB algorithm, developed by King et al. (2001). *'Amelia II performs multiple imputation, a general-purpose approach to data with missing values. Multiple imputation has*

been shown to reduce bias and increase efficiency compared to listwise deletion' Honaker et al.. This algorithm is for example also used by von Cramon-Taubadel et al. (2009) for imputing missing values in similar price series.

Even with the AMELIA algorithm at our disposal, a city-time-good series (i.e. 55 months for one good for one city) is only included if it has a minimum number of observations. The cut-off point for inclusion used is 15 observations (or just over 25 percent of observations). AMELIA diagnostics show that this is a reasonable approach, as confidence intervals of point estimates increase quite substantially when reducing the number of actual observations.

In total, Burundi has 529 missing observations (out of a total of 55 months * 24 goods * 7 cities=9240). 5 series had less than 15 observations, such that the total number of imputed values is equal to 389. For Rwanda, the equivalent figures are: 465 missing observations (out of a total of 55*24*10 = 13200). 10 series had less than 15 observations, such that the total number of imputed values is equal to 31.

FIGURE D.1: Missing observations for Burundi

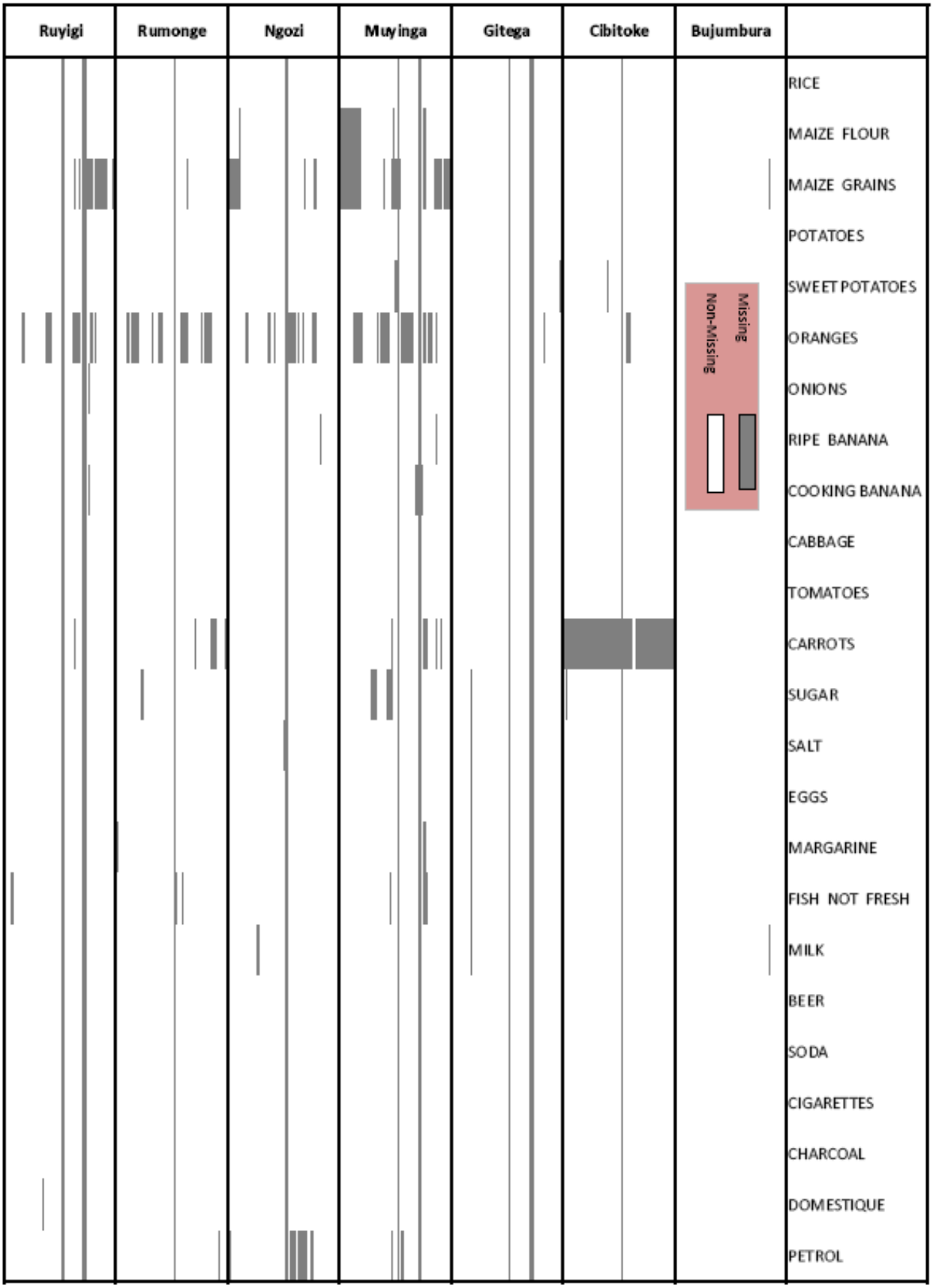
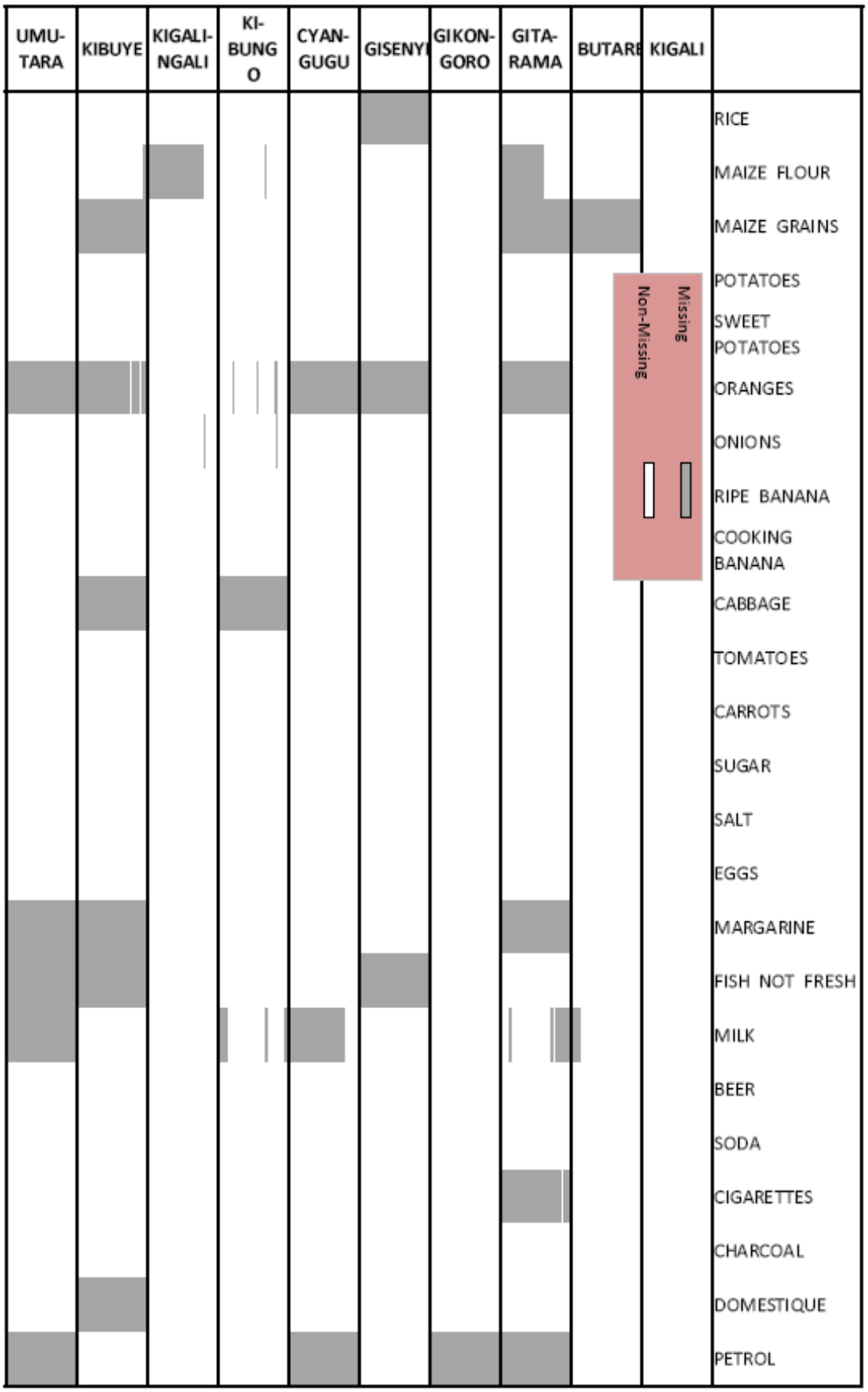


FIGURE D.2: Missing observations for Rwanda



Appendix E

Border effect graphs

E.1 Kernel densities of relative prices

FIGURE E.1.1

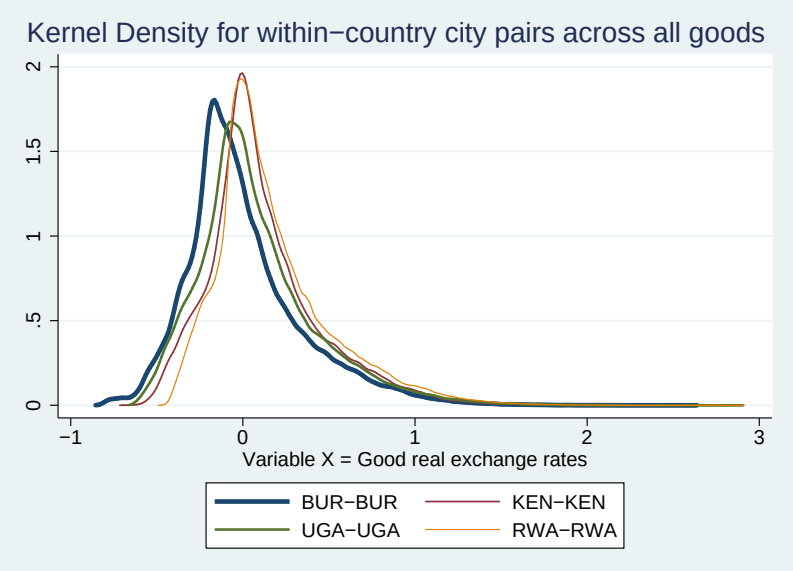


FIGURE E.1.2

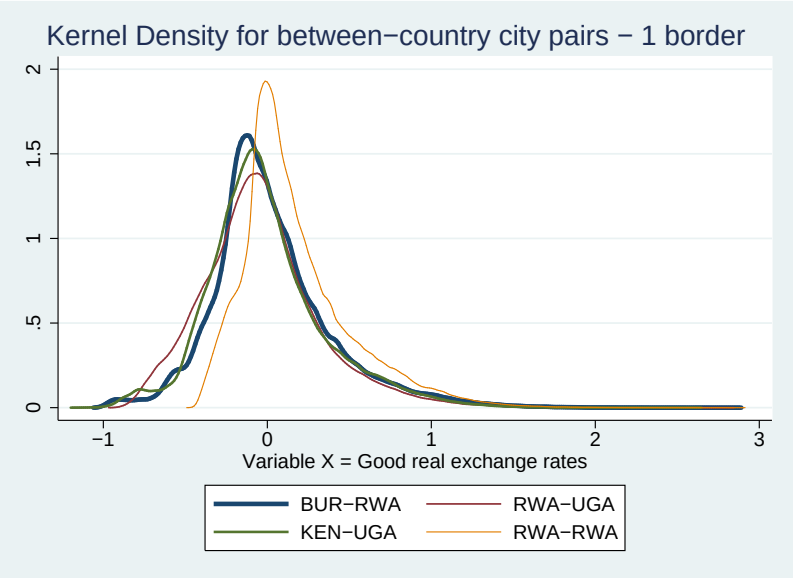
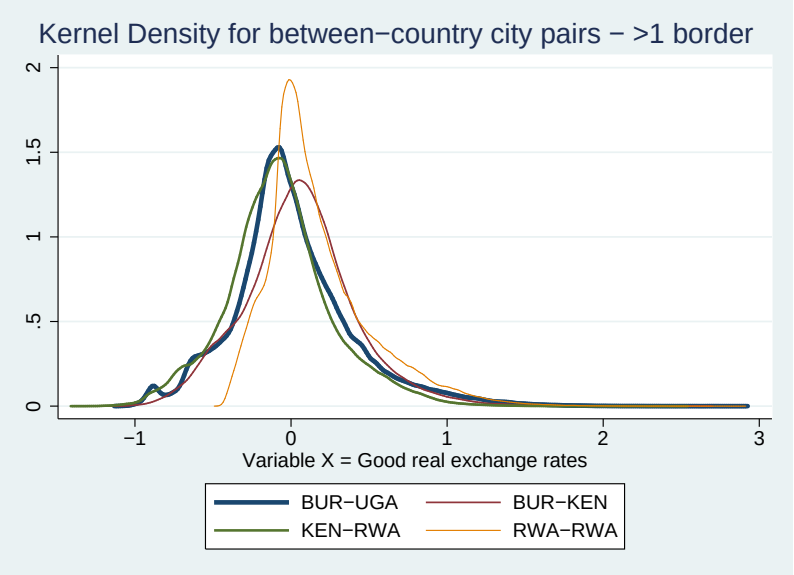


FIGURE E.1.3



Note: All kernel densities shown here are conditional on distance, plus dummies for cities, goods and months.