Private Enterprise Development in Low-Income Countries

Productivity and Competition in India's Brick Industry

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A detailed survey of the Indian brick industry, collected for this study, shows substantial productivity dispersion, attributable to both technology differences and efficiency variation within each technology. Consistent with results from developed countries, this dispersion decreases in larger markets. However, in contrast to previous results, average productivity does not increase with market density.

Firms in developing countries exhibit large variations in revenue and output, even conditional on inputs. This empirical observation has motivated a large and growing literature on capital misallocation (Banerjee and Duflo 2005, Hsieh and Klenow 2009) that has compelled academics and policymakers to rethink the underlying causes of low productivity and growth. These studies imply that it is not so much the low levels of capital and technology in developing countries that perpetuate poverty, but rather that resources are not allocated to the entrepreneurs who would make the most productive use of them. Yet several fundamental questions remain unanswered by this literature. First, the link between the high variability in revenue and capital misallocation across firms, remains largely theoretical. Second, the question of why forces of competition have not, as theory would predict, led to a uniformly high level of productivity remains unresolved.

This project takes an approach new to the development literature by studying a single industry (bricks) across a wide variety of markets with different conditions. The brick industry has several advantages for this type of research: its output is relatively homogeneous, production is simple, and bricks are difficult enough to transport that markets remain quite separate. Finally, the industry is very large, with well over 100,000 firms across India.

Data collection activities

The project has conducted two rounds of surveys in three Indian states. The first round carried out a census of 6,794 brick firms across 11 districts in 3 states of India, designed to measure the market-level outcomes by obtaining information on their output, price, employment and a few other measures. This census interviewed 6,794 firms. The more-detailed second round surveyed firm managers and owners from a random sample of 600 firms. The sample was stratified by market density, with 400 firms drawn from 100 dense brick clusters, and 200 from more isolated locations. Data was collected on the inputs, prices, wages, and other costs of the firm, and also on the financial status of the firm owner in terms of his access to credit and savings.

Finding 1: Large Regional Heterogeneity

Bricks are a relatively homogeneous good, with a simple production process. Therefore one might expect that a single brick manufacturing technology would be used throughout India, and all factories would be similar. This is far from the truth, both across and within markets. The brick study covers three states, each with distinctive market characteristics:

- Northern India (Uttar Pradesh): Essentially all firms produce bricks using *Bull's Trench Kilns*, a large scale method that employs up to 250 workers during the main summer production season. Kiln density is relatively low.

Fig.1 - Kiln heterogeneity in Karnataka: open kiln (foreground) and Hoffman kiln (background)

- Central India (Madhya Pradesh): All firms produce bricks using *clamps*, a small scale method that frequently uses only family labor for production. Kiln density is high.
- South India (Karnataka): Firms use a variety of production technologies, ranging from the same small *clamps* seen in Madhya Pradesh to mid-sized *Open Kilns* to large-scale *Hoffman Kilns*. Kiln density is highly variable by market within the state.

Even with no further data on output or input use, these major differences in the fundamental technologies used to produce bricks suggest substantial productivity differences. While the variation between northern and central states might be explained by different soil types or market conditions, these factors cannot explain why very different technologies co-exist in Karnataka, often only a few hundred meters apart (Figure 1).

Finding 2: Substantial Productivity dispersion across and within technologies

Quantitative data on brick output confirms the productivity heterogeneity suggested by the variety of brick kiln types. A simple regression of (log) bricks produced on indicator variables for kiln type and flexible polynomials of other inputs demonstrates this phenomenon. Since the major input is fuel, these regressions can be interpreted as measures of the relative efficiency of different technologies in transforming energy into bricks. Table 1 reports the coefficients of this regression relative to the productivity of the Bull's trench kiln. All kiln types are substantially less efficient than the Bull's trench kiln, and even among these there are significant differences. In particular, open kilns are significantly less productive than Hoffman kilns, again raising the question of how the two firms visible in Figure 1 both remain in production.

While these productivity differences derive from observable technologies, the existing literature has focused on the unobserved components of productivity, where we also find substantial heterogeneity. We estimate the brick-fuel production function of all kilns in the sample[1], and examine the productivity distributions. Even controlling for kiln type, the 75th percentile firm produced 84% more output than the 25th percentile, a spread of .61 log points. In contrast, Syverson's (2004) study of the US ready mix concrete sector finds a spread of .28 and Hsieh and Klenow find an average spread of 1.55 across all Indian industries. Since both of those studies exclude all small firms (whereas I do not) their results are likely biased downward relative to mine. Thus while productivity dispersion remains economically significant and important, my results from the brick industry do not show the much larger dispersion in developing countries as documented by Hsieh and Klenow (2009).

	Coefficients	Productivity loss vs. bull's trench kiln
Clamp	-0.970 (0.195)	-62%
Open Kiln	-0.899 (0.225)	-59%
Intermittent / Hoffman kiln	-0.503 (0.245)	-40%
Robust standard errors in parentheses.		

Fig. 2 - Productivity by Kiln Type

Finding 3: Substantial quality heterogeneity

Previous studies of productivity in manufacturing have generally avoided the issue of product quality, largely because of data limitations. However ignoring quality differences both introduces a potential source of bias into the measures of productivity as well as limits our understanding of the market forces that may allow productivity dispersion to persist.

The study collected bricks from 583 firms (the remaining 17 did not have bricks in stock when visited) and subjected them to tests of compressive strength and water absorbency. Both these measures are highly correlated with brick price, even after controlling for very fine measures of the geographical location of the kiln. Kiln type affects quality as well as productivity. Bull's trench kilns (BTK) produce the highest quality, with open, intermittent and Hoffman kilns producing slightly lower (10%-14%) quality. Clamps kilns are by far the worst quality, with 54% lower compressive strength than BTKs and 38% greater water absorption.

[11] Production function details available from the author.

These results are also robust to controlling for district fixed effects (i.e. district-level unobservable characteristics that might confound the estimates).

Turning to the unobserved dimension of productivity, we find no correlation between a firm's fuel productivity (as discussed in Finding 2) and the quality of bricks that it produces. Controlling for quality does not reduce the observed variation in productivity for each kiln type.

Further, the quality data deepen the mystery of coexistence of different kiln types. The low estimated productivity of open kilns and clamps cannot be explained by the fact that they are producing higher quality products - indeed the opposite is true.

Finding 4: Larger markets do not have higher productivity

A robust finding of both the productivity literature and the agglomeration literature has been that larger markets have both reduced productivity dispersion and higher average productivity. This is taken as evidence of either the selection effects of tightened competition or of the agglomerative spillovers present in larger markets. The brick study, with its coverage of multiple geographically independent markets of different sizes, is an ideal setting to examine these predictions.

The firm-level results show a clear reduction in productivity dispersion in larger markets but no evidence of an increase in the mean level of productivity. Repeating the analysis at the market level (results available from the author) confirms this finding: larger markets have decreased productivity spreads, but their firms are not, on average, more productive.

Moving Forward…

The project has already generated unique datasets on market-level competitive outcomes in the brick sector (from the Census) and on the production processes of firms (from the manager and owner surveys). A second round of manager and owner surveys beginning June 2014 continues to develop this resource into a panel dataset.

The preliminary results suggest at least two promising directions for future research that have received little attention in the productivity literature. First, quality differences may be enabling productivity dispersion, rather than mediating it. If different customers have heterogeneous preferences for quality, firms may target different sectors of the market and competition will be less intense than if all firms were to sell identical products. This in turn reduces the competitive pressures on low-productivity firms, and allows them to maintain production in an environment where they might otherwise be forced to exit. Second, the forces that increase productivity in large markets in developed countries appear to be absent in this context. Perhaps the market forces that lower firms' profits in tighter competition are also reducing their ability to invest in higher productivity technologies (as in Aghion, Howitt 2005).

Finally, the data collected so far have been observational, but there is much to be learned from introducing an experimental element to the brick research project. This would allow additional dimensions of variation in the data, and would increase the credibility of the inference. In collaboration with Indian non-profits working in the brick sector, we are currently investigating the potential for upgrading the technology of randomly selected brick firms. The impacts—both on the recipients of the productivity upgrades and on their competitors—might allow new insights into the development, or lack thereof, of the Indian brick industry and SMEs in developing countries more broadly.