Market accessibility and economic growth: Insights from a new dimension of inequality

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Abstract. We modify an endogenous growth model to allow for households' differential access to markets. Such local production spillovers highlight a new dimension of inequality arising through geographic remoteness. The model is tested using an instrumental variables approach that takes advantage of the relationship between market accessibility and plausibly exogenous geographic features of the landscape. We find evidence that production spillovers diminish concavely across space before tapering off convexly in remote areas. This result suggests that the marginal household exhibiting production spillovers is located approximately five hours from the nearest market center. The policy implications are that governments could adopt pro-growth inequality-reducing policies using targeted infrastructural investments or relocation subsidies. Based on our spillover threshold estimates, these policies would be access-equality enhancing for 5.1 billion people globally and access-equality reducing for 825 million people globally. We also present findings that growth divergence occurs among countries with geographically less pervasive markets.

Keywords: Market accessibility, spillovers, inequality, public good provisioning and growth.

JEL codes: D6, O4, O5, R1.

1. Introduction.

Since the seminal article by Kuznets (1955) relating income inequality to countries' levels of economic development, economists have sought to explain and measure the relationship between initial income inequality and economic growth. The predominant theory, posed originally by Stiglitz (1969), contends that in the presence of credit market imperfections and diminishing marginal product of capital, households are unable to invest optimally, which causes aggregate output and its rate of growth to decrease in the presence of unequally distributed income (Banerjee and Newman 1993; Galor and Zeira 1993; Benabou 1996; Aghion et al. 1999). The effect of income inequality on growth has been tested extensively with mixed results (Forbes 2000; Barro 2000; Barro 2008). With the exception of asset inequality (Birdsall and Londoo 1997), less attention has been focused on identifying and analyzing empirically other forms of inequality that may affect growth. Here, we focus on inequality of access that arises through geographic remoteness[2].

Barriers to market participation create isolated areas of economic disadvantage (Bloom et al. 2003; Barrett 2008). This disadvantage is exacerbated when remote households become reliant on degradable natural assets, which can perpetuate a poverty trap (Barbier 2010). Remote households appear to earn a lower return to labor than similarly skilled laborers with better market access (Hering and Poncet 2010). Such relationships arising through remoteness imply that market access across households, is highly unequal, and could impact aggregate economic growth. This relationship is policy relevant because market accessibility is affected by not just geographic factors (e.g. terrain, navigable waterways, etc.), which policymakers cannot control, but also by institutional factors (e.g. road placement, rail placement, city location, etc.) that policymakers can influence.[3]

Frankel's (1962) AK growth model, often used to relate initial income inequality and economic growth (Aghion and Howitt 2009), is modified to relate market access with economic growth. In this model, each household is treated as a producer with an exogenous initial wealth. The income-equality version shows that in the presence of diminishing marginal productivity of capital and imperfect credit markets, increased equality of wealth will increase economic growth (Stiglitz 1969; Galor and Zeira 1993; Benabou 1996). Households that would borrow to finance increased capital investment gain in production disproportionately relative to households that would lend and forego some capital investment. The access-equality model relates growth and equality of access through the presence of relocation barriers and production spillovers, which originate in market centers and diffuse across space. We show that the relationship between economic growth and market access distribution is driven by the rate at which production spillovers diminish across space. This geographic exclusiveness of production spillovers also predicts divergent growth patterns among countries with poorly market-integrated households.

[2] Aghion et al. (1999) show that in the presence of capital market imperfections unequal access to investment opportunities cause volatility in investment, GDP and interest rates. Our approach examines unequal access to market spillovers, or positive production externalities, which determine production technologies across space. Similarly, Biller et al. (2014) examine inequality of access to infrastructure services in South Asia. Here, access to transportation is proxied for using the total road network per 1,000 people.

[3] It is possible to construct tunnels through mountains or use levees to affect river flow. We recognize these policymaker options but argue that geographic factors generally characterize a market's level of inherent accessibility.

To map households located in remote areas, a unique dataset is constructed using a Geographic Information System (GIS) and spatially explicit population and market accessibility data. This dataset quantifies the average time of travel (in minutes) of the average household from a market city of 50,000 or more individuals. The distribution of these households across space is used to construct remoteness Lorenz curves and corresponding Remoteness GINI (RGini) coefficients for 204 countries in 2000.[4] A cross-sectional dataset is employed to explain the rate of economic growth from 2000-2013 while incorporating a vector of control variables used commonly in inequality analyses. Highway, major road and rail placement are some of the components defining travel time to market cities. Although these data are lagged, it is likely that unobserved institutional characteristics, which determined these investments, persist through the growth period being analyzed. Geographic instruments are constructed that summarize landscape characteristics surrounding city centers (e.g. elevation, slope and major waterways) that affect inherent levels of market access[5].

A Generalized Method of Moments (GMM) estimator is employed to investigate the hypotheses that (i) *a higher average time of travel to market centers* and (ii) *unequal distribution of that level of market access* reduce economic growth. Results suggest that market access inequality and the average level of access jointly affect economic growth. Access inequality reduces economic growth when the average distance to markets is sufficiently low but has a growth-enhancing effect when households are particularly remote. These results are consistent with the notion that production spillovers diminish at an increasing rate when sufficiently close to the market center but at a decreasing rate when sufficiently distant from the market center.

This outcome suggests that there is a critical switching point where market access inequality becomes harmful to growth. Globally, we estimate this point occurs at 297 minutes of travel time to the nearest market center, which is noticeably close to the threshold travel time of five hours used often to characterize remote households. In developing countries, we estimate this threshold to occur around 343 minutes of travel time to the nearest market. Our policy proposals, based on these findings, suggest that growth-oriented investments should (i) aim to reduce the average distance of travel of the average household to the nearest market, which can be done by integrating the most remote households to markets while also (ii) focusing infrastructural investments towards the marginal consumers of market access surrounding these spillover-threshold points. In areas with costly barriers to these infrastructural investments, governments may consider subsidizing the relocation of households to areas with more potent spillovers.

We stratify our sample based on the overall level of market access in each country. Robust evidence is presented that growth divergence is characteristic of those countries with geographically less pervasive markets. This divergence disappears in countries with well-integrated markets. These theoretic predictions of growth divergence are supported empirically and warrant a reconsideration of our classic growth divergence and convergence hypotheses.

In section II we present our endogenous growth model that relates the distribution of market ac-

[4] This dataset marks a notable extension to the completeness of the best currently available inequality datasets (Income inequality, 120 countries (Barro 2008); Asset inequality, 43 countries (Birdsall and Londono 1997).).

[5] This approach was inspired by Banerjee, Duflo and Qian (2010) instrumenting for endogenous transportation network placement using geographic proximity to historical locations.

cess across households to economic growth. We also show the effect that diminishing spillovers has on economic growth. In section III we present the dataset constructed for the market access distribution for a cross-section of countries. In section IV we conduct an empirical analysis to test our two main hypotheses concerning market access and growth. The final section presents our conclusions about the role of market access inequality on economic growth and summarize the policy implications based on these findings.

2. A model of market access inequality and economic growth.

Following Aghion and Williamson (1998), we assume a continuum of overlapping-generation households indexed by $i \in [0,1]$. Each household maximizes its intertemporal utility by choosing both current (c_t^i) and future (f_t^i) consumption in period t

$$\max_{c_t^i, f_t^i} U_t^i = ln(c_t^i) + \rho ln(f_t^i) \tag{1}$$

where ρ is a constant discount rate. To differentiate the growth implication of market access inequality from that of initial wealth inequality, we assume that each household is endowed with exogenous and constant wealth $\bar{w}$. Perfect wealth equality exists. Each household is an independent producer (Frankel 1962; Stiglitz 1969; Benabou 1996, Aghion and Williamson 1998) and household production (y_t^i) follows the AK production function

$$y_t^i = (k_t^i)^\alpha A_t^i(At, \delta^i) \qquad 0 < \alpha < 1 \tag{2}$$

where k_t^i is the household's choice of capital investment, α is a returns to scale parameter and A_t^i resembles a household-specific technology or production spillover. Production spillovers originate in markets for healthcare (Chandra and Staiger 2007), education (Moretti 2004) and research and development (Audretsch and Feldman 1996; Javorcik 2004) and are assumed to originate in market centers where hospitals, secondary and higher education institutions and manufacturing sectors are present and well-functioning. This production spillover is increasing in the level of aggregate technology, $\frac{\partial A_t^i}{\partial A_t} > 0$, where aggregate technology is determined by aggregate production in the prior period $A_t = \int_0^1 y_{t-1}^i di = y_{t-1}$. A_t also represents the strength of the production spillover at the market center. In other words, as the distance of household i from the nearest market center (δ^i) approaches zero, the technology shock approaches its undiminished level ($\lim_{\delta^i \to 0} A_t^i = A_t$).

After substituting in both the household production constraint and exogenous wealth constraint[6] the household chooses capital to maximize intertemporal utility following

$$\max_{k_{i,t}} U_t^i = ln(\bar{w} - k_t^i) + \rho ln(k_t^{i\alpha} A_t^i(A_t, \delta^i)) \tag{3}$$

where each household's capital choice in equilibrium, $k_t^{i*} = \frac{\bar{w}\rho\alpha}{1+\rho\alpha}$, depends only on exogenous parameters. Each household therefore allocates a constant share of its wealth to first period consumption and a constant share to capital investment, which creates future consumption. The aggregate

[6]These two constraints on the objective function, equation (7), are $c_t^i = \bar{w} - k_t^i$ and $f_t^i = y_t^i = k_t^{i\alpha} A_t^i(A_t, \delta^i)^{1-\alpha}$.

output in the economy (y_t) from all households is

$$y_t = \left(\frac{\bar{w}\rho\alpha}{1+\rho\alpha}\right)^{\alpha} \int_0^1 A_t^i(A_t, \delta^i)di. \tag{4}$$

Growth of output (g_t) is defined as the logged ratio of output in the current period and output in the prior period, $ln\frac{y_t}{y_{t-1}}$, which can be rewritten as

$$g_t = \alpha ln \frac{w\rho\alpha}{1+\rho\alpha} + \ ln\int_0^1 A_t^i(y_{t-1}, \delta^i)di - \ ln(y_{t-1})$$

where the first term on the right-hand side is the share of growth from capital investment. The second term is the actual growth attributed to production spillovers and the third term is the potential growth attributed to production spillovers. Actual production spillovers equal potential production spillovers when all households are located within market centers. In this scenario, growth in output is positive and constant, which is consistent with the standard AK growth prediction. Differential access to markets among households creates a wedge between the second and third terms representing foregone production spillovers. These foregone spillovers reduce a country's constant growth rate. If spillovers do not diminish across space growth pis again positive and constant.

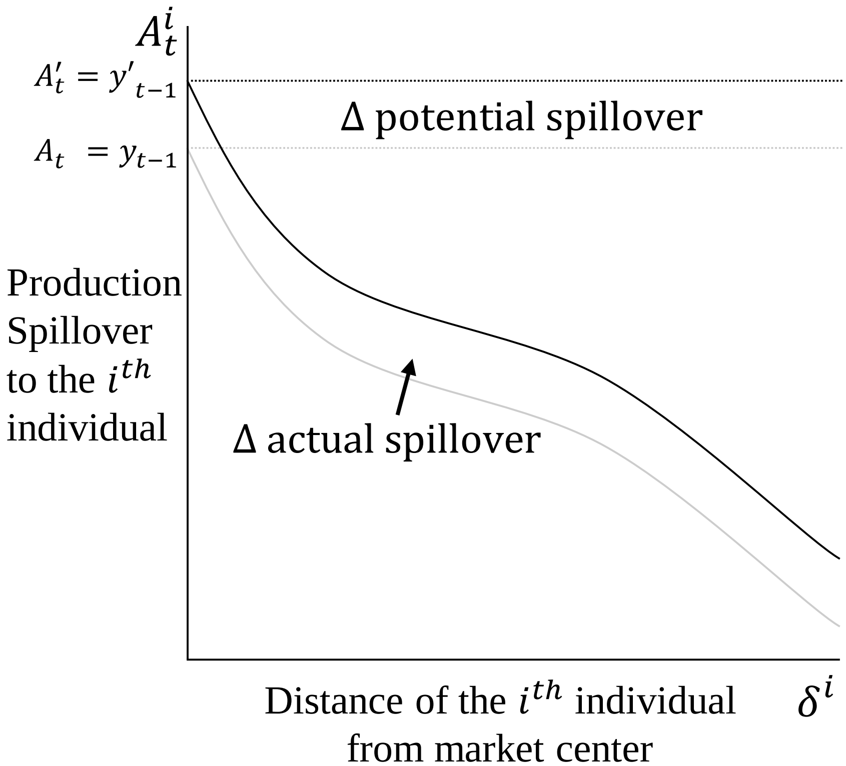
Economic growth is increasing in the contribution from productive spillovers. The relationship between both access inequality and average distance on growth will depend on the functional form of $\int_0^1 A_t^i(y_{t-1}, \delta^i)di$ or how production spillovers and technology shocks, originating in market centers, diffuse across space. Following Jensen's Inequality, if production spillovers are undiminishing across space, $\frac{\partial A_t^i}{\partial \delta^i} = 0$ and $\frac{\partial^2 A_t^i}{\partial d^{i2}} = 0$, average distance to market access and the equality of that distance will have no effect on growth. Assuming that production spillovers do not diminish across space collapses the model to the classic AK case where household proximity to market centers has no role.

If production spillovers diminish across space, $\frac{\partial A_t^i}{\partial \delta^i} < 0$, an increasing average distance to market access will decrease growth. As households are located closer to markets, their technology-specific component increases thus raising the aggregate level of growth in the economy. The effect of access inequality on growth can also be inferred from the curvature of the production spillover curve.

If production spillovers diminish across space convexly (concavely), $\frac{\partial A_t^i}{\partial \delta^i} < 0$ and $\frac{\partial^2 A_t^i}{\partial d^{i2}} > 0$ ($\frac{\partial A_t^i}{\partial \delta^i} < 0$ and $\frac{\partial^2 A_t^i}{\partial d^{i2}} < 0$), an increasing level of access inequality will increase (decrease) growth.[7] In the case of convexly diminishing production spillovers, households located nearest market centers lose production technology disproportionately faster than households distant from market centers. In this case, growth is highest when suburban households are well-integrated into market centers. In the case of concavely diminishing production spillovers, households located farthest market centers

[7] These conditions are sufficient when we assume that the cross-partial effect of distance on the marginal household-level access from lagged output is assumed to be zero ($\frac{\partial A_t^i}{\partial A_t \partial \delta^i} = 0$). This is a reasonable assumption as we would not expect the distance of a household to influence the production spillover they would receive if located at the city center (would not expect the distance of household i to affect the vertical intercept).

Figure 1. Dissipating production spillovers across space.



lose production technology disproportionately faster than households nearer market centers. In this case, growth is highest when remote households are well-integrated into market centers.

However, introducing diminishing production spillovers can also lead to growth divergence. The effect of a country's initial level of wealth on its growth rate

$$\frac{\partial g_t}{\partial y_{t-1}} = \frac{A_t - \int_0^1 A_t^i(y_{t-1}, \delta^i)di}{A_t \int_0^1 A_t^i(y_{t-1}, \delta^i)} \geq 0 \tag{5}$$

approaches zero as actual spillovers approach potential spillovers ($\int_0^1 A_t^i(y_{t-1}, \delta^i)di \to A_t$), which occurs when all households are located within market centers ($\delta^i \to 0 \; \forall \; i$). Increasing initial output (y_{t-1}) causes both actual and potential spillovers to increase. These increases offset each other when households have perfect market access. The result is that the economy will attain positive and constant growth, as predicted by the standard AK growth model. However, condition (5) is greater than zero if households have differential access to markets and spillovers are diminishing across space. The area between actual spillovers and potential spillovers, or foregone spillovers, create a drag on growth (Figure 1). An increase in initial income (y_{t-1} to y'_{t-1}) increases initial technology (A_t to A'_t) and reduces foregone spillovers as a share of potential spillovers (Figure 1).

Growth among higher-income poorly market-integrated countries outpaces growth among similar lower-income countries. In this case, larger spillovers from prior production close the gap between actual and potential spillovers compensating for distant markets. This prediction is consistent with growth divergence in countries with poorly market-integrated households. Because this gap becomes increasingly small among countries with well market-integrated households, classic AK predictions of no growth divergence nor growth convergence hold.

3. Hypotheses and empirical strategy.

The above modeling results concerning the possible influence of market accessibility on production spillovers and growth suggest three testable hypotheses:

H_1: Increasing the average level of market accessibility increases economic growth.

In the presence of diminishing production spillovers, market accessibility has a direct effect on economic growth. This effect operates through the average household's level of market accessibility.

H_2: Increasing the equality of market accessibility increases (decreases) economic growth.

Concavely (convexly) diminishing production spillovers create an indirect ($H2$) effect, operating through the market accessibility distribution, on economic growth.

H_3: Increasing the equality of market accessibility increases (decreases) economic growth in countries with high market accessibility and decreases (increases) economic growth in countries with low market accessibility.

Production spillovers may be concavely (convexly) diminishing near market centers and convexly (concavely) diminishing in remote areas ($H3$).

The following specification is tested

$$G_{i,2000-2012} = \alpha_0 + \alpha_1 D_{i,2000} + \alpha_2 R_{i,2000} + \alpha_3 R_{i,2000} D_{i,2000} + \alpha_4 V_{i,1995-2000} + \varepsilon_i$$

where G is the average growth rate from 2000-2012, R is a remoteness GINI index capturing the equality of market accessibility within a country in the base year 2000, D is the average distance in time of travel to the nearest market center and is inversely related to a country's level of market accessibility in the base year 2000, V is a vector of control variables averaged over the base year's five preceding years, ε is assumed to be an i.i.d. distributed random variable and i subscripts represent the $i'th$ country in our cross-sectional dataset where $i = 1, 2, ..., n$.

Support for the first hypothesis, H_1, follows $\alpha_1 < 0$, consistent with diminishing production spillovers, where an increased time of travel to the nearest market center decreases economic growth. The null result of $\alpha = 0$ would suggest production spillovers are non-diminishing. Because a higher GINI index corresponds to greater inequality, support for the second hypothesis, H_2, follows $\alpha_2 < 0$ ($\alpha_2 > 0$) if production spillovers are diminishing concavely (convexly). The null result of $\alpha_2 = 0$

would suggest linear production spillovers. Support for the the third hypothesis, H_3, follows $\alpha_3 < 0$ ($\alpha_3 > 0$) if an increased time of travel to the nearest market center attenuates (enhances) the growth elasticity of access equality. This effect is consistent with an inflection point in the production spillover curve.

We control for income inequality effects consistent with prior examinations of income inequality and growth (Forbes 2000; Barro 2000; Barro 2008; Bjørnskov 2008)[8]. Barriers to relocation will be more pronounced in poorer countries where public infrastructure is less developed and accessible. We would expect our market access effects to be stronger in regions where this assumption holds. We examine this assumption by stratifying our sample into the following three sub-samples (i) low- and lower-middle income countries with a GNI per capita (2012)< \$4,035 (ii) all developing countries with a GNI per capita (2012)< \$12,475 and (iii) all countries.

Despite explanatory variables being measured outside of our growth period, it is possible unobserved institutional characteristics influenced both the market accessibility distribution and long-run growth trends. To correct for the potential endogenous placement of access-enhancing infrastructure, we estimate our model using two-stage least squares (2SLS) and the generalized method of moments (GMM) in addition to the ordinary least squares (OLS) estimator. Our instruments include the country's land area[9], the percentage of roads that were paved in 1990[10], the average terrain slope surrounding market cities and the average terrain elevation surrounding market cities[11]. We also included interactions between the first and last two pairs of instruments. The identifying assumption is that these three geographic variables and decade-lagged infrastructure variable, conditional on observable variables, influence economic growth only through inhibiting market accessibility.

Our model also predicts growth divergence among poorly market-integrated countries and neither growth divergence nor convergence among countries with higher household-level accessibility to markets. This leads to a fourth testable hypothesis:

H_4: Increasing initial income increases growth among countries with lower market accessibility and has no effect on high market accessibility countries.

[8]The correlation coefficient between GINI and RGINI is -0.1931 for the developing country sample and -0.1907 for the all countries sample. The correlation coefficient between GINI and DIST is 0.3229 in the developing country sample and 0.2417 for the all countries sample.

[9]Alcalá and Ciccone (2001) show average labor productivity within a country is unrelated to that country's land area. Frankel and Romer (1999) argue that country size increases income per person after controlling for international trade. This is attributed to a balance between within-country trade and more abundant natural resources. Because larger countries are inherently less accessible, a positive direct influence of land area on economic growth would bias our estimates towards the null

[10]Formerly colonized countries generally have better-developed road networks. In many cases these former colonies, as argued by (Engerman and Sokoloff (2005), exhibit slower growth and increased inequality of opportunity. Because the percentage of roads that are paved act as an access-increasing measure, a resulting bias from from colonized status would be towards the null.

[11]Steep terrain may create biophysical constraints on land, which inhibit agricultural production. Barbier and Hochard (2014) show that the share of rural individuals located on less favored agricultural land has no direct impact on economic growth. This is likely to be particularly true in the vicinity of markets, not characterized by geographic remoteness, where our instrumental variables are calculated.

We use a set of conditional and absolute convergence tests on our sample stratified by average level of market access. The estimating equation,

$$\begin{aligned} G_{i,2000-2012} = \beta_0 + \beta_1 GDP_{i,2000} + \beta_2 GINI_{i,1995-2000} \\ + \beta_3 GINI_{i,1995-2000} GDP_{i,2000} \\ + \beta_4 V_{i,1995-2000} + \varepsilon_i, \end{aligned}$$

follows model assumptions by controlling for income heterogeneity using the classic GINI coefficient. Here, $V_{i,1995-2000}$ is a vector of control variables in tests of conditional convergence and an empty vector in tests of absolute convergence and ε is assumed to be an i.i.d. distributed random variable and i subscripts represent the $i'th$ country in each of our stratified samples. Our sample is stratified four ways based on average time of travel to the nearest market center to include (i) <60 minutes, (ii) <120 minutes, (iii) >120 minutes and (iv) >180 minutes. Each additional stratification, being more restrictive than the last, represents decreasing levels of market accessibility among in-sample countries. Support for the fourth hypothesis follows $\beta_1 > 0$ among countries with lower levels of market access and $\beta_1 = 0$ among countries with higher levels of market access.

4. Data.

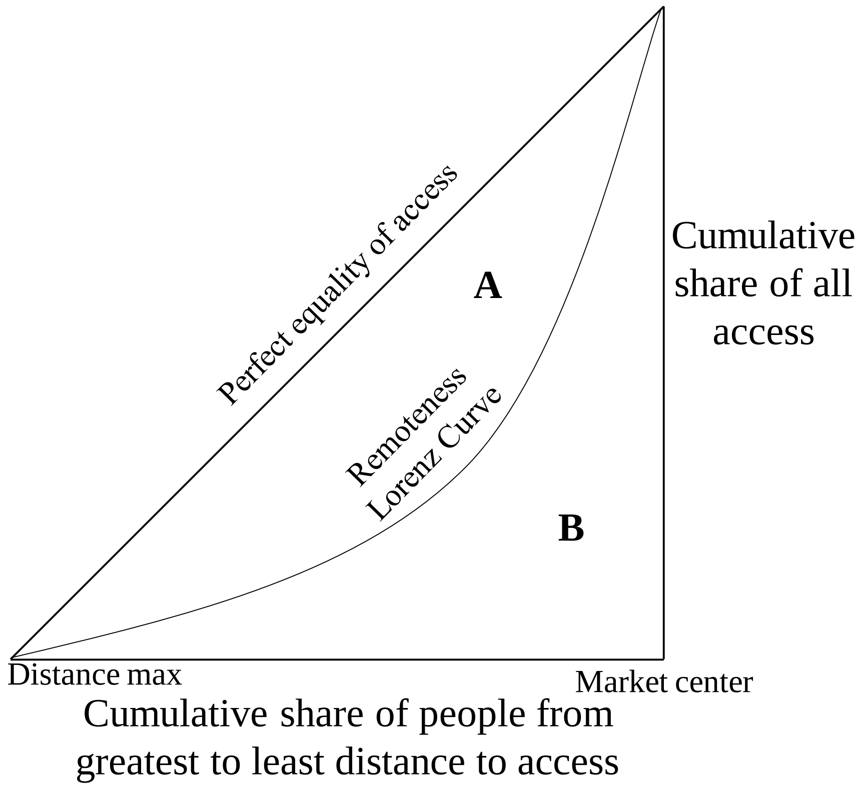
A collection of data was used to construct market access measures using geospatial techniques. National administrative boundaries were collected from the CIESIN Gridded Population of the World (GPW), v3 where territory boundaries were removed. Population count data was collected from the same source with a 2.5 arc-minute resolution (approximately 5 km spatial resolution at the equator). A global dataset of market accessibility was employed, which defines the travel time to market cities of 50,000 or more individuals (WDR, 2009; Uchida and Nelson, 2009)[12]. Travel time to market access is determined using the location of motorways, major roads and tracks, the location of railways, the location of navigable rivers, the location of major waterbodies, the location of shipping lanes, the relative density of land cover in places where foot travel may be prevalent as well as changes in slope and elevation.[13] The population of each cell was matched with the travel time to the nearest market. This mapping was exported to table format and ordered by increasing distance of access against the number of individuals affected. Following Dixon et al. (1988) and Damgaard and Weiner (2000), the RGINI coefficient was computed using

$$RGini = \frac{\sum_{j=1}^{n}(2j-n-1)n'_j}{n^2\bar{n}} \frac{n}{n-1} \tag{6}$$

[12]Settlements of 50,000 individuals are used to map urban agglomeration in the 2009 World Development Report (WDR). The report argues “The threshold of 50,000 for a sizable settlement is reasonable for developing and developed countries. Many developing nations have more than 10 percent of their total population in urban centers of between 50,000 and 200,000. Some examples include Chile in 2002, Brazil in 2000, and Malaysia in 2000, all with around 17 percent of their national population living in urban centers of 50,000–200,000 inhabitants. Of India’s urban population in 2001, 20 percent lived in settlements of this size. According to the World Urbanization Prospects database, the worldwide urban share in 2000 was 47 percent. Using the base case criteria, this ratio is 52 percent, but using 100,000 as the minimal settlement size, it is 44 percent, according to the agglomeration index." (WDR, 2009).

[13]Further details about the construction of travel times and accompanying assumptions can be found from the source dataset’s metadata.

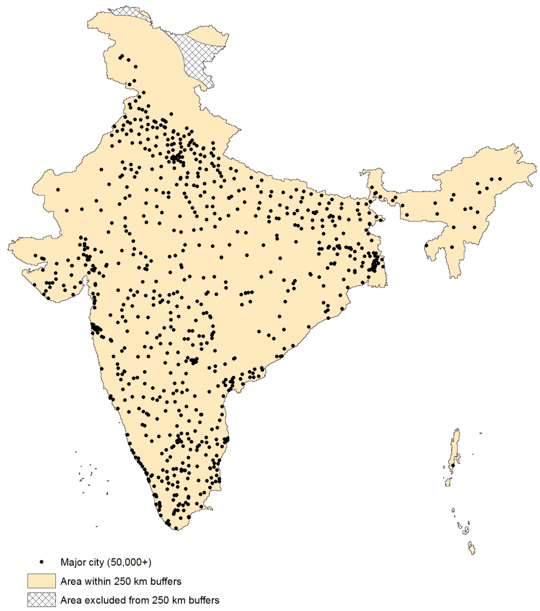
Figure 2. Market access inequality: a remoteness Lorenz curve.



where n is the number of different levels of market access within a country, $\bar{n}$ is the average number of people affected across all n levels of market access and n'_j is the transpose of the number of households at the $j'th$ level of market access. This computation for the remoteness GINI coefficient is equivalent to constructing a remoteness Lorenz curve, figure (2), and computing $RGINI = \frac{A}{A+B}$ where perfect access equality is given by $RGINI = 0$ and perfectly unequal access is given by $RGINI = 1$.

Although many of the factors determining household market access are influenced by country-specific institutions, factors such as an areas elevation or gradient are inherent to the local geography. The effect of these variables on market access will be particularly prevalent in the surrounding area of a market where geographic barriers play an enhanced role. Circular buffers were created around each major city with a population of 50,000 or greater. These are the cities that constitute a market center in the 2009 WDR and the global map of accessibility dataset and were identified using the CIESIN Global Rural-Urban Mapping Project (GRUMP), v1 Settlement Points dataset for the year 2000. These buffers were dissolved to remove overlapping areas and clipped against country boundaries to avoid considering landscape covariates that were (i) outside of the countries territory or (ii) located on water. The average elevation (meters) and average slope (terrain slope in-

Figure 3. India: Area used for instrument calculations.



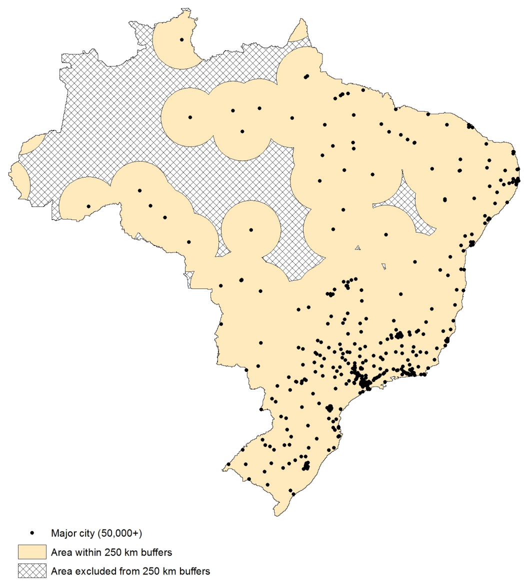
dex) of the city-center buffer areas were calculated for buffers of 100 km and 250 km creating two sets of instruments[14]. Slope (30 arc-seconds resolution) and elevation (5 arc-minutes resolution) data were retrieved from the Food and Agriculture Organization's (FAO) Global Agro-Ecological Zones (GAEZ) data portal.

India, Brazil and Australia are given as visual examples (see Figure (3), Figure (4) and Figure (5)) to display the variation in buffered land across large countries. India, for example, has 874 major cities of 50,000 or greater population while Australia has only 36 such cities. This causes the majority of India's landscape to be considered for instrumental variable calculation while a small share of Australia's landscape is considered. Brazil has 403 major market cities that are concentrated in a relatively small area. This causes a large portion of Brazil's landscape to be used for instrumental variable calculation while the remaining, still sizable portion with rain forest cover, is ignored.

Data on several control variables, commonly used in empirical inequality analyses, was collected from World Bank databases. The dependent variable of this analysis is the average rate of growth of per capita GDP measured in constant 2005 US$ from 2000 to 2012. Only countries with a

[14]The buffer radius defines the extent of the local average treatment effect (LATE) we receive from our instrumented estimation. A small radius captures the geographic variation most relevant for disrupting or enabling access to the market center but is highly local. Expanding this radius makes the treatment effect more expansive but may aggregate away the landscape's topographic variation.

Figure 4. Brazil: Area used for instrument calculations.



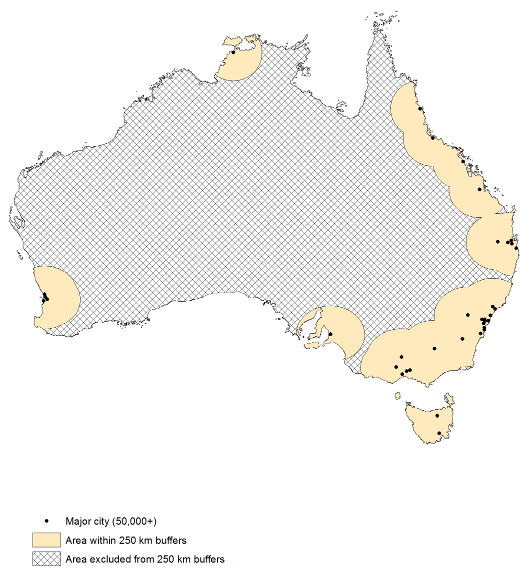
minimum of six years of growth data were considered. Although some countries were missing annual observations, the majority of countries have complete data from 2000-2012 (mode 13 years, mean 12.66 years). Logged GDP per capita, logged GDP per capita squared and the Heritage index for overall economic freedom were measured in 2000. Trade (% of GDP), rule of law: estimate, gross capital formation (% of GDP), duration of primary and secondary education summed (years), general government final expenditure consumption (% of GDP) and one over the logged fertility rate (total births per women) are all average values from 1995-2000. Developing countries are defined as those non-high income countries with a 2012 GNI per capita of $12,615 or less and are represented with a binary variable.

5. Empirical results.

5.1. Access equality, distance and growth.

In rejection of the second null hypothesis, market access inequality has a robustly negative effect on economic growth (Table 1). A one standard deviation increase in inequality (RGINI $STD = 0.108$), evaluated at the DIST mean, reduces annual growth rates by approximately 0.25%. This effect is enhanced in poorer countries. Developing countries (RGINI $STD = 0.114$) see a 0.35% reduction while low and lower-middle income countries (RGINI $STD = 0.116$) see a 1.26% reduction in annual growth rates. Our estimates also suggest, in rejection of the first null hypothesis, that

Figure 5. Australia: Area used for instrument calculations.



increasing the average time of travel for the average household will reduce growth directly. A one standard deviation increase in DIST, evaluated with percent access equality ($RGINI = 0$), is expected to reduce growth by 2.37% in all countries (DIST $STD = 186.827$) and 3.62% in developing countries (DIST $STD = 210.58$). In rejection of the third null hypothesis, this effect of increased distance on economic growth is attenuated by decreasing the equality of market access within a country. Average distance of market access does not appear to influence growth in low- and lower-middle income countries.

Negative "growth elasticity of access inequality" is mitigated by increasing the average distance within a country, which suggests increasing access equality has growth-enhancing effects when individuals have reasonable access to markets to begin with. Highly inaccessible markets overshadow the relative importance of market access equality. This effect disappear in the poorest countries where distance effects are insignificant and inequality effects are of the largest magnitude.

A negative (positive) growth elasticity of access inequality (equality) is consistent with the notion of production spillovers diminishing concavely across space. Households located farther from markets receive production spillovers disproportionately less than households located nearer to markets. In both the developing country and all country samples, increasing average distance of individuals from markets mitigates the effect of disproportionate spillover access. Eventually, the average distance effect overwhelms the equality effect. In the developing countries (all countries)

Table 1. Summary Statistics (all countries sample).

Dependent	Time	Source	Obs	Mean	STD	Min	Max
GROWTH	Average 2000-2012	World Bank	97	4.118	2.382	-2.556	12.789
Endogenous	Time	Source	Obs	Mean	STD	Min	Max
RGINI	2000	EC-JRC/CIESIN	97	0.8119	0.108	0.466	0.990
DIST	2000	EC-JRC/CIESIN	97	169.019	186.827	11.656	1455.13
RGINI*DIST	2000	World Bank	97	130.881	122.014	9.791	818.369
Exogenous	Time	Source	Obs	Mean	STD	Min	Max
FREEDOM	2000	World Bank	97	59.575	11.258	24.3	89.5
GOVT	AVG 1995-2000	World Bank	97	15.520	5.500	4.548	30.858
RULE OF LAW	AVG 1995-2000	World Bank	97	-0.008	1.017	-1.655	1.928
CAPITAL	AVG 1995-2000	World Bank	97	21.863	5.681	5.51	41.604
EDU	AVG 1995-2000	World Bank	97	11.842	0.780	10	13
TRADE	AVG 1995-2000	World Bank	97	83.944	51.304	17.436	341.543
LOG(FERTILITY)	AVG 1995-2000	World Bank	97	0.413	0.237	0.0447	0.894
POP GROWTH	AVG 1995-2000	World Bank	97	1.279	1.280	-1.594	6.371

Figure 6. Diminishing spillover curves derived from model and estimates.

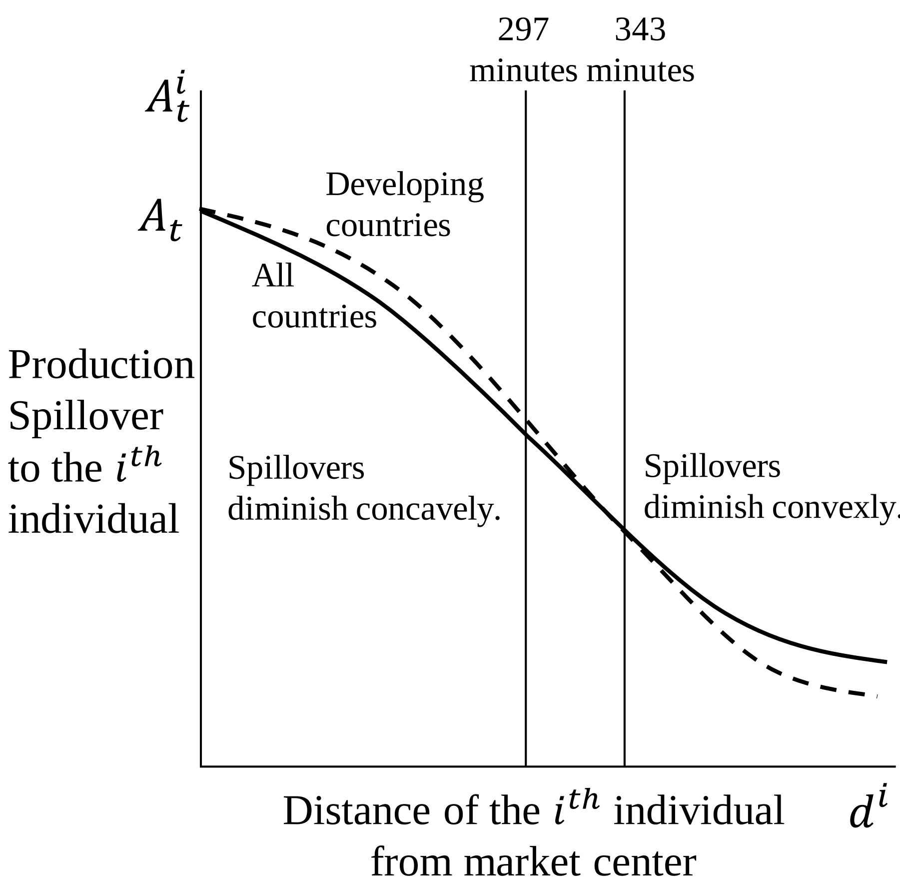


Figure 7. Populations and spillovers threshold (293 minutes).

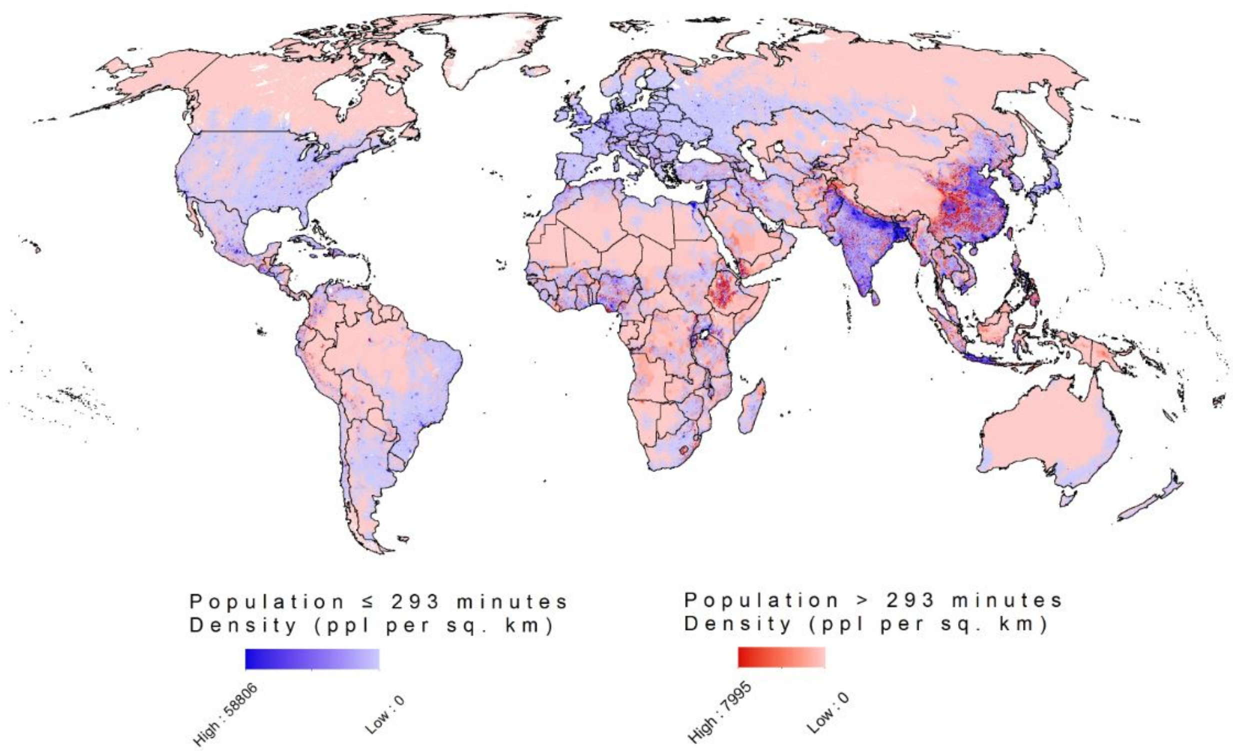


Table 2. Growth and access inequality estimates.

Dependent variable: *Average rate of economic growth (2000-2012)*.							
				Instruments use 100 km buffers around cities		Instruments use 250 km buffers around cities	
	OLS	OLS	OLS	2SLS	GMM	2SLS	GMM
RGINI (2000)	-16.07***	-8.763**	-5.444**	-14.06**	-15.20**	-14.21*	-17.50**
	(-3.42)	(-2.24)	(-2.04)	(-2.09)	(-2.43)	(-1.86)	(-2.49)
DIST (2000)	-0.0139	-0.0172**	-0.0127**	-0.0280	-0.0299	-0.0334	-0.0416**
	(-1.57)	(-2.57)	(-2.28)	(-1.26)	(-1.48)	(-1.55)	(-2.20)
RGINI*DIST	0.0204	0.0256**	0.0183*	0.0449	0.0481	0.0521	0.0661**
	(1.40)	(2.26)	(1.92)	(1.35)	(1.60)	(1.56)	(2.31)
GINI (1995-2000 AVG)	-3.928	-9.471	-11.00	-18.67	-13.55	-18.05	-16.89
	(-0.14)	(-0.52)	(-0.96)	(-1.25)	(-1.00)	(-1.23)	(-1.28)
LOG(2000 per capita GDP)	1.182	-0.320	-0.511	-1.132*	-0.948	-1.142*	-1.135**
	(1.05)	(-0.36)	(-1.31)	(-1.81)	(-1.60)	(-1.84)	(-1.98)
GINI*LOG(2000 per capita GDP)	-2.124	0.953	1.342	2.836	2.430	2.942*	3.072*
	(-0.75)	(0.46)	(1.22)	(1.60)	(1.47)	(1.66)	(1.93)
Constant	7.151	16.32	12.89*	19.96**	18.05**	19.82**	20.56**
	(0.47)	(1.62)	(1.98)	(2.32)	(2.22)	(2.24)	(2.48)
Developing region FE	Y	Y	Y	Y	Y	Y	Y
N	38	64	97	65	65	65	65
Low and Lower-Middle Income	X						
GNI per capita (2012) < $4,035							
All developing		X					
GNI per capita (2012) < $12,475							
All countries			X	X	X	X	X
N	38	64	97	65	65	65	65
R^2/Uncentered R^2	0.8086	0.5284	0.5886	0.8822	0.8755	0.8859	0.8656
Hansen J stat (p-val)				0.4057	0.4057	0.3900	0.3900
Kleibergen-Paap (p-val)				0.3027	0.3027	0.0428	0.0428
Endogeneity H-D-W (p-val)				0.1902	0.1902	0.2858	0.2858

t statistics (OLS)/*z* statistics (2SLS/GMM) in parentheses calculated using robust standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Additional controls include: government final consumption expenditure (% of GDP AVG 1995-2000), rule of law: estimate (AVG 1996, 1998, 2000), gross capital formation (% of GDP average from 1995-2000), years of education (summation of primary and secondary average 1995-2000), trade (% of GDP average 1995-2000), log(fertility rate, total births per women) (average 1995-2000), Heritage overall index of economic freedom (2000), population growth (annual % average 1995-2000). Distance is measured in minutes of travel time of the average citizen to the nearest city of 50,000 or greater (2000). Regional fixed effects include dummy variables for those countries classified in the developing regions of East Asia and Pacific, Europe and Central Asia, Latin America and Carribean, Middle East and North Africa, South Asia and Sub-Saharan Africa as per the 2012 World Bank categorizations.
Log(fertility rate, total births per women) was included and 1/life expectancy at birth (total years average 1995-2000) was excluded as controls because these two indicators have a correlation coefficient of 0.7482.
Instruments include (1) average slope, (2) average elevation and (3) their interaction term all calculated within city buffer zones. Additionally, (4) Log(land area km^2), (5) percent of roads paved in 1990 and (6) their interaction term all calculated for the entire country's territory.

sample, this switching point occurs at 343 (297) minutes of travel time (Figure 6)[15]. Beyond this switching point, access inequality enhances growth, which is consistent with convexly diminishing production spillovers. We estimate approximately 5.1 billion people are within the global threshold, residing under convexly diminishing spillovers, while approximately 825 million people are located beyond this spillover threshold (Figure 6).

The inequality of market access and the average distance of the average household to the nearest market are calculated using data from 2000, the base year of the growth analysis, and earlier years. Despite being lagged from the growth analysis, it is possible that institutional factors, which drove prior public infrastructural investment, persisted through our growth period and had growth-enhancing or growth-reducing effects. This feedback between public investment in infrastructure and future growth would cause our key parameter estimates to be biased. This potential issue is addressed using instrumental variable (IV) techniques.

Table 3. Absolute divergence in poorly market-integrated countries hypothesis (assuming income equality, $GINI = 0$).

	DIST<60 min	DIST<120 min	DIST>120 min	DIST>180 min
GINI	9.603	11.40	22.39*	64.09**
	(0.58)	(0.89)	(1.82)	(2.25)
LOG(2000 per capita GDP)	-0.343	-0.164	1.487**	4.532**
	(-0.44)	(-0.32)	(2.44)	(2.42)
GINI*LOG(2000 per capita GDP)	0.0614	-0.0632	-2.760**	-8.178*
	(0.03)	(-0.04)	(-2.08)	(-2.05)
Constant	2.188	0.304	-11.18*	-33.65**
	(0.35)	(0.08)	(-1.99)	(-2.80)
Developing Region FE	Y	Y	Y	Y
N	18	46	57	30
R^2	0.5043	0.5607	0.4185	0.3660
Root MSE	1.2053	1.2967	2.1698	2.6269

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The first set of instruments are calculated using 100 km buffers around market centers and employed using the Two-Stage Least Squares (2SLS) and Generalized Method of Moments (GMM) estimators where $RGINI$, $DIST$ and $RGINI * DIST$ are treated endogenously. We fail to reject the Kleibergen-Paap test for underidentification suggesting that our model may be underidentified. We address this by expanding the buffer areas used for IV calculation to 250 km. We reject at the 95% level that our model is underidentified using the 250 km instrument set. We also fail to reject that the Hansen J stat is zero validating the overidentification restrictions. Results are robust using the

[15]We cannot estimate directly the production spillover curves. From our model we can infer the curvature of the function given the relationship between inequality and growth as well as identify the inflection point from our estimated interaction effect of access inequality and average distance.

Table 4. Conditional divergence in poorly market-integrated countries hypothesis (assuming income equality, $GINI = 0$).

	DIST<60 min	DIST<120 min	DIST>120 min	DIST>180 min
GINI	-4.715	11.33	21.53	47.91
	(-0.50)	(0.81)	(1.45)	(1.56)
GINI*LOG(2000 per capita GDP)	1.457	-0.414	-3.163	-6.703
	(1.17)	(-0.24)	(-1.58)	(-1.72)
LOG(2000 per capita GDP)	-0.616	-0.0495	1.849**	3.982*
	(-1.44)	(-0.09)	(2.13)	(2.03)
CAPITAL	0.187***	0.130**	0.0932	0.132*
	(5.17)	(2.52)	(1.57)	(1.75)
POP GROWTH	0.0170	0.0580	0.875**	1.506***
	(0.02)	(0.16)	(2.54)	(3.15)
EDU	-0.197	-0.424*	-0.716	-1.484*
	(-0.54)	(-1.91)	(-1.42)	(-1.91)
CONSTANT	3.166	2.388	-6.695	-12.52
	(0.66)	(0.55)	(-0.69)	(-0.83)
Developing Region FE	Y	Y	Y	Y
N	18	46	54	28
R^2	0.8662	0.6669	0.5993	0.6923
Root MSE	0.7343	1.1779	1.8378	1.9416

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

instrumented estimators but the Hausman-Durbin-Wu (H-D-W) test for endogeneity suggests that OLS estimates are preferred.

5.2. Access equality, distance and divergent growth.

Our model of market access inequality and economic growth also makes testable growth divergence predictions. Countries with higher average travel times to market centers are characterized by a larger gap between potential spillovers and actual spillovers. These countries should exhibit growth divergence. Countries with lower average travel times to market centers are characterized by a smaller gap between potential spillovers and actual spillovers. These countries should exhibit weaker divergence or no divergence. This model never predicts growth convergence. These predictions are made assuming perfect income equality. We test these predictions using both absolute and conditional convergence tests while controlling for the potential impact of income inequality on growth (Barro 2008).

In rejection of our fourth null hypothesis, our estimates predict absolute growth divergence among countries with poorly market-integrated households (>120 minutes average time of travel to the nearest market) (Table 3). This divergence effect increases three-fold in countries with particularly remote households (>180 minutes average time of travel to the nearest market) (Table 4). Countries with relatively well market-integrated households (< 120 minutes average time of travel to the nearest market) display neither growth convergence nor divergence. This result is consistent with our prediction that countries with high levels of market access have a smaller gap between potential spillovers and actual spillovers, which causes our model to collapse to the classic AK growth model. These estimates are robust when predicting conditional growth divergence among countries with poorly market-integrated households. The magnitude of this effect increases two-fold in countries with particularly remote households (Table 4)[16].

5. Conclusion.

A model is presented that relaxes the implicit assumption, embedded in the classic endogenous growth framework, that all households have equal access to production spillovers. Introducing differential levels of market access to households creates a set of three hypotheses relating how these spillovers diminish across space and the effect that the average level of market access and the distribution of that market access have on economic growth. A new dataset is created using geospatial data to characterize the average level of market access and the equality of that access for a large cross-section of countries. We then test empirically the relationship between access equality and economic growth. A strong relationship is found between economic growth and both the average level of market access and the distribution of that access. Based on our empirical results, we conclude that production spillovers diminish concavely in areas near markets and convexly in the most remote areas. The policy implications are clear.

Countries seeking to adopt pro-growth policies should make targeted infrastructural investments designed to reduce households' average travel time to markets. These investments may also consider how public infrastructure will affect the equality of market access. Near markets, investments in infrastructure should be access-equality enhancing thus limiting the dispersion in access across households. Those households farther from markets benefit disproportionately to those households nearer markets. This is true until a critical switching point is reached. In remote areas beyond this switching point, equality of access is of secondary concern because production spillovers are depleted and begin decreasing at a decreasing rate.

There is a caveat to implementing these policies. Most countries have households within and beyond the critical market access distance where production spillovers shift from concavely diminishing to convexly diminishing. This requires investment in areas where the rate of diminishing production spillover is fastest. Our analysis also suggests that spillovers diminish fastest at the production spillover inflection point (around 297 minutes of travel in all countries and 343 minutes of

[16] Additional robustness tests are offered in the appendix.

travel in developing countries). Although we cannot determine whether those spillovers diminish at a faster rate before or beyond that inflection point, we can conclude that public infrastructure should be focused on households other than those nearest market centers or located in very remote areas. This caveat calls for randomized control trials designed to examine production spillover decay across space. Settings particularly amenable to such trials may include production spillovers from manufacturing centers, hospitals, or educational institutions.

Unlike income redistribution policies, it is not practical for a policy maker to take market access from one household and give it to another household. However, a policy maker can increase market access by targeting those households that would benefit most from investment in public infrastructure. Any investment in public infrastructure will drive down the average travel time of all households to market access. Therefore such investment will increase growth. Infrastructure investments that serve a dual purpose of better-integrating remote individuals into market environments *and* increase the equality of access near markets will yield highest returns to growth.

This work presents an alternative explanation of wealthier nations' divergent growth paths, relative to poorer nations, throughout the 20th century (Lin and Rosenblatt 2012). Here, constant and sustained endogenous growth predictions come with a disclaimer. The magnitude of growth depends on spillovers from prior production *and* the portion of those spillovers a country is able to capture. Poorly market-integrated countries forego a large portion of these production spillovers. The amplifies the importance of production spillover magnitudes where higher initial wealth acts as a counterweight to forgoing a portion of production spillovers. Among countries with poorly marketed-integrated households, growth in wealthier nations outpaces growth in poorer countries.

An important direction for future research should be to focus on the joint role of income inequality and access inequality on economic growth. Such analysis requires examining the covariance between the distributions of income inequality and access inequality. This result could determine whether policymakers should consider making household income redistribution conditional on household market access. Such an analysis could extend "opportunity-enhancing" effect of income redistribution (see Aghion et al., 1999) to investment in public infrastructure and relocation subsidies.

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Appendix 1.

Each household maximizes its intertemporal utility by choosing both current (c_t^i) and future (f_t^i) consumption in period t

$$\max_{c_t^i, f_t^i} U_t^i = ln(c_t^i) + \rho ln(f_t^i) \tag{7}$$

where ρ is a constant discount rate and $\bar{w}$ is the household's initial wealth endowment. Household production (y_t^i) follows the AK production function

$$y_t^i = (k_t^i)^\alpha A_t^i(At, \delta^i) \qquad 0 < \alpha < 1 \tag{8}$$

where k_t^i is the household's choice of capital investment, α is a returns to scale parameter and A_t^i resembles a household-specific technology or production spillover. This production spillover is increasing in the level of aggregate technology, $\frac{\partial A_t^i}{\partial A_t} > 0$, where aggregate technology is determined by aggregate production in the prior period $A_t = \int_0^1 y_{t-1}^i di = y_{t-1}$ adopting a linear specification. A_t also represents the strength of the production spillovers at the market center ($\lim_{\delta^i \to 0} A_t^i = A_t$).

The household faces a constraint on current-period consumption

$$c_t^i = \bar{w} - k_t^i \tag{9}$$

and a constraint on production

$$f_t^i = y_t^i = k_t^{i\alpha} A_t^i(A_t, \delta^i)^{1-\alpha}. \tag{10}$$

Substituting both constraints into the households maximization problem has a household choosing current-period capital investment to maximize intertemporal utility following

$$\max_{k_t^i} U_t^i = ln(\bar{w} - k_t^i) + \rho ln(k_t^{i\alpha} A_t^i(A_t, \delta^i)). \tag{11}$$

In the first-order condition, capital investment is governed by

$$\frac{dU_t^i}{dk_t^i} = \frac{\alpha \rho k_t^{i\alpha - 1}}{k_t^{i\alpha} A_t^i(A_t, \delta^i)} - \frac{1}{\bar{w} - k_t^i} = 0, \tag{12}$$

which is solved for optimal capital choice $k_t^{i*} = \frac{\bar{w}\rho\alpha}{1+\rho\alpha}$.

The aggregate output in the economy (y_t) from all households is

$$y_t = \left(k_t^{i*}\right)^\alpha \int_0^1 A_t^i(A_t, \delta^i) di. \tag{13}$$

or

$$y_t = \left(\frac{\bar{w}\rho\alpha}{1+\rho\alpha}\right)^\alpha \int_0^1 A_t^i(A_t, \delta^i) di. \tag{14}$$

Growth of output (g_t), $ln\frac{y_t}{y_{t-1}}$, is

$$g_t = \alpha ln\frac{w\rho\alpha}{1+\rho\alpha} + \overbrace{ln\int_0^1 A_t^i(y_{t-1},\delta^i)di}^{\text{Actual growth from spillovers}} - \overbrace{ln\,(y_{t-1})}^{\text{Potential growth from spillovers}}. \tag{15}$$

If production spillovers do not dimish across space, $\frac{\partial A_t^i}{\partial \delta^i} = 0$ and $\frac{\partial^2 A_t^i}{\partial d^{i2}} = 0$, average distance to market access and the equality of that distance will have no effect on growth. Assuming that production spillovers do not diminish across space collapses the model to the classic AK case where household proximity to market centers has no role.

If production spillovers diminish across space, $\frac{\partial A_t^i}{\partial \delta^i} < 0$, an increasing average distance to market access will decrease growth. As households are located closer to markets, their technology-specific component increases thus increasing the aggregate level of growth in the economy.

Following Jensen's Inequality, if production spillovers diminish across space convexly (concavely), $\frac{\partial A_t^i}{\partial \delta^i} < 0$ and $\frac{\partial^2 A_t^i}{\partial d^{i2}} > 0$ ($\frac{\partial A_t^i}{\partial \delta^i} < 0$ and $\frac{\partial^2 A_t^i}{\partial d^{i2}} < 0$), an increasing level of access inequality will increase (decrease) growth.[17]

Dissimilar to the classic AK growth model, introducing diminishing production spillovers creates clear growth divergence predictions. The effect of a country's initial level of wealth on its growth rate

$$\frac{\partial g_t}{\partial y_{t-1}} = \frac{A_t - \int_0^1 A_t^i(y_{t-1},\delta^i)di}{A_t\int_0^1 A_t^i(y_{t-1},\delta^i)} \tag{16}$$

approaches zero as actual spillovers approach potential spillovers ($\int_0^1 A_t^i(y_{t-1},\delta^i)di \rightarrow A_t$), which occurs when all households are located within market centers ($\delta^i \rightarrow 0\ \forall\ i$). This prediction is consistent with growth divergence in poor market access countries and neither divergence nor convergence in countries with households well-integrated to markets.

[17]These conditions are sufficient when we assume that the cross-partial effect of distance on the marginal household-level access from lagged output is assumed to be zero ($\frac{\partial A_t^i}{\partial A_t \partial \delta^i} = 0$). This is a reasonable assumption as we would not expect the distance of a household to influence the production spillover they would receive if located at the city center (would not expect the distance of household i to affect the vertical intercept).

Appendix 2.

Appendix Table 1. Summary Statistics (developing sample).

Dependent	Time	Source	Obs	Mean	STD	Min	Max
GROWTH	Average 2000-2012	World Bank	64	4.863	2.453	-2.556	12.789
Endogenous	Time	Source	Obs	Mean	STD	Min	Max
RGINI	2000	EC-JRC/CIESIN	64	0.8005	0.114	0.466	0.983
DIST	2000	EC-JRC/CIESIN	64	221.028	210.580	35.945	1455.13
RGINI*DIST	2000	World Bank	64	169.353	133.274	35.331	818.369
Exogenous	Time	Source	Obs	Mean	STD	Min	Max
FREEDOM	2000	World Bank	64	55.103	9.630	24.3	71.6
GOVT	AVG 1995-2000	World Bank	64	14.044	5.393	4.548	30.858
RULE OF LAW	AVG 1995-2000	World Bank	64	-0.597	0.536	-1.655	0.824
CAPITAL	AVG 1995-2000	World Bank	64	21.220	6.149	5.51	41.604
EDU	AVG 1995-2000	World Bank	64	11.690	0.823	10	13
TRADE	AVG 1995-2000	World Bank	64	76.789	39.052	17.436	207.579
LOG(FERTILITY)	AVG 1995-2000	World Bank	64	0.529	0.204	0.077	0.894
POP GROWTH	AVG 1995-2000	World Bank	64	1.720	1.269	-1.594	6.371

Appendix Table 2. Summary Statistics (low- and lower-middle income sample).

Dependent	Time	Source	Obs	Mean	STD	Min	Max
GROWTH	Average 2000-2012	World Bank	38	4.485	2.345	-2.556	10.107
Endogenous	Time	Source	Obs	Mean	STD	Min	Max
RGINI	2000	EC-JRC/CIESIN	38	0.7824	0.116	0.466	0.983
DIST	2000	EC-JRC/CIESIN	38	256.141	257.419	35.945	1455.13
RGINI*DIST	2000	World Bank	38	190.976	160.650	35.331	818.369
Exogenous	Time	Source	Obs	Mean	STD	Min	Max
FREEDOM	2000	World Bank	38	53.852	7.529	36.8	65
GOVT	AVG 1995-2000	World Bank	38	12.803	4.617	4.548	22.630
RULE OF LAW	AVG 1995-2000	World Bank	38	-0.704	0.456	-1.587	0.143
CAPITAL	AVG 1995-2000	World Bank	38	19.472	5.753	5.51	31.457
EDU	AVG 1995-2000	World Bank	38	11.763	0.908	10	13
TRADE	AVG 1995-2000	World Bank	38	74.608	38.434	26.598	207.579
LOG(FERTILITY)	AVG 1995-2000	World Bank	38	0.604	0.196	0.097	0.857
POP GROWTH	AVG 1995-2000	World Bank	38	1.928	1.380	-1.594	6.371

Appendix Table 3. Full Summary Statistics (In-sample and out-of-sample).

Dependent	Time	Source	Obs	Mean	STD	Min	Max
GROWTH	Average 2000-2012	World Bank	196	4.145	2.639	-2.556	14.313
Endogenous	Time	Source	Obs	Mean	STD	Min	Max
RGINI	2000	EC-JRC/CIESIN	204	0.7562	0.148	0.284	0.994
DIST	2000	EC-JRC/CIESIN	204	355.393	669.528	11.656	4588.458
RGINI*DIST	2000	World Bank	204	243.449	443.649	9.791	2961.852
Exogenous	Time	Source	Obs	Mean	STD	Min	Max
FREEDOM	2000	World Bank	159	58.074	12.439	8.9	89.5
GOVT	AVG 1995-2000	World Bank	173	16.198	6.517	4.548	48.207
RULE OF LAW	AVG 1995-2000	World Bank	194	-0.0450	0.995	-2.279	1.928
CAPITAL	AVG 1995-2000	World Bank	175	22.607	8.699	3.481	83.899
EDU	AVG 1995-2000	World Bank	200	11.992	0.746	10	14
TRADE	AVG 1995-2000	World Bank	182	83.797	47.046	1.698	341.543
LOG(FERTILITY)	AVG 1995-2000	World Bank	194	0.469	0.2326	0.037	0.894
POP GROWTH	AVG 1995-2000	World Bank	205	1.548	1.276	-1.594	6.371
Instruments	Units	Source	Obs	Mean	STD	Min	Max
SLOPE (100km)	Terrain slope index	GAEZ	205	61.626	29.947	0	97.885
ELEV (100km)	Meters	GAEZ	180	540.357	529.331	6.263	2925.86
SLOPE*ELEV (100km)			180	32731.34	28087.45	0	125721.4
SLOPE (250km)	Terrain slope index	GAEZ	205	65.238	27.187	0	97.827
ELEV (250km)	Meters	GAEZ	187	521.806	529.798	5.0225	2864.94
SLOPE*ELEV (250km)			187	32326.3	27274.35	483.2857	108534.8
Log(land area)	land area ha^2	CIESIN	205	10.938	2.9650	0.693	16.612
ROADS1990	% paved	World Bank	131	47.427	32.757	0.8	100
ROADS1990*Log(land area)			131	511.882	359.466	11.237	1263.506

Appendix Table 4. Growth and access inequality estimates.

Dependent variable: *Average rate of economic growth (2000-2012).*							
				Instruments use 100 km buffers around cities		Instruments use 250 km buffers around cities	
	OLS	OLS	OLS	2SLS	GMM	2SLS	GMM
RGINI (2000)	-16.07***	-8.763**	-5.444**	-14.06**	-15.20**	-14.21*	-17.50**
	(-3.42)	(-2.24)	(-2.04)	(-2.09)	(-2.43)	(-1.86)	(-2.49)
DIST (2000)	-0.0139	-0.0172**	-0.0127**	-0.0280	-0.0299	-0.0334	-0.0416**
	(-1.57)	(-2.57)	(-2.28)	(-1.26)	(-1.48)	(-1.55)	(-2.20)
RGINI*DIST	0.0204	0.0256**	0.0183*	0.0449	0.0481	0.0521	0.0661**
	(1.40)	(2.26)	(1.92)	(1.35)	(1.60)	(1.56)	(2.31)
GINI (1995-2000 AVG)	-3.928	-9.471	-11.00	-18.67	-13.55	-18.05	-16.89
	(-0.14)	(-0.52)	(-0.96)	(-1.25)	(-1.00)	(-1.23)	(-1.28)
LOG(2000 per capita GDP)	1.182	-0.320	-0.511	-1.132*	-0.948	-1.142*	-1.135**
	(1.05)	(-0.36)	(-1.31)	(-1.81)	(-1.60)	(-1.84)	(-1.98)
GINI*LOG(2000 per capita GDP)	-2.124	0.953	1.342	2.836	2.430	2.942*	3.072*
	(-0.75)	(0.46)	(1.22)	(1.60)	(1.47)	(1.66)	(1.93)
GOVT	-0.0769	0.0171	-0.0128	-0.0682	-0.0794	-0.0617	-0.0867
	(-0.80)	(0.26)	(-0.28)	(-1.00)	(-1.22)	(-0.89)	(-1.34)
ROL	0.234	0.0257	-0.556	-0.426	-0.268	-0.399	-0.239
	(0.35)	(0.04)	(-1.65)	(-0.92)	(-0.60)	(-0.88)	(-0.54)
CAPITAL	0.204***	0.103	0.102*	0.0657	0.0572	0.0598	0.0439
	(3.12)	(1.48)	(1.98)	(1.28)	(1.14)	(1.25)	(0.95)
EDU	-0.184	-0.506	-0.403	-0.208	-0.0763	-0.232	-0.0323
	(-0.30)	(-0.95)	(-1.18)	(-0.49)	(-0.19)	(-0.53)	(-0.08)
POP GROWTH	1.199***	0.839*	0.710*	0.897***	0.956***	0.856***	1.016***
	(3.04)	(1.98)	(1.99)	(3.01)	(3.32)	(2.66)	(3.36)
TRADE	-0.0237***	-0.0147	-0.00403	-0.0152**	-0.0161***	-0.0140*	-0.0174**
	(-3.90)	(-1.23)	(-0.82)	(-2.34)	(-2.62)	(-1.89)	(-2.55)
LOG(FERTILITY)	1.375	1.127	0.768	-0.643	-0.883	-0.379	-0.925
	(1.07)	(1.09)	(0.92)	(-0.61)	(-0.88)	(-0.32)	(-0.88)
FREEDOM	0.111*	0.0126	0.0193	0.0799*	0.0710*	0.0787*	0.0721*
	(2.04)	(0.27)	(0.59)	(1.83)	(1.65)	(1.85)	(1.71)
LAC	0.663	-1.404	-1.245	-2.080	-2.097	-2.498	-2.912
	(0.25)	(-0.63)	(-0.98)	(-0.94)	(-1.04)	(-1.20)	(-1.63)
SSA	-1.312	-2.133	-1.401	-2.002	-1.737	-2.255	-2.572
	(-0.73)	(-0.95)	(-1.01)	(-0.95)	(-0.89)	(-1.09)	(-1.41)
EAP	1.250	0.562	0.708	1.459	1.587	1.928	1.891
	(1.13)	(0.33)	(0.77)	(0.82)	(0.93)	(1.12)	(1.13)
ECA	6.198***	3.771**	3.114***	4.138***	4.537***	3.970***	4.416***
	(5.20)	(2.51)	(3.46)	(3.47)	(4.00)	(3.49)	(4.09)
MNA	1.048	-0.748	-0.463	0.925	1.226	0.758	1.103
	(0.70)	(-0.49)	(-0.58)	(0.79)	(1.08)	(0.67)	(1.03)
SA	-2.381**	-1.164	-0.607	-1.807	-1.474	-2.083	-2.243
	(-2.30)	(-0.56)	(-0.47)	(-0.98)	(-0.85)	(-1.23)	(-1.57)
Constant	7.151	16.32	12.89*	19.96**	18.05**	19.82**	20.56**
	(0.47)	(1.62)	(1.98)	(2.32)	(2.22)	(2.24)	(2.48)
N	38	64	97	65	65	65	65
R^2/Uncentered R^2	0.8086	0.5284	0.5886	0.8822	0.8755	0.8859	0.8656
Hansen J stat (p-val)				0.4057	0.4057	0.3900	0.3900
Kleibergen-Paap (p-val)				0.3027	0.3027	0.0428	0.0428
Endogeneity H-D-W (p-val)				0.1902	0.1902	0.2858	0.2858

Appendix Table 5. Divergence in poorly market-integrated countries hypothesis (assuming income equality, $GINI = 0$).

	DIST<60 min	DIST<120 min	DIST>120 min	DIST>180 min
GINI	10.24	17.19	-10.59	60.66**
	(0.71)	(0.75)	(-0.51)	(2.34)
GINI*LOG(2000 per capita GDP)	-0.198	-1.320	0.710	-8.591**
	(-0.14)	(-0.48)	(0.27)	(-2.75)
LOG(2000 per capita GDP)	-0.350	0.117	-0.527	4.367***
	(-0.65)	(0.13)	(-0.43)	(2.82)
Constant	2.891	0.0622	11.23	-26.18**
	(0.53)	(0.01)	(1.15)	(-2.06)
Developing Region FE	N	N	N	N
N	18	46	57	30
R^2	0.4337	0.1284	0.0454	0.1599
Root MSE	1.142	1.7144	2.618	2.6521

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 6. Divergence in poorly market-integrated countries hypothesis (assuming income equality, $GINI = 0$).

	DIST<60 min	DIST<120 min	DIST>120 min	DIST>180 min
GINI	-23.22	6.006	26.88	2.665
	(-0.87)	(0.21)	(1.56)	(0.06)
GINI*LOG(2000 per capita GDP)	2.341	-0.264	-4.507**	-2.217
	(0.69)	(-0.08)	(-2.14)	(-0.39)
LOG(2000 per capita GDP)	-0.785	-0.108	2.344***	1.139
	(-0.78)	(-0.12)	(2.85)	(0.40)
GOVT	-0.150	-0.0245	0.116*	0.189
	(-1.00)	(-0.51)	(1.70)	(1.45)
ROL	-1.695	-1.283	0.172	0.120
	(-0.92)	(-1.70)	(0.37)	(0.08)
CAPITAL	0.00202	0.0155	0.113*	0.124
	(0.01)	(0.20)	(1.78)	(1.46)
EDU	-0.132	0.158	-0.800	-1.850*
	(-0.13)	(0.42)	(-1.62)	(-2.19)
POP GROWTH	0.310	0.220	1.002**	1.602**
	(0.19)	(0.41)	(2.60)	(2.87)
TRADE	0.00464	0.00506	-0.0151	-0.00626
	(0.58)	(1.21)	(-1.57)	(-0.36)
LOG(Fertility)	0.287	1.344	-0.0536	4.700
	(0.13)	(0.94)	(-0.04)	(1.64)
FREEDOM	-0.00833	0.00118	0.0103	0.0554
	(-0.07)	(0.03)	(0.23)	(0.83)
Constant	16.42	0.647	-10.99	3.203
	(0.87)	(0.09)	(-1.14)	(0.14)
Developing Region FE	Y	Y	Y	Y
N	17	44	53	27
R^2	0.9385	0.7670	0.6547	0.7863
Root MSE	.80445	1.0979	1.8308	2.017

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 7. A unique market accessibility dataset.

Country	RGINI (2000)	DIST (2000)	Population share (2000) < 293 minutes	Population share (2000 ≥ 293 minutes
Afghanistan	0.87	309.48	0.60	0.40
Albania	0.68	147.31	0.86	0.14
Algeria	0.95	155.72	0.84	0.16
American Samoa	0.68	3869.74	0.20	0.80
Andorra	0.65	114.68	1.00	0.00
Angola	0.71	478.51	0.37	0.63
Antigua and Barbuda	0.79	252.83	0.99	0.01
Argentina	0.95	108.96	0.89	0.11
Armenia	0.73	127.86	0.85	0.15
Aruba	0.44	243.58	0.98	0.02
Australia	0.97	63.42	0.93	0.07
Austria	0.81	91.23	0.93	0.07
Azerbaijan	0.74	143.84	0.87	0.13
Bahrain	0.61	23.58	1.00	0.00
Bangladesh	0.78	101.43	0.95	0.05
Barbados	0.54	21.96	1.00	0.00
Belarus	0.74	79.60	0.98	0.02
Belgium	0.90	21.20	1.00	0.00
Belize	0.61	330.59	0.57	0.43
Benin	0.74	172.35	0.82	0.18
Bermuda	0.35	1713.93	0.45	0.55
Bhutan	0.76	828.05	0.16	0.84
Bolivia	0.77	474.45	0.50	0.50
Bosnia and Herzegovina	0.58	181.51	0.82	0.18
Botswana	0.85	320.22	0.55	0.45
Brazil	0.98	98.79	0.93	0.07
Brunei Darussalam	0.81	186.24	0.80	0.20
Bulgaria	0.80	91.06	0.95	0.05
Burkina Faso	0.76	230.21	0.70	0.30
Burundi	0.60	155.31	0.85	0.15
Cambodia	0.83	171.52	0.84	0.16
Cameroon	0.86	240.88	0.71	0.29
Canada	0.99	66.09	0.94	0.06
Cape Verde	0.55	171.47	0.78	0.22
Cayman Islands	0.54	599.13	0.23	0.77
Central African Republic	0.85	383.21	0.44	0.56
Chad	0.90	396.72	0.43	0.57
Chile	0.90	164.71	0.80	0.20

China	0.99	193.70	0.81	0.19
Colombia	0.95	214.72	0.76	0.24
Comoros	0.47	916.82	0.09	0.91
Congo, Dem. Rep.	0.81	333.20	0.54	0.46
Congo, Rep.	0.86	362.27	0.49	0.51
Costa Rica	0.76	178.81	0.75	0.25
Cote d'Ivoire	0.81	196.73	0.79	0.21
Croatia	0.72	137.13	0.92	0.08
Cuba	0.81	80.69	0.96	0.04
Cyprus	0.75	48.53	1.00	0.00
Czech Republic	0.84	44.27	0.99	0.01
Denmark	0.61	79.13	0.99	0.01
Djibouti	0.72	205.91	0.82	0.18
Dominica	0.65	279.61	0.79	0.21
Dominican Republic	0.81	107.16	0.93	0.07
Ecuador	0.91	164.88	0.84	0.16
Egypt, Arab Rep.	0.98	35.94	0.99	0.01
El Salvador	0.77	49.43	0.99	0.01
Equatorial Guinea	0.50	276.64	0.62	0.38
Eritrea	0.72	323.04	0.61	0.39
Estonia	0.81	66.36	0.97	0.03
Ethiopia	0.75	428.56	0.43	0.57
Faeroe Islands	0.49	866.93	0.12	0.88
Fiji	0.58	462.41	0.48	0.52
Finland	0.89	81.59	0.95	0.05
France	0.93	34.55	0.99	0.01
French Polynesia	0.86	189.11	0.87	0.13
Gabon	0.81	474.05	0.44	0.56
Gambia, The	0.57	179.28	0.69	0.31
Georgia	0.75	150.77	0.83	0.17
Germany	0.81	45.37	0.99	0.01
Ghana	0.76	150.84	0.87	0.13
Greece	0.82	78.83	0.95	0.05
Greenland	0.99	2304.33	0.17	0.83
Grenada	0.48	394.76	0.07	0.93
Guam	0.55	104.62	1.00	0.00
Guatemala	0.87	160.10	0.83	0.17
Guinea	0.72	220.47	0.74	0.26
Guinea-Bissau	0.66	245.57	0.64	0.36
Guyana	0.73	989.40	0.19	0.81
Haiti	0.64	133.72	0.90	0.10
Honduras	0.89	132.26	0.89	0.11

Hong Kong SAR, China	0.84	11.66	1.00	0.00
Hungary	0.82	51.70	0.99	0.01
Iceland	0.91	117.32	0.79	0.21
India	0.98	115.77	0.93	0.07
Indonesia	0.96	168.26	0.84	0.16
Iran, Islamic Rep.	0.84	187.59	0.79	0.21
Iraq	0.76	181.12	0.81	0.19
Ireland	0.77	70.45	0.99	0.01
Isle of Man	0.75	275.99	0.87	0.13
Israel	0.80	43.52	0.99	0.01
Italy	0.91	44.15	0.98	0.02
Jamaica	0.76	73.12	0.97	0.03
Japan	0.96	30.23	0.99	0.01
Jordan	0.84	72.70	0.94	0.06
Kazakhstan	0.86	176.99	0.69	0.31
Kenya	0.81	199.70	0.77	0.23
Kiribati	0.75	3132.49	0.65	0.35
Korea, Dem. Rep.	0.75	179.66	0.81	0.19
Korea, Rep.	0.89	47.09	0.98	0.02
Kuwait	0.79	104.41	0.86	0.14
Kyrgyz Republic	0.87	292.46	0.65	0.35
Lao PDR	0.75	313.42	0.55	0.45
Latvia	0.75	65.88	0.99	0.01
Lebanon	0.77	55.49	0.99	0.01
Lesotho	0.48	522.78	0.44	0.56
Liberia	0.59	426.29	0.47	0.53
Libya	0.94	133.17	0.84	0.16
Liechtenstein	0.51	118.19	0.96	0.04
Lithuania	0.70	64.15	1.00	0.00
Luxembourg	0.79	33.89	1.00	0.00
Macao SAR, China	0.45	60.23	1.00	0.00
Macedonia, FYR	0.73	100.36	0.91	0.09
Madagascar	0.73	221.35	0.75	0.25
Malawi	0.79	167.41	0.84	0.16
Malaysia	0.79	201.81	0.83	0.17
Mali	0.91	248.35	0.65	0.35
Malta	0.74	15.78	1.00	0.00
Marshall Islands	0.78	3692.02	0.87	0.13
Mauritania	0.89	388.00	0.45	0.55
Mauritius	0.85	44.81	0.98	0.02
Mexico	0.91	109.66	0.90	0.10
Micronesia, Fed. Sts.	0.62	2335.21	0.22	0.78

Moldova	0.63	76.18	0.99	0.01
Mongolia	0.80	374.17	0.36	0.64
Morocco	0.91	136.77	0.88	0.12
Mozambique	0.73	260.50	0.66	0.34
Myanmar	0.90	211.77	0.75	0.25
Namibia	0.71	609.39	0.18	0.82
Nepal	0.91	285.99	0.69	0.31
Netherlands	0.84	27.75	1.00	0.00
New Caledonia	0.59	267.11	0.63	0.37
New Zealand	0.93	60.77	0.96	0.04
Nicaragua	0.86	160.22	0.84	0.16
Niger	0.93	258.78	0.73	0.27
Nigeria	0.85	164.35	0.85	0.15
Northern Mariana Islands	0.88	398.89	0.23	0.77
Norway	0.80	172.78	0.81	0.19
Oman	0.86	163.10	0.81	0.19
Pakistan	0.93	166.31	0.84	0.16
Palau	0.67	1604.46	0.34	0.66
Panama	0.78	198.21	0.77	0.23
Papua New Guinea	0.56	1455.13	0.09	0.91
Paraguay	0.87	197.42	0.71	0.29
Peru	0.91	281.94	0.72	0.28
Philippines	0.83	151.33	0.83	0.17
Poland	0.83	45.28	1.00	0.00
Portugal	0.89	99.14	0.96	0.04
Puerto Rico	0.80	29.39	1.00	0.00
Qatar	0.88	34.71	1.00	0.00
Romania	0.82	76.40	0.97	0.03
Russian Federation	0.98	78.92	0.91	0.09
Rwanda	0.62	200.66	0.79	0.21
Saint Kitts and Nevis	0.45	386.09	0.27	0.73
Saint Lucia	0.48	55.09	1.00	0.00
Saint Vincent and the Grenadines	0.43	346.97	0.32	0.68
Samoa	0.51	4146.13	0.09	0.91
San Marino	0.28	61.35	1.00	0.00
Sao Tome and Principe	0.40	239.42	0.68	0.32
Saudi Arabia	0.76	680.54	0.31	0.69
Senegal	0.75	144.60	0.87	0.13
Seychelles	0.52	1838.05	0.16	0.84
Sierra Leone	0.69	159.33	0.89	0.11
Singapore	0.63	20.68	1.00	0.00
Slovak Republic	0.79	70.73	0.97	0.03

Slovenia	0.77	89.60	0.96	0.04
Solomon Islands	0.48	721.78	0.25	0.75
Somalia	0.58	388.89	0.45	0.55
South Africa	0.58	124.95	0.86	0.14
Spain	0.88	46.80	0.98	0.02
Sri Lanka	0.72	135.23	0.89	0.11
Sudan	0.82	308.41	0.60	0.40
Suriname	0.94	222.52	0.75	0.25
Swaziland	0.47	235.38	0.69	0.31
Sweden	0.91	77.25	0.94	0.06
Switzerland	0.89	51.28	0.98	0.02
Syrian Arab Republic	0.69	145.76	0.92	0.08
Tajikistan	0.92	248.00	0.74	0.26
Tanzania	0.78	281.40	0.65	0.35
Thailand	0.85	176.56	0.83	0.17
The Bahamas	0.79	160.16	0.75	0.25
Timor-Leste	0.50	729.44	0.02	0.98
Togo	0.68	177.77	0.79	0.21
Tonga	0.65	4588.46	0.16	0.84
Trinidad and Tobago	0.85	45.91	0.97	0.03
Tunisia	0.84	129.24	0.90	0.10
Turkey	0.72	150.69	0.88	0.12
Turkmenistan	0.70	305.50	0.52	0.48
Turks and Caicos Islands	0.45	386.25	0.17	0.83
Tuvalu	0.49	1782.14	0.84	0.16
Uganda	0.83	155.22	0.87	0.13
Ukraine	0.86	58.06	0.99	0.01
United Arab Emirates	0.71	309.81	0.62	0.38
United Kingdom	0.93	27.56	1.00	0.00
United States	0.98	45.12	0.98	0.02
Uruguay	0.70	131.85	0.85	0.15
Uzbekistan	0.89	106.03	0.91	0.09
Vanuatu	0.53	1242.75	0.07	0.93
Venezuela, RB	0.97	149.12	0.84	0.16
Vietnam	0.88	106.92	0.92	0.08
Virgin Islands (U.S.)	0.60	279.78	0.59	0.41
Yemen, Rep.	0.70	428.54	0.44	0.56
Zambia	0.73	380.98	0.51	0.49
Zimbabwe	0.73	188.16	0.77	0.23
South Asia and East Asia and Pacific	-	-	0.85	0.15
East and Central Asia	-	-	0.90	0.10
Latin America and Caribbean	-	-	0.87	0.13

Middle East and North Africa	-	-	0.85	0.15
Sub-Saharan Africa	-	-	0.69	0.31
Developing countries	-	-	0.84	0.16
High-income countries	-	-	0.96	0.04