The Impact of Agricultural Extension and Roads on Poverty and Consumption Growth in Fifteen Ethiopian Villages: A Replication

William Bowser

1 Why replicate?

Dercon et al. (2009) provide crucial insight into the value of public investments on poverty and household well-being. Within many contexts, this study lays the foundation for important extensions into policy design. Notably, the mixed look at rural infrastructure developments and agricultural extension services corresponds with the multidimensional approach to public resource allocation. Mogues (2011) argues that public investment decisions, especially in the developing world, are made by necessity across multiple sectors. Dercon et al. (2009) constitute a rare account of the impact of a diversified public investment strategy which reaches policy makers on familiar terms and enriches the understanding for the development community.

Moreover, the focus on rural infrastructure projects in a localized setting provides a basis for forming expectations about the impact of developments with a broader reach, such as regional or national highway projects. Such broader development projects are natural extensions to localized investments (BenYishay and Tunstall, 2011). Evidence of these successes on relatively small scales can support the advancement of initiatives for scaling-up, which can impact a larger populace simultaneously.

Part of the motivation for replicating the Dercon et al. (2009) study is the newly available data documenting the survey reporting from the seventh round in 2009. With this new round of data, we can examine the impact of road developments over a longer trajectory of time. McKenzie (2012) emphasizes the importance of examining the impact of interventions over a longer time window to achieve more convincing insights into their efficacy. Dercon et al. (2009) cover the periods from 1994, 1995, 1997, 1999, and 2004. While their previous work covers a substantial portion of the Road Sector Development Program period,

the results do not convey the growth effects during the final years of the project.[1] Hence, the extended round of data provides a much warranted opportunity to maximize the time coverage of the evaluation and enhance the credibility of the findings.

Additionally, the provision of agricultural extension services generates a channel for productivity gains that may otherwise be foregone due to the difficulties involved in establishing a market for agricultural information diffusion. Agricultural extension services are characterized by their public good nature, which makes efficient pricing a challenge, despite their obvious value Maffioli et al. (2011). It is generally understood that growth in the agricultural sector will stimulate growth in other sectors of an economy (Dercon and Zeitlin, 2009). Ultimately, the goal of public investments like agricultural extension services is to accelerate growth in agricultural production and overall incomes, especially for agricultural smallholders. Dercon et al. (2009) illustrate this point by uniquely characterizing the impact of access to agricultural extension services in terms of consumption growth for smallholders. This is an important perspective to take, particularly in Ethiopia where the GoE's Plan for Accelerated and Sustained Development to End Poverty (PASDEP) points to the agricultural sector to spearhead its economic growth with a special focus on enhancing the position of smallholders in the sector (Dercon and Zeitlin, 2009).

The emphasis on investments that impact the rural segment of the country are made transparent by the rapid growth of investments dedicated to agriculture and road construction. Between 1999 and 2008, the GoE increased alloca-

[1] The availability of the latest survey round is also important because it allows us to examine poverty and growth effects within the context of the Government of Ethiopia's (GoE) 10 year Road Sector Development program which began in 1997 and concluded in 2007. However, data which is directly related to the program suitable for formal evaluation is not available, which does not permit a formal cost-benefit analysis of the national program. Additionally, the primary objective of the program was to improve trunk roads between major cities. Rural road development initiatives emerged as an offshoot of the original program (World World Bank, 1997,).

tions to rural investments by 97.5 percent with 23.8 percent of its expenditures constituting investments in rural areas (Dorosh and Schmidt, 2010). Hence, the findings by Dercon et al. (2009) documenting the experience in Ethiopia is likely to influence future policy designs both in Ethiopia and other developing countries. Therefore, validation of the findings can enhance confidence in the resulting policy trajectory.

2 Remarks on original study

Dercon et al. (2009) adapt a reduced form economic growth model into a model depicting the growth path of household consumption as a function of access to technology (extension services), capital stock (road infrastructure) and transitory shocks. There are two potential sources of endogeneity in their empirical model which must be addressed. To do so, Dercon et al. (2009) employ a Generalized Method of Moments Instrumental Variable (GMM-IV) estimator with corrections for household level fixed-effects due to unobserved time-invariant heterogeneity in their sample. Their primary results use lags of log livestock units held per adult equivalent, log land size per adult equivalent, and log adult equivalent in the instrument set to control for the endogeneity of lagged log consumption in the growth equation. The authors apply an important underlying assumption in the specification of their empirical growth model. Specifically, they assume that log consumption, access to technology, and capital stocks change very slowly such that the initial period levels are approximately equal to the observed levels in all subsequent periods. This assumption enables the authors to measure the growth process as an average growth rate across the entire sample period, while simplifying the identification of the parameter estimates on the explanatory variables; the need for simplifying the parameter estimates arises due to the uneven spacing between the periods in the sample.

The original authors provide an extensive array of robustness checks for their estimator: testing the sensitivity to weak instruments with Limited Maximum Likelihood estimation results; testing the sensitivity to outliers; treating access to technology as endogenous (adding the lag number of extension agents to the instrument set); additional controls for household characteristics; and functional forms. They also disaggregate the estimated impacts through stratification on household characteristics. Generally, these robustness checks seem to imply a conservative estimate of the impact from public investments based on their main results.

3 Further robustness checks

3.1 Unreconciled endogeneity

The authors indicate that the instrument employed in the endogeneity correction for access to technology may be weak and lack sufficient coverage in the sample. This may warrant the use of alternative instrument(s) and/or methods to correct selection bias affecting the impact estimates. Additionally, the issue of non-random road improvements is mentioned by the authors but never directly addressed. Since road development occurs at the village level in this study, it is difficult to disentangle the causal effect of capital stocks given the small number of clusters (villages) available to measure village level effects. However, there may be other village level instruments available to improve the estimates.

3.2 Uneven time spacing

Another focus area for further investigation is the plausibility of the slow growth assumption and the costs of violating this assumption, particularly as it regards the change in capital stock (i.e. road infrastructure). The original authors

indicate that access to all-weather roads increases relatively sharply over the sample period. This may imply the violation of the assumption that capital stock is approximately the same across all periods. Violation of this assumption may introduce bias due to misspecification of the functional form of the growth equation, thereby warranting alternative specifications.

4 Replication plan

4.1 Pure replication with additional robustness checks

The replication will begin by validating the original results of Dercon et al. (2009), maintaining their assumptions and employing the same GMM-IV estimator with fixed effects. Following the pure replication, the assumptions about the evolution of log consumption, access to technology, and capital stocks will be further investigated to determine their validity. Next, the sensitivity of the empirical growth model to the violation of these assumptions will be examined. This can be done by constructing the respective p-period averages of each variable up to period $t-1$ characterized in equation (4) of Dercon et al. (2009).[2] These additional assumptions are less applicable to the poverty regression and hence more attention is given to the consumption growth equation here and in the following extensions of the study.

[2] Following Dercon et al. (2009), in the violation of the above assumptions, the empirical equation to be estimated is

$$(\ln y_t - \ln y_{t-p})/p = \delta + \alpha(\ln y_{t-1} + \ldots + \ln y_{t-p})/p + \beta(k_{t-1} + \ldots + k_{t-p})/p + \gamma(\ln R_{t-1} - \ln R_{t-p})/p + \lambda X + \varepsilon_t$$

where $\ln y_t$ is the household log consumption in period t, k_{t-1} is the vector of variables representing capital stock and access to technology, and $\ln R_{t-1}$ represents the transitory shocks occurring in period $t-1$, X represents unobservable time-invariant households characteristics, and ε_t is an idiosyncratic error term.

4.2 Statistical replication

4.2.1 Evenly spaced time intervals

It is possible to expect serious divergences from the authors' original results in the event that their assumptions about the evolution of capital stocks is violated within the data. In this case, re-specifying the growth equation in a standard format using evenly spaced periods may be well justified. Given the available data from the original study, this strategy will employ data from 1994, 1999, and 2004 survey rounds to estimate the effect of access to technology and improved capital stocks on household consumption growth. Omitting 1997 may improve the precision of estimates since data for this round was collected during a different part of the season, relative to other rounds (Dercon et al., 2009).

4.2.2 Alternative instrument sets

While Dercon et al. (2009) correctly control for endogeneity of the lagged dependent variable, they do not control for changes in observables that may impact road improvements. Rather they employ fixed effects to eliminate bias due to unobservable characteristics. However, public investments, especially road projects, are also endogenous to time varying observables (van de Walle and Mu, 2007; van de Walle, 2009; Gibson and McKenzie, 2010). Within the GMM-IV framework, instrumenting the variable indicating program placement could also be employed if there are suitably excludable instruments available. In Dercon et al. (2009) all weather roads were made available to an increasing number of households/villages over the sample period. In this dynamic setting, lagged outcomes also make suitable instruments for contemporary program placement (Khandker and Koolwal, 2011).

The replication will further investigate the choice of instruments used to correct for the endogeneity in the lagged consumption variable as well as the

variable indicating access to technology (receiving an extension visit). In particular, the replication will examine the original authors' choice to model both access to all weather roads and agricultural extension services simultaneously. It is possible that visits by extension officers are hindered or facilitated by the ease of access to the village. In this case, agricultural extension services may not be independent of all weather road access. Thus, including access to all weather roads as an instrument for extension visits may improve the estimates. The alternative instrument set will be deployed onto both the original data, and the evenly spaced panel.

4.2.3 Alternative corrections for selection bias

Additionally, it is interesting to examine the estimates from the GMM-IV fixed effects approach against the first-differenced GMM-IV estimator. Differencing is another means of controlling for selection bias due to time-invariant unobserved household and village characteristics. Unobserved initial conditions related to the geographic allocation of public investments may be important sources of bias (Jalan and Ravallion, 2002). Additionally, removing the unobserved fixed effects with the first-differenced GMM estimator can also account for bias due to time-invariant characteristics correlated with systematic attrition of households (Flossmann, 2009). If detected, attrition bias due to selection on observables can be accounted for with inverse probability weights constructed from a probit model estimating the probability of attrition (Fitzgerald et al., 1998).[3] However, estimating the first-differenced GMM is best executed over an evenly spaced panel. Furthermore, the number of available (evenly spaced) periods in the original data may be too short to yield effective lagged instruments.

[3] The fixed effects estimator used in Dercon et al. (2009) accounted for attrition due to time-invariant unobservables, but they neither test nor correct for the possibility of attrition due to the selection on observables problem. The authors attribute the 13.2 percent attrition rate in their sample between 1994 and 2004 completely to time-invariant village and household characteristics (Hoddinott and Yohannes, 2011).

The first-difference GMM has been shown to have severe downward bias, in small samples (Blundell and Bond, 1995). Hence, there may be potential gains to employing the system GMM-IV as well in this context (Blundell et al., 2000). Therefore, as an extension of the pure replication, the statistical replication will incorporate the 2009 survey round data into the analysis and derive estimates from a first-differenced and a system GMM-IV specification. These results will be compared against the original authors' GMM-IV fixed effects estimates on the evenly spaced data including the 2009 round of data.[4]

One concern in adding the 2009 survey round is the substantial inflation realized throughout the Ethiopian economy between 2004 and 2009. For example, inflation in 2009 exceeded 24 percent, while in 2004 it was just under 4 percent (World Bank, 2012). In the original study, Dercon et al. (2009) correct for inflation in food prices with a Laspeyres food consumer price index. Although, the suitability of this deflator being extended to the 2009 data depends on the importance of non-food items in the household consumption bundle constructed in the data. If the proportion of non-food items is small, there may be less risk of bias due to any residual inflation in the remaining in the expenditure measure. However, Dercon et al. (2012) indicate that household durable holdings have noticeably increased between 1994 and 2009. While including such non-food items in the consumption bundle might seem applicable, the original authors exclude durables related to investment (e.g. education and health care expenditures) because of the difficulty in accurately measuring the use values. Hence, to maintain interpretive consistency with the original study, this replication will

[4] An alternative estimation approach might involve using a difference -in-differences (DD) estimator combined with propensity score matching (PSM) to control for initial conditions. This DD-PSM estimator has been employed in van de Walle and Mu (2007) and Mu and van de Walle (2011) to evaluate the impact of rural roads at the commune level in Vietnam. However, the small number of villages in the current context creates difficulty in applying PSM to match villages. While DD-PSM could still be employed for the analysis of extension visits, standard errors from DD estimates on data with more than two time periods have been shown to be inconsistent in the presence of serially correlated outcomes (Bertrand et al., 2004). Therefore, a dynamic panel approach may perform better in this context.

maintain the composition of consumption as the sum of the value of food items and non-food items not related to investment. The food price index will be employed with base year 1994 as in Dercon et al. (2009), and more recently Dercon et al. (2012).

4.3 Scientific replication

4.3.1 Investigating the theory of change

In addition to the extension of the data to include the 2009 survey round, there are some additional measures of impact that are of interest. Specifically, this replication aims to test hypotheses regarding the impact on additional outcome variables, in order to unravel the causal chain. An important complementary research question relative to other important outcomes of public investment might consider how access to better roads affected growth in off-farm income and earnings from activities with links to external markets/villages. Non-farm activities have been shown to be important sources of income in rural areas (Barrett et al., 2001). Off-farm opportunities often provide higher incomes when attainable on a regular basis (Lanjouw, 2001). However, most of these opportunities require migration either on a daily, short-term or long-term basis to a distant locale. Such opportunities may be inaccessible to households if road travel is difficult or unreliable. Therefore, it is interesting to examine the extent to which off-farm income generation contributed to the overall consumption growth results reported in Dercon et al. (2009).

Another channel through which public investments could increase household consumption growth might be via increased crop income. Did access to public investments increase crop income growth? Increased consumption growth could be attributed (in part) to either increased crop income, increased on-farm consumption, or both. However, while it is difficult to measure on-farm con-

sumption, a measure for crop income can be constructed from the existing data. Therefore, the replication will also examine crop income growth as an outcome of public investments. These additional outcomes will be measured first on the data from the original study, using the authors' first differenced GMM-IV approach. Then the evenly spaced data up to 2004 and 2009 will be employed.

While there are a myriad of outcome variables that could be impacted by the public investments considered in Dercon et al. (2009), (see Khandker et al. (2009)), these two variables represent plausible intermediary outcomes realizable by a household as a result of public investments. Identifying the effect of extension visits and improved roads on off-farm and crop income growth help to clarify the pathway to increased consumption growth. Growing off-farm income in the rural sector is considered to be an important first step in the economic advancement of developing economies (Lanjouw and Stern, 2003). Extending the previous analysis to address these questions is useful in determining how public investments support a structural transformation of the Ethiopian economy.

5 Synopsis

In the study proposed for replication, the original authors employ the GMM-IV with fixed effects to control for selection bias. Many targeted development programs, especially those related to public investments, suffer from selection biases due to initial conditions (Jalan and Ravallion, 2002; Khandker et al., 2009). This replication aims to further investigate the original findings from (Dercon et al., 2009) by first replicating the original results and validating the assumptions which drive the primary empirical model. Following this, the replication will examine the sensitivity of the results to evenly spaced time intervals using the authors' GMM-IV fixed effects model, with alternative considerations for the set of instruments used to correct endogeneity. Then, first-differenced

and system GMM-IV estimators will be deployed on the evenly spaced data, with the inclusion of the 2009 survey round data. And finally, the replication will consider intermediary outcomes along the causal chain to clarify the theory of change.

Ultimately, the replication is intended to provide a platform for the validation of the implications for public investments found in Dercon et al. (2009). Successful public investments in Ethiopia and other developing countries which target rural areas can support the transition to larger scale national investment programs. Additionally, corroborative evidence of an effective public investment initiative can support the design of pro-poor economic policy in the future. Therefore, ensuring the robustness of the results found by Dercon et al. (2009) is a meaningful exercise for the future of development policy.

References

Barrett, C. B., Reardon, T., Webb, P., 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. Food Policy 26 (4), 315–331.
URL http://linkinghub.elsevier.com/retrieve/pii/S0306919201000148

BenYishay, A., Tunstall, R., 2011. Impact evaluation of infrastructure investments: the experience of the Millennium Challenge Corporation. Journal of development effectiveness.
URL http://www.tandfonline.com/doi/abs/10.1080/19439342.2010.545892

Bertrand, M., Duflo, E., Mullainathan, S., Feb. 2004. How Much Should We Trust Differences-In-Differences Estimates? The Quarterly Journal of Economics 119 (1), 249–275.
URL http://qje.oxfordjournals.org/cgi/doi/10.1162/003355304772839588

Blundell, R., Bond, S., 1995. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics 87 (1), 115–143.
URL http://discovery.ucl.ac.uk/15767/

Blundell, R., Bond, S., Windmeijer, F., 2000. Estimation in dynamic panel data models: improving on the performance of the standard GMM estimator. Fiscal Studies 15, 53–91.
URL http://eprints.ucl.ac.uk/4070/

Dercon, S., Gilligan, D. O., Hoddinott, J., Woldehanna, T., Nov. 2009. The Impact of Agricultural Extension and Roads on Poverty and Consumption Growth in Fifteen Ethiopian Villages. American Journal of Agricultural Economics 91 (4), 1007–1021.
URL http://ajae.oxfordjournals.org/cgi/doi/10.1111/j.1467-8276.2009.01325.x

Dercon, S., Hoddinott, J., Woldehanna, T., 2012. Growth and chronic poverty: Evidence from rural communities in Ethiopia. Journal of Development Studies 48 (2), 238–253.

Dercon, S., Zeitlin, A., 2009. Rethinking agriculture and growth in Ethiopia: A conceptual discussion.
URL http://www.economics.ox.ac.uk/members/Stefan.Dercon/ethiopia paper 2_v2.pdf

Dorosh, P., Schmidt, E., 2010. The Rural-Urban Transformation in Ethiopia.
URL http://www.ifpri.cgiar.org/sites/default/files/publications/esspwp013.pdf

Fitzgerald, J., Gottschalk, P., Moffitt, R., 1998. An Analysis of Sample Attrition in Panel Data: The Michigan Panel Study of Income Dynamics. The Journal of Human Resources 33 (2), 251–299.
URL http://www.jstor.org/stable/146433?origin=crossref

Flossmann, A., Jan. 2009. Accounting for missing data in M-estimation: a general matching approach. Empirical Economics 38 (1), 85–117.
URL http://www.springerlink.com/index/10.1007/s00181-009-0257-y

Gibson, J., McKenzie, D., 2010. The Development Impact of New Zealand's RSE Seasonal Worker Policy.
URL http://newsettlers.massey.ac.nz/publications_pdfs/J Gibson - Pthways 2010.pdf

Hoddinott, J., Yohannes, Y., 2011. Ethiopia Rural Household Survey Dataset, 1989-2009.
URL http://hdl.handle.net/1902.1/15646

Jalan, J., Ravallion, M., Jul. 2002. Geographic poverty traps? A micro model of consumption growth in rural China. Journal of Applied Econometrics 17 (4), 329–346.
URL http://doi.wiley.com/10.1002/jae.645

Khandker, S. R., Bakht, Z., Koolwal, G. B., Jul. 2009. The Poverty Impact of Rural Roads: Evidence from Bangladesh. Economic Development and Cultural Change 57 (4), 685–722.
URL http://www.journals.uchicago.edu/doi/abs/10.1086/598765

Khandker, S. R., Koolwal, G. B., 2011. Estimating the long-term impacts of rural roads: A dynamic panel approach.
URL http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1952496

Lanjouw, P., Mar. 2001. Nonfarm Employment and Poverty in Rural El Salvador. World Development 29 (3), 529–547.
URL http://linkinghub.elsevier.com/retrieve/pii/S0305750X00001054

Lanjouw, P., Stern, N., 2003. Opportunities off the farm as a springboard out of

rural poverty: five decades of development in an Indian village. In: Fields, G., Pfeffermann, G. (Eds.), Pathways out of poverty: private firms and economic mobility in developing countries. Kluwer Academic Publishers, Boston, pp. 123–154.

Maffioli, A., Ubfal, D., Baré, G. V., Cerdán-Infantes, P., Nov. 2011. Extension services, product quality and yields: the case of grapes in Argentina. Agricultural Economics 42 (6), 727–734.
URL http://doi.wiley.com/10.1111/j.1574-0862.2011.00560.x

McKenzie, D., 2012. Beyond baseline and follow-up: the case for more T in experiments. Journal of Development Economics (April).
URL http://www.sciencedirect.com/science/article/pii/S030438781200003X

Mogues, T., May 2011. The Bang for the Birr: Public Expenditures and Rural Welfare in Ethiopia. Journal of Development Studies 47 (5), 735–752.
URL http://www.tandfonline.com/doi/abs/10.1080/00220388.2010.509925

Mu, R., van de Walle, D., May 2011. Rural Roads and Local Market Development in Vietnam. Journal of Development Studies 47 (5), 709–734.
URL http://www.tandfonline.com/doi/abs/10.1080/00220381003599436

van de Walle, D., Mar. 2009. Impact evaluation of rural road projects. Journal of Development Effectiveness 1 (1), 15–36.
URL http://www.tandfonline.com/doi/abs/10.1080/19439340902727701

van de Walle, D., Mu, R., Nov. 2007. Fungibility and the flypaper effect of project aid: Micro-evidence for Vietnam. Journal of Development Economics 84 (2), 667–685.
URL http://linkinghub.elsevier.com/retrieve/pii/S0304387806002069

World Bank, 1997. Ethiopia road sector development program support project: Project appraisal document. Tech. rep., World Bank.

World Bank, 2012. World Development Indicators 2012.
URL http://hdl.handle.net/10986/6014