December 2015

Report

Trade facilitation and concentration: evidence from Sub-Saharan Africa

Olivier Cadot, Alexander Himbert and Marie-Agnès Jouanjean

Acknowledgements

This background research paper is an output of a DFID-funded project titled Regional infrastructure for trade facilitation – impact on growth and poverty reduction. We are grateful for support from DFID. However, the views expressed are those of the authors and not necessarily those of DFID or ODI.

The team for the overall study is coordinated by Marie-Agnès Jouanjean and Dirk Willem te Velde and involves a range of ODI researchers (including Judith Tyson, Neil Balchin, Linda Calabrese, Alberto Lemma, Andrew Scott and Catherine Simonet) and international experts (including Olivier Cadot, Douglas Brooks, Ben Shepherd and Marie Gachassin) and others.

The authors are grateful to Marius Brülhart, Douglas Brooks, Dirk te Velde and Department for International Development (DFID) research staff for useful comments.

Table of contents

Figures

Abbreviations

Abbreviation	Description
COMESA	Common Market for Eastern and Southern Africa
EAC	East African Community
ECOWAS	Economic Community of West African States
LPI	Logistics Performance Index
OSBP	One-stop border posts
RTA	Regional trade agreement
SSA	Sub-Saharan Africa
WAEMU	West African Economic and Monetary Union

1 Introduction

This paper asks whether trade facilitation can contribute to the reduction of the spatial agglomeration of economic activity in sub-Saharan Africa. It is often perceived that the opposite is true: i.e. that, as a country opens up to trade (or opens up more), inequality between regions is bound to widen. For instance, the World Bank's 2009 *World Development Report* asserted that

'[t]he openness to trade and capital flows that makes markets more global also makes subnational disparities in income larger and persist for longer in today's developing countries. Not all parts of a country are suited for accessing world markets, and coastal and economically dense places do better. China's [gross national product] GDP per capita in 2007 was the same as that of Britain in 1911. Shanghai, China's leading area, today has a GDP per capita the same as Britain had in 1988, while lagging Guizhou is closer to the Britain of 1930.'[1]

If the *World Development Report*'s view is true, it has very important implications for the priorities of development partners, in particular those involved in trade-related projects and policy advice. If more trade leads to more concentration, then projects and policy advice leading to reduced trade barriers and hence more trade should be 'flanked' by compensatory measures aimed at mitigating its negative spatial effects, including wider inter-regional inequality and urban crowding.

However, while the *World Development Report*'s view is intuitively appealing, it does not have clear-cut support in either theory or empirics. In fact, a number of models and empirical tests predict just the opposite, suggesting instead that openness to trade has a role to play in the *reduction* of spatial inequalities. Almost twenty years ago, Krugman and Livas Elizondo (1996) argued that

'the trade policies of developing countries and their tendency to develop huge metropolitan centers are closely linked. [This paper] argues that the rise of giant metropolises in developing countries after World War II may have been due in large part to the rise of import-substituting industrialization policies. Correspondingly, the shift away from such policies may well limit the future growth of huge Third World cities.'[2]

In the Krugman–Livas model, as in most spatial-economics models, the location of economic activity results from the interplay of transport costs and economies of scale.[3] Transport costs encourage production location close to markets, that is, in rough proportion to pre-existing settlement patterns. By contrast, economies of scale do not determine where production locates initially; rather, they induce its agglomeration wherever it happens to be. Firms locate where markets are (what Krugman and Livas Elizondo called 'backward linkages') while spatially mobile consumers migrate to production centres, contributing to deeper markets there

[1] World Bank, World Development Report 2009, p. 12; quoted in Brülhart (2011).
[2] Krugman and Livas Elizondo (1996), p. 138.
[3] See Thisse (2009) for a review of the issues.

(‘forward linkages’). These forces create a positive feedback loop leading to the agglomeration of activity and population in large production (urban) centres.

In a closed country, the only counterforce is congestion, e.g. in the form of rising land prices, leading to a core-periphery spatial equilibrium generally characterised by over-congestion.[4] As the country opens up, by contrast, forward and backward linkages lose relative importance for both export-oriented firms and those importing their intermediates from abroad. For those firms, congestion factors become relatively more important, creating an incentive to locate away from traditional production centres. This phenomenon was observed in Mexico when trade liberalisation in the 1990s led to a dramatic shift of production away from Mexico City towards Northern provinces close to the US market.

However, while plausible, this logic is not the only possible, as dispersion forces may also be affected by trade liberalisation. For instance, the presence of immobile farmers, the main centrifugal force in the model of Krugman (1991), would be weakened if trade liberalisation led to accelerated structural transformation away from agriculture. Indeed, simulations in the models without urban congestion of Monfort and Nicolini (2000) or Monfort and van Ypersele (2003) suggest that more trade could *reinforce* agglomeration. Thus, although the Krugman–Livas hypothesis rests on strong logic and has dominated economic thinking on the issue, it is fair to say that theory is somewhat ambiguous on whether trade opening leads to more or less agglomeration, which remains an empirical question (see Brülhart (2011) for a fuller discussion).

In the particular case of coastal countries, the models of Brülhart et al. (2004) and Crozet and Koenig (2004) show that two forces are at play. On one hand, traditional agglomeration forces encourage location along the coast where access to foreign markets is easiest. On the other hand, inland location may provide natural protection against foreign competition.[5]

If theory is somewhat ambiguous, so are the empirics. Ten out of eleven cross-country studies surveyed by Brülhart (2011), including a much-cited article by Ades and Glaeser (1995), suggest that measures of country-level spatial concentration correlate *negatively* with levels of openness, e.g. proxied by Sachs and Warner’s openness variable, in accordance with the Krugman–Livas hypothesis.[6] Within-country studies show more mixed results, although partly because many of them focused on the case of Mexico where maquiladora activity concentrated heavily in the northern part of the country, creating a second agglomeration pole which came to overtake the traditional one (Mexico City) in terms of manufacturing production. A similar pattern has been observed in China, where activity has concentrated in the south-east coastal region (Kanbur and Zhang, 2005). Two recent papers using the fall of the Berlin Wall as a natural experiment (Redding and Sturm, 2008; Brülhart, Carrère and Trionfetti, 2012) support the Krugman–Livas hypothesis. Both papers document an ‘iron-curtain’ effect whereby, before reunification, activity and population density progressively shrank as one got closer to the iron curtain, which

[4] In the model of Behrens et al. (2007), as in Krugman (1991), another counterforce against agglomeration is the presence of immobile farmer populations, a factor that is undoubtedly important in most of sub-Saharan Africa’s countries, where over half of the population is still employed in agriculture.

[5] For instance, steel minimills in the US were located far inland (away from both coasts and from the Great Lakes) in the 1990s in order to gain shelter from Japanese competition. Similarly, Uganda is developing a small steel industry sheltered from Asian competition by the cost of transporting steel up the long Mombasa–Kampala corridor.

[6] Most relevant for sub-Saharan Africa, Ades and Glaeser (1995) correlated urban concentration with high tariffs, high costs of internal trade, and autocracies, the latter being associated, on average, with 50% more concentration than democracies. Egger et al. (2005) was the only one showing divergence in the spatial distribution of real wages. Duranton (2008) argues that institutional and political factors weigh more heavily than trade as determinants of urban concentration.

was a dead end for trade. After the demise of communism, growth was stronger in cities close to the old iron curtain's location, and Redding and Sturm show that the effect is stronger for smaller cities. Brülhart et al. also show that employment grew much more than wages in those cities.

The issue of spatial agglomeration is particularly pregnant in sub-Saharan Africa (SSA). As African governments have proved largely unable to build the sanitary and transportation infrastructure that urban growth requires, living conditions have deteriorated steadily in most of Africa's cities over the post-World War II period, in spite of higher-than-average incomes.[7] For instance, UN-Habitat (2003) estimates that over two thirds of SSA's urban population live in slums, and Montgomery et al. (2003) report that urban children are more exposed to diseases than rural ones after controlling for household income. Thus, if the Krugman–Livas hypothesis holds for Africa, trade openness can contribute to alleviating Africa's urban problem by leaving governments and donors more time to build adequate infrastructure. We now turn to an exploration of the hypothesis in the SSA context, combining night lights captured by satellites to measure the location of activity, with trade-facilitation indicators that measure effective openness to trade.

[7] For instance, in the early 2000s Addis Ababa accounted for 4% of Ethiopia's population but a fifth of its GDP.

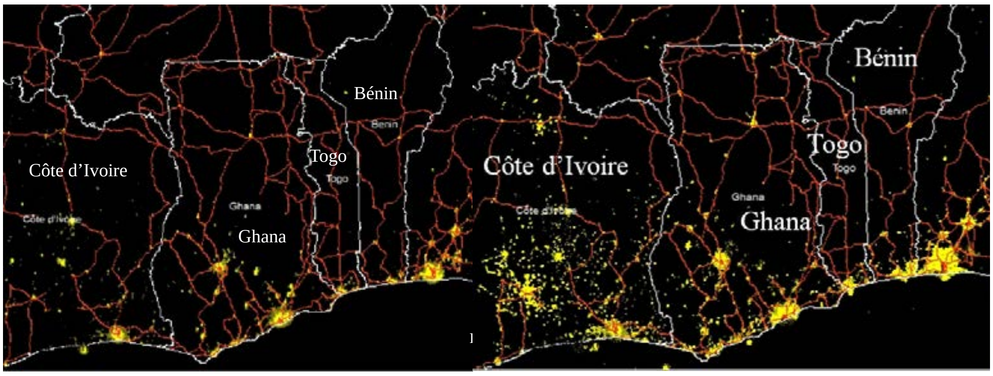
2 Agglomeration and trade in sub-Saharan Africa: what the lights say

Beyond the issue's immediate policy relevance for development partners, sub-Saharan Africa provides an interesting ground to explore the effect of expanding trade on the location of economic activity. First, the continent has only recently embarked on a structural transformation process away from agriculture, and urban migration is largely ongoing (Kessides, 2006). Second, it has undergone substantial trade liberalisation in the years during which night-light data has become available. Night lights, captured by satellites, provide a good signal of the density of economic activity in very finely-disaggregated geographical areas (Box 1). While trade liberalisation has been effective vis-à-vis the outside world, intra-African liberalisation has remained partial, as high transport costs and numerous non-tariff barriers still hamper the free movement of goods and people across the continent's inland borders. Thus, while trade liberalisation was largely completed in other regions before night-light data became available, it is still an ongoing process in SSA. Finally, for development partners engaged in trade-facilitation projects, understanding the projects' effects on spatial growth patterns is crucial in order to design them for inclusive and sustainable development.

As a first pass at the data, Figure 1 shows the initial level (panel a) and absolute increase (panel b) in night-light emissions along the Abidjan–Lagos coastal corridor in West Africa over 1995-2013. Some of the increase is clearly driven by idiosyncratic events such as the political crisis and stabilisation in Côte d'Ivoire, where panel (b) shows a large and widespread increase in light. Agglomeration along the coastal corridor, in line with the models of Brülhart et al. (2004) and Crozet and Koenig (2004), is also clearly visible in panel (b). Thus, the effect of agglomeration near ports (where access to overseas markets is easiest) seems, a priori, to dominate the 'natural protection' argument in this particular case. This is to be expected given that the region is home to very little manufacturing (McMillan and Rodrik; 2011; McMillan and Harttgen, 2014; Rodrik, 2014). Interestingly, there seems also to be some spatial convergence as there is relatively little light increase relative to the initial level in the Lagos metropolitan area (to the south-east in the picture), suggesting that the force of congestion is at play. Thus, by and large the stylised facts suggested by simple inspection of light patterns along the Abidjan–Lagos corridor seem in line with what can be expected from the models.

Figure 1: Coastal agglomeration and congestion along the Abidjan–Lagos corridor

(a) Night lights in 1995 | (b) Absolute increase in night lights, 1995-2013



Note: Major highways are shown in red, national borders in white, and night lights in different shades of yellow depending on their intensity (panel a) or the intensity of their increase (panel b).

Source: ArcGIS software

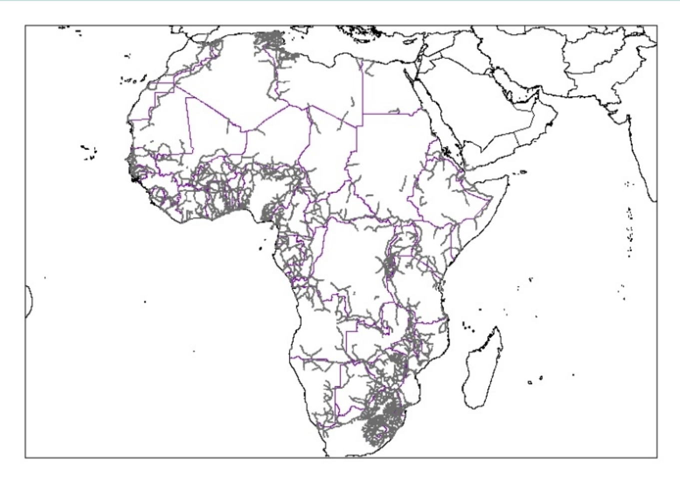
Figure 2 shows the Nairobi–Kampala–Kigali segment of the Mombasa–Kigali corridor, which is, unlike the Abidjan–Lagos corridor, perpendicular to the seashore. As in West Africa, the picture reveals an unmistakable pattern of recovery from political violence after Rwanda's genocide, as the whole country was 'dark' in 1995. Growth is also concentrated along the Kampala–Jinja–Malaba–Kisumu corridor leading to Nairobi, with areas to the north remaining largely black (the region at the centre of the picture is Lake Victoria).[8]

[8] Northern Uganda was also home to endemic political violence until the Lord's Resistance Army of Joseph Kony, a highly violent group, was tamed (although never completely eliminated) around 2013.

Box 1: Measuring economic activity by night lights

We match georeferenced night-light data with highway data and national border data for sub-Saharan Africa into a single digitalised dataset amenable to analysis using GIS software. In a first step, we construct buffers with a width of five kilometres around all border-crossing roads using the Natural Earth dataset, using georeferenced highway data shown below. On these buffers, we impose a grid with a maximum cell size of 10 x 10 kilometres (cell size varies because roads and borders don't run in perfectly straight lines. Focusing only on sub-Saharan African countries (Sudanese borders excluded) excluding South Africa, we obtain around 9,000 cells for our analysis.

For each of the resulting cells, we compute the distance of its centre to the closest border. In addition, roads are classified by their importance: highway, major road, local road, in decreasing order. National road names are used to identify individual roads. Using the Gridded Population of the World,[9] we also compute the average population density per square kilometre for each road piece in each year. Lastly, we also match our blocks with georeferenced altitude data.



Next, we correct light data for overglow. Weaknesses in the optics of DMSP satellites (scanning elliptical areas on the Earth's surface but ascribing observed light to significantly smaller square pixels) leads to the misattribution of light from emitting locations to neighbouring, non-emitting areas. As our analysis focuses on distinguishing border effects in very narrow corridors, overglowing poses a problem, potentially undermining the verification of our hypothesis. While waiting for a more precise correction mechanism to be made available, we follow the spatial-econometrics approach of Pinkovskiy (2013), who finds lights in neighbouring cells to be correlated with an autoregressive coefficient of -0.23.

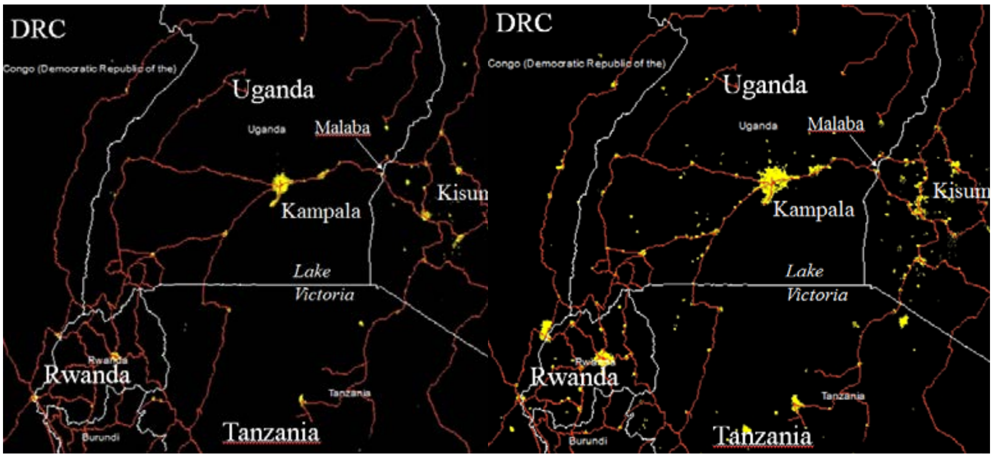
After correcting for overglow, we compute the average light intensity within each cell for 1995, 2000, 2007 and 2013, years in which satellite light measurements are available.

[9] http://www.ciesin.columbia.edu/data/gpw-v4/

Figure 2: Agglomeration along the Nairobi–Kampala–Kigali corridor

(a) Night lights in 1995

(b) Absolute increase in night lights, 1995-2013

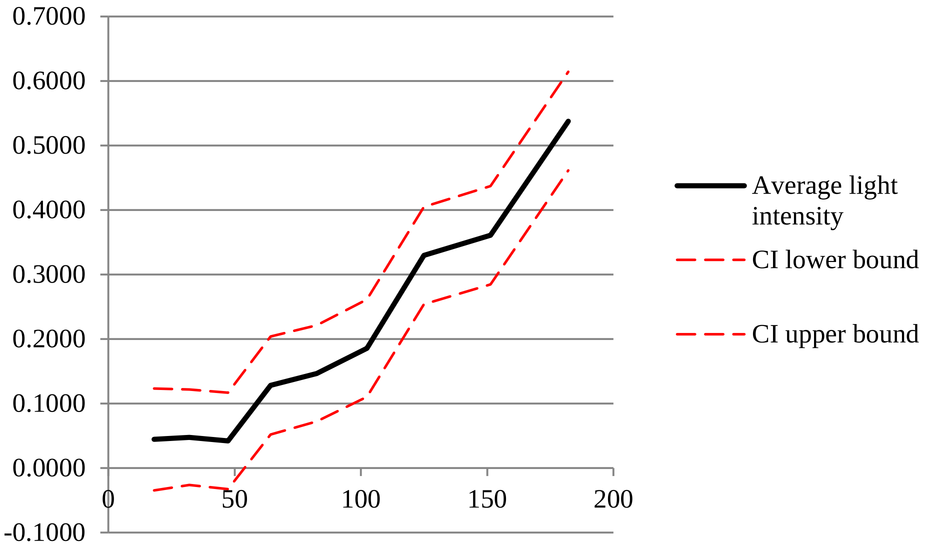


Note: Major highways are shown in red, national borders in white, and night lights in different shades of yellow depending on their intensity (panel a) or the intensity of their increase (panel b). Light intensity not corrected for glow (see Box 1).

Source: ArcGIS software

In spite of substantial improvements due, in large part, to the efforts of development partners, Africa's intra-continental borders are still relatively trade-unfriendly, being plagued with (among other things) long clearance times, congestion due to poor infrastructure, redundant paperwork, and lack of automation. One would thus expect to observe an 'iron-curtain effect' whereby activity, as measured by night lights, decreases along the continent's main cross-border corridors as one gets closer to borders. This is indeed visible in Figure 3, which shows average light emissions as a function of distance to the border. The curve in Figure 3 is constructed by regressing night-light emissions on ten dummy variables marking deciles of the distance to the border over a 200 km range around borders along the continent's main cross-border highways. The regression controls for altitude (as economic activity is typically stronger in plains), population density, and country and year fixed effects. The black curve shows the point estimates, and the red dotted curves mark the limits of the 95% confidence interval. The decrease in night light as one gets closer to the border is quite visible.

Figure 3: Light intensity along cross-border corridors increases with distance from borders



Note: The horizontal axis measures distance from the border, in km, within a 200-km buffer around Africa's cross-border highways. The vertical axis measures the point estimate of the coefficient on dummy variables, one for each of those deciles (the first omitted because of collinearity), in a regression where the dependent variable is light intensity in 'bins' of variable size, controlling for altitude, population density, and year and country fixed effects. The 'counterfactual' for each coefficient is average light intensity in all other deciles; thus, zero on the vertical axis does not mean zero light. Only the relative position of deciles along the curve matters.

Source: Authors' calculations using ArcGIS software.

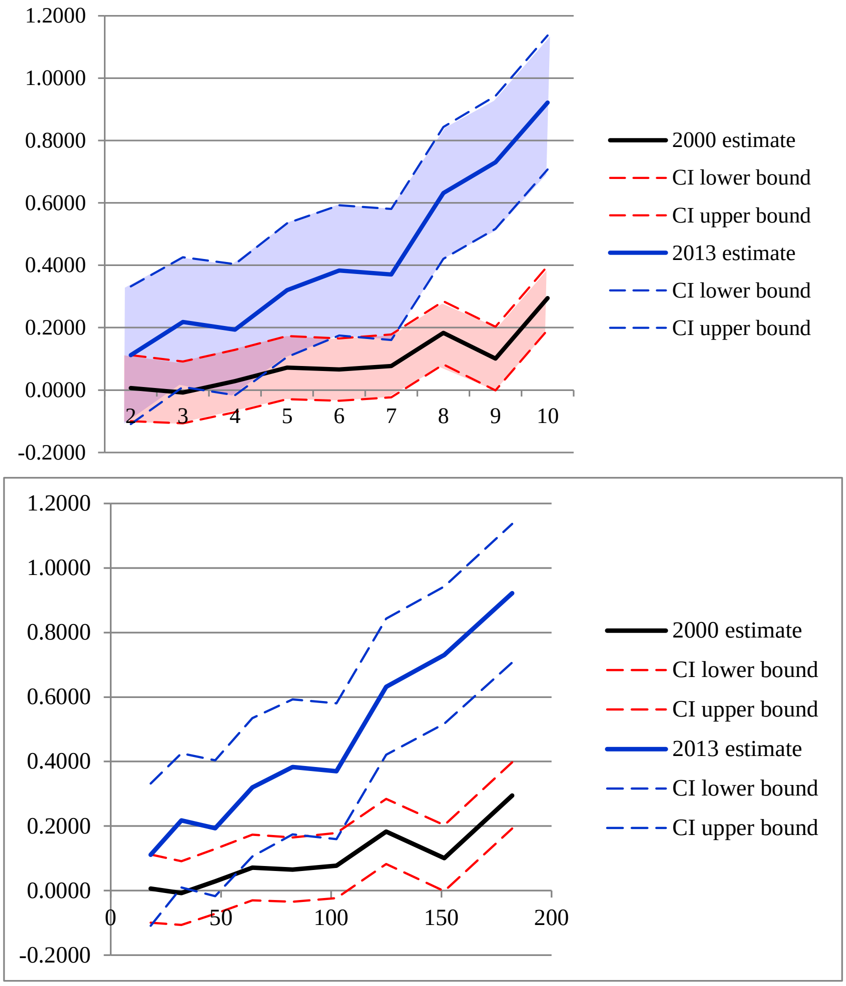
Moreover, Figure 4 shows that this pattern has reinforced itself over time. Figure 4 decomposes the curve in Figure 3 by year, with one curve for 2000 (with the pink confidence interval) and one for 2013 (with the blue confidence interval). The latter is substantially steeper, showing that activity has agglomerated away from borders, towards national production centres – a pattern opposite to that observed in Mexico where maquiladoras all located along the Northern border.

Consider the case of Uganda, which under Museveni rule has been pursuing open-trade policies for several decades. While one may not expect Ugandan firms to locate close to the border with Rwanda given the small size of Rwanda's market,[10] they could be expected at least to locate near the Kenyan border as Kenya is Uganda's larger partner in the East African Community (EAC) and in the Common Market for Eastern and Southern Africa (COMESA). They don't, agglomerating instead towards the middle of the country (Figure 2) as the Krugman–Livas hypothesis predicts for relatively closed economies. This is a puzzle given the outward orientation of Uganda's formal trade policy. If the Krugman–Livas hypothesis is true, other factors besides trade policy – landlockedness, poor infrastructure and logistics – must have contributed to preventing Uganda from opening up fully. This motivates our use of a measure of trade facilitation as the relevant determinant of agglomeration rather than formal trade policy.

---

[10] However, eastern Democratic Republic of the Congo is a large market for many Ugandan companies, so agglomeration towards the Eastern border would not be impossible either.

Figure 4: Light intensity along cross-border corridors and distance to border: activity agglomerates away from borders



Note: See the note below Figure 2 for details of the curves' construction.

Source: Authors' calculations using ArcGIS software.

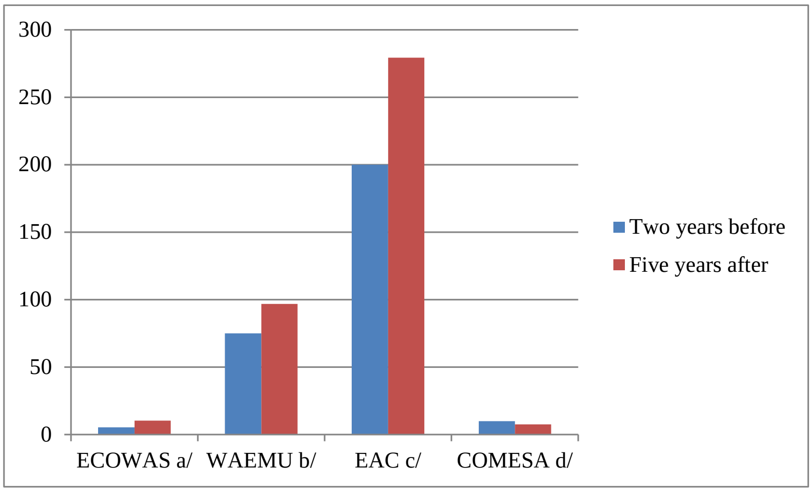
Given the inability of SSA governments to put in place the governance structure and resources needed to accompany the growth of cities, the agglomeration trend visible in Figure 4 should be seen as a source of concern, especially as Kessides (2006, p. 8) notes that 'the real surge in Africa's urbanization is yet to come'. Against a background of extremely dynamic demographics (the population of many of East Africa's countries is growing at over 3% per year), uncontrolled city growth without proportional improvements in infrastructure and job opportunities could turn into a powerful factor of political destabilisation. How do initiatives to facilitate intra-African trade play in this regard? Do they foster spatial dispersion, as the literature suggests for other countries, or spatial concentration?

3 Has trade facilitation reduced spatial inequalities?

It is a well-known observation that Africa's borders are 'thick', although how thick remains a matter of debate. Quantity-based evidence suggests that intra-African trade is well below gravity-predicted benchmarks (see de Melo and Tsikata 2014 for a review), but estimates are plagued by the lack of reliability of trade statistics for overland trade. Price-based evidence (Brunelin and Portugal-Perez, 2013; Aker et al., 2014) yields variable estimates of border effects, generally substantial although not prohibitive; interestingly, Aker et al. find larger effects around ethnic borders than around national ones.

Before turning to the effect of trade-facilitation measures, we consider a crude measure of trade policy. African governments have long pursued regional-integration schemes in order to reduce barriers to intra-African trade. Has African regionalism led to the dispersion of economic activity? One should not expect too much. While the continent's many regional trade agreements (RTAs) all aim to reduce trade barriers, results on the ground have been uneven. Figure 5, taken from de Melo and Tsikata (2014), compares trade-intensity indices, a conventional measure of a bloc's relative importance in the overall trade of its members, before and after implementation dates. In most cases, the rise is modest, with no rise at all in the case of COMESA. Anecdotal evidence is replete with accounts of non-tariff barriers, including, among other things, the non-recognition of certificates of origin, denying the benefits of regional liberalisation schemes.

Figure 5: Trade intensity indices show little rise around Free Trade Area implementation dates

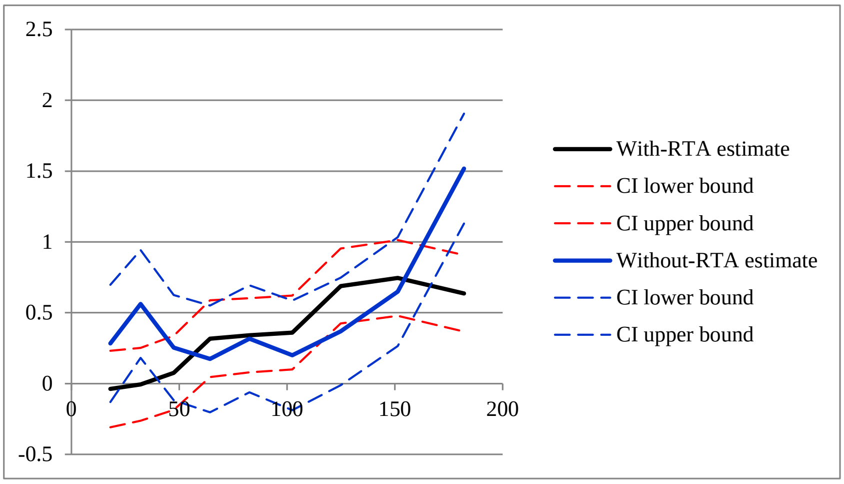


Notes: Time periods: 1991-1992 and 1997-1998 for the Economic Community of West African States (ECOWAS) and COMESA, 1992-1993 and 1998-1999 for the West African Economic and Monetary Union (WAEMU), 1997-1998 and 2003-2004 for EAC. WAEMU members excluded from ECOWAS. The trade intensity index is calculated here as the ratio of the bloc's share in members' exports to its share in non-members' exports (Tij = (xij/Xit)/(xwj/Xwt)).

Source: Adapted from de Melo and Tsikata (2014), Table 2.

Against this background, Figure 6 reproduces Figure 4 but, instead of splitting the sample by year, it splits it between within-RTA borders and borders between countries not belonging to the same RTA. Consistent with the anecdotal evidence, African regionalism does not seem to have much effect on spatial development patterns, as the effect of distance on light along cross-border corridors does not change in any clear-cut way between intra-RTA borders (red band) and non-RTA borders (blue band), except in the most distant decile.

Figure 6: Regionalism does not seem to have tamed the force of agglomeration



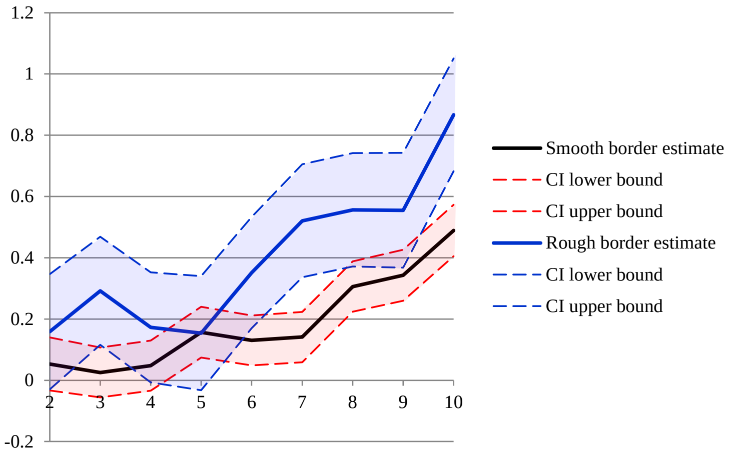
Note: See the note below Figure 2 for details of the curves' construction.

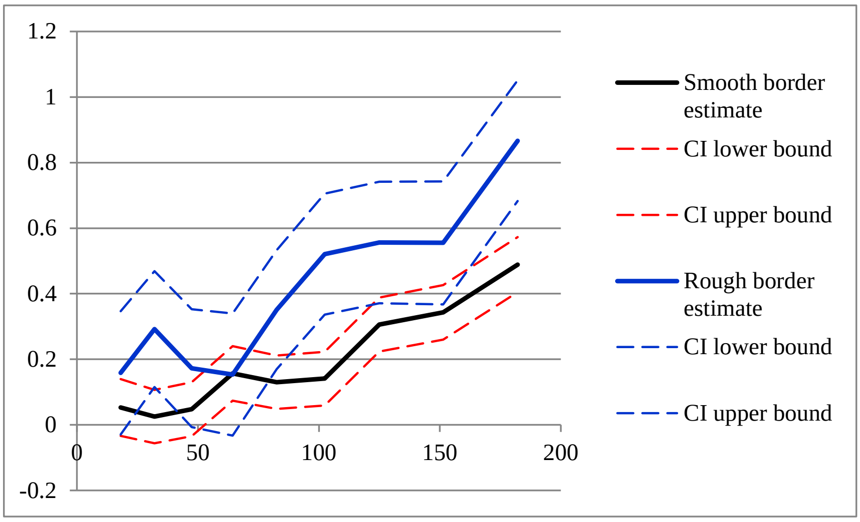
Source: Authors' calculations using ArcGIS software.

We now turn to the effect of trade facilitation. Trade facilitation has involved a much broader agenda covering customs automation through the adoption and regular upgrading of ASYCUDA (Automated SYstem for CUstoms DAta.), the use of post-control audits and risk management, and the adoption of international standards including, among other things, the World Trade Organization's Agreement on Customs Value, the revised Kyoto convention on the simplification and harmonisation of Customs procedures, and the revised Arusha Declaration on Customs Integrity (Zake, 2011). In a few cases, one-stop border posts (OSBP) have been established – as in Malaba, at the border between Kenya and Uganda, in 2006, and in Chirundu, at the border between Zambia and Zimbabwe, in 2009. OSBPs allow trucks to be checked only once each way, with crossing times reduced by factors of four or five, from over a day to a few hours (see below). Time delays have been shown to restrict trade (Freund and Rocha, 2011), while reductions in clearance and crossing times have substantial effects on the ability of firms to export and grow, as has been shown in a Latin American context by Volpe Martincus et al. (2015).

Thus, the reductions in time barriers to trade achieved by trade-facilitation efforts can be seen as trade-liberalisation measures and should have similar effects on spatial patterns of activity. This is what Figure 7 shows, by splitting cross-border corridors according to their 'trade-friendliness'. Corridors are classified as 'smooth' when the product of the two bordering countries' 'efficiency of customs clearance' score in the World Bank's Logistics Performance Index is above the median, and 'rough' when it is below. The iron-curtain effect is clearly dampened in the case of smooth borders, as the two curves are significantly different from one another starting at decile six, with the one for 'rough' borders much steeper.

Figure 7: Light intensity along cross-border corridors and distance to border: logistics friendliness matters





Note: See the note below Figure 2 for details of the curves' construction.

Source: Authors' calculations using ArcGIS software.

The results of Figure 7 are confirmed in Table 1, which reports panel regression results on the effect of distance from the border on light intensity under a variety of specifications. The regressors of interest are the distance from the border and its interaction with the product of the two bordering countries' Logistics Performance Index scores. The 'iron-curtain effect' implies a positive coefficient on distance from the border, with light going down as one gets closer to the border and vice versa. The stronger the force of agglomeration, the higher the coefficient. The Krugman–Livas hypothesis implies a negative coefficient on the interaction, as higher LPI scores (a smoother border) should reduce the iron-curtain effect.

Column 1 reports pooled ordinary least square (OLS) results with time fixed effects, in which the identification relies on variation between borders within a year. Column 2 adds country fixed effects (one for each bordering country) and therefore controls for time-invariant heterogeneity between the two sides of each border. As our dataset contains few borders with more than one border post, country fixed effects are roughly equivalent to border-post fixed effects. Column 4 uses country-year fixed effects, thus controlling for fluctuations in the overall level of activity in each bordering country as well as changes in electricity supply, which are typically felt at the grid level rather than locally. Country-year fixed effects are used in columns 3-5. Column 4 uses weighted least squares to take into account heterogeneity in light-bin size.[11] Column 5 uses a zero-inflated Poisson (ZIP) estimator commonly used in gravity estimation to take account of a high proportion of zero values and of the fact that light emissions are measured in discrete (integer) pixels from zero to 63. The ZIP estimator uses an auxiliary regression to determine the status of observations between zero-value and positive-value ones (see Papadopoulos and Santos Silva, 2008 or Staub and Winkelmann, 2011); our auxiliary regression uses population and altitude as explanatory variables. Column 6 uses a Poisson instrumental variable estimator where population is taken as endogenous and instrumented by a vector of land-use dummies and a city dummy, based on the assumption that both land use and the presence of cities (as opposed to their size) are predetermined to the pattern of night lights along highways. Finally, column 7 uses again a ZIP estimator, our preferred specification, but with an RTA dummy in order to verify formally the absence of effects suggested by Figure 6.

[11] Light intensity is measures within cells of various sizes ; the weights are proportional to cell surface area.

The iron-curtain effect (distance) is highly significant in all specifications, with light intensity increasing with distance from the border. The ease of clearance processes as measured by the product of the LPI clearance-efficiency score of the two countries sharing the border also correlates positively with overall lights levels along corridors. Most importantly, smoother borders (higher LPI clearance-efficiency scores around the border) dampen the effect of distance in all specifications except weighted least squares (column 3). Control variables have the expected signs, with altitude and population (both measured at the light-bin level) having negative and positive effects respectively on light emissions.

Thus, by and large, our results go in the direction of the Krugman–Livas effect, namely a reduction in spatial concentration as trade is liberalised. This is an important result for development partners, as it suggests that trade-facilitation projects are valuable not just for their growth effects but also for their induced spatial effects.

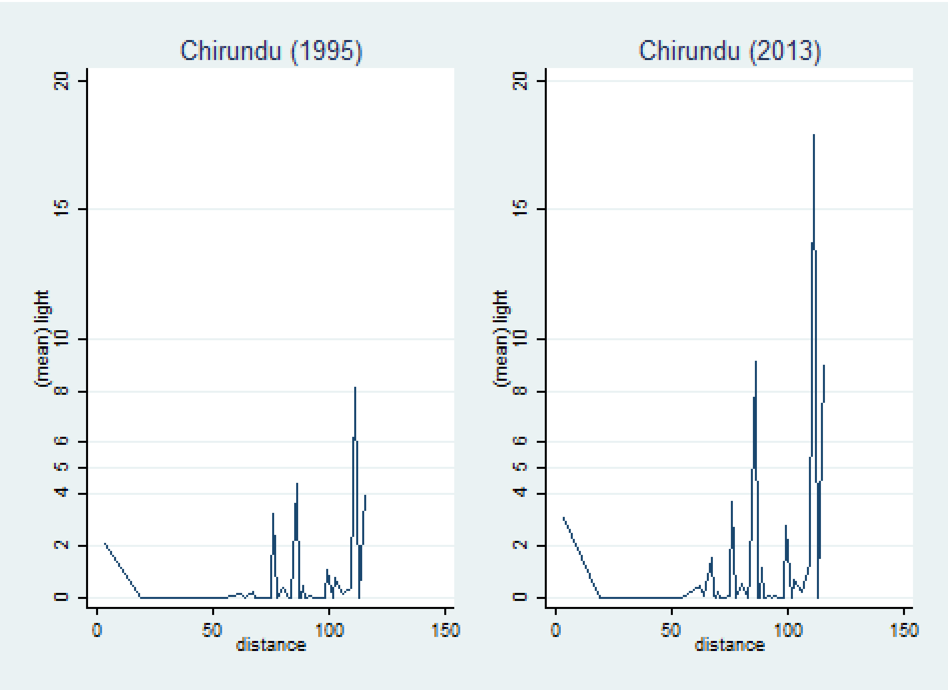
Table 1: How logistics friendliness affects the location of activity: estimation results

Dependent variable	Light intensity						
Estimator	OLS, pooled (1)	OLS, within (2)	OLS, within (3)	WLS (4)	ZIP (2nd stage) (5)	IV (2nd stage) (6)	ZIP (2nd stage) (7)
Explanatory variables							
Distance to border	0.013 (8.22)***	0.010 (6.52)***	0.010 (6.85)***	0.011 (5.99)***	0.021 (7.49)***	0.029 (4.83)***	0.007 (6.13)***
Product of countries' LPIs	0.233 (6.47)***	0.157 (4.46)***	0.166 (3.95)***	0.180 (3.72)***	0.312 (4.33)***	0.551 (5.74)***	
Distance × product of LPIs	-0.001 (4.95)***	-0.001 (2.98)***	-0.001 (3.37)***	-0.001 (3.01)***	-0.002 (5.10)***	-0.004 (4.00)***	
RTA between border countries							0.307 (1.12)
Distance interacted with RTA							-0.002 (1.23)
Altitude	-0.000 (4.95)***	-0.000 (1.58)	-0.000 (1.53)	-0.000 (1.98)**	-0.000 (0.75)	-0.000 (4.78)**	-0.001 (3.54)***
Population density a/	0.001 (4.74)***	0.001 (4.70)***	0.001 (4.69)***	0.003 (4.07)***	-0.009 (11.24)***	0.003 (3.00)***	0.000 (2.71)***
Population density, squared	-0.000 (3.43)***	-0.000 (3.40)***	-0.000 (3.39)***	-0.000 (3.56)***	-0.000 (1.14)		-0.000 (1.57)
Constant	-1.034 (4.14)***	-0.787 (3.65)***	-0.284	-1.283 (5.58)***	-1.387 (2.60)***	-5.192 (7.33)***	1.414 (9.40)***
Fixed effects							
Country	no	yes	no	no	no	no	yes
Year	yes	yes	no	no	no	yes	no
Country-year	no	no	yes	yes	yes	no	no
Observations	35,645	35,645	35,645	35,645	35,645	21,347	19,913
R-squared	0.16	0.18	0.18	0.28			

Source: Authors' calculations using ArcGIS software.

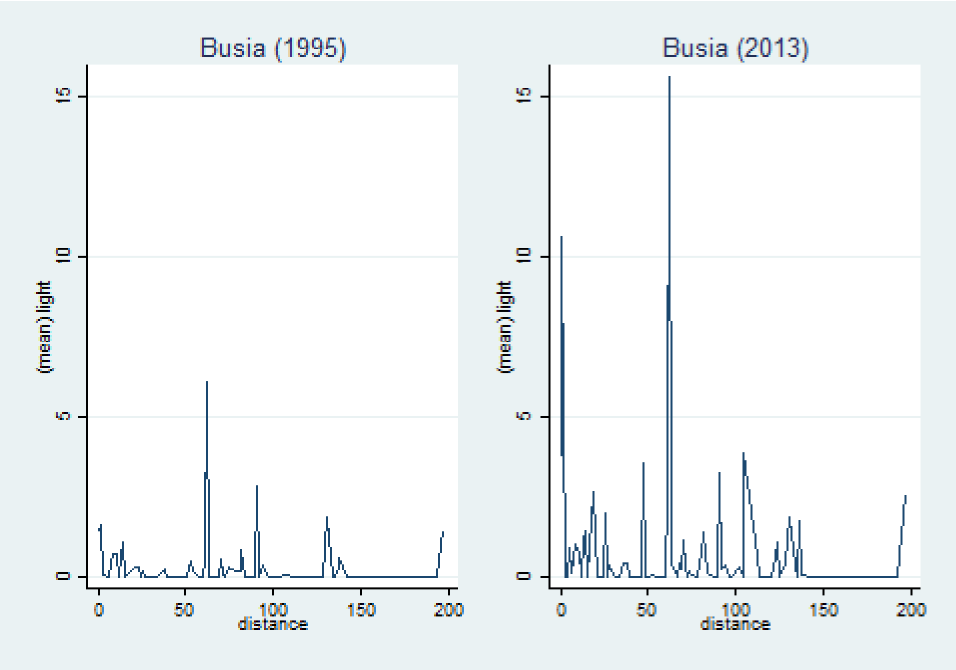
These effects, however, are ‘global’ ones. Locally, trade barriers and slow clearance times give rise to a host of formal and informal service activities directed at truckers (food, accommodation and other) as well as smuggling-related activities that require physical presence at the border. By cutting clearance times, facilitation reforms can affect the rationale for locating such services and activities around border posts. These effects can be substantial. In Malaba, where more than 600 trucks cross every day from Kenya to Uganda, average crossing times have been cut from 24 hours on average before the OSBP’s implementation to 4 hours after, with a maximum of 6. At Katuna, at the border between Uganda and Rwanda, crossing times after modernisation were reduced to 3 hours. At Chirundu, where traffic averages more than 250 trucks per day, the OSBP has substantially reduced congestion and dwell times as well (Ben Barka, 2012). Thus truckers spend less time at the border, cutting their demand for local services, and one might expect to observe a reduction in the local light peak at the border after facilitation reforms. In Chirundu, Figure 8, which shows light peaks along the highway around the border as function of distance (an average of both sides) suggests that while light-emissions have increased along the highway, they have increased much less at the border peak. However, it is the case neither for Busia (Figure 9), a border town, nor for Malaba (Figure 10), and regressions of the border light peak on trade-facilitation variables similarly yield ambiguous or non-significant results.

Figure 8: Light peaks around Chirundu before and after modernisation



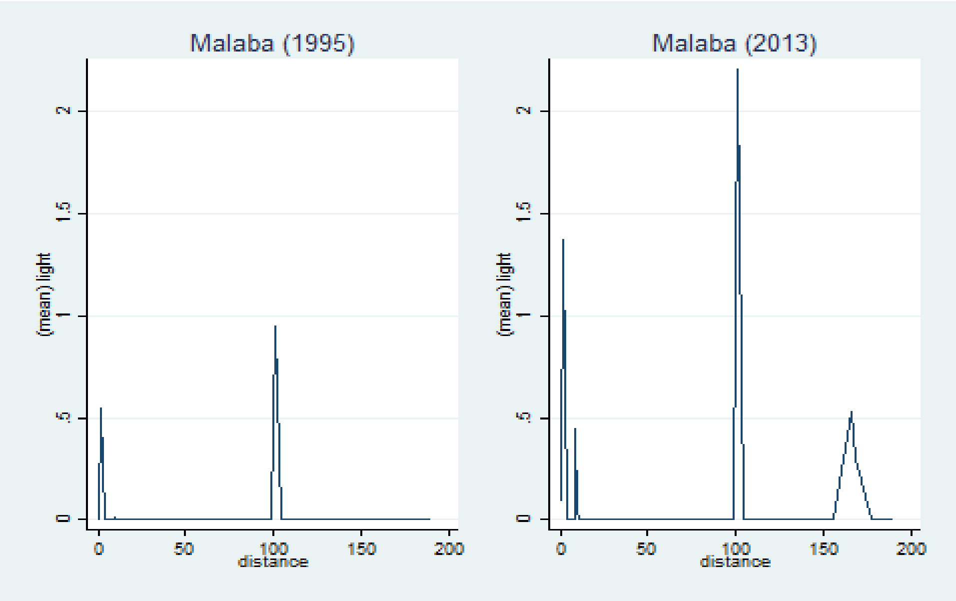
Source: Authors’ calculations using ArcGIS software.

Figure 9: Light peaks around Busia before and after modernisation



Source: Authors' calculations using ArcGIS software.

Figure 10: Light peaks around Malaba before and after modernisation



Thus, one cannot conclude in general whether activities linked to informal trade, smuggling, and trade-related services are systematically reduced by trade-facilitation initiatives. More research is needed on this particular issue, which is of potential importance for the populations involved, often vulnerable ones (ethnic groups straddling borders and women in particular).

4 Concluding remarks

This paper has used a novel approach to explore the relationship between spatial agglomeration and trade facilitation in an African context. The Krugman–Livas hypothesis (Krugman and Livas Elizondo, 1996) states that agglomeration should go *down* with trade openness by weakening the forward and backward linkages that underpin spatial agglomeration in large urban centres. The case of sub-Saharan Africa is particular in many respects. First, urban migration is far from over, as structural transformation away from agriculture is still incomplete. Second, most sub-Saharan African countries have substantially liberalised their trade regime; in particular, many are part of regional trade agreements. Third, in spite of formal trade liberalisation, anecdotal evidence suggests that many non-tariff barriers linger on, hampering intra-African trade; but little is known directly of how important those barriers are, because intra-African trade is reported only on a fragmentary basis.

Our approach consists of proxying the location of economic activity through the measurement of night-light emissions, an approach that has been recently gaining popularity in the literature, and by proxying the reduction of trade barriers by improvements in Logistics Performance Index scores.

Our results suggest that activity seems to have agglomerated away from borders in sub-Saharan Africa, but that this agglomeration effect was dampened by trade facilitation. We identify agglomeration through an 'iron-curtain' effect whereby night-light emissions captured by satellites decrease along major cross-border highways as one gets closer to border. This effect is strongly present and has reinforced itself over time. However, it is significantly dampened by trade facilitation, an effect that seems robust to the inclusion of powerful arrays of fixed effects and a variety of estimation approaches.

These results are important for policy-makers and development partners, as they suggest that, beyond their well-understood effects on trade and growth, trade-facilitation projects can also have desirable effects on the location of economic activity, making growth more balanced spatially. The development of activity in peripheral areas is a highly desirable alternative to sprawling urban centres with severely deficient sanitary and transport infrastructures; moreover, it can contribute to more inclusive growth and to the local consolidation of peace processes.

References

Ades, Alberto, and Glaeser, E. (1995) ‘Trade and Circuses: Explaining Urban Giants’, *Quarterly Journal of Economics* 110, 195-227.

Aker, Jennifer, Klein, M., O’Connell, S. and Yang, M. (2014) ‘Borders, Ethnicity, and Trade’, *Journal of Development Economics* 107: 1-16.

Amin, Mukhtar and Hoppe, M. (2013) ‘Where Informal Procedures are Quasi-Formal: Cross-Border Trade between West and Central Africa’. World Bank Africa Region Policy Note 37. Washington, DC: The World Bank.

Araujo Bonjean, Catherine and Brunelin, S. (2013) ‘Le Commerce agricole en Afrique de l’Ouest et du centre: Les frontières sont-elles abolies?’, *Revue d’Economie du Développement* 1: 5-32.

Behrens, Kristian, Gaigné, C., Ottaviano, G. and Thisse, J.-F. (2007) ‘Countries, Regions, and Trade: On the Welfare Impacts of Economic Integration’, *European Economic Review* 51: 1277-1301.

Ben Barka, Habiba (2012) ‘Border Posts, Checkpoints, and Intra-African Trade: Challenges and Solutions’. Tunis: African Development Bank.

Brülhart, Marius (2011) ‘The Spatial Effects of Trade Openness: A Survey’, *Review of World Economics* 147: 59-83.

Brülhart, Marius, Crozet, M. and Koenig, P. (2004) ‘Enlargement and the E.U. Periphery: The Impact of Changing Market Potential’, *World Economy* 27: 853-875.

Brülhart, Marius, Carrère, C. and Trionfetti, F. (2012) ‘How Wages and Employment Adjust to Trade Liberalization: Quasi-experimental Evidence from Austria’, *Journal of International Economics* 86: 68-81.

Brunelin, Stéphanie and Portugal-Perez, A. (2013) ‘Food Markets and Barriers to Regional Integration in West Africa’. Mimeo. CERDI/The World Bank.

Crozet, Mathieu and Koenig, P. (2004) ‘E.U. Enlargement and the Internal Geography of Countries’, *Journal of Comparative Economics* 41: 689-736.

de Melo, Jaime and Tsikata, Y. (2014) ‘Regional Integration in Africa: Challenges and Prospects’. WIDER Working Paper 2014/037. Helsinki: World Institute for Development Economics Research.

Duranton, Gilles (2008) ‘From Cities to Productivity and Growth in Developing Countries’, *Canadian Journal of Economics* 41: 689-736.

Egger, Peter, Huber, P. and Pfaffermayr, M. (2005) ‘A Note on Export Openness and Regional Wage Disparity in Central and Eastern Europe’, *Annals of Regional Science* 39: 63-71.

Fox, Sean (2013) 'The Political Economy of Slums: Theory and Evidence from Sub-Saharan Africa'. Mimeo. Department of International Development, London School of Economics and Political Science.

Freund, Caroline and Rocha, N. (2011) 'What Constrains Africa's Exports?', *World Bank Economic Review* 25: 361-386.

Kanbur, Ravi and Zhang, X. (2005) 'Fifty Years of Regional Inequality in China: A Journey through Central Planning, Reform and Openness', *Review of Development Economics* 9: 87-106.

Kessides, Christine (2006) *The Urban Transition in Sub-Saharan Africa: Implications for Economic Growth and Poverty Reduction.* Cities Alliance/The World Bank.

Krugman, Paul (1991) 'Increasing Returns and Economic Geography', *Journal of Political Economy* 99: 483-499.

Krugman, Paul and Livas Elizondo, R. (1996) 'Trade Policy and the Third World Metropolis', *Journal of Development Economics* 49: 137-150.

McMillan, Margaret and Rodrik, D. (2011) 'Globalization, Structural Change, and Productivity Growth'. NBER Working Paper No. 17143.

McMillan, Margaret and Harttgen, M. (2014) 'What is Driving the African Growth Miracle'. NBER Working Paper No. 20077.

McMillan, M., Rodrik, D. and Verduzco-Gallo, I. (2014) 'Globalization, Structural Change and Productivity Growth, with an Update on Africa', *World Development* 63: 11-32.

Monfort, Philippe and Nicolini, R. (2000) 'Regional Convergence and International Integration', *Journal of Urban Economics* 48: 286-306.

Monfort, Philippe and van Ypersele, T. (2003) 'Integration, Regional Agglomeration and International Trade'. CEPR discussion paper # 3752. London: CEPR.

Montgomery, Mark, Stren, R., Cohen, B. and Reed, H. (eds) (2003) *Cities transformed: Demographic change and its implications in the developing world.* National Research Council of the National Academies. Washington, DC: National Academies Press.

Papadopoulos, Giorgios and Santos Silva, J. (2008) 'Identification issues in models for underreported counts'. Mimeo. University of Essex.

Pinkovskiy, M. L. (2013). Economic discontinuities at borders: Evidence from satellite data on lights at night. Unpublished manuscript, Massachusetts Institute of Technology.

Redding, Stephen and D. Sturm (2008) 'The Costs of Remoteness: Evidence from German Division and Reunification', *American Economic Review* 98: 1766-1797.

Rodrik, Dani (2014) 'An African Growth Miracle?'. CEPR discussion paper #10005. London: CEPR.

Staub, Kevin and Winkelmann, R. (2011) *Consistent Estimation of Zero-Inflated Count Models*. University of Zurich Socioeconomic Institute working paper 0908.

Thisse, Jacques-François (2009) 'How Transport Costs Shape the Spatial Pattern of Economic Activity'. OECD/International Transport Forum Joint Transport Research Centre Discussion paper 2009-13. Paris: OECD.

UN-Habitat (2003) *The Challenge of slums: Global report on human settlements 2003.* Nairobi: Global Urban Observatory.

UN-Habitat (2008) *State of the World's Cities 2010/2011: Bridging the Urban Divide*. London: Earthscan Publications.

USAID (2007) 'Northern Corridor Case Study: Malaba OSBP'. Mimeo. East and Central Africa Global Competitiveness Hub.

Volpe Martincus, C., Carballo, J. and Graziano, A. (2015) 'Customs', *Journal of International Economics* 96:119-137.

Zake, Justin (2011) *Customs Administration Reform and Modernization in Anglophone Africa – Early 1990s to Mid-2010*. IMF Working Paper WP/11/184. Washington, DC: International Monetary Fund.

ODI is the UK's leading independent think tank on international development and humanitarian issues.

Our mission is to inspire and inform policy and practice which lead to the reduction of poverty, the alleviation of suffering and the achievement of sustainable livelihoods.

We do this by locking together high-quality applied research, practical policy advice and policy-focused dissemination and debate.

We work with partners in the public and private sectors, in both developing and developed countries.

ISSN: 2052-7209

Overseas Development Institute
203 Blackfriars Road
London SE1 8NJ
Tel +44 (0)20 7922 0300
Fax +44 (0)20 7922 0399