The impact of urban growth on agricultural and rural non-farm growth in Kenya

Hans P. Binswanger-Mkhize, Timothy Johnson,
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Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Abstract

To estimate the impact of urban growth on agricultural and rural nonfarm income growth we develop an urban gravity variable that reflects the economic activity of a city– total nighttime light emitted – which is a proxy income of each city. The light intensities were transformed into urban gravity variables depending on the distance of sample villages from the city, and their growth rates used for the analysis in regression equations. The key findings are as follows: Equal urban growth in all locations has an elasticity of 0.50 on agricultural income growth, and of 0.19 on rural non-farm income growth. Urban growth also has a large effect on education, followed by commercialization and then on the use of modern varieties. These in turn have a strong impact on agricultural and rural non-farm income. National urban growth has a larger impact on agricultural and rural non-farm growth than local urban growth. Once we account for the other control variables (roads, education, commercialization, modern varieties), the urban growth impact on agricultural growth is cut in half and for rural non-farm growth the urban growth impact disappears. For non-farm income almost the full impact of urban growth can be explained by its impacts on education. The elasticities of urban growth with respect to agricultural incomes via education, commercialization and HYV are 0.12, 0.10 and 0.05 respectively. Curiously, we cannot show an impact of agricultural growth on rural non-farm income growth.

[1] Hans Binswanger is extraordinary professor in the department of agricultural economics of the University of Pretoria, Samboko is an independent consultant, Timothy Johnson and Liangzhi You are Senior Research Assistant and Senior Scientist respectively at the International Food Policy Research Institute.
[2] This research was generously supported by the International Fund for Agricultural Development. It was part of the work program for the rural development report of 2016 entitled “Towards Inclusive Rural Transformation.” We are very grateful for the support.

CONTENTS

1. INTRODUCTION

In the literature on structural change, the impact of urban growth on agriculture was considered to come from the growing urban demand for food and agricultural raw materials and for labor provided by rural urban migrants. Productivity growth in agriculture made it possible to increase the output to satisfy the demand as well as releasing labor freed up by productivity growth. However it is likely that urban growth today has impacts on rural growth other than through these channels. For example, urban growth may make it more attractive for agricultural populations to invest in education, leading to an increase in years of schooling completed, while at the same time the growth in fiscal resources may allow for more funding of education in rural areas. The increased education may then lead to productivity and income growth in agriculture. Commercialization may offer opportunities for agricultural diversification leading to additional income boosts, while growing scientific capacity may lead to improvements in agricultural technology. This would enrich the analysis of rural-urban interactions in the process of structural transformation.

But urban growth not only has impacts on agriculture. Rural non-farm sectors (RNFS) have been growing in all regions of the world. In Kenya they amounted to 38 percent of agricultural household income in 2007, and is likely to have grown (Suri et al., 2008). When in the 1970's attention first shifted to the sources of growth of the RNFS in developing countries, researchers found that agricultural growth, via production and consumption linkages, was the most important determinant of RNFS growth. These causal links between agricultural and non-farm growth are now very well understood (Haggblade, Hazell and Reardon 2007a), and allow for the analysis of the non-farm sector across countries, regions and over time. In the last decade it became clear that urban-rural linkages to the non-farm sector have become important additional sources of growth for the RNFS. Possible Growth spill-overs can arise from: (i) growing urban markets for non-farm goods that are resource-based (ranging from baskets and woven goods to higher-order items such as tourism, lumber and wood products, such as doors and furniture); (ii) remittances of rural-urban migrants; (iii) the relocation of urban manufacturing enterprises in search of low-cost labour; (iv) proximity to urban infrastructure and commuting opportunities in urban labour markets; and (v) urban-rural skills transfers. (Haggblade et al. eds., 2007). What are the impacts of urban growth on rural non-farm sector growth via agricultural growth (also dependent on urban growth) relative to the impacts via such factors?

While the expanded role of urban impacts on and scope of these linkages are well understood there are many questions left: What is the size of urban growth on agricultural and non-farm incomes? What are the pathways of the impacts of urban growth on rural incomes via demand side factors, education, commercialization, or technology? How does the impact differ if it is caused by growth in the metropolitan centers or in nearby towns? How does the impact vary with the distance of a rural area from nearby or metropolitan cities? Studies examining these linkages are reviewed in the next section.

One of the reasons why it has been difficult to answer these questions is that urban growth data, if available at all, were only available for metropolitan cities. There are no countries that produce such data for smaller cities and towns. Recently, however, it has become possible to use the intensity of night light emissions measured from space as proxies for GDP and GDP growth at any particular point of the world (Henderson et al, 2012,; Binswanger and Savastano, 2016). Economic growth in a city will increase the total amount of light it emits in two ways: By growth within the initial city boundaries, and by adding more pixels to the city as it grows.

A city's impact on agricultural, nonfarm and total income growth in a village will not only depend on the growth of light intensities of cities, but also on the distance of the city to the village. In this paper we use an exponential function to translate the light intensity and distance from the cities into an urban gravity variable. We compute two urban gravities for each village: The urban gravity of the nearest town of more than 50,000 inhabitants in 2000, and the total of all urban gravities of the country with respect of each village, except that for the nearest town. In Kenya there are nine such cities including two metropolitan areas. This computation leads to separate estimates of local and national urban gravity for each enumeration area in which the households are included. The growth of these urban gravities are proxies for the urban growth of the nearby city and the remaining national urban economy.

We are using four rounds of the national agricultural household survey of the Tegemeo Institute of Agricultural Policy. These data will capture the full urban impact on agricultural incomes, but only the impact of urban growth on the non-farm income of agricultural households (including landless workers). What will be left out are incomes of rural non-farm households, and the incomes generated by rural enterprises. To overcome the first problem the use of rural household surveys such as the LSMS-ISA surveys of African countries. For the second issue census data provide main occupations, and analysis of such data could also shed light on the urban impact on non-farm employment in specialized households, including those working in rural firms.

The econometric analysis involves the regressions of agricultural income, rural non-farm income and total income on the local and national urban growth (LUG and NUG). We first estimate the gross impact of LUG and NUG on the three income variables without any other control variables such as the distance to the nearest motorable road, or the growth in education of the household head. The coefficients of LUG and NUG measure their impacts gross of the impacts via the other control variables.

However, a number of other household and village variables are also influenced by urban growth such as the distance of the village to a motorable road, education of the head of household (EHH), use of modern varieties (HYV) and the household's commercialization index. In the second set of regressions these variables, as well as agricultural income (AI) for rural non-farm income. These regressions therefore measures the net impact of UG on income growth, net of the contribution of the other included variables. Combining coefficients from the two sets of regressions allows us to estimate the impact of UG on the rural incomes via the impact of UG on EHI, HYV, CI and AI. However there are both household and village fixed effects as well as endogeneity issues to be resolved. We do this by using double differencing and the use of jackknived village means for all these variables for each household from which the observation of the household is extracted. In the regressions the error term is therefore no longer correlated with the jackknived mean.
The main findings of the paper are as follows:

1. Equal urban growth in all locations has an elasticity of 0.50 on agricultural income growth, and of 0.21 on rural non-farm income growth.
2. We find that urban growth has a large effect on education, followed by commercialization and then on the use of modern varieties. These in turn have a strong impact on agricultural and rural non-farm income.
3. National urban growth has a larger impact on agricultural and rural non-farm growth than local urban growth.
4. Once we account for the other control variables (roads, education, commercialization, modern varieties), the urban growth impact on agricultural growth is cut in half and the impact disappears for rural non-farm growth.
5. For non-farm income almost the fully impact of urban growth can be explained by its impacts on education. The elasticities of urban growth with respect to agricultural incomes via education, commercialization and HYV are 0.12, 0.10 and 0.05 respectively.
6. Curiously, we cannot show an impact of agricultural growth on rural non-farm income growth.

The paper first will present a review of the relevant literature, followed by the construction of the proxy for urban growth, the growth in urban gravity. Then follows the analytical framework and the description of the data. This is followed by the results section, and conclusions and implications follow.

2. LITERATURE REVIEW

The review discusses urban-rural linkages associated with structural transformation, the growing importance of the rural non-farm sector, the agricultural to rural non-farm linkages, and the determinants of the importance urban-rural linkages.

2.1 Urban-Rural Linkages

How one defines an urban area is important in analyzing the urban-rural growth linkages. One extreme is to treat major cities as urban and the rest of the regions outside the major cities as rural. Another definition includes the small- to medium-sized cities connecting the rural areas and the major cities. Evidence shows that the small- to medium-sized cities connecting the rural areas play a very important role in rural transformation. They can be hubs of economic growth. In Latin America they account for a large share of the total population (Berdegue et al. 2015). Moreover, Christiansen & Todo (2014) have shown that economic diversification in intermdiate cities in Ghana reduce poverty more than that in metropolitan urban areas. This paper therefore adopts the broader definition of urban areas that includes both nearby secondary cities and metropolitan areas.

The literature on structural change has shown that agricultural productivity is able to ensure the food supply of growing urban areas as well as providing the rural-urban migrants to grow the urban labor force in industry and services (Lewis, 1954, Timmer, 2009). While in an early stage of development, the non-farm sector is primarily driven by agricultural growth, in the second stage of economic development, the urban influence on the growth of the rural nonfarm sector becomes more important as the rural and urban areas become more integrated. The type of goods and services produced also changes towards goods and services that use more modern techniques, or serve more complex markets.

The rural nonfarm sector contributes to rural employment, incomes and rural poverty reduction. In many developing countries it has grown rapidly and now contributes more to farmer income than agriculture. The share of nonfarm income in total income was 37% in Africa, 47% in Latin America, and 51% in Asia (Haggblade, Hazell, & Reardon, 2007a). The rural non-farm sector includes all natural resources-based industries, most importantly forestry, mining, tourism; non-tradable services and goods such as input supply, marketing and consumer services or bricks, and some manufacturing. It can also include subcontracting of rural households for production and remittances. Rural poverty can decline more quickly where these non-farm activities grow rapidly and generate significant employment opportunities (Lanjouw & Lanjouw 2001). Except for highly capital-intensive activities such as those involving the processing of sugarcane or tea, the non-farm goods and services produced are usually labor intensive and their production takes place in very small businesses, often having only one worker.[3]

Using Haggblade Hazell and Brown, (1989), Lanjouw, (1999), Hazell and Haggblade, (1989), and Haggblade, Hazell and Reardon (2010), there are five different ways in which the rural nonfarm sector is linked to agriculture and these are summarized as follows:

1. Product market linkages which include:
    a. Backward production linkages from agriculture to rural input suppliers.
    b. Forward production linkages from agriculture to processors and distributors.
    c. Consumer market linkages generated as a result of increasing farm incomes.
2. Factor market linkages involving:
    a. Capital flows.
    b. Labour flows.

Backward production linkages have been shown to be smaller than the forward linkages. These linkages have been weaker for African countries when compared to green revolution Asia (Haggblade, Hazell and Brown 1989) as a consequence of low use of inputs and limited marketing and processing of outputs. Agricultural income growth triggers rising demand for non-food goods and services. The resulting consumer demand linkages are usually larger than the production linkages. To the extent that the goods and services can be imported from urban areas, the demand will leak out of the rural areas. However, there is also the demand for rural non-tradable goods and services such as housing, health, prepared foods, transport, communication, visits to town, etc. When there are rising returns from the rural nonfarm sector, some households diversify their employment and businesses into these new areas, while other households switch from part-time into full-time provision of such goods and services.

Rising income from agriculture may increase the rural savings rate. Some of the savings from agriculture allow for capital flows to nonfarm activities, and some of the profits from nonfarm activities can be used to finance capital investments on the farm (Reardon, Crawford & Kelly 1994).

Access to nonfarm opportunities by the poor is not guaranteed. Haggblade Hazell and Reardon, (2010) and Lanjouw and Shariff (2004) show that in India, access to different types of nonfarm employment depends on education levels and the possession of assets, with the odds of finding better paying nonfarm employment increasing with the level of education and size of land assets. The same conclusion is arrived at by Isgut (2004) in Honduras, and by

[3] The location of industries in low wage areas is good for inclusiveness because these are usually left out as growth proceeds. During the Green Revolution in India industries located in areas bypassed by it, where wages were relatively lower than in those where they had been pushed up by the rapidly growing agriculture (Foster and Rosenzweig 2003). This helped reduce the growth in the income gap between included and left out Regions

Barett, Reardon and Webb, (2001) for Africa. With low levels of education and little to no land owned, the poor are likely to engage in the unskilled and low-return farm and nonfarm employment activities which Reardon, Berdegue and Escobar (2001) refer to as "an equivalent of subsistence farming." Evidence on the poverty impact of rural nonfarm growth is mixed, it may greatly improve the income of the poor or in other cases the rich earn more of the share (Haggblade, Hazell & Reardon 2007b)

The employment and poverty reduction potential of the rural non-farm sector has been found to depend on both the impacts of the farm-nonfarm linkages and the urban-rural linkages. The impact of these linkages most and foremost depends on the growth rate of agriculture and of urban areas. Agricultural growth creates strong linkages to the non-farm economy, while urban growth fuels demand for agriculture and outputs of the rural non-farm sector. The impact of urban areas on agricultural growth further boosts the non-farm sector.

The effect of urban areas on the rural nonfarm sector is a combined result of different channels:

1. Urban income growth fuels agricultural demand and production, and that in turn fuels non-farm growth.
2. Urban areas also demand natural resources or natural resource-based products from the rural areas. These may range from the low order products such as baskets, reed mats and other woven items to the higher order items such as tourism and lumber and wood products that include doors, door frames, and furniture (Haggblade et al., 1989).
3. Where urban wages grow at faster rates than rural wages, urban wage growth may induce manufacturing firms to move to rural areas as was the case in India where lower wages in the rural areas attracted small factories (Foster & Rosenzweig, 2003).
4. Rural-urban migration leads to remittances, part of which is invested in housing, farm and non-farm enterprises.
5. Proximity to urban areas and/or access to infrastructure have positive effects on nonfarm growth (see Lanjouw & Shariff 2004). They provide opportunities of commuting to urban area jobs. The dividing line between urban and rural areas becomes blurred (Hagbladde et al. eds., 2007)
6. Technology spillovers such as those from motorization, information technology, electricity coverage and other innovations originating in urban areas lead to establishment of new services in rural areas.

2.2 What Determines the Importance of the Urban-Rural Linkages?

The urban-rural linkages are likely to be influenced by the size of the urban demand for agricultural products, natural resource products, and rural amenities, including tourism. But they also depend on the nature of growth in the cities. Countries dominated by mineral and oil exports create consumption cities with small manufacturing and tradable service sectors which could have a relatively lower positive impact on rural growth than production cities

(Jedwab, 2011). The size of the city or urban area near a rural economy has been shown to have a positive effect on the size of the linkages. High return nonfarm self-employment declines with increasing distance to urban areas. There is also a threshold city size for triggering greater growth and reducing territorial poverty (Berdegue et al., 2015; Deichmann, Shilpi & Vakis 2009).

Proximity to an urban area also increases the size of the urban-rural linkages. Proximity enhances accessibility and the development of public infrastructure, motorization and other innovations. Nearby towns and cities also provide more nonfarm employment for temporary migrants or commuters. In Bangladesh, the closer one is to an urban area, the higher the likelihood to be employed in higher earning nonfarm activities. Those far from the urban centers are less likely to engage in higher paying nonfarm activities even if their area is experiencing rapid agricultural growth (Deichmann, Shilpi & Vakis 2009). Haggblade, Hazell and Brown (1989) observed that low order activities such as basket making and weaving become less important as one moves closer to urban areas, while high return activities such as processing, manufacturing, carpentry, and metal work become more important.

For the urban rural linkages the level and development of manufacturing and services, and their labor intensity determines the demand for labor, and in particular for rural-urban migrants. The migrants tend to send significant amounts of remittances into the rural areas. These in turn lead to higher demand for non-tradable goods and services, including especially housing construction, commerce and services such as prepared food.

Berdegue et al. (2015) in Latin America examine the effect of human capital from the cities to the rural areas, and find little support for a human capital effect except in Mexico. A greater presence of professionals, and technicians in the overall population decreased poverty, while the presence of university students in the population was associated with higher poverty levels because of its adverse impact on inequality.

East, South-East and South Asian countries have done well both in urban and agricultural growth. Their agricultural production uses high levels of inputs and modern technologies, and their agricultural mechanization level is increasing. Most of these countries invest much public resources into rural infrastructure and education. They have small farmer based agrarian structures conducive to consumer demand linkages. Production systems are still highly labor intensive, as are the rural non-farm activities. Population densities are high, urban centers are nearby and many of these are large. Savings rates are also very high. Given all these positive forces, it is therefore not surprising that the share of non-farm income in rural incomes is high at 51% (Haggblade, Hazell and Reardon, 2007a).

In Latin America there are several factors that are less conducive to the rural non-farm sector. Both urban and agricultural growth rates have generally been lower than in Asia. In the smallholder sector input and labor intensity of production is also lower than in Asia, and varies a lot across more and less favorable agricultural zones. There are a number of regions that have benefitted little from green revolution technologies. Most countries are characterized by dual farm structures, with much of the income of the large farms leaking out of rural areas. Compared to Asia, population densities are generally lower distances between farms and urban centers higher, and populations of nearby cities often quite small. Rural savings rates also tend to be lower. The overall impact of these differences is that the share of rural non-farm income in rural incomes is lower, at 47 percent (ibid).

In Africa rates of per capita income growth are also lower than in Asia but they have accelerated over the past two decades, and some of the fastest growing countries of the World are in Africa (e.g. Kenya and Nigeria). In most countries, growth rates of per capita income are now positive and quite large (in 2013, annual GDP per capita growth rates were at 2.9% for Kenya, 2.5% Nigeria, 5.6 for Democratic Republic of Congo and 3.3% for Zambia)[4]. However the intensity of use in agriculture of inputs, irrigation, other capital and modern technology is still very low, implying low backward linkages from agriculture. The agricultural sector is still more subsistence oriented than in the other regions, reducing the size of the forward linkages. The small farm size structure is favorable for consumer demand linkages, but rural incomes are very low, which limits the power of consumer demand linkages. Population density, while rising, is still less than in Asia and remains low in land-abundant countries. Distances to cities are higher, and except for the mega cities, they tend to be smaller than in Asia. Finally rural savings and investment rates are very low. The cumulative impact of the mostly negative factors is that the share of non-farm income in rural income remains small at 37% (ibid).

In all Regions the share of the non-farm incomes is likely to increase as a consequence of rapid urbanization, rapid economic growth, the spread of agricultural technologies, inputs, and mechanization, the rising commercialization of smallholder agriculture and the growing adoption of technologies such as motorized transport and cellphones that have an urban origin.

[4] http://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG

3. TECHNICAL APPROACH AND DATA SOURCES

This section discusses the approach to estimating measures of urban gravity, and the impact of urban gravity on rural household incomes. Further, it also presents the data, and data sources. Variables used in the econometric estimation are also discussed.

3.1 Estimation of urban growth

In order to estimate the impact of urban growth on the farm and non-farm sectors, agricultural and rural panel data covering a significant time period are needed. For agriculture such data fortunately are now becoming widely available. However, apart from national level urban growth, there are usually no data available on the growth rate of specific cities. This constraint is now being overcome by the use of the change in light intensity of cities as a proxy for economic growth in the city. It is therefore possible to get a proxy estimate of the growth of each city across the globe, which can be used to estimate the impact of cities at different levels on rural growth. To account for the fact that urban influences will be larger near the cities than far away, the light intensities can be transformed into measures of urban gravity that decays with the distance from the cities.[5]

Following Henderson et al. (2012), we use intensity of night light measured from space as a proxy measurement for economic activity (see Annex 1 for details). While light intensity is not a direct measure of economic activity, it is highly correlated with it. If GDP data are flawed, they may be a superior measure of economic activity at the national level. A great advantage of light intensity is that it can be used as proxies for GDP for sub-units of countries for which GDP data are not available, as is the case for most cities in Africa. To measure the aggregate emission of light at night from a city, we aggregate the light intensity of each pixel over all pixels of the city.

To calculate the city night intensity, night light satellite data was used from the Defense Meteorological Satellite Program (DMSP). The 30 arc second data (~1Km^2 at equator), covers the period from 1992-2013 (Small, et. al, 2011, NOAA). The data for light intensity come from the Defense Meteorological Satellite Program (DMSP) of the National Geophysical Data Center. The resulting light emission should be correlated to the economic output and income of the city, and therefore be a proxy for the food demand emanating from it.

[5] A limitation of working with household data is that the urban impact that is evaluated is the impact of urban growth on household income or separately on its farm and non-farm components. However, urban growth will also expand enterprise growth in the rural areas, some of which are household based, while others are firm based. Using household data, therefore, leaves out the impact of urban growth on the growth of firms that are not household-based.

The influences of urban growth on rural incomes is assumed to decrease with distance from the urban centers. A negative exponential function was used since it results in a gradual decline with distance. The following negative exponential distance weighting function described in Accessibility indicators in GIS (Deichmann 1997) was used:

$$UG_h = \sum_h CityNight_h \times e^{\left(-d_{ih}^b/2a^2\right)} \qquad (1)$$

Where:

UG_h = Urban gravity (accessibility) calculated for village *h*

$CityNight_h$ = the sum of all city nights within the urban extent of city *j*

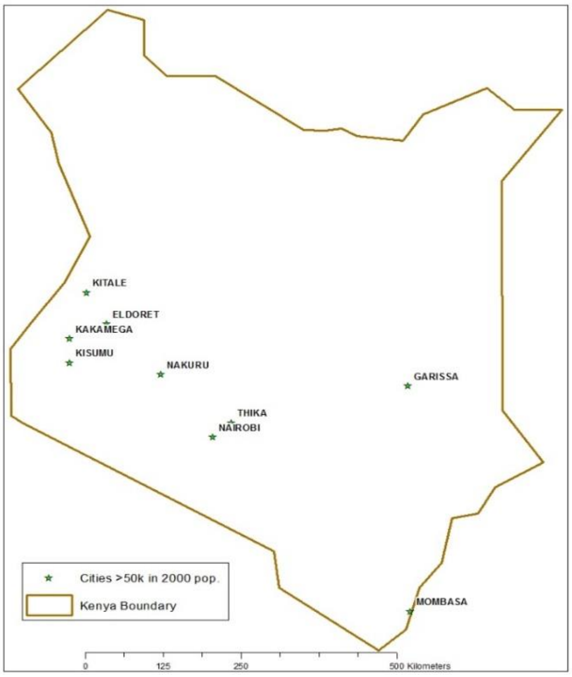
D_{hj} = distance between village *h* and city *j*.

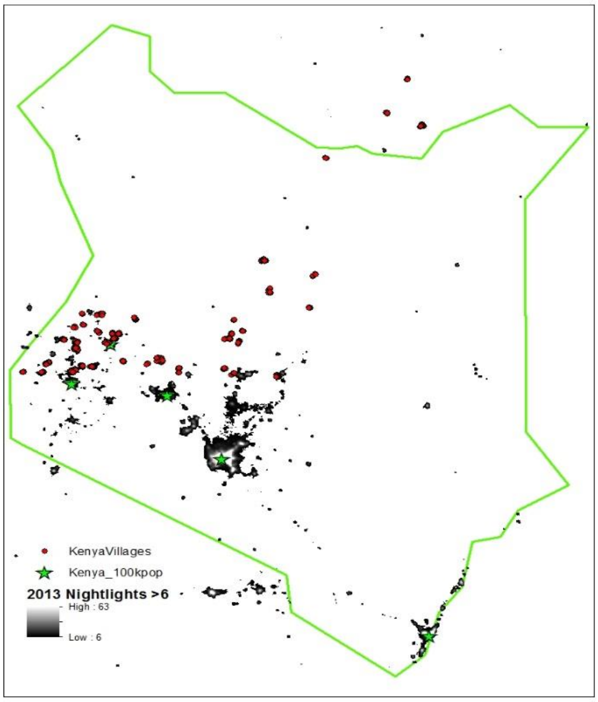
a, b are two parameters which are affecting the shape and speed of the distance decay function. We choose *b* =2, and various *a* values (*a* = 50, 100, 150, 200).

Equation (1) shows how the urban gravity to an individual town or city is computed. As a measure of local urban gravity we use the urban gravity to the nearest town of population of over 50,000 in the year in 2000, which is the midpoint of the years over which light intensities are available. There are nine such cities (Map 1a). For the remaining national urban gravity we sum up the urban gravities of the remaining eight cities. Map 1. Annex 1 describes in detail how we calculated city populations, the cutoff point of light intensity between urban and rural areas, the extent of urban areas, and distances between villages and cities.

Map 1: Variables used in computing urban gravities

(a) Cities over 50,000 population (2000)   (b) Light intensities and location of villages





3.2 Determining the rate of decay (a) in the urban gravity equation

If we use a specific decay rate of the impact of urban growth, it means that we already have made an important decision on a parameter that will influence the resulting regression results. Consider the case where urban gravity operates only up to 1 hour of travel time to the village, and compare it to the case where it operates up to 8 hours. In the first case we assume that all urban centers beyond the one hour distance are irrelevant, while they are significant if urban gravity goes close to zero only after as many as 8 hours. But we really do not know which is the right assumption. In order to get to the right value of a, we could compute urban gravities for different parameter values and then estimate the system of equations with each of the data sets. We will choose the decay parameter that gives the best fit, as judged by R-square.

3.3 Estimating the impacts of urban growth on rural areas

Regressions are used to estimate these impacts. Let R be either the level of agricultural or rural non-farm incomes, and U stand for local or national urban gravity. Let X stand for any exogenous conditioning variables.[6] Then a reduced form estimation equation can be formulated as follows:

$$R_{iht} = \alpha_i + \sum_{k=1}^{2} \beta_k U_{kht} + \sum_{j=1}^{n} \gamma_j X_{jht} + \tau_{it} + \varphi_{it} + \varepsilon_{iht} \qquad (2)$$

Where i stands either for agricultural, rural non-farm or total household income, h stands for the household and t stands for the time periods. φ_{it} is the household-specific effect, τ_t is the time-specific effect and ε_{iht} is the random error.

Let lower case variables stand for the first differences of the respective variables across time periods. The equation in first differences is given by:

$$r_{hit} = \alpha_{hit} + \sum_{k=1}^{2} \beta_k u_{kht} + \sum_{i=1}^{n} \gamma_k x_{kht} + \varepsilon_{hit} \qquad (3)$$

Note that formulating the equations in terms of first differences means that fixed household, village and city effects have already been taken care of. The lower case variables can also be interpreted as rates of growth, and we actually estimate the equations in first differences of rates of growth (double differencing).

Identification of the direct impact of urban growth rural non-farm growth

Consider equation (3) If r is agricultural income growth, this equation is properly specified, and β_k will pick up agricultural demand effects and other effects of urban income growth agricultural income growth. However if r_{it} is rural non-farm growth β_k will pick up both the direct impact of urban growth on the rural non-farm sector, as well as the indirect effect via agricultural growth linkages to the non-farm income. But this is not what we are looking for. Instead we need to add agricultural income growth a_{it} to equation (4) so that β_k is the impact of urban growth on non-farm income net of its impact on agricultural growth.

$$r_{iht} = \alpha_i + \sum_{k=1}^{2} \beta_k u_{kht} + \sum_{j=1}^{n} \gamma_j x_{jht} + \gamma a_{ht} + \varepsilon_{iht} \qquad (4)$$

We assume that agricultural growth influences non-farm growth via backward and forward linkages and via consumer demand linkages for rural home goods (i.e. goods and services that are produced locally and not traded in the national or international market). This causality is well captured by γ in equation (4). If we assume that all agricultural products are traded nationally or regionally, the growth of income from non-farm goods will not have any price effects on the agricultural commodities, and therefore no impact on agricultural production. However, there are likely to be agricultural home goods, and if their share is significant, there is also causality from non-farm to agricultural income.

6 Even if light intensity is a poor proxy for the absolute income of a city, its change is much more reliable, as any measurement errors affect the estimates for each year are largely netted out.

3.4 Econometric approach

To get elasticities for estimated variables, we normalize the variables by dividing by their means prior to estimation. Equation 3 and 4 are already is in first differences, eliminating fixed effects that are associated with the household or village. We convert the first differences into rates of growth. We then difference these once more, so that the regressions are run on changes of growth rates. This double differencing also eliminates household fixed effects that affect their income growth rate, rather than just their income levels.

The equation also contains endogenous variables on the right hand side, including not only the other one of the two incomes variables but also education, commercialization and HYV, all of which are themselves influenced by urban growth. To address these endogeneity problems we replace that individual household's variables on the right hand side with their village means from which the household's observation has been extracted (jackknifing). The household error term is therefore no longer correlated with the jackknifed village means of the other right hand side variables.[7] This technique has been successfully used in empirical work on growth and inequality (e.g. see Benjamin, Brandt, & Giles, 2011)

3.5 Data and Variables

Kenya has one of the longest agricultural household panels in Africa; it covers five waves of data collected in 1997, 2000, 2004, 2007, and 2010. The data was collected by Egerton University's Tegemeo Institute of Agricultural Policy Research Project (TAPRA) in collaboration with Michigan State University. For this paper, we use four waves of the nationally representative longitudinal data (i.e. 2000, 2004, 2007 and 2010). The datasets are for small farming households in 8 agro-ecological zones. The household-level information collected in these surveys included, GPS coordinates, farm and off-farm income sources, size of landholdings irrespective of ownership status, other productive asset ownership, remittances, crop and livestock output values, distances to facilities and services, and socio-demographic characteristics of household members.

The sampling was conducted in such a way that within a designated area, all villages were listed while taking into account the Agro-ecological zones as well as whether the selected district belonged to those districts where TAPRA had conducted much research before. In the first step, the spatial distribution of the various agro-ecological regions was identified following which the districts were divided into divisions, locations and sub-locations and then villages/wards. The list of households within a selected village was then used to randomly select households to be interviewed.

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[7] Since village fixed effects have also been eliminated through double differencing, such effects no longer cause dependence of the village variables with the error terms in the equations.

The 1997 sample consists of 1540 interviewed households. Out of these, 1,446 were re-interviewed in 2000. In 2004, from a Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA) survey comprising 1540 households, 1397 households were re-interviewed. This number declined slightly in 2007, with a total of 1,342 households re-interviewed from the 2004 households. The 2010 sample was composed of only those households that were interviewed in 2007. It covered about 1309 randomly selected households from the original 1,342 households in 2007. So in total, from the five waves of data, there are 1309 panel households covering the 13 year period. For this analysis, 1,047 panel households were used.

Explanatory variables include the mean value of non-land capital per hectare with mean computed without using a household's own observations (in Kenyan Shillings), the mean years of education of the household members resident in a village, with mean computed without a household's own observation, the crop commercialization index (measure as percentage of crop output that is marketed), distance to fertilizer seller, distance to motorable roads, and the mean percentage of high yielding maize seed varieties planted in a village with mean computed without using a household's own observations.

4. FINDINGS

This section discusses the study's main findings. We first discuss the gross impact of local urban gravity (LUG) and national urban gravity (NUG) on the growth of rural non-farm income (RNFI), agricultural income (AGI) and gross income (TI), on the growth in average education of the household (EHH), the farm's use of modern varieties (HYV), and the growth of its crop commercialization index (CI). All these six variables are likely to grow as a consequence of urban growth. The second set of estimates relate the growth of the three income forms to LUG and NUG, as well as to EHH, HYV and CI. The UG coefficients of these regressions therefore measures the impact of UG net of the contribution of EHI, HYV and CI. The two sets of regressions allow us to estimate the impact of UG on the rural incomes via the impact of UG on EHI, HYV and CI.

4.1 Impacts of urban growth on rural areas

Table 1 presents regressions of rural non-farm income growth and agricultural growth on the urban growth variables, without other controls. The coefficients of the UGs measure the gross elasticities of LUG and NUG on the two income types, before taking account of other conditioning variables. For agricultural income they are near 0.3, while for the non-farm incomes they are near 0.1impact. For both incomes national UG is slightly more important than local UG, but the differences are within their respective standard errors. The elasticity of equal growth of the LUG and NUG on the incomes can be calculated as the sum of the local and national UGs, net of the interaction between the two. The interaction term is negative in all equations, implying that the two UGs are substitutes. For non-farm income, the elasticity of equal growth of both UGs is 0.19, while for AGIG it is 0.50.Therefore a 1% increase in the growth rate of both UGs will lead to a 0.19% increase in RNFIG and a larger 0.50% increase in AGIG.

The curious missing impact of agricultural income on non-farm income

The role of agriculture as a driver of non-farm growth has been much stressed in the literature. It arises from forward and backward linkages of agriculture to RNF activity, and the consumer demand linkages, the impact of agricultural income growth on the demand non-traded goods and services of the NRF sector. The estimated AGI coefficient cannot be distinguished from zero, however.

How could that be? Is there an endogeneity issue left between AGI and RNFI income? This is not likely given that the jackknifed village means of AGI are not correlated with the own household's RNFI. Additionally, the fixed effects are eliminated by first differencing the variables. Another question we asked is whether urban growth or other explanatory variables pick up the impact of AGI on RNFI. When we left all these variables out, however, the agricultural income coefficient remained insignificant. This result may be partially explained by the limited backward and forward linkages associated with low use of external inputs into Kenyan agriculture, and limited food processing in the villages. However, that would still leave the consumer demand linkages.

The impact of UG on education commercialization and use of modern varieties

The elasticity of education with respect to local urban growth is 0.07, and 0.15 for national urban growth. The impact of equal growth in both UGs is 0.21. The larger impacts of national UG on education than of local UG may be because education funding and policies depend on national rather than local decisions. Still, local UG leads to growth in education, but via unknown pathways.

The impact of HYV with respect to local UG is 0.15, while that of national UG growth is 0.31. Their combined impact is 0.24. The elasticity of the commercialization index with respect to the local UG on CI is 0.19, and 0.31 for national UG. Their combined elasticity is 0.21.
R-squares range from near zero for the rural non-farm equation to 0.26 for the HYV equation.

In summary we see a strong gross impact of urban growth on agricultural income with an elasticity of 0.50, and significant impacts on rural non-farm income, education, HYV use and commercialization with elasticities with respect to equal growth between 0,19 for non-farm income and 0.26 for HYVs. The impact of national urban growth exceeds the impact of local urban growth in all cases. On the other hand we cannot show an impact of agricultural income growth on rural non-farm growth.

Table 1: The gross impact of UG on rural incomes

VARIABLES	(1) Total Income	(2) Non-farm Income	(3) Agriculture Income	(4) Education	(5) Modern Varieties	(11) Crop Commercialization Index
Local urban gravity	0.234***	0.094*	0.290***	0.074***	0.149***	0.193***
	(0.028)	(0.051)	(0.030)	(0.004)	(0.005)	(0.011)
National urban gravity	0.297***	0.128	0.354***	0.151***	0.310***	0.238***
	(0.045)	(0.082)	(0.051)	(0.010)	(0.018)	(0.032)
Urban and local gravity interaction	-0.148***	-0.061	-0.153***	-0.011***	-0.116***	-0.217***
	(0.035)	(0.059)	(0.044)	(0.004)	(0.010)	(0.020)
Agricultural income, Jackknifed		0.050				
		(0.046)				
Nonfarm income, Jackknifed			0.053**			
			(0.025)			
Constant	0.603***	0.784***	0.441***	0.785***	0.646***	0.766***
	(0.040)	(0.071)	(0.044)	(0.010)	(0.018)	(0.027)
Observations	4,944	4,944	4,944	4,944	4,944	4,944
Number of households	1,236	1,236	1,236	1,236	1,236	1,236
Overall R-squared	0.0553	0.0060	0.0800	0.1538	0.2576	0.0742

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2 The net impact of UG on rural incomes

Non-farm income

When the average household education, use of modern varieties, and the crop commercialization index are included in the three income equations (Table 2), the coefficient of UG declines, as expected. In the case of rural non-farm income the impact of UG disappears, and is instead taken up by a large education impact at 0.51. None of the other variables have a significant impact on RNFI.

Agricultural Income

For agricultural income growth the net impact of UG remains at 0.15 and 0.14 for local and national UG respectively. The net impact of equal local and national UG is 0.25. The net elasticities most likely reflects the urban demand side effect on agricultural growth, and perhaps of other unobserved urban variables. Growth in education has an even larger impact on agricultural income growth (0.68) than on non-farm income growth. The importance of crop commercialization for AGI is shown by the elasticity of 0.48. HYV have a lower impact on AGI of 0.10, which appears to be low compared to the other variables. The growth in landholding size has an elasticity of only 0.05, which would suggests that other constraints dominate the land constraint to agricultural income in Kenya.

4.3 The pathway of UG on agricultural and non-farm incomes

UG has a significant impact on education and education has a large impact on the growth of agricultural and rural non-farm incomes. The elasticity of UG on agricultural income growth via education is the product of the elasticity of equal UG on education computed from table 1 (0.21) with the elasticity of education on agricultural income in Table 2 (0.68), which is 0.12. The same value is obtained for the impact of UG on non-farm income growth via education. Therefore the impact of education is very similar for agricultural and rural non-farm income. UG has a significant impact on commercialization and commercialization has a larger impact on AGIG. Therefore, the impact of UG on AGIG via commercialization is 0.10. The impact of UG via HYV computed this way, however, is only 0.05.

For agricultural income growth the gross elasticity of an equal growth in the two UGs is 0.5. The education pathway accounts for about a fourth of the gross UG impact, commercialization for about a fifth and HYV for about 10 percent. This leaves about half of the gross UG effect to be explained by other urban growth impacts such the demand side impacts of urban growth on agriculture.

Table 2: The net impact of urban growth on rural incomes

	(1)	(2)	(3)	(4)	(5)	(6)

VARIABLES	Non-farm Income	se	Agriculture Income	se	Total Income	Se
Local urban gravity	0.079	(0.051)	0.148***	(0.030)	0.134***	(0.028)
National urban gravity	0.085	(0.084)	0.136***	(0.044)	0.149***	(0.043)
Urban and local gravity interaction	-0.062	(0.060)	-0.039	(0.044)	-0.072**	(0.035)
Average household education, Jackknifed	0.513***	(0.166)	0.678***	(0.104)	0.587***	(0.088)
Value of non-land productive assets per Ha of operated land, Jackknifed	0.000	(0.001)	0.000	(0.003)	0.000	(0.002)
Size of operated land (Ha), Jackknifed	0.017	(0.044)	0.054**	(0.023)	0.025	(0.020)
Distance to tarred road, Km	-0.002	(0.003)	-0.001	(0.002)	-0.000	(0.003)
Nonfarm income, Jackknifed			0.042	(0.026)		
Percentage of high yielding varieties, Jacknifed			0.104***	(0.038)		
Crop commercialization index			0.480***	(0.026)	0.350***	(0.025)
Agricultural income, Jacknifed	-0.004	(0.053)				
Constant	0.376**	(0.168)	-0.595***	(0.089)	-0.178**	(0.088)
Observations	4,944		4,944		4,944	
Number of households	1,236		1,236		1,236	
Overall R-squared	0.0119		0.2360		0.1654	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. CONCLUSION AND MAIN IMPLICATIONS

The primary purpose of this paper was to investigate the impact of urban gravity or growth on rural household incomes in rural Kenya. Specific questions included: (i) How large is the gross impact of urban growth on agricultural and rural non-farm income? (ii) How much of the gross urban growth effects are generated by the growth of the nearest city, and how much by the remaining growth in the country? (iii) What is the impact of agricultural growth on rural non-farm growth and vice versa? (iv) What is the impact of urban growth on education, commercialization, and new crop varieties? (v) What are the pathways by which urban growth causes the growth of agricultural and rural nonfarm income via urban demand and the above three variables? And (vi) What is the impact of agriculture on rural non-farm growth.

We find that urban growth has a large impact on agricultural growth and a much smaller but significant impact on rural non-farm growth. This result is consistent with the lack of tradability of most RNF products and services.

For farm, non-farm and total incomes the impact of national urban gravity is larger than the impact of local urban gravity. This is consistent with the importance of national consumer demand for AGI and perhaps national labor markets for RNFI. We find no impact of agricultural income growth on non-farm growth. A possible explanations could be poor forward and backward linkages in Kenya. However that would still leave the usually larger consumer demand linkages.

UG has a large effect on education, followed by commercialization and then on the use of modern varieties. These in turn have a strong impact on agricultural and rural non-farm income. The resulting endogeneity issues for the net impact equations were addressed via double differencing that eliminates household and time period fixed effects. By computing the village means of the variables involved by leaving out the observation of each respective household (jackknifing).

Once the impact of education, commercialization and HYV for AGI and RNFI are accounted for the impact of urban gravity on agricultural income is cut in half from 0.50 to 0.25. Leaving 0.25 of the total to be accounted for by other variables influenced by urban growth

For the rural nonfarm sector the UG impact disappears, and the only impact left is via education. The impacts of urban growth on agricultural incomes via education, commercialization and HYV are 0.12, 0.10 and 0.05 respectively. Their sum at 0.27 therefore explains the gross impact via other factors such as distance to roads or farm size.

Urban growth is seen to have a profound impact on agricultural income growth with about half of the impact being via education, commercialization and modern varieties, and the other half probably mostly via urban agricultural demand. There also is a smaller impact of urban growth on the rural non-farm sector that, interestingly, seems to be fully accounted for by its impact via education. Clearly urban growth has an impact on agricultural growth not only because of its demand for food and labor, but also by its impact on other growth factors. These other effects need to be accounted for in the analysis of structural and agricultural transformation.

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