Private Enterprise Development in Low-Income Countries

It Takes Two: Experimental Evidence on the Determinants of Technology Diffusion

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Previous studies of peer-to-peer technology diffusion have primarily focused on the decision of potential adopters. Often equally relevant for observed diffusion is the willingness of incumbent adopters to actively share technology. In a real network of garment making firm owners in Ghana, we randomly seed training in a newly-developed weaving technique, and technique-specific, time-limited, one-time contracts. Contract offers increase both learning by potential adopters and sharing by incumbent adopters. Further analysis exploiting random order size and random order timing suggests that the rival nature of contract offers disincentivized sharing by potential teachers yet to receive a contract.

Background

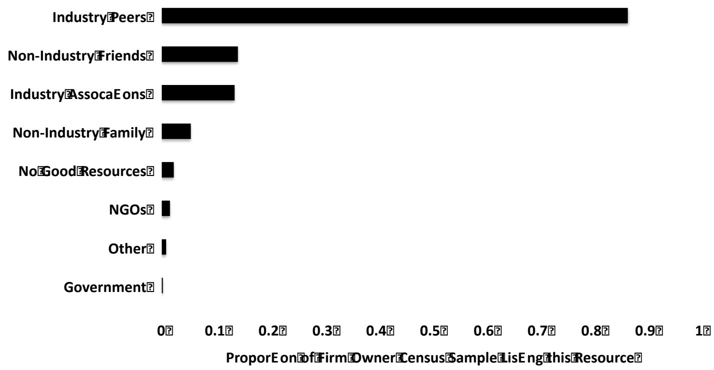

Figure 1: Resources for Accessing New Technologies

Figure 2: Garment Making Shop, Hohoe Ghana

Firm productivity in low-income countries is both lower on average than in rich countries, and distributed with a far thicker left tail. One important source of productivity dispersion is the use of inferior technology and managerial practices. Much of the literature on firms in developing countries has focused on (sometimes quite successful) interventions targeting capital, labour, and managerial skill constraints. While technology upgrading can indeed require capital, skilled workers, and managerial aptitude, basic access to information about a new technology is also a necessary condition to adoption. The primary resource cited for learning about and accessing new business relevant skills and technologies are within-industry peers (Figure 1). An influential body of research in development economics has analyzed peer-to-peer technology diffusion and specifically learning about new technology in the context of agriculture; however, relatively little work has been done on network-based learning in manufacturing and industry in low-income countries.

There is reason to believe that peer-to-peer diffusion findings from small-scale agriculture, where farmers tend to produce highly tradable cash crops or subsistence products for home consumption, may not generalize to other contexts where demand is more rival[1]. Most small-scale manufacturing (and services) firms in developing countries service exclusively local demand, leading to direct competition between neighbouring firms. The potential presence of these strategic disincentives to share a new technology highlights a more generic point about this literature. Namely, it focuses almost exclusively on the adoption decision of the potential new user despite the fact that diffusion of skill-based technologies will in general depend on both the desire of potential adopters to learn the skill and the willingness of incumbent adopters to teach it.

[1] In economics, we tend to identify goods as rival if only one agent can possess or consume them.

We consider the incentives of both parties involved in peer-to-peer technology diffusion. We study garment making microenterprises in Ghana, and our sample consists of the universe of garment making firm owners in a mid-size district capital (Figure 2). Made-to-order garments are a staple of Ghanaian culture, making up the majority of clothing worn to weddings, funerals, church, mosque, and holiday events, as well as a sizable share of professional and casual everyday wear. It is typical for new garment styles to become popular periodically and for garment makers to learn these new styles in order to attract and retain customers. In our market research survey, conducted with 1,600 district residents, availability (or lack) of desired styles is the number one reason for choosing (or leaving) specific garment makers.

Our analysis begins with a realization that how learning and teaching behaviour respond to the rival nature of local demand is difficult to discern from observational data alone. Analyzing our baseline network map (Figure 3) and competitor relationships linked through shared customers in a market research survey of 1,600 district residents, we find a positive correlation between being competitors and technology diffusion over the previous year. Putting this positive correlation into a framework, one could argue that firm owners learn from and teach to competitors in an effort to share demand risk. However, confounding factors are an equally likely explanation. Relevant technologies are endogenously seeded[2] in observational data, and that seeding pattern could be correlated with competition related market incentives.

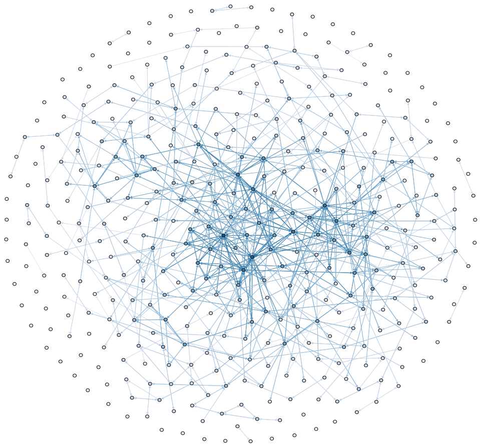

Figure 3: Baseline Network Graph

Figure 4: New Technology - Sharawakil

Experiment Design

In an effort to empirically disentangle the relationship between market competition and technology diffusion, we created a new technology that can be exogenously seeded into the market. We collaborated with a designer in Accra to design our own style innovation, which we called Sharawakil (Figure 4). The technique involves the use of the motor from a commonly available toy car as a weaving tool to produce a specific pattern in multi-coloured thick thread that can be added to augment any garment. The technique was intentionally designed to be difficult to figure out without being shown. However, once shown how to construct the weaving tool from the toy car and the correct way of folding the twisted thread so it releases with the correct pattern, it is extremely easy to execute.

We began the experiment by randomly inviting 15% of the firm owners in our sample to participate in a skills training in this new technique and receive the weaving tool required to produce it. This training exogenously divided our sample into incumbent and potential technology adopters. After several weeks,

[2] This means that technologies may enter the market in a way that is systematically related to firm or network characteristics.

we observed limited adoption and limited diffusion, resulting from little to no organic demand. It was determined that in order to study diffusion of our new technology, we would have to create the demand for it.

Our experimental demand was rolled out in waves, to allow for real-time management of project resources, and to introduce random variation in the rivalness of demand for our new technology. Half of the firms in the sample, stratified by gender and training treatment status, were offered garment orders in the first wave. These orders randomly varied in size and required that the garments be adorned with Sharawakil. On the basis of order acceptance rates in Wave 1, a random subset of the remaining sample were offered garment orders in the second wave. These cross-cut supply and demand randomizations generate three treatment groups (and a control group).

The below figure visually depicts our experiment design (Figure 5). Firms in the training-only group and training-plus-demand groups are incumbent adopters, while firms in the demand-only and control groups are potential adopters. In addition, all order offers were without replacement, meaning that each firm owner was made to understand that the order was one off. Thus for training-plus-demand firms, demand for this buyer and this style was demonstrably non-rival. In contrast, training-only firms were operating under business as usual, with implicitly rival demand for Sharawakil-making skills.

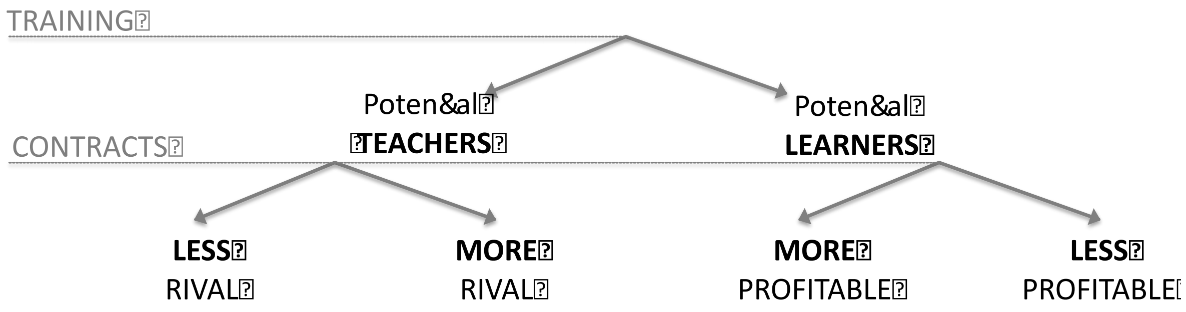

Figure 5: Experiment Design

Findings

Our first main finding is that demand drives diffusion of our technology. (Figure 6) Demand-only firms are far more likely than control firms to report learning the skill. Consistent with our qualitative work in the baseline survey, and the intentional structure of the weaving technique, nearly all demand-only firms who completed an order in our experiment reported learning the skill from another garment maker in the sample.

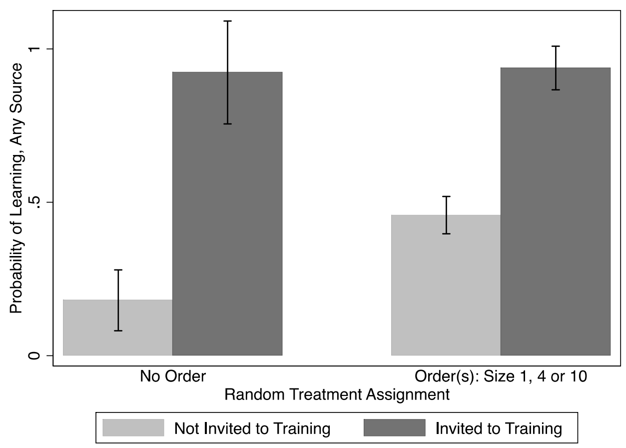

Figure 6: Learning by Treatment Group

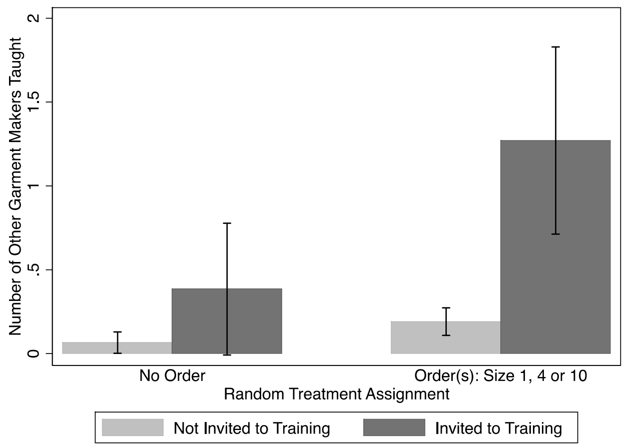

Figure 7: Teaching by Treatment Group

Our second main finding is that training-plus-demand firms are more likely to teach anyone, and teach significantly more firm owners (Figure 7), than training-only firms. We argue that this is experimental evidence of strategic disincentives to share technology among incumbent adopters, in a setting designed to mirror business as usual rival demand, and in a real network of small manufacturing firms. Training-plus-demand firms faced non-rival demand, randomly, while training-only firms faced rival demand, as would be the case under normal market activity.

We consider an important alternative interpretation, namely learning by doing, the argument that demand-driven practice increased training-plus-demand firm owners' ability, rather than willingness to teach the skill. We find no evidence for this alternative interpretation. First, using random variation is order size, we show that larger orders do not significantly increase the likelihood of teaching among training-plus-demand firms. Next, we consider order timing, where training-plus-demand firms participating in diffusion experience no lag between order and teaching (in contrast to demand only firms who teach after a learning lag). Using two measures of ability, we find no evidence of differential ability by training-plus-demand firms relative to training-only firms on either the extensive or the intensive margin. Taking self-reports of ability to produce the design at the end of the experiment, training-only firms and training-plus-demand firms are remarkably similar. Considering instead expert-verified physical garment and Sharawakil quality data collected on long-term follow-up orders a year after the experiment, we find that training-only and training-plus-demand firms are equally likely to produce Sharawakil on their garments, and that the distribution of Sharawakil quality is nearly identical.

To explore the external validity of our experimental findings, we re-examine the relationship between baseline market competition and technology diffusion, this time looking at the diffusion of our new and exogenously seeded technology. We now observe a negative correlation between market competition and the diffusion of Sharawakil within previously connected dyads. Taken together with our experimental results, these findings suggest that the rival nature of demand may be an important barrier to technology diffusion in the context of small-scale manufacturing in low-income countries.

Moving Forward…

Increases in firm productivity are the backbone of economic growth. Understanding how and when technology upgrading occurs is thus a central challenge for academics and policymakers interested in combating poverty. As a conceivably scalable alternative to direct intervention, network-based technology diffusion presents both an opportunity and a puzzle. Why do we observe some peer-to-peer technology diffusion within industry networks, but not full access to new technologies across the board? What market incentives and barriers drive the observed pattern?

Our findings suggest that the incentives for both the potential learners and potential teachers are important to consider in understanding the determinants of technology diffusion. In particular, contexts in which demand for new technologies is rival may exhibit diffusion dynamics that are different from those where demand is non-rival. This point has important implications for policy design as well as for future research focused on peer-to-peer diffusion.