# Road Infrastructure and Enterprise Development in Ethiopia

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# Background & Question

Africa's poor infrastructure:

- Small manufacturing sector; little exports
- High transport costs offer protection from competition for local firms

➢ A large share of small firms supplying the local market (Collier, 2000; Tybout, 2000).

- Ethiopia: Landlocked; practically no railways; few navigable rivers.
- Big improvements in road infrastructure over the last decade thanks to the Road Sector Development Program (RSDP) 1997-2010.

# Background & Question

Over the same period:

- The number of formal manufacturing firms in the country more than **doubled**
- The **geographical distribution** of firms has changed: Decentralization; less concentration of firms to biggest towns.

➢ Have improved roads played a role for these developments?

➢ To find out: Match census data on firms with GIS panel data on roads development and investigate the relationships.

- Literature: Duflo, Banerjee & Qian (2012); Baum-Snow et al. (2012; presented at GW); Donaldson (2012). China & India.
- No similar study on Africa.

# Road Placement in Ethiopia

- The road sector has been a policy priority during the last decade.
- Three RSDPs during the period 1997-2010. Total cost $4.12 Billion, partly donor financed.
  - 43 projects to rehabilitate / upgrade major trunk roads,
  - upgrading of 32 link roads
  - construction of 73 link roads.
- According to the Ethiopian Road Authority, the total road network expanded from 26,550 km in 1997 to 46,812 km in 2007 (ERA , 2009).

Table 1: Improvements in Road Infrastructure

| Indicator | 1997 | 2009 |
|---|---|---|
| Proportion of asphalt roads in good condition | 17% | 70% |
| Proportion of gravel roads in good condition | 25% | 54% |
| Proportion of rural roads in good condition | 21% | 50% |
| Proportion of total road network in good condition | 22% | 54% |
| Road Density/ 1000 sq. km | 24.1km | 42.6km |
| Road Density/ 1000 Population | 0.46km | 0.57km |
| Road Density/ 1000 sq. km (including community roads) | 24km | 120.5km |
| Proportion of area more than 5km from all weather road | 79% | 65.3% |
| Average distance to all weather road | 21.4km | 11.8km |

Source: Table 8, ERA (2009)

# The political process: Road Placement

- Proposals for **new** roads come mainly from regional states.
- The ERA assesses the regional proposals using the following **five** criteria
  - Roads providing access to areas with economic development potential (20%)
  - Roads leading to areas with surplus food and cash crop production (20%)
  - Roads that link existing major roads (20%)
  - Roads providing access to large and isolated population centers (30%)
  - Roads that bring balanced development amongst the regions in the country and that provide access to emerging regions (10%)
- Proposal goes to the government.
- Road upgrading: similar procedure; more weight to traffic density.
- Not clear what specific variable ERA uses to determine economic development potential etc.

# Data & Descriptive Statistics

- Using GIS data obtained from the ERA, we measure **travel time** between fixed points, and **areas accessible** from a particular location (node).
- We match these data to census panel data on formal manufacturing firms.
- We identify 106 towns in the country which have hosted at least one manufacturing firm at some point during the sampling period.

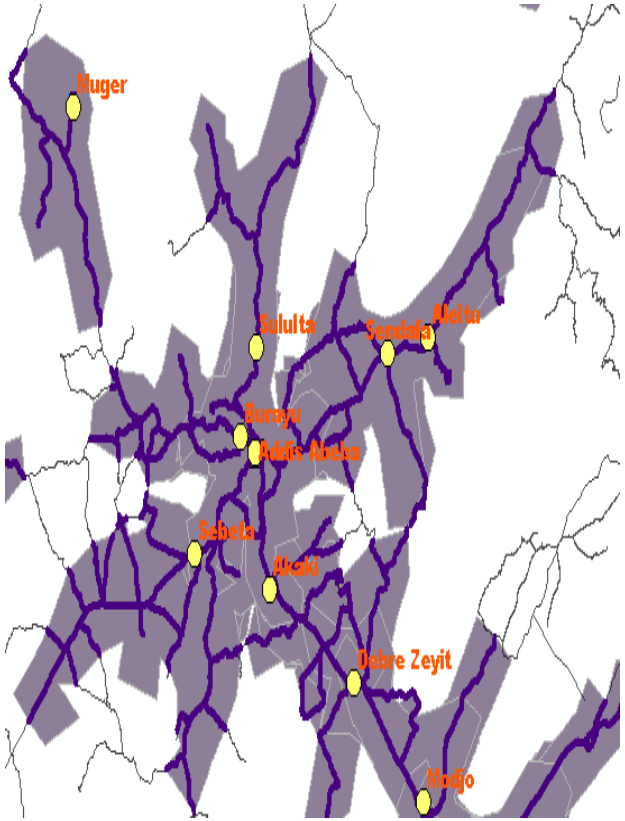
# Data & Descriptive Statistics

- Three measures of infrastructure quality
  - Total **distance** travelled during a 60-minute drive from node (using all roads serving the town)
  - Areas **accessible** during those 60 minutes of drive, using a 5 km buffer zone ("area of influence") on both sides of the road.
  - An aggregate measure of town's **connectivity** using the average travel time to major economic centers using the "Origin Destination (OD) matrix" analysis tool of GIS. 15 major economic destinations were selected; we then calculate the average travel time from each town (origin) to these major economic destinations as a measure of town's connectivity.

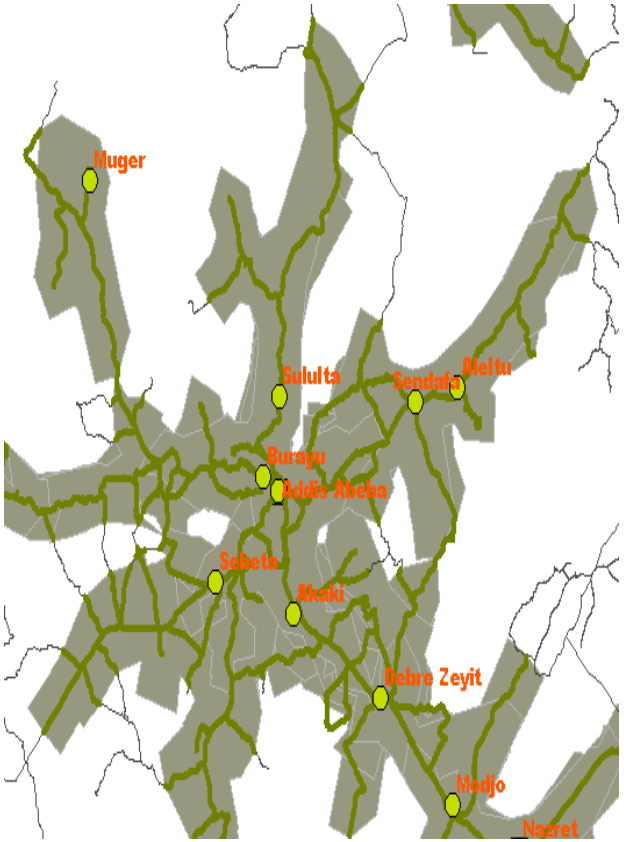
➢ Constructed for 1996, 1998, 2000, 2004, 2006 and 2008.

# Illustration: Area accessible during a 1hr Drive from Addis Ababa

1996




2008



# Summary statistics: Infrastructure variables

- Improvements are visible in the data
- Only minor improvements in the beginning of the period; because
  - Initial focus on restoration (new roads later)
  - Significant lags

Table 2: Trends in Road Accessibility (Annual Mean)

| Year | Area Accessible (Km2) | Travel Distance (Km) | Travel Time to Major Destinations (hours) |
|---|---|---|---|
| 1996 | 1098.2 | 210.6 | 379.9 |
| 1997 | 1100.9 | 210.9 | 379.8 |
| 1998 | 1103.7 | 211.2 | 379.7 |
| 1999 | 1108.5 | 211.8 | 378.5 |
| 2000 | 1113.3 | 212.5 | 377.3 |
| 2001 | 1139.7 | 216.3 | 369.4 |
| 2002 | 1166.2 | 220.1 | 361.4 |
| 2003 | 1181.2 | 222.3 | 359.7 |
| 2004 | 1196.1 | 224.4 | 358.0 |
| 2005 | 1235.3 | 230.4 | 350.9 |
| 2006 | 1274.6 | 236.4 | 343.9 |
| 2007 | 1317.7 | 246.4 | 334.7 |
| 2008 | 1360.9 | 256.4 | 325.5 |
| 2009 | 1360.9 | 256.4 | 325.5 |

Source: Authors' computation based on ERA data

# Firms

- Census panel data (source: CSA) covering (supposedly) all MFG firms in the country that
  - have >10 workers
  - use power in production
- The total number of firms increased from about 617 in 1996 to 1,713 in 2009
- Concentration changes: Small towns have seen a faster entry rate of firms than the biggest towns
  - In 1996, 76% of all firms located in 5 largest towns
  - In 2009, 55%

# Road Accessibility and Firm Location

- The geographical distribution of firms in the country has changed. Have improved roads played a role?
- Cross-sectional analysis:

$$\ln(N)_i = \beta_0 + \beta_1 RN_i + u_i$$

N = number of mfg firms in town i;

RN = measure of road accessiblity of firms town i.

$$\ln(N)_i = \beta_0 + \beta_1 RN_i + u_i$$

- Road placement not exogenous.
- Add to the specification proxies which we hope control for endogenous road placement.
  - Proxy agricultural potential by dummy for food self-sufficiency (info obtained from the Productive Safety-Nets Program; woredas participating in the PSNP are considered low agricultural potential).
  - Initial condition: The number of mfg firms in the town in the beginning of the period (recall v. little change in infrastructure before 1999).
  - Population (one of the criteria for road placement; measured in 2007 – not ideal but it's the best we've got).
  - Region fixed effects.

# Cross-Sectional Analysis: Results

Table 4: OLS Estimates: Dependent variable log number of Firms (Town Level) - Area Accessible as Measure of Road Accessibility

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| ln(acc_9909) | 1.0417 | 0.4709 | 0.4795 | 0.7699 |
| | (0.3456)*** | (0.2501)* | (0.2719)* | (0.2840)*** |
| ln(N_9698) | | 0.9279 | 0.9474 | 0.8810 |
| | | (0.0701)*** | (0.0867)*** | (0.1061)*** |
| Food Surplus | | | -0.0796 | 0.2197 |
| | | | (0.3010) | (0.3198) |
| ln(woreda_pop) | | | -0.0825 | 0.0555 |
| | | | (0.1360) | (0.1571) |
| Region Dummies | No | No | No | Yes |
| Constant | -6.3902 | -2.7589 | -1.8195 | -4.6934 |
| | (2.4285)** | (1.7722) | (2.5053) | (2.6266)* |
| $R^2$ | 0.13 | 0.67 | 0.66 | 0.70 |
| $N$ | 88 | 79 | 73 | 73 |

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% level of significance.

Robust standard errors in parenthesis

# Travel distance

Table 5: OLS Estimates: Dependent variable log number of Firms (Town Level) – Travel Distance as Measure of Road Accessibility

| 1 | | | | |
|---|---|---|---|---|
| ln(trvd_9909) | 0.8909 | 0.3743 | 0.3867 | 0.6251 |
| | (0.2756)*** | (0.2091)* | (0.2296)* | (0.2437)** |
| ln(N_9698) | | 0.9229 | 0.9425 | 0.8775 |
| | | (0.0730)*** | (0.0889)*** | (0.1088)*** |
| Food Surplus | | | -0.0896 | 0.2091 |
| | | | (0.2941) | (0.3164) |
| ln(woreda_pop) | | | -0.0847 | 0.0465 |
| | | | (0.1393) | (0.1612) |
| Region Dummies | No | No | No | Yes |
| Constant | -3.8030 | -1.4318 | -0.4643 | -2.5367 |
| | (1.4634)** | (1.1192) | (2.0259) | (2.2548) |
| $R^2$ | 0.14 | 0.66 | 0.66 | 0.70 |
| $N$ | 88 | 79 | 73 | 73 |

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% level of significance.

Robust Standard errors in parenthesis

# Panel Data Approach

- Use internal instruments (lags) to adress endogeneity (SYS-GMM; Blundell & Bond, 1998)
- Controls for town fixed effects and also year effects common across the towns:

$$\ln(N)_{it} = \beta_0 \ln(N)_{it-1} + \beta_1 RN_{it} + v_t + e_i + u_{it}$$

➢ System of equations: Levels eq. + 1st differenced eq.

- Lagged levels instruments for differences
- Lagged diffs instruments for levels

# SYS-GMM Results: Dependent Variable: $\log(N_{it})$

| | (1) Travel Distance | (2) Area Accessible | (3) Travel Time to Major Destinations |
|---|---|---|---|
| $Ln(N)_{it-1}$ | 0.7524 | 0.7490 | 0.7939 |
| | (0.0641)*** | (0.0702)*** | (0.4096)* |
| $ln(trvd)_{it}$ | 0.3559 | | |
| | (0.1596)** | | |
| $ln(acc)_{it}$ | | 0.4076 | |
| | | (0.2064)** | |
| $ln(ttod)_{it}$ | | | -0.1492 |
| | | | (0.7765) |
| Year Dummies | Yes | Yes | Yes |
| Observations | 1170 | 1170 | 1118 |
| Number of Towns | 90 | 90 | 86 |
| Sargan statistic and p-value | 81.498 (0.207) | 82.004 (0.196) | 77.436(0.734) |
| AR1 | 0.000 | 0.000 | 0.000 |
| AR2 | 0.405 | 0.410 | 0.374 |

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% level of significance. Standard errors in parentheses

# Compare to simple FE model

**Table 8: Fixed Effects Estimates: Dependent variable log number of firms**

| | (1) Travel Distance | (2) Area Accessible | (3) Travel Time to Major Destinations |
|---|---|---|---|
| ln(trvd) | 0.3482 | | |
| | (0.1583)** | | |
| ln(acc) | | 0.3128 | |
| | | (0.1585)** | |
| ln(ttod) | | | -0.5350 |
| | | | (0.1875)*** |
| Year | Yes | Yes | Yes |
| Observations | 1260 | 1260 | 1204 |
| Number of towns | 90 | 90 | 86 |
| R-squared | 0.23 | 0.23 | 0.23 |

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% level of significance. Standard errors in parentheses

# The Size of New Start-Ups

- If better infrastructure implies better market access, we might expect to see an increase in size of new entrants.
- Outcome of interest: The average size of firms entering the market.

# Positive association between average size of entrants and infrastructure quality

| | (1) Travel Distance | (2) Area Accessible | (3) Travel Time to Major Destinations |
|---|---|---|---|
| ln(acc) | 0.1457 | | |
| | (0.0787)* | | |
| ln(trvd) | | 0.1329 | |
| | | (0.0769)* | |
| ln(ttod) | | | -0.2258 |
| | | | (0.0968)** |
| ln(woreda_pop) | 0.1261 | 0.1294 | 0.1868 |
| | (0.0407)*** | (0.0410)*** | (0.0394)*** |
| Food Surplus | -0.3383 | -0.3172 | -0.3089 |
| | (0.1566)** | (0.1578)** | (0.1562)** |
| Year Dummy | Yes | Yes | Yes |
| Region Dummy | Yes | Yes | Yes |
| Observations | 2016 | 2016 | 1979 |
| R-squared | 0.05 | 0.05 | 0.05 |

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% level of significance. Robust standard errors in parentheses

# Infrastructure and Value-Added Productivity

$$\ln\left(\frac{Y}{L}\right)_{it} = \beta_0 + \beta_1 RN_t + \beta_2 X_{it} + \gamma_t + \eta + \tau + \varepsilon_{it}$$

| | OLS | | Firm fixed effects | | Differenced equations | |
|---|---|---|---|---|---|---|
| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
| $lacc_t$ | 0.0214 | | 0.784** | | 1.152** | |
| | (0.0955) | | (0.333) | | (0.493) | |
| $ltrvd_t$ | | 0.0455 | | 0.760** | -0.151 | 0.916*** |
| | | (0.0858) | | (0.325) | (0.445) | (0.337) |
| $lod\_mean_t$ | -0.279** | -0.277** | 0.432 | 0.316 | 0.306 | 0.101 |
| | (0.123) | (0.122) | (0.462) | (0.469) | (0.499) | (0.523) |
| $Ln(K/L)_t$ | 0.216*** | 0.216*** | 0.0627*** | 0.0627*** | 0.0817*** | 0.0818*** |
| | (0.0122) | (0.0122) | (0.00993) | (0.0100) | (0.0116) | (0.0116) |
| $Public_t$ | 0.564*** | 0.566*** | 0.0281 | 0.0287 | 0.0534 | 0.0529 |
| | (0.0724) | (0.0720) | (0.0851) | (0.0852) | (0.0558) | (0.0560) |
| Export $Dummy_t$ | 0.491*** | 0.492*** | 0.150* | 0.147* | 0.317** | 0.315** |
| | (0.174) | (0.175) | (0.0785) | (0.0787) | (0.152) | (0.152) |
| Constant | 8.505*** | 8.421*** | 0.112 | 2.156 | -0.0692** | -0.0689** |
| | (1.031) | (0.898) | (4.718) | (4.198) | (0.0338) | (0.0338) |
| Sector | Yes | Yes | | | | |
| Region | Yes | Yes | | | | |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 6,220 | 6,220 | 6,220 | 6,220 | 3,411 | 3,411 |
| R-squared | 0.289 | 0.289 | 0.016 | 0.016 | 0.017 | 0.016 |
| Number of eid | | | 2,613 | 2,613 | | |

# Conclusions

- Existing literature: Little evidence on the relationship btw road infrastructure & firm development in SSA.
- Roads placement endogenous. Safest to interpret our results as indicating associations, rather than causality.
- Consistent with the prevalent notion in the literature, the results suggest better roads lead to:
  - more start-ups
  - larger start-ups

# Conclusions (cont'd)

- Infrastructure improvement associated with productivity increase
- This effect appears to be **temporary**; a few years after the infrastructure innovation, productivity differences can no longer be observed.

# Policy implications?

- Better roads result in more, larger firms… so build more roads??
  - Not necessarily: Depends on the return to building roads (look across all sectors)
- Adds to accumulating evidence on how the market structure in Ethiopia shapes business decisions (Fafchamps and Söderbom, 2012; Bigsten et al. 2012).
- Fragmented markets & high transport costs provide incentives for strategic substitution: Find a niche unique to the local market, extract local rents. Disinctive for firms to cluster.
- Policy measures that strengthen incentives to agglomerate may raise aggregate productivity & generate more jobs.
- Reduce local rents. Roads may be one such instrument, but may or may not be the most cost-effective one. Market integration.

Thank you