Title
Introduction

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Introduction

Technological innovation is an essential driver of human and economic development. It can improve the functioning of markets (Jensen, 2007), promote government accountability (Callen and Long, 2014), build human capital (Foster and Rosenzweig, 1996), and reduce the risks we face from global environmental change (Dar et al., 2013). Yet designing technologies that improve the lives of the poor is notoriously challenging. The path from ideation to scale-up is rarely linear, or even successful.

The problems associated with poverty—including weak institutions, human capital constraints, credit constraints, lack of information, and poor infrastructure—are complex and multi-faceted. Further, private businesses often fail to see a market for innovative technologies designed to meet the needs of the poor. As a result, low-income households are excluded from markets, leaving them unable to influence the direction of technological innovation. For lack of data, their needs and desires remain "hidden.".

We do know that people living in poverty face a kind of cognitive scarcity, which biases their decision-making (Mani et al., 2013). But the persistent lack of information about poor households, including their preferences, makes it difficult for innovators to understand end-users and forecast the demand for new products. There are also important challenges that fall outside the market framework. These include cultural values and informal institutions that are difficult for outsiders to understand, but which may influence the relevance and utility of an innovation.

As a result, the field of 'technology for development' is littered with failures, from community water infrastructure that quickly falls into disrepair (Thomas, 2016), to improved cookstoves that are never adopted by potential beneficiaries (Mobarak et al., 2012). Even seemingly promising technologies—like solar microgrids, school laptops, and improved crop varieties—can fail to improve welfare, sustain impact, or achieve scale. Innovations may also have unintended consequences, especially in developing countries where weak regulation can result in unchecked pollution, large-scale fraud, and worsening inequality.

In the for-profit sector, technology developers have access to rich data describing customer preferences and demand—from smart meters and computerized receipts, to market surveys and web logs. Engineers in the U. S. tech sector are supported by entire units devoted to business analytics, marketing, and user-centered design (Levy, 2011). The resulting insights can be used to iteratively refine products for the market.

In the absence of a profit motive, pro-poor innovation has largely occurred within universities and non-profit organizations, where resources and rewards for cross-disciplinary collaboration are limited (Chesbrough, 2006). Academic engineers have weak incentives and lack the tools needed to understand markets, social norms, and the behavioral biases facing those in poverty. Similarly, social scientists have toiled in the field without access to modern technologies—like remote sensing—that could accelerate our understanding of poor households and their preferences.

We are now at a turning point. Academic innovators have begun collaborating across disciplines and international boundaries to more effectively apply technology to the problems of poverty. To promote and recognize this work, we have launched Development Engineering, an open-access scholarly journal that presents peer-reviewed technological research inspired by development economics and other social sciences.

The journal is driven by the hypothesis that earlier integration of economic insights into the engineering design process will yield solutions that are more likely to achieve development impact and scale. Development Engineering allows us to test this hypothesis, by providing a respected forum for pioneering collaborative work. The journal will build a foundation for future generations of innovators, by publishing seminal studies that can be used in teaching and research training.

1. The role of technology in development

In launching this new journal, we do not unquestioningly embrace technology as a solution to poverty. While it plays an important role in driving economic development, technology is not a panacea. It can take the form of objects (like machinery and appliances), or ideas (like digitizing payments or crowdsourcing information)—but in most cases, technology requires accompanying institutions, policies, markets, and human capital to achieve real benefits (Romer, 1993).

Thus Development Engineering will span innovations in engineering and technology as well as social science and policy research. It will focus, in part, on problems in the distribution and adoption of new technologies, which remain among the most difficult and overlooked challenges in development. Without users to adopt new technologies, social and economic development cannot occur.

It will also highlight products and services that target firms and governments, in addition to households and communities. When we think about 'technology for development', we too often focus on consumer products and services. Consumer-targeted innovations can help individuals maintain social networks (e.g. mobile phones), promote health (e.g. latrines, water filters), save money (e.g. digital accounts), invest in education (e.g. mobile apps), and secure access to food (e.g. storage technology). These technologies are particularly essential where governments have failed to invest adequately in public goods.

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However, in this journal we broaden our footprint to include technologies that affect the productivity of firms and the public sector, for example through mechanization or automation. Business technologies, when appropriately used, can transform markets. They can facilitate the matching of supply and demand, and they can coordinate flows between producers and consumers. This includes the flow of information in agricultural markets (e.g. through mobile phones, as in Aker (2010)) as well as the movement of goods along roads (Gertler et al., 2016) and the payment of salaries through mobile money (Blumenstock et al., 2015).

Business innovations can also promote collective action and inter-firm collaboration, for example through supply chain management technology, which can generate efficiencies at scale (Reardon et al., 2003). Still other technologies promote the resilience of firms and the self-employed. New drought-resistant crops, which can attenuate the weather risks facing agricultural communities, can provide just enough "insurance" for poor farmers to innovate and adapt to change (Dar et al., 2013).

Of course technology can fail as well. In this first issue, Suresh de Mel and colleagues evaluate the use of RFID to track inventories and measure the profits of small firms in Sri Lanka. They find that the technology performs poorly in practice, in part because microenterprises are space constrained (and, as a result, they stack inventory more densely than large commercial outlets). While the application of this technology failed in the microenterprise context, we see major benefits from publishing studies that find weak or no impacts. In global development, there should be no silent failures; there is inherent value in learning from interventions that fail to achieve their intended impacts.

When innovations do achieve impact, and are adopted by governments, they can amplify the impact of public sector investments. Information and communication technologies (ICTs) have promoted accountability in elections and improved regulation, by providing information about government performance to citizens and auditors (Callen et al., 2016). This can have knock-on benefits for the poor, by drawing attention to corruption, inequality, and gaps in service coverage. Technologies like electronic payments systems can reduce transactions costs for governments, while reducing leakage and wastage in the distribution of public resources (Muralidharan et al., 2014).

Even satellites play an important role in economic policy, by improving poverty mapping and the targeting of public resources to low-income communities (Elvidge et al., 2009). In this issue, Kenneth Lee and colleagues combine satellite imagery with geo-coded survey data, to identify households, businesses, and public facilities adjacent to power transformers in Western Kenya. They reveal major gaps in access to the electric power grid—findings that are now being used by the Kenyan government to refine its energy subsidy policy.

Within government programs, the adoption of sector-specific innovations (e.g. vaccines, traffic monitoring, or smart meters) can improve the quality of services delivered, thereby contributing to development overall. But there are also public benefits from technologies that conserve natural resources and the environment. Here, Daniel Wilson and colleagues study the introduction of improved cookstoves in Sudan, performing a life cycle analysis of carbon emissions for the product. Their findings suggest that the technology can reduce lifetime CO_2 emissions relative to traditional cookstoves. Indeed, many technologies that improve productivity or welfare can have co-benefits for the environment. High-yielding technologies adopted during the Green Revolution are estimated to have prevented the destruction of natural ecosystems covering millions of hectares (Stevenson et al., 2013).

Overall, this journal will focus on two core themes in technology and development. First is the design and evaluation of technology-driven interventions, adapted to the context of poverty —be they objects or ideas. Second is innovation in the measurement of human welfare and development indicators, for example through remote sensing technologies such as satellites, sensors and ICTs.

The focus on measuring development outcomes reflects the need for further innovation in the social sciences, including both technologies for acquiring data, and new analytic approaches. In this issue, Evan Thomas and colleagues describe a platform using sensors to measure the performance and impacts of cookstoves, water filters, water hand pumps, and electricity connections. These technologies, and other remote sensing tools, are particularly useful for lowering the costs of engaging with distant or dispersed populations. It can also increase the frequency of data collection, eliminate some classes of bias in survey data, and measure behaviors and outcomes that were previously "hidden," or unobservable.

Similarly, new statistical methods and tools from computer science (like machine learning and deep learning, see Xie et al. (2015)) are increasingly being applied to address social and economic policy challenges, including within the development sector. In this issue, Guiteras et al. describe a new method for designing randomized field trials, allowing for stratification of the study population through sequential assignment to treatment. Their approach, which relies on rapid communication between the lab and the field, is enabled by improvements in electronic survey tools and mobile computing.

While Development Engineering emphasizes empirical, scientific, and quantitative approaches, the journal is intended to serve a wider audience, including development practitioners and policymakers. The aim is to grow a body of evidence to inform decision-making, while simultaneously building the foundation for a new approach to social innovation—one that can be taught in universities throughout the world.

2. Sustainable development

The launch of this journal coincides with the United Nations' Sustainable Development Goals (SDGs) and the post-2015 development agenda. Technology innovation will be essential for each of the SDGs—from food security, water, and sanitation to energy access, economic growth, and resilient cities. Innovative measurement tools will also be crucial, both for tracking progress towards the SDGs and for improving the design of programs intended to achieve shared development goals.

Of course to improve development outcomes, the scientific community must maintain high standards for the credibility, reliability, and reproducibility of research. This is particularly important in the context of the SDGs, since research results are intended for use in policy design. A single policy can affect millions of people, over many years.

With this in mind, a guiding principle for the journal is an emphasis on open science and research transparency. Development Engineering is committed to the transparent reporting of findings and the open availability of data for future research, including replications. Towards this end, the journal editors will be establishing a set of standards to promote openness and reproducibility, based on the TOP guidelines (Nosek et al., 2005).

The journal is complemented by a new designated emphasis (or minor) for doctoral students in Development Engineering, established by an interdisciplinary faculty committee at the University of California, Berkeley. The program is helping to institutionalize the field, building on nearly a decade of applied research and coursework in engineering and development economics at Berkeley. Other universities are implementing similar programs, including the Ecole Polytechnique Federal de Lausanne. It is our goal for the research published by this journal to inform curriculum development, providing case studies for use in academic programs.

Finally, the journal's leadership recognizes the value of insights from researchers across diverse geographies and backgrounds. Unfortunately, there remains a dearth of high-quality research published by authors from developing countries, with the field of international development being no exception. While policy-makers are increasingly relying on rigorous research to guide decision-making, the expertize and perspectives of scholars in developing countries remain under-represented (Freeman and Robbins, 2005).

In order to close this publication gap, the journal seeks to bolster the capacity of developing country scholars to publish their work, both in Dev Eng and beyond, through an innovative co-mentorship program. This effort will pair interested junior authors from developing countries with established researchers throughout the world. The objective is to provide support in developing manuscripts, extending initial research, and facilitating future collaboration.

The launch of Development Engineering brings both excitement and *anti*cipation. It offers a forum to share innovations that address the exclusion of poor people from traditional markets. It will reveal new tools for capturing reliable feedback from people in low-resource settings. It will create a space for interdisciplinary teams of researchers to demonstrate technologies that are built to achieve scale and impact, in the context of poverty.

Perhaps most of all, it will help the scientific community learn how to better innovate for the base of the economic pyramid, enabling us to design new services and products that responsibly advance welfare for billions of people around the globe.

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References

Aker, J.C., 2010. Information from markets near and far: the impact of mobile phones on agricultural markets in Niger. Am. Econ. J.: Appl. Econ. 2 (3), 46–59.
Blumenstock, J.E., Callen, M., Ghani, T., Koepke, L., 2015. Promises and pitfalls of mobile money in Afghanistan: evidence from a randomized control trial. ACM ICTD . http://dx.doi.org/10.1145/2737856.2738031.
Callen, M., Long, J.D., 2014. Institutional corruption and election fraud: evidence from a field experiment in Afghanistan. Am. Econ. Rev. 105 (1), 354–381.
Callen, M., Gibson, C., Jung, D.F., Long, J.D., 2016. Improving electoral integrity with information and communications technology. J. Exp. Polit. Sci. FirstView 10, 1–14.
Chesbrough, H.W., 2006. The era of open innovation. Manag. Innov. Chang. 127 (3), 34–41.
Dar, M., de Janvry, A., Emerick, K., Raitzer, D., Sadoulet, E., 2013. Flood-tolerant rice reduces yield variability and raises expected yield, differentially benefitting socially disadvantaged groups. Science 3 (3315).
Elvidge, C.D., Sutton, P.C., Ghosh, T., Tuttle, B.T., Baugh, K.E., Bhaduri, B., Bright, E., 2009. A global poverty map derived from satellite data. Comput. Geosci. 35 (8), 1652–1660.
Foster, A.D., Rosenzweig, M.R., 1996. Technical change and human-capital returns and investments: evidence from the green revolution. Am. Econ. Rev.
Freeman, P., Robbins, A., 2005. Closing the 'publishing gap' between rich and poor. Scidev.Net, 2 September 2005. ⟨http://www.scidev.net/global/capacity-building/opinion/closing-the-publishing-gap-between-rich-and-poor.html⟩.
Gertler, P.J., Gonzalez-Navarro, M., Gracner, T., Rothenberg, A.D., 2016. How Road Quality Investments Boost Local Economic Activity and Welfare: Evidence from Indonesia. CEGA Working Paper No. WPS-058. University of California, Berkeley.
Jensen, R., 2007. The digital provide: information (technology), market performance and welfare in the south Indian fisheries sector. Q. J. Econ. 122 (3), 879–924.
Levy, Steven, 2011. In The Plex: How Google Thinks, Works, and Shapes Our Lives. Simon & Schuster.
Mani, A., Mullainathan, S., Shafir, E., Zhao, J., 2013. Poverty Impedes Cognitive Function. Science, 976–980.
Mobarak, A.M., Dwivedi, P., Ballis, R., Hildemann, L., Miller, G., 2012. Low demand for nontraditional cookstove technologies. Proc. Natl. Acad. Sci. 109 (27), 10815–10820.
Muralidharan, K., Niehaus, P., Sukhtankar, S., 2014. Building State Capacity: Evidence from Biometric Smartcards in India. NBER Working Paper 19999.
Nosek, et al., 2005. Promoting an open research culture. Science 348 (6242). http://dx.doi.org/10.1126/science.aab2374.
Reardon, T., Timmer, C.P., Barrett, C.B., Berdegué, J., 2003. The rise of supermarkets in Africa, Asia, and Latin America. Am. J. Agric. Econ. 85 (5), 1140–1146.
Romer, P., 1993. Idea gaps and object gaps in economic development. J. Monet. Econ. 32 (3), 543–573.
Stevenson, J.R., et al., 2013. Green Revolution research saved an estimated 18 to 27 million hectares from being brought into agricultural production. Proc. Natl. Acad. Sci. 110 (21), 8363–8368. http://dx.doi.org/10.1073/pnas.1208065110.
Thomas, E.A., 2016. Broken Pumps and Promises: Incentivizing Impact in Environmental Health. Springer Internationalhttp://dx.doi.org/10.1007/987-3-319-28643-3.
Xie, M., Jean, N., Burke, M., Lobell, D., Ermon, S., 2015. Transfer Learning from Deep Features for Remote Sensing and Poverty Mapping. arXiv preprint arXiv:1510.00098.

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