Econometrica Supplementary Material

SUPPLEMENT TO “ACHIEVING SCALE COLLECTIVELY”

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THIS SUPPLEMENT IS DIVIDED INTO FOUR SECTIONS: Appendix A reports additional empirical results that expand on evidence presented in Section 3. Appendix B includes proofs and details on the model solution. In Appendix C, we detail the computation of calibrated parameters and moments that are not already described in the paper. Finally, in Appendix D, we study the prevalence of the rental market across countries. A Supplemental Appendix not intended for publication can be found on the authors' websites.

APPENDIX A: ADDITIONAL RESULTS ON THE ORGANIZATION OF PRODUCTION

A.1. *Additional Firm Descriptives*

Table AI provides additional descriptive evidence to suggest that our surveyed firms are established and operate regular business activities, in spite of their small scale. The average firm has been in business for 10 years, and a majority of them are registered with the local authority (Panel A). The average owner works 9 hours per day for the firm, so this is the primary job for most of them (Panel B). The average employee has 3.5 years of tenure and works 9.9 hours per day for the firm (Panel C). Taken together, the evidence shows that our sample is composed of established and profitable firms that employ workers who hold stable, regular, and well-paying jobs by Ugandan standards. There is no substantial heterogeneity across sectors along these dimensions.

A.2. *Additional Results on the Rental Market in Carpentry*

Revenues From the Rental Market

Figure A1 plots average machine prices against average annual income from renting out machines. The figure shows that managers clearly benefit from renting out their excess

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TABLE AI

ADDITIONAL FIRM DESCRIPTIVES.

	All sectors (1)	Carpentry (2)	Metal fabrication (3)	Grain milling (4)
Panel A: Firm characteristics				
Monthly profits (USD)	236.9	219.5	257.2	244.9
Markup	0.22	0.23	0.21	0.24
Firm age (years)	10.1	10.4	8.9	12.0
Firm has trading license (%)	82.2	76.4	85.7	91.3
Panel B: Owner characteristics				
Owner is male (%)	96.3	97.9	99.2	83.0
Owner age (years)	40.2	39.2	37.9	50.1
Hours usually worked per day for the firm	9.1	9.8	9.3	6.7
Panel C: Employee characteristics				
Employee is male (%)	98.0	97.7	99.5	95.2
Employee age (years)	28.4	29.0	26.6	30.7
Employee years of education	9.3	8.9	10.2	7.9
Employee tenure (years)	3.5	3.5	3.3	3.9
Hours usually worked per day for the firm	9.9	9.7	10.0	10.0
Employee hourly wage (USD)	0.29	0.33	0.29	0.19

Note: Means are reported. 1 USD = 3800 UGX for monetary amounts. Monthly profits: average of profits reported by managers for each of three months preceding the survey. Markups: average revenues over variable costs minus 1 (see Section C.2). Profits, profits per worker, and markups are trimmed at the 99th percentile.

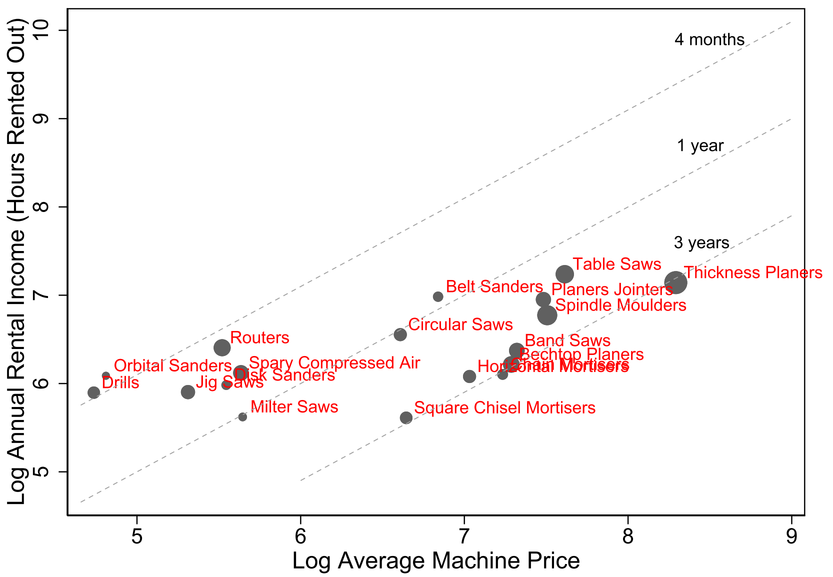

FIGURE A1.—Rental income as a function of machine price. Notes: The figure reports the log of annual rental income from renting out machines against log purchase prices, conditional on renting out machines in carpentry. Machines are weighted by the share of firms who report renting in the machine, so that larger dots correspond to machines rented out more intensively in the data. Diagonal lines depict the time taken to recover the purchase price of a machine by renting it out. Machine prices and rental income are both trimmed at the top and bottom 1%.

capacity: machine owners can recover the cost of the typical machine with about one year of revenues from the rental market. This is in line with evidence presented in Section 5 that the cost of capital faced by managers is high on average. In addition, the figure shows that revenues from renting out machines are relatively higher for the *cheapest* ones.[31]

Evidence on Competition in the Rental Market

We provide five pieces of evidence which suggest that the rental market operates competitively, though subject to transaction costs. First, the concentration of machines is limited: focusing on the three most commonly rented machines (i.e., thickness planers, spindle moulders, and table saws), we find that there are typically more than two machine owners of each machine type in each sub-county, conditional on there being at least one owner. This likely creates competition and limits the monopoly power of machine owners.[32] Second, Table AII regresses hourly rental prices on the number of machine owners in the sub-county. If machine owners have market power, we would expect prices to decrease as the number of owners increases, due to higher competition. Instead, we fail to find a negative coefficient in any of the specifications. Third, if machine owners have market power, we would expect rental prices to be relatively higher for more expensive machines, as there is a higher entry cost in supplying them. However, as discussed above, Figure A1 shows that this is not the case. In fact, revenues from the rental market are higher for relatively *smaller* machines.

Fourth, firms that rent out their machines were asked how they decide what price to charge machine renters, and two thirds explicitly say that they take into account the price charged by other carpenters, as shown in Table AIII. In line with this, when asked how

TABLE AII

RELATIONSHIP BETWEEN RENTAL MARKET PRICE AND MACHINE CONCENTRATION.

Dependent Variable: Log Hourly Rental Price				
	Baseline (1)	No Sub-county FE (2)	Baseline (3)	Baseline (4)
Number of Machine Owners	0.000933 (0.00101)	0.00324 (0.00111)		
Number of Machines Owned			0.00115 (0.000846)	
Number of Machine Owners (no weight)				0.00185 (0.0100)
Machine FE	Yes	Yes	Yes	Yes
Sub-county FE	Yes	No	Yes	Yes
Number of Sub-counties	29	43	29	29
Adjusted R^2	0.343	0.064	0.346	0.341
Observations	192	192	192	192

Note: OLS regression coefficients, robust standard errors in parentheses. Sample: door producers; data aggregated to machine-types per sub-county. Explanatory variables: number of machine owners in a sub-county (columns 1–2); number of machines owned in a sub-county (column 3); number of machine owners in a sub-county (column 4).

[31]This result suggests that renting out cheaper machines, which can be easily moved around/stolen, may lead to relatively large costs for machine owners, possibly due to larger monitoring costs.

[32]See the Supplemental Appendix for more details on this point.

TABLE AIII

DESCRIPTIVES ON THE RENTAL MARKET FOR MACHINES.

Questions	(%)
(a) When setting rental prices, machine owner compares own prices to those of other carpenters	65.2
(b) Renter had prior connection to the rental place	30.5
(c) Main reason for choosing the specific rental place	
Quality of machines	23.7
Skill of machine operators	7.6
Distance (Travel time)	37.8
Prices	0
They have machines that are otherwise hard to find	12.2
Prior connection or friendly atmosphere	0
Accessibility to timber in location	10.2
Many types of machines available	4.4
Short waiting time	2.7
No other rental places nearby	0
Other	1.6
(d) Reasons for owning rather than renting machines	
Do not know where to rent	0
Rented machines are not reliable	7.0
Rented machines are of lower quality	0
(e) Reasons for not using certain machines in carpentry	
Do not know where to rent	2.9
Do not know where to buy	0

Note: Panel (a) reports the share of machine owners who compare their price to that charged by other carpenters in the area (firms could choose among a list of 7 options selecting multiple responses). Panel (b): for each rental source, renters were asked if they knew someone working there before they started going there for business. Panel (c): renters were asked the reasons for going to each of their current rental locations (each firm could choose a maximum of 3 reasons and we report the top-ranked reason). Panel (d): each machine owner was asked why they own rather than rent machines (firms could select among a list of 8 options and could select multiple responses). Panel (e): firms neither using nor owning certain machines were asked the reasons for that (firms could choose 3 among a list of 11 reasons and we report the distribution of relevant reasons, that is, of reasons included in the top 3 most relevant).

they choose machine providers, renters do not mention prices as an important determinant of their choice, while distance from the rental place and quality of machines are reported as important reasons. Finally, we find limited evidence of search frictions due to lack of information in the rental market. In particular, Table AIII shows: (i) the limited role of social networks and referrals in rental market interactions, as only 30% of renters already knew someone working at the place where they rent machines, and prior personal connections are not cited as an important reason for choosing a particular machine provider; (ii) lack of information on where to rent machines is not reported as an important reason for not using certain machines or for owning instead of renting; (iii) lack of quality/reliability of rented machines is not reported as an important reason for owning rather than renting.[33] Taken together, this evidence shows that there is a substantial degree of competition in the rental market, and that search frictions are limited.

[33]Table AIII uses data from a follow-up survey conducted in three of our sampled sub-counties about four months after the end of the main survey. See the Supplemental Appendix for more details.

TABLE AIV

DESCRIPTIVES ON RENTAL MARKET TRANSACTION COSTS.

Panel A: Descriptive statistics on rental market transaction costs	
Number of different rental places the firm goes to	1.7
Number of machines rented from each rental place on average	5.4
Total number of visits per month to all rental places the firm goes to	5.6
Share of renters staying at the premises of rental place while machine is operated	61.3%
Time from arrival to rental place to job completion for average visit (minutes)	162.7
Time spent idle at premises of rental place for average visit (minutes)	73.3
Total travel time for the average completed visit to the rental place (minutes)	48.1
Share of renters traveling to the rental place by motorcycle taxi	53.1%
Share of managers who travel themselves to rental place	56.5%
Panel B: Calculated monthly transaction costs for renters	
Value of time to access machines (USD, valued at average wage)	10.5
Value of time to access machines (USD, valued at average opportunity cost, A)	23.3
Direct transportation cost (USD, B)	22.1
Total cost of time and transportation (USD, A+B)	45.5
Total direct expenditure on machine rentals (USD)	180.1

Note: Panel A shows average statistics regarding rental market transaction costs. The total number of visits (Panel A, row 3) is defined as the number of separate times the firm reports going to all rental places to use their machines per month. The first four rows of Panel B show average monthly costs for renters calculated from Panel A. The final row in Panel B reports the total direct expenditure on machine rentals at the firm level, valued at median machine prices (see Table AX), which was collected in a subsequent phone survey of our sample of carpenters 7 months after the main survey. See the Supplemental Appendix for additional evidence on wait times at the premises of machine owners.

Direct Evidence on Transaction Costs in the Rental Market

Panel A of Table AIV presents descriptive evidence on transaction costs related to transportation and time costs in the rental market in carpentry.[34] The table shows that renters typically visit machine owners 16 times per month, and every time they go: (i) they spend around 50 minutes traveling (and do so primarily using motorcycle taxis); (ii) they spend almost three hours at the premises of machine owners and about half of this time is spent idle, waiting for machine access. In line with wait times being important, our survey further reveals that 70% of machine owners report avoiding wait times as a primary reason for owning instead of renting, and that wait times can in part be explained by congestion, as more than one fourth of renters report visiting machine owners in the early morning.

To quantify these transaction costs, in Panel B of Table AIV, we compute for each renter: (i) their monthly value of time spent traveling to the machine owners' premises and waiting for machine access; (ii) their direct monthly transportation costs from using motorcycle taxis. We present two alternative measures of the value of time. The first (Panel B, row 1) is calculated as the sum of the total travel time and the time spent idle at the premises of the rental place, valued at the average wage. The second measure (Panel B, row 2) is the same total time, but valued reflecting the average income of managers and employees, respectively.[35] This second measure is our preferred estimate since it accounts for the difference in value of time between managers and employees.[36] If renters travel by

[34]The data come from a short follow-up phone survey conducted four months after the end of the main survey in three of our sampled sub-counties. See the Supplemental Appendix for more details.

[35]That is, when employees travel to the rental place, we value their time at the average wage; instead, when managers are the ones who go, we value their time at the average hourly profit (see Table AI).

[36]Panel A shows that this distinction is important, as in 56% of cases the managers themselves are the ones who travel to the premises of machine owners to use rented machines.

motorcycle taxis, we compute their direct transportation cost (Panel B, row 3) using typical motorcycle fares that we collected in Kampala. The direct transportation cost is set to zero if renters report walking or using a bicycle. In 22% of cases, renters report mainly using other means of transport such as buses, cars, or vans. We value those at zero direct cost, since we do not have reliable information on the cost of such means of transport per trip.

Comparing the sum of the monthly transportation costs (Panel B, row 3) and the value of time from our preferred measure (Panel B, row 2) with the monthly expenditures on machine rentals (Panel B, row 5) shows that transportation and time costs represent $\$45.5/\$180.1 = 24.4\%$ of direct expenditures on rentals. That is, we are able to explain about 60% of the estimated rental market transaction costs from Table 4 through transportation and time costs.

Robustness of Estimation of Rental Market Transaction Costs

Figure A2 reports a battery of 27 robustness checks on our estimate of the coefficient β_1 from equation (1). Each circle inside the plot area corresponds to a point estimate, and we show both 90% and 95% confidence intervals. The bottom panel displays features of each regression specification: a dark circle implies that the specification includes that feature; red circles highlight features in our preferred specification.

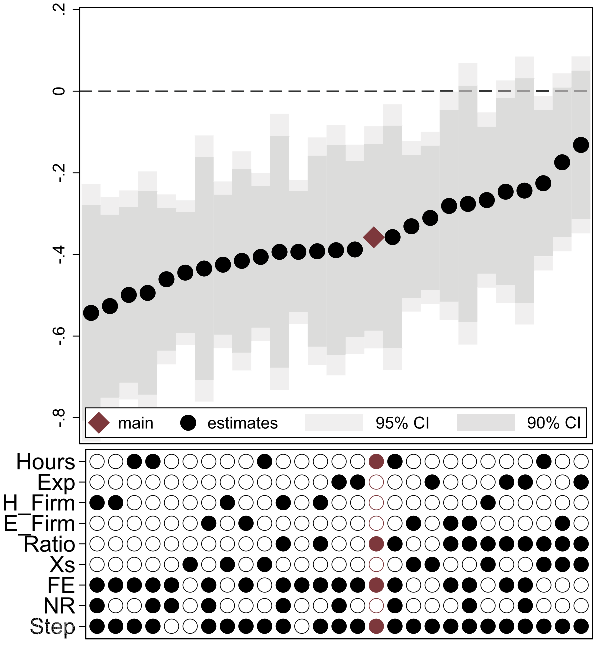

FIGURE A2.—Estimates of transaction costs in the rental market—robustness. Notes: Standard errors are clustered at the firm level throughout. Sample: door producers. We use predicted wages from a regression of worker wages on firm size and individual worker characteristics (Table AVII) to alleviate endogeneity concerns. When Ratio = 0, the appropriate standard errors would require bootstrapping as labor utilization (on the right-hand side) is a generated regressor. The figure was constructed with the STATA package speccurve. Due to the limited flexibility of the package, we do not report bootstrap standard errors, but note that these are very similar.

Features labeled “Hours”, “Exp”, “H_Firm”, “E_Firm” refer to alternative ways of aggregating machine hours within steps to calculate the dependent variable. “Hours” denotes that the aggregation uses weights based on machine utilization in the data, so that machines that are used more heavily in a given step get a higher weight in that step. “Exp” implies that the aggregation uses weights based on aggregate expenditure in the data, using the relative price of each machine type, so that machines that represent a higher share of expenditure in a given step get a higher weight in that step. “H_Firm” and “E_Firm” are similar to “Hours” and “Exp” respectively, but use firm-level hours and expenditure instead. “Ratio” indicates whether the left-hand side is the capital-labor expenditure ratio (Ratio = 1) or if we include only capital utilization on the left-hand side and control for labor utilization on the right-hand side (Ratio = 0). The latter option relies less heavily on the firm cost-minimization problem of the firm. “Xs” denote that firm controls including sub-county fixed effects, managerial ability, and dummies for door types produced are included in the regression (step fixed effects are included in all specifications). “FE” indicates whether firm fixed effects are used instead. “NR” shows whether the sample excludes machine owners who do not rent out their machines. “Step” indicates if the regression is at the step level versus at the machine level.

Across all specifications, the figure shows that: (i) estimates of β_1 are negative, and (ii) the great majority are between −0.2 and −0.5, with our preferred estimate of −0.358 roughly in the middle of the range. In the Supplemental Appendix, we verify that estimates of β_1 are mostly negative when the estimation is carried out separately for each of production steps 3–9 (i.e., the seven most common steps), justifying our use of a pooled specification. We also show that machine-level controls (e.g., machine value, age, expected remaining life, and dummy for manufacture abroad) are not predictive of the capital-labor ratio for machine owners or renters.

Heterogeneity in Rental Market Transaction Costs

Table AV reports estimates of our preferred specification from equation (1), but where we add interactions between the share of rented machines in a production step and different firm and sub-county level characteristics. This allows us to test for heterogeneity in transaction costs. Column 1 shows that there is no evidence of significant heterogeneity by manager ability: the estimated interaction is small in magnitude and far from significant. In columns 2 and 4, we consider two measures of firm density, one based on the number of other firms operating within a 500 meter radius from each firm in our data (column 2), and one based on the number of firms per square kilometer in the sub-county (column 3). In both cases, we find that the estimated transaction costs are lower in areas with higher firm density. Column 2 shows that the interaction term is 0.477 with 95% confidence interval [0.009; 0.945], indicating that transaction costs are $e^{(0.639-0.477)} - 1 = 0.176$ in areas with above median firm density (while they are 0.430 in the average sub-county). Column 3 shows similar results: the estimated interaction term is 0.328, although not precisely estimated. These results further confirm that our estimates primarily capture transaction costs related to the time and physical costs of travel, as we would expect these to be smaller in areas with higher firm density, while firm scale should not matter for the size of these costs.

A.3. *Additional Results on Labor and Output Markets in Carpentry*

Labor Market Frictions

Table AVI reports descriptive evidence on the labor market in carpentry. The table presents a number of facts that are consistent with the presence of substantial search fric-

TABLE AV

HETEROGENEITY IN ESTIMATES OF TRANSACTION COSTS IN THE RENTAL MARKET.

Dependent Variable: Log Capital-Labor Expenditure Ratio			
	(1)	(2)	(3)
Share of Rented Machines (0–1)	−0.346	−0.639	−0.528
	(0.144)	(0.188)	(0.175)
Interaction with:			
Manager Ability (Std.)	−0.057		
	(0.135)		
Avg. Firms within 500 m above Med.		0.477	
		(0.239)	
Firms per km^2 above Med.			0.328
			(0.245)
Sub-county FE	No	No	No
Step and Firm FE	Yes	Yes	Yes
Adjusted R^2	0.483	0.487	0.485
Observations	1137	1137	1137

Note: OLS regression coefficients, standard errors clustered at the firm level in parentheses. Sample: door producers. Level of observation: production steps. We restrict attention to the seven most common steps for the production of doors, that is, steps 3–9. All specifications control for the number of machines used in each production step. For the definition of the dependent variable and the Share of rented machines, see Table IV. The variable Avg. Firms within 500 m above Med. is a dummy equal to 1 if the average number of carpentry firms within a 500 m radius of each surveyed firm in a sub-county is above the median. The variable Firms per km^2 above Med. is similarly defined. To maintain a balanced number of observations above/below the median, the median is defined across all observations in the data used for estimation (rather than across sub-counties).

tions driven by lack of information on workers at recruitment. In short, our data reveal that: (i) most workers are hired through referrals; (ii) it takes on average over a month to replace workers who leave; (iii) in about a third of cases, the manager would be willing to raise the workers' wages if they threatened to leave; (iv) turnover is low despite the absence of any firing or hiring laws. When asked about the sources of labor market frictions, managers indicate difficulties in screening workers at recruitment as their pri-

TABLE AVI

DESCRIPTIVES ON THE LABOR MARKET.

Questions	
Lack of employees with the right skills is a serious problem (%)	26.1
Finding workers with the right skills is a serious problem (%)	30.0
Screening workers at recruitment is a serious problem (%)	33.2
Number of employees who left in the last six months	0.57
Share of firms with no workers leaving in the last six months (%)	75.2
Share of workers hired through referrals (%)	57.5
Would offer wage rise to keep current workers from leaving (%)	32.9
Employees received any on-the-job training in the firm (%)	49.8
(If received) Average duration of the on-the-job training (months)	7.6
Time until an employee is able to work under minimal/no supervision (days)	64.7
Expected time taken for finding a replacement for an employee (days)	38.8

Note: This table shows descriptives on the labor market in carpentry. Each row corresponds to a different question asked to firm owners/managers. Rows 1–5 report averages across firms. Rows 6–11, instead, report weighted averages across all employees, since the manager answered the associated questions separately for each employee in the firm.

mary concern. This evidence suggests that the cost of hiring an extra worker increases with firm size. For instance, since networks are such an important recruitment channel, we can expect the cost of recruitment to increase as the manager needs to extend beyond her network of contacts in order to hire more employees (Chandrasekar, Morten, and Peter, 2020).

It is worth highlighting the contrast with the rental market on this point: as discussed in Section 3.3, managers report knowing who owns machines and the quality/reliability of rented machines is not perceived as a problem, so that, in the rental market, we do not find evidence of information frictions. This dissimilarity can be explained by the different nature of the capital and labor inputs: the productivity and reliability of rented machines can be easily assessed by managers as firms use similar machines and these are simple to test, while learning about workers' abilities and whether they can be trusted is more costly due to the lack of skills certification in these contexts.[37] In line with this, managers report substantial investment in training and supervision of their workers: for instance, the average worker needs more than two months of training/supervision from the time of hiring until they are able to work independently.

Table AVII shows the results of Mincerian regressions of worker monthly earnings in carpentry. In columns 1–3, the key independent variable is our standardized index of managerial ability; in columns 4–6, it is the log of firm size. All regressions control for monthly hours worked and sub-county fixed effects. In columns 2 and 5, we additionally control for worker education, age, tenure, and a dummy for whether the worker received vocational training. Columns 3 and 6 additionally control for cognitive and non-cognitive skills, and so are our preferred specifications. Focusing on column 6, the coefficient on log number of workers is 0.146, indicating that a 1% increase in firm size is associated with a 0.15% increase in wages. As shown in column 3, we find similar results using our standardized index of managerial ability as a measure of firm scale. This shows that larger firms pay higher wages, which is in line with frictional labor models with monopsony wages such as Burdett and Mortensen (1998).

The main identification concern in these regressions is sorting on unobservables: if more able workers are more likely to sort into higher ability/larger firms, then the coefficient on our key independent variables of interest would be upward biased. The inclusion of sub-county fixed effects limits concerns related to sorting across locations. Our rich set of controls for worker skills also limits concerns related to sorting on unobserved ability. Still, we cannot claim that these results are causal. Therefore, in the model, we prefer to target a bundle of moments to identify the parameter ν, rather than relying solely on the regressions in Table AVII.

Organization of Labor Across the Size Distribution

We also study how labor specialization, teamwork, and hours worked vary across the firm size distribution, to check whether a more efficient or intense use of labor could create economies of scale in the labor input. Figure A3 reports the results for carpentry, and shows that: (i) while we do see some evidence that specialization increases with firm size, this is not strong: the average employee works on half of the production steps even in large firms, which is far from full specialization; (ii) there is little evidence that teamwork increases with firm size, except at the very top of the distribution; and (iii) we do not

[37]See Alfonsi et al. (2020), Bassi and Nansamba (2022), Abebe, Caria, Fafchamps, Falco, Franklin, and Quinn (2020), and Carranza, Garlick, Orkin, and Rankin (2020).

TABLE AVII

RELATIONSHIP BETWEEN WAGE AND FIRM SIZE.

Dependent Variable: Log Employee Monthly Earnings						
	(1)	(2)	(3)	(4)	(5)	(6)
Manager Ability (Std.)	0.088 (0.037)	0.073 (0.036)	0.060 (0.037)			
Log Num Workers				0.166 (0.067)	0.142 (0.066)	0.146 (0.065)
Years of Schooling		0.029 (0.008)	0.029 (0.008)		0.027 (0.008)	0.027 (0.008)
Age		0.048 (0.007)	0.046 (0.008)		0.048 (0.007)	0.046 (0.008)
Age Squared		−0.000 (0.000)	−0.000 (0.000)		−0.000 (0.000)	−0.000 (0.000)
Tenure at the Firm (Yrs)		0.013 (0.006)	0.013 (0.006)		0.013 (0.006)	0.012 (0.006)
Vocational Training (0/1)		0.039 (0.063)	0.049 (0.062)		0.052 (0.064)	0.060 (0.062)
Log hours worked	0.320 (0.075)	0.330 (0.073)	0.321 (0.072)	0.333 (0.080)	0.340 (0.077)	0.324 (0.075)
Skills Controls	No	No	Yes	No	No	Yes
(Joint p-value)			0.013			0.001
Subcounty FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.201	0.267	0.274	0.198	0.264	0.274
Observations	1062	1062	1062	1062	1062	1062

Note: OLS regression coefficients, standard errors clustered at the firm level in parentheses. Sample: carpentry sector; regressions are at the employee level. Dependent variable: log monthly earnings. All independent variables refer to the employee, except Manager Ability (standardized index based on multiple survey questions—see the Supplemental Appendix for details). Worker skills controls (Columns 3 and 6): cognitive ability (4-item Raven matrices test), agreeableness, conscientiousness, extraversion, neuroticism, and openness (10-item Big Five test). The Joint p-values in columns 3 and 6 are from a joint F-test that the additional skills controls are jointly insignificant in predicting earnings.

find that larger firms use labor more intensively: workers spend close to three hours per day idle, and this does not vary much by firm size. In short, a more efficient organization of labor or a more intense use of labor are unlikely to drive economies of scale in labor. Coupled with the results in the previous paragraph, this confirms that the cost of hiring an extra worker increases with firm size due to labor market frictions and to the absence of any significant economies of scale potentially driven by a more efficient or intense use of labor.

Demand and Competition in the Output Market

We provide two pieces of evidence that suggest that competition in the output market is low. First, we show that firms produce differentiated varieties of the same product. To document this, we focus on firms producing 2-panel doors, which is the most common type of door produced, and compute the residual variation in price and in a standardized index of output quality, controlling for sub-county fixed effects.[38] We find substantial residual

[38]The index of output quality is constructed using multiple measures of product quality recorded through direct observation by our enumerators.

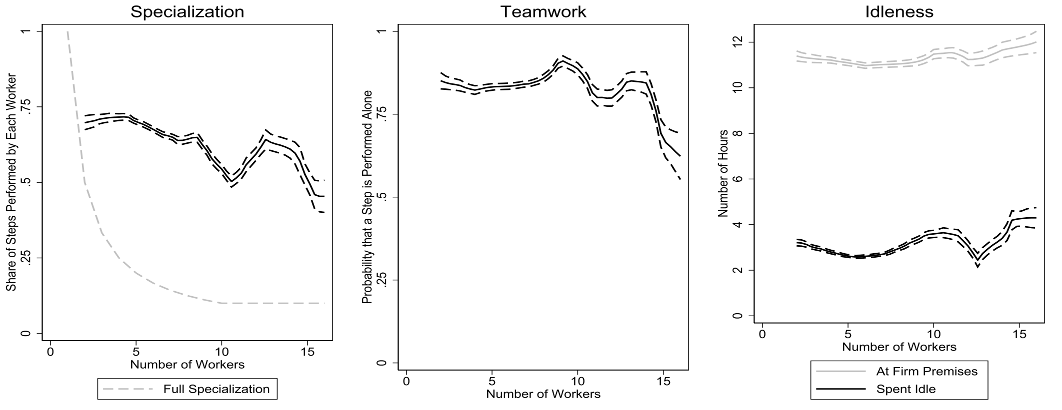

FIGURE A3.—Organization of labor across the size distribution. Notes: Sample: carpentry. The left panel compares the mean share of production steps performed by each worker (solid black curve) with the minimum share of steps that each worker would have to complete under full specialization, given the total number of steps performed by the firm (gray dotted curve). The middle panel plots the probability that a production step is performed alone rather than in teams (solid black curve). The right-hand panel shows the average number of daily hours spent by workers at the firm premises in total (solid gray curve) and spent idle at the firm premises (solid black curve). Mean functions are estimated conditional on number of workers (x-axis) throughout, and dotted lines depict 95% confidence intervals.

dispersion in both prices and quality even *within* sub-counties. For instance, the ratio of the 75th to the 25th percentile of the quality distribution is more than 2. This confirms that there is differentiation even within narrowly defined products.[39]

Second, we present evidence consistent with output market frictions. Table AVIII reports descriptive evidence on access to demand and relationships with customers in carpentry, and shows that: (i) the majority of customers originate from within the local urban area; (ii) firm owners engage in extensive interactions with customers, for example, they try to persuade customers of the quality of their products, and there is price variation across customers for the same product driven by bargaining; and (iii) firms have few customers and cite lack of demand as a very serious problem. This evidence suggests that demand is geographically segmented and that relationships with customers are important, which are both factors that can limit competition.[40]

In line with limited competition due to product differentiation and output market frictions, we estimate markups of 23% for the carpentry sector (and markups are not related to mechanization). For the estimation of markups, see Section C.[41]

[39]See the Supplemental Appendix for more details on residual dispersion in product prices and quality.

[40]In addition, the Supplemental Appendix reports: the share of customers originating from (i) outside the parish but within the district, and (ii) outside the district; the breakdown of: (i) the share of sales to other types of customers such as subsidiaries, wholesalers, and government agencies; (ii) the share of other routes through which orders are placed (e.g., besides walk-ins); the breakdown of: (i) the share of firms citing other reasons (besides bargaining) as main reason for price variation; (ii) the share of firms that communicate the quality of their products through other means; (iii) the share of firms that cite other reasons as main reason for locating the business premises (beyond proximity to customers); (iv) the share of firms that indicate other reasons (besides lack of demand) as a main constraint to growth.

[41]Another potential reason for limited competition in firm clusters would be collusive behavior on prices. Brooks, Kaboski, and Lee (2018) documented the importance of this channel in Chinese manufacturing.

TABLE AVIII
DESCRIPTIVES ON DEMAND.

Panel A: Location of customers	
% of firms reporting that most customers come from within the LC1	20.1%
% of firms reporting that most customers come from outside the LC1 but within the parish	34.0%
Panel B: Location of transactions	
% of sales to final customers	94.8%
% of firms that sold to final customers at the business premises	96.9%
% of firms that sold to final customers through shipping in Uganda	15.6%
% of firms that sold to final customers through shipping outside Uganda	0.6%
% of firms where orders are placed in person through walk-ins	79.6%
Panel C: Customer relations	
Average number of customers coming to the business per day	3.4
Average ratio of highest to lowest selling price for the same product to final customers	1.43
% firms citing Bargaining as main reason for price variation for the same product	43.2%
% of firms that communicate the quality of their products by directly talking to customers	55.5%
% of firms citing being close to customers as main reason for locating the business premises	28.5%
% of firms indicating lack of demand as a main constraint to growth	54.3%

Note: The table reports descriptive statistics on demand in the carpentry sector. Panel A shows the share of firms reporting that most customers come from within the LC1 or within the parish. LC1 stands for the lowest level of administrative unit, which corresponds to a village for rural areas and to a neighborhood for a town or a city. Panel B shows the share of sales in the last three months to final customers, the location of deliveries, and the share of customers placing orders at the firm premises. Panel C shows the descriptives on customer relations.

APPENDIX B: PROOFS OF THE THEORETICAL RESULTS

In this section, we include the main steps of the proofs of the theoretical results of Section 4. Details on the quantitative extension of Section 5 and further details on the algebra are included in the Supplemental Appendix.

Profit Functions and Comparative Statics

We first solve the optimal variable inputs for each one of the four possible combinations of mechanization ($\mathbb{I}_K$) and ownership ($\mathbb{I}_C$). Through simple algebra, left to the Supplemental Appendix, we can show that the profit function is given by

$$\pi(x,z)=\max\Big\{\underbrace{\tilde{A}_L z^{\tilde{\gamma}_L}}_{\text{Non-Mechanized }(\pi_L)};\ \underbrace{\tilde{A}_L z^{\tilde{\gamma}_L}+\tilde{m}(x)}_{\text{Non-Mechanized Owners }(\pi_{L,b})};\ \underbrace{\tilde{A}_{M,r} z^{\tilde{\gamma}_M}}_{\text{Renters }(\pi_M)};\ \underbrace{\tilde{A}_{M,b} z^{\tilde{\gamma}_M}+\tilde{m}(x)}_{\text{Owners }(\pi_{M,b})}\Big\},$$

where

$$\tilde{\gamma}_L=\frac{(1+\nu)(1-\eta)}{\nu+\eta},$$

$$\tilde{\gamma}_M=\frac{(1+\nu)(1-\eta)}{\nu+\eta-(1-\eta)\nu\alpha},$$

$$\tilde{A}_L=\big[A_L^{1-\eta}PW^{-\frac{1-\eta}{1+\nu}}(1-\eta)^{\frac{1-\eta}{1+\nu}}\big]^{\frac{1+\nu}{\eta+\nu}}\left(\frac{\nu+\eta}{1+\nu}\right),$$

$$\tilde{A}_{M,r} = \left(\frac{\nu+\eta-(1-\eta)\nu\alpha}{1+\nu}\right)\left[\frac{A_M^{1-\eta}P(1-\eta)^{(1-\eta)(\frac{1+\nu\alpha}{1+\nu})}}{\left((1+\tau)\frac{p_r}{\alpha}\right)^{\alpha(1-\eta)}\left(\frac{W}{1-\alpha}\right)^{\frac{(1-\alpha)(1-\eta)}{1+\nu}}}\right]^{\frac{1+\nu}{\nu+\eta-(1-\eta)\nu\alpha}},$$

$$\tilde{A}_{M,b} = (1+\tau)^{\frac{\alpha(1-\eta)(1+\nu)}{\nu+\eta-(1-\eta)\nu\alpha}}\tilde{A}_{M,r},$$

$$\tilde{m}(x) = \left(\frac{\xi}{1+\xi}\right)\chi^{-\frac{1}{\xi}}p_r^{\frac{1+\xi}{\xi}} - (\delta+x)p_b.$$

Equipped with these expressions, we notice a few comparative statics that are useful throughout this section: (i) $\pi_L(x,z)$ does not depend on either τ or p_r; (ii) $\pi_{L,b}(x,z)$ does not depend on τ, but it increases in p_r; (iii) $\pi_K(x,z)$ decreases in $(1+\tau)p_r$; (iv) $\pi_{K,b}(x,z)$ does not depend on τ, and it increases in p_r.

Notice that we used Assumption 1 in the solution of $\pi_{M,b}$. In the Supplemental Appendix, we include the general solution which holds also if Assumption 1 is violated.

Equilibrium Rental Price

As a preliminary result, we characterize the relationship between p_r and τ and prove that, as stated in Proposition 1, part 3: *p_r decreases, while the cost of renting in*, $(1+\tau)p_r$, *increases in τ*.

First, consider the demand for capital in the rental market. It is decreasing in τ and in p_r for two reasons: (i) each renter decreases capital utilization due to higher marginal cost; (ii) the share of renters in the economy reduces since $\pi_M(x,z)$ decreases, while all other options either increase or stay constant (see previous subsection).

Second, consider the supply for capital in the rental market. It is increasing in τ and p_r for two reasons: (i) a higher p_r leads each machine owner to increase machine capacity and decrease utilization, thus increasing rented capital $C-K$; (ii) the share of individuals that invest increases since $\pi_{L,b}(x,z)$ and $\pi_{M,b}(x,z)$ increase relative to $\pi_M(x,z)$ and $\pi_L(x,z)$.

Finally, let us prove the result by contradiction. Consider an increase in τ, but keeping p_r constant. Total demand for rented capital drops, while supply is unaffected. As a result, price p_r must fall for the rental market to reach back the equilibrium. The fall in price p_r cannot more than compensate the increase in τ so that $(1+\tau)p_r$ also falls; otherwise, the demand for rented capital would increase, thus implying that p_r should increase, and reaching a contradiction. We have thus proved that p_r decreases in τ and $(1+\tau)p_r$ increases in τ.

Proof of Lemma 1

To prove the lemma, we solve for the investment and mechanization decisions and show that they follow cutoff policies as stated.

Investment

Consider managers that do not mechanize. Since $\pi_{L,b}(x,z)$ decreases in x, there will be a cutoff $\hat{x}$ such that if and only if $x<\hat{x}$, the manager invests. Moreover, notice that if a manager z does not mechanize, the investment cutoff does not depend on z, and it is in fact given by $\tilde{x}$ such that $\tilde{m}(\tilde{x}) = 0$:

$$\tilde{x} = \frac{p_r^{\frac{\xi+1}{\xi}}}{p_b} \chi^{-\frac{1}{\xi}} \left(\frac{\xi}{1+\xi}\right) - \delta.$$

Next, consider a manager that mechanizes. She invests if and only if $\pi_{M,b}(x, z) \geq \pi_M(z)$, which gives

$$x \leq \hat{x}(z) \equiv \left((1+\tau)^{\frac{\alpha(1-\eta)(1+\nu)}{\nu+\eta-(1-\eta)\nu\alpha}} - 1\right)\frac{\pi_M(z)}{p_b} + \frac{p_r^{\frac{\xi+1}{\xi}}}{p_b} \chi^{-\frac{1}{\xi}} \left(\frac{\xi}{1+\xi}\right) - \delta,$$

where $\hat{x}(z)$ is an increasing function of z if $\tau > 0$, while it does not depend on z if $\tau = 0$. Also, notice that $\hat{x}(z) \geq \tilde{x}$ and that if and only if $\tau = 0$, then $\hat{x}(z) = \tilde{x}$.

Mechanization

Consider managers that do not invest. They mechanize if and only if $\pi_M(z) \geq \pi_L(z)$. Since $\pi_M(z)$ is more convex in z (because $\tilde{\gamma}_M > \tilde{\gamma}_L$ as long as $\nu > 0$), we know that there must exist a value $\tilde{z}_a$ such that if and only if $z \geq \tilde{z}_a$, then the manager mechanizes.

Next, consider managers that invest. They mechanize if and only if

$$\pi_{M,b}(x, z) \geq \pi_{L,b}(x, z),$$
$$(1+\tau)^{\frac{\alpha(1-\eta)(1+\nu)}{\nu+\eta-(1-\eta)\nu\alpha}} \pi_M(z) \geq \pi_L(z).$$

Therefore, also among the managers that invest, the choice to mechanize does not depend on x and it is given by a cutoff $\hat{z}_b$ such that a manager mechanizes if and only if $z \geq \hat{z}_b$. Importantly, we notice that $\hat{z}_b > \hat{z}_a$ if $\tau > 0$, while $\hat{z}_b = \hat{z}_a$ if $\tau = 0$. Finally, notice that $\hat{z}_a$ is decreasing in τ, while $\hat{z}_b$ does not depend on it directly (but only through the price p_r). As a result, when $\tau \to \infty$, only the managers that invest will mechanize, which then implies that $\hat{x}(z) = \hat{z}^{-1}(x)$.

Proof of Proposition 1

Part 1: Higher Profits for All Managers

Since we have proved that p_r decreases in τ, while $(1+\tau)p_r$ increases in τ, the comparative statics discussed above immediately imply that profits must be weakly decreasing in τ for each production choice. As a result, their max—that is, $\pi(x, z)$—must decrease as well.

Part 2: Higher Engagement in the Capital Market

Similarly to part 1, this result is directly implied by the comparative statics just discussed: $\pi_L(x, z)$, which is the only production choice not engaged in the capital market, is also the only function that does not depend on τ, while $\pi_{L,b}(x, z)$, $\pi_M(x, z)$, and $\pi_{M,b}(x, z)$ all decrease in τ. As a result, the lower is τ, the fewer managers will decide to not mechanize nor invest.

Part 3: An Improvement in the Allocation of Capital

Since we are keeping p_r constant by assumption, only $\pi_M(x, z)$ is affected by the decrease in τ. As $\pi_M(x, z)$ increases, some managers will shift their choices and the overall number of renters must increase, while all the other groups must weakly decrease. Recall that renters are managers that mechanize but do not invest. As long as not all the new renters were non-mechanized owners absent the decrease in τ, the correlation between mechanization and investment would strictly decline. Notice that this must not be true if we let p_r increase. In this case, we could observe a net increase of other groups of managers, which could affect the overall correlation.

Part 4: A Higher Ability to Overcome the Indivisibility Through Collective Scale

First notice that, if all managers have identical cost of capital, $x(\omega) = \bar{x}$, there cannot be any non-mechanized owners in equilibrium, as otherwise everyone would invest. The reason is that, for a given cost of capital, mechanized owners have more to gain from a machine investment (rental income, cost savings on own use) than non-mechanized owners (rental income). The equilibrium thus has the lowest productivity managers being non-mechanized, the medium productivity ones being renters, and the most productive ones being owners. A decrease in τ, as we have seen, increases $\pi_M(x, z)$ and $\pi_{M,b}(x, z)$ relative to $\pi_L(x, z)$. As a result, mechanization must decrease in τ, proving the result.

APPENDIX C: Calibrated and Estimated Parameters, and Moments

In this section, we provide more details on each calibrated parameter, and on the computation of each moment used in estimation. We then include the Jacobian matrix showing the relationship between parameters and moments.

C.1. *Details on Calibrated Parameters*

Capital Share (α). Table AIX reports details of how we compute α. As discussed in Section 5.2, and as shown formally in the Supplemental Appendix, α is pinned down by

TABLE AIX

Step-level capital intensity.

	Share of firms performing step with modern machines (1)	Share of firms performing step with modern machines that are owned (2)	Median labor expenditure for owners, as share of total labor expenditure across steps (3)	α (4)
Step 3—Cutting	77%	23%	15%	0.59
Step 4—Planing	77%	14%	17%	0.60
Step 5—Thicknessing	75%	12%	15%	0.46
Step 6—Edging	76%	19%	14%	0.42
Step 7—Sanding	32%	14%	17%	0.49
Step 8—Mortising	69%	22%	16%	0.51
Step 9—Finishing	52%	28%	16%	0.44
Average across steps	65%	19%		0.50

Note: Sample: door producers. Expenditure shares (column 3) are trimmed at the 1st and 99th percentile. Machine owners are defined at the step level, that is, firms that own all the machines used in a given step are classified as owners for that step. We restrict attention to the seven most common steps (out of ten) for the production of doors, that is, steps 3–9. See the Supplemental Appendix for more details on steps 3–9.

the capital-labor ratio. To compute the numerator, we calculate the total hours of machine time used by a firm in a given step per month.[42] We price these at the average hourly rental rate for each machine type, computed using information on all machines rented in our data. For the denominator, we calculate the total monthly labor hours used in a given step. These are priced at the within-firm average predicted hourly wages, predicted from the same regression as in column 6 of Table AVII. We then take the ratio of monthly capital to labor expenditure for each step, and use this ratio for machine owners to compute the value of α for each step. Column 4 reports the median value of α, and shows that this does not vary substantially across steps. This justifies taking the average across steps. We do this in the last row, where each step is weighted by the median labor expenditure of owners on that step, as a share of labor expenditures across all steps (column 3).

We highlight two further results that reassure us about the validity of our approach. First, we find that the production process of renters is less capital intensive, which is consistent with the rental market transaction costs estimated in Table IV. Specifically, we find that the capital-labor ratio for owners (averaged across steps) is 1.05, while this is 0.75 for renters. Second, we find that the labor expenditure shares of owners and renters across steps are very similar. This is consistent with the production function being the same for renters and owners, and so validates an important modeling assumption.

Machine Price (p_b)*, Rental Price* (p_r)*, and Depreciation Rate* (δ). These are reported in Panel A of Table AX. To compute the machine purchase (p_b) and rental prices (p_r), we use our machine-level data, where firms were asked to report the price paid for each machine (if they own it) and the hourly rental rate they pay to use the machine (if they rent it). We take the median across machines for both these prices. To construct p_r, we additionally subtract from the median hourly rental rate the median cost of labor incurred by machine owners, as we are interested in isolating the share of the rental cost that captures payment to capital.[43]

The depreciation rate δ is computed as: $1 - (V/P)^{1/A}$, where V is the current machine value, P is the purchase price of the machine, and A is the age of the machine in years. We report the average depreciation rate in row 3 of Panel A.

In column 1, machines are aggregated by weighting each machine type by the share of total machine time it accounts for in the data, so that machine types used more intensively get a higher weight.[44] Column 2 shows that our results are robust to aggregating

[42]To be precise, we have data on: (i) which production steps each machine is used for and (ii) how many hours the machine is used. For those machines used in more than one step, we assign machine time to steps proportionally to the distribution of machine usage across steps in the data. Machines are rarely used in more than one step and the concentration of machine time across steps is high. For instance, a table saw is used in 1.38 steps, and is used in its most common step (i.e., cutting) 87% of the time. The average machine is used in 1.2 steps. See the Supplemental Appendix for more details on how we assign machines to steps.

[43]This is estimated with the following procedure. Our data show that: in 65.5% of cases, the employees of machine owners perform all operations on machines that are rented out to other firms; in 19.9% of cases, the employees of machine owners supervise the employees of firms who are renting their machine; and, in 14.6% of cases, machine owners let the employees of other firms use their machines without supervision. Median hourly wages in carpentry are \$0.26, so we subtract from the median hourly rental rate: $\$0.20 = (0.655 \times 0.26) - (0.199 \times 0.5 \times 0.26)$. That is, when the employees of machine owners perform the operations themselves, we remove from the rental price their hourly wage. For similar reasons, we remove half of the hourly wage when the employees of machine owners supervise the employees of machine renters. This information on supervision of renters by machine owners was collected in a short follow-up phone survey conducted about 3 months after the end of the main survey. Details on additional data collection are provided in the Supplemental Appendix.

[44]The information on machine usage at the firm level was collected in a short follow-up phone survey conducted about 7 months after the end of the main survey.

TABLE AX

CALIBRATED PARAMETERS AND MOMENTS.

	Aggregation weighted by machine hours (1)	Aggregation unweighted (2)
Panel A: Calibrated parameters		
Median purchase price of machines in USD (p_b)	776.2	579.3
Median hourly machine rental price in USD (p_r)	0.514	0.490
Average depreciation rate (δ)	0.069	0.082
Share of machine capacity rented from specialized providers ($\phi/(1+\phi)$)	0.494	0.684
Panel B: Moments		
Average machine-level capacity utilization	0.531	0.533
Average firm-level capacity utilization	0.356	0.354
Average firm-level capacity utilization, owners	0.380	0.381
Average firm-level capacity utilization, renters	0.338	0.336
Average firm-level capacity rented out	0.151	0.152

Note: Sample: door producers. Median purchase and rental prices of machines (Panel A) are trimmed at the 1st and 99th percentile and converted to nominal U.S. dollars using an exchange rate of 3800 UGX/USD.

without weights. We note that machine purchase prices are significantly larger in column 1 than column 2. This is in line with more expensive machines being used more heavily by firms.[45]

Share of Machine Capacity Rented From Specialized Providers ($\frac{\phi}{1+\phi}$). This is reported in Panel A of Table AX, and is defined as $(HR_i - HR_o)/HR_i$, where HR_i are weekly total hours of machine usage reported by renters, and HR_o are weekly total hours of machine time that owners report supplying to renters. Since we have a random sample of firms, this ratio would be zero if machine renters were only renting from machine owners. However, Table AX shows that the machine time used by renters is about twice as large as what machine owners report renting out. This indicates that about 50% of the rented machine time originates from other providers that are not carpentry firms. Our data further show that such providers are mostly workshops that specialize in renting out machines: machine renters were asked where they rent their machines from, and around 39% of door producers report renting from intermediary retailers (while 58% report renting from other carpentry firms in the same area, and 3% from other sources such as family and friends).[46] As described above, in column 1, machines are aggregated weighting each machine type by the share of total machine time it accounts for in the data. In column 2, we show that our results are robust to aggregating without weights.

[45] If a firm uses more than one machine of each type (i.e., more than one thickness planer), then our data contain one observation for each type of machine, and in this case, the machine purchase price refers to the last machine purchased by the firm, the current value refers to the average machine, the age to the average machine, and the hourly rental rate refers to the typical machine of that type rented by the firm. Firms use more than one machine of each type in less than 7% of cases.

[46] Specialized rental workshops likely have higher machine capacity available for rent (since they do not use the machines themselves) and so this can explain why the share of rented machine time accounted for by specialized workshops (50%) is higher than the share of renters using specialized workshops (39%).

C.2. *Details on Moments*

This section describes the computation and estimation of additional moments not already described in the main text, and should be read in conjunction with Table VII. In each paragraph, we refer to the rows of Table VII that include these additional computed moments. Two rows are missing: row 12 includes p_r, already described in the previous section; row 27 includes the average wage from Table AI.

Capacity Utilization (Rows 13–17)

The moments related to capacity utilization are shown in Panel B of Table AX. To compute the average machine-level capacity utilization, we use information from machine owners, who were asked how many hours per week they use their machines for *all* their products, and how many hours they rent them out to other firms. We consider as total demand the total time that the machine is operated per week (for both own use and for renting out), and as total supply 60 hours per owned machine. To compute the average firm-level capacity utilization, firms were asked how many hours per week they use each machine for the production of *all* their products. We set full capacity at 60 hours per week. We then recompute the firm-level capacity utilization separately for owners and renters, where owners and renters are defined at the machine level. The average firm-level capacity rented out is computed using only machine owners, and dividing the weekly hours that the machine is rented out by 60.

Cost of Capital (Rows 32–33)

Firm owners who reported borrowing for the business at the time of the survey were asked their interest rate. Column 1 of Table AXI shows that the mean interest rate is 33%, with standard deviation of 28%. However, we note that only 29 carpentry firms reported to be borrowing and provided a value for the interest rate.

To provide more evidence on the cost of capital, in column 2 we report the mean and standard deviation of the *hypothetical* interest rate that firms expect to face if they had to borrow to cover an unforeseen expense. Specifically, we first asked if firm owners would be able to cover a UGX 1 Million (USD 263) expense, either through borrowing or through own savings. If they said No, then we asked if they could cover lower amounts. For those that said Yes to any of these questions, we then asked if they would be able to cover the expense by borrowing or through savings. To those who would need to borrow, we

TABLE AXI

INTEREST RATE.

Sample:	Firms that are borrowing (1)	Firms that would need to borrow to cover unforeseen expense (2)
Average interest rate	0.329	0.593
Standard deviation of interest rate	0.281	0.432
Number of firms	29	191

Note: Sample: carpentry sector. Column 2 reports a hypothetical interest rate for firms that would need to borrow to cover unforeseen expenses, and is trimmed at the 95th percentile to correct for outliers. This information was collected in a short follow-up phone survey conducted about 7 months after the initial survey.

TABLE AXII

PREDICTORS OF ACCESS TO LIQUIDITY.

	Able to cover unforeseen expense of UGX 1M		Would need to borrow to cover unforeseen expense	
	(1)	(2)	(3)	(4)
Manager Ability (Std.)	0.059		−0.021	
	(0.023)		(0.025)	
Investment Rate (0–1)		0.508		−0.553
		(0.132)		(0.152)
Sample	All Firms	Door Prod.	All Firms	Door Prod.
Subcounty FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.054	0.062	0.099	0.181
Observations	477	326	475	324

Note: OLS regression coefficients, robust standard errors in parentheses. Sample: carpentry sector. Manager ability: standardized index based on multiple survey questions; see the Supplemental Appendix for details. Investment rate: See Table 3.

then asked the interest rate they would expect to face.[47] First, we note that 39% of firms reported that they would need to borrow. This shows that about 60% of entrepreneurs have substantial savings, and so likely have a lower cost of capital. Second, comparing columns 1 and 2 suggests that those managers who borrow face a lower interest rate than those who do not have substantial savings and do not currently borrow. Taken together, this evidence shows that there is substantial variation in the cost of capital across firms.

In Table AXII, we verify that higher ability managers and machine owners face a lower cost of capital. Column 1 shows a positive correlation between managerial ability and whether the manager would be able to cover an unforeseen expense of UGX 1M (with either own savings or a loan). Column 3 shows that, conditional on being able to cover an unforeseen expense, there is a negative association between managerial ability and the probability that the manager would need to borrow to cover the expense (as opposed to using own savings), though this result is imprecisely estimated. Columns 2 and 4 show that firm owners who own a higher share of machines face easier access to capital and have more liquidity available through savings. These results are in line with the model estimates that higher ability managers face a lower cost of capital, and that managers with lower cost of capital are more likely to invest.

Finally, we also show that managers with lower cost of capital, as proxied by their ability to cover the unforeseen expense, are more likely to own machines, even conditional on managerial ability, and that mechanization and investment rates are both higher in areas with easier access to banks, even conditional on managerial ability. These results provide additional evidence of variation in cost of capital across entrepreneurs resulting in heterogeneity in mechanization and investment. See the Supplemental Appendix for more details.

[47]This information is thus available only for firms that would need to borrow to cover it (as opposed to using own savings). This information is missing also for firm owners who would not be able to cover the expense at all (neither with a loan nor with own savings), but we note that only 2 firms reported not being able to cover it.

TABLE AXIII

CAPITAL STOCK AND LABOR CHOICE.

	Log Capital Stock Used		Log Number of Workers	
	(1)	(2)	(3)	(4)
Manager Ability (Std.)	0.474	0.398	0.113	0.135
	(0.094)	(0.111)	(0.028)	(0.036)
Sample	All Firms	Door Prod.	All Firms	Door Prod.
Subcounty FE	Yes	Yes	Yes	Yes
Product Controls	Yes	Yes	Yes	Yes
Adjusted R^2	0.212	0.237	0.239	0.230
Observations	421	311	522	381

Note: OLS regression coefficients, robust standard errors in parentheses. Outcome variable in columns 1–2: log value of capital stock used (owned and rented). Product controls: dummies for the most common door type and for producing two-panel doors in the last 3 months. Manager ability: standardized index based on multiple survey questions; see the Supplemental Appendix for details.

Labor Market Frictions (Rows 28–31)

To be conservative, for the identification of the labor market friction parameter ν we prefer to target the bundle of moments described in Section 5, rather than relying exclusively on the direct estimates of ν from column 6 of Table AVII. In particular, we also target: (a) the relationship between wages and managerial ability from column 3 of Table AVII, and (b) the correlation between managerial ability and (i) capital stock and (ii) firm size, reported in Table AXIII. The results from part (a) indicate that an increase in managerial ability of one standard deviation is associated with a 6% increase in earnings. For part (b), in Table AXIII we regress the log value of the capital stock used and log firm size on managerial ability. Our preferred specifications limit the sample to door producers (i.e., columns 2 and 4). These show that a one standard deviation increase in managerial ability is associated with a 40% increase in capital and a 14% increase in labor.[48]

Managers' Selection (Rows 34–38)

We are interested in the relationship between managerial ability and the decision to become a manager (relative to the outside option of being a worker in the same industry, as suggested by our data). However, managerial ability is available only for managers, and so is predicted by running a regression of our standardized index of managerial ability on a set of individual characteristics available for both managers and workers.[49] In columns 1–2 of Appendix Table AXIV, we regress predicted managerial ability (standardized) on a dummy for being a worker. Column 1 shows that workers score about 0.29 of a standard deviation lower on the predicted measure of managerial ability. This result is robust to excluding sub-county fixed effects (column 2).

In columns 3–4, we regress a dummy for being a manager on the rank of the individual on the same measure of predicted managerial ability described above. To construct the rank, we weight observations so that the weighted sample includes an equal share of managers and workers. We report both standard errors clustered by firm and bootstrap

[48]The regressions in Table AXIII are robust to excluding product controls.

[49]These are: years of schooling, age, age squared, a dummy for whether attended vocational training, the score on a 4-item Raven matrices test, and the Big five traits, measured through a 10-item Big five test.

TABLE AXIV
OUTSIDE OPTION AND ENTRY CHOICE.

	Predicted Man. Ability (Std.)		Manager (0/1)	
	(1)	(2)	(3)	(4)
Worker (0/1)	−0.285 (0.051)	−0.240 (0.053)		
Rank of predicted man. ability (0–1)			0.275 (0.050) [0.216]	0.204 (0.044) [0.187]
Subcounty FE	Yes	No	Yes	No
Adjusted R^2	0.176	0.012	0.014	0.014
Observations	1433	1433	1433	1433

Note: OLS regression coefficients. Sample: workers and managers in carpentry. Standard errors clustered at the firm level are shown in parentheses, whereas bootstrapped standard errors with 1000 replications and resampling clustered by firm are provided in square brackets. To create the predicted measure in column 1 (column 2), this regression does (does not) control for sub-county fixed effects.

standard errors (with resampling by firm) as the independent variable is constructed using a generated regressor. The results show that an increase in the rank of 10pp is associated with an increase in the probability of being a manager of about 2–2.8pp. This result is imprecisely estimated once we account for the generated regressor.

Finally, Table AXV reports the ratios of the standard deviations of workers to managers for: (i) income (row 1) and (ii) predicted managerial ability (row 2), predicted as described above. Column 1 reports our preferred specification where the standard deviations are calculated netting out sub-county fixed effects. As a robustness check, column 2 shows the ratios without controlling for sub-county fixed effects. The results are similar.

Markups (Row 26)

We calculate markups as revenues over variable cost (measured as revenues minus profits), minus 1. This approach recovers markups under the assumption that profit measures in the survey correspond to variable profits (i.e., managers do not take into account fixed

TABLE AXV
WORKERS-MANAGERS GAP IN VARIANCE OF INCOME AND ABILITY.

	Sub-county FE (1)	No Sub-county FE (2)
Ratio of Workers-Managers Std of Income	0.898	0.700
Ratio of Workers-Managers Std of Managerial Ability	0.970	0.925

Note: Sample: carpentry. First row: ratio of the standard deviation of workers' monthly earnings and managers' average monthly profits. Second row: ratio of the standard deviation of workers' and managers' predicted managerial ability. The statistics in column 1 (column 2) control (do not control) sub-county fixed effects.

costs when reporting monthly profits). We believe this to be the case given how the profit question was worded. Estimates of markups are reported in Table AI.[50]

C.3. *Elasticity of Moments to Model's Parameters*

To formally explore the connection between parameters and moments, we compute the elasticity of each (model generated) moment to each model parameter (as commonly done in the literature, e.g., Kaboski and Townsend (2011b)), restricting attention to the 14 parameters that are jointly estimated.[51] Specifically, we start from the estimated vector of parameters φ^*, and we create 28 alternative vectors, two for each parameter j, as follows: $\underline{\varphi}(j) = \{\varphi^*_{-j}, 0.95\varphi^*_j\}$ and $\overline{\varphi}(j) = \{\varphi^*_{-j}, 1.05\varphi^*_j\}$, where $\underline{\varphi}(j)$ keeps all parameters except for j constant and decreases j by 5%, while $\overline{\varphi}(j)$ does the same, but increasing j by 5%.

We then compute with our model the vectors of moments corresponding to each vector of parameters and use them to compute

$$\Delta_{jr} = m_r\big(\overline{\varphi}(j)\big) - m_r\big(\underline{\varphi}(j)\big).$$

Δ_{jr} measures how much moment r would change if we changed parameter j by 10% around the estimated value while keeping all the other parameters constant.

To ease comparison across the different moments, we then normalize Δ_{jr} for each moment j so that, when rounded, it sums to 28 across all parameters: $\sum_j Round(\Delta_{jr}) = 28$. The result of this procedure is the Jacobian matrix shown in Figure A4, which illustrates which parameter is most important for each moment. Our normalization helps to generate interpretable magnitudes: if all parameters have an identical impact on a specific moment, then we should see a value of 2 for each parameter in the corresponding row; if only four parameters matter for a moment, with equal relevance, then we should see a value of 7 for those parameters and 0 otherwise, and so on.

The results from the Jacobian are quite intuitive and they connect different blocks of parameters to the moments that we would expect, as we discuss in detail in Section 5.3. In Table 7 in the main text, we report for each moment the three most relevant parameters, as long as they have a value bigger than or equal to 2 in the Jacobian matrix (to guarantee that the parameter has a more than average relevance).

APPENDIX D: PREVALENCE OF RENTAL MARKETS ACROSS COUNTRIES

To study the prevalence of the rental market across countries, we use the World Bank Enterprise Surveys (WBES). Importantly for our purposes, in the waves of the WBES

[50]For robustness, we also calculate markups using hypothetical questions. Managers were asked how much revenues they could generate from UGX 250,000 of intermediate inputs. They were then asked how much of these revenues would: (i) go to wages; (ii) cover other variable costs (e.g., machines, fuel etc.); (iii) be left as variable profits. We compute markups as the ratio of the stated revenues over the sum of intermediate input costs, wage costs, and other operating costs. This alternative procedure yields markups that are very similar.

[51]Recall that while there are 15 parameters in total, the curvature of the capacity cost ξ is solved within each loop to clear the rental market given the observed price of capital p_r. For this reason, we are not going to include it in this exercise.

	A_M	μ_z	σ_z	θ	$\rho_{x,z}$	π_N	χ	ψ	θ_2	W	μ_x	σ_x	ν	η
Mechanization Rate	14	0	0	3	0	0	1	0	0	6	0	0	2	2
Investment Rate	10	3	1	2	0	0	1	0	0	4	0	0	3	4
Share of Machine Hours Rented In	10	3	3	0	0	0	4	1	0	3	1	0	2	1
Mech. Rate on Number of Workers	9	3	2	2	1	0	1	0	0	4	1	0	2	3
Inv. Rate on Number of Workers	11	2	1	2	2	0	3	0	0	4	1	0	0	2
Share of Mach. Hrs Rented on Num. of Workers	9	3	2	1	3	0	2	0	0	4	2	0	0	2
Ratio of Size of Machine Owners vs. Renters	9	3	2	1	2	0	3	0	0	3	1	0	1	3
Mech. Rate on Managerial Ability	4	2	3	6	2	0	1	0	0	2	0	0	1	7
Inv. Rate on Managerial Ability	10	0	3	1	7	0	3	0	0	2	0	0	0	2
Share of Mach. Hours Rented on Man. Ability	1	3	2	2	7	0	3	0	0	1	2	0	3	4
Owners-Renters Managerial Ability Gap	2	3	0	1	7	0	3	0	0	2	1	0	3	6
Average Machine-Level Capacity Utilization	11	0	1	3	0	0	8	0	0	4	0	0	1	0
Average Firm-Level Capacity Utilization	0	5	1	0	0	0	11	1	0	0	1	0	3	6
Average Firm-Level Cap. Utilization, Owners	6	1	0	2	0	0	14	0	0	2	2	1	0	0
Average Firm-Level Cap. Utilization, Renters	0	6	2	0	0	0	9	1	0	0	0	0	4	6
Average Firm-Level Cap. Rented Out	15	0	1	3	0	0	1	0	0	5	1	0	1	1
Log Revenues on Man. Ability	4	0	9	0	0	0	0	0	0	2	0	0	7	6
Log Revenues p.w. on Man. Ability	4	2	7	2	1	0	0	0	0	2	0	0	2	8
Log Rev. on Man. Ability (and Mech. Rate)	4	1	8	0	0	0	0	0	0	1	0	0	8	6
Log Rev. p.w on Man. Ability (and Mech. Rate)	3	1	9	0	0	0	0	0	0	1	0	0	8	6
Log Revenues on Mech. Rate	7	2	7	4	1	0	1	0	0	4	1	0	0	1
Log Revenues p.w. on Mech. Rate	2	4	7	4	1	0	2	0	0	2	2	0	1	3
Log Rev. on Mech. Rate (and Man. Ability)	15	2	1	1	0	0	2	0	0	6	0	0	0	1
Log Rev. p.w. on Mech. Rate (and Man. Ability)	9	4	2	1	0	0	2	0	0	4	1	0	1	4
Ratio of Number of Managers to Workers	0	0	0	0	0	19	0	0	9	0	0	0	0	0
Workers-Managers Managerial Ability Gap	0	0	2	0	0	0	0	18	4	0	0	0	2	2
Ratio of Std of Income of Workers vs. Managers	0	0	0	0	0	0	0	28	0	0	0	0	0	0
Ratio of Std of Man. Ability of Workers vs. Man.	0	0	2	0	0	3	0	15	5	0	0	0	1	2
Entry Choice on Man. Ability (Normalized)	0	0	2	0	0	2	0	16	5	0	0	0	1	2
Average Markup	1	1	1	0	0	0	0	0	0	0	0	0	14	11
Log Hourly Wage on Number of Workers	0	0	0	0	0	0	0	0	0	0	0	0	28	0
Log Hourly Wage on Managerial Ability	2	0	10	1	0	0	0	0	0	1	0	0	7	7
Log Capital Used on Managerial Ability	5	2	5	2	1	0	0	0	0	2	0	0	4	7
Log Labor Used on Managerial Ability	2	0	9	0	0	0	0	0	0	0	0	0	11	6
Hourly Worker Wage Rate	13	1	0	0	0	0	1	0	0	12	0	0	1	0
Average Interest Rate	7	2	1	2	0	0	2	0	0	3	3	3	2	3
Std of Interest Rate	7	3	2	2	0	0	4	0	0	2	2	1	2	3

FIGURE A4.—Normalized partial derivatives of moments with respect to parameters. Notes: The matrix includes the normalized values of Δ_{jr} computed as described in the text. Each row is a moment and each column is a parameter. We use the symbols π_N and θ_2 instead of $\tilde{\pi}_N$ and $\tilde{\theta}$ due to Matlab formatting.

collected between 2012 and 2014, firms are asked their total expenditures on rental of machinery, vehicles, and equipment in the fiscal year before the survey. In total, we have this information for 6836 firms in 44 countries. For each firm, we construct a dummy equal to 1 if the firm reports any rental market expenditure in the previous year.[52] Figure A5 plots the share of firms that rent capital in each country, against GDP per capita.[53] The figure shows a clear negative correlation, thus confirming that the rental market is indeed less prevalent in more developed economies. Uganda does not appear to be an outlier, showing levels of prevalence of the rental market comparable to other sub-Saharan African countries such as Ghana, Zambia, or Sudan.

[52]Across all countries, 43% of firms report any involvement with the rental market.

[53]To reduce the impact of outliers, we exclude countries with less than 20 firms and weight each country by the number of firms. Our results are robust to using the full country sample and not weighting the estimates.

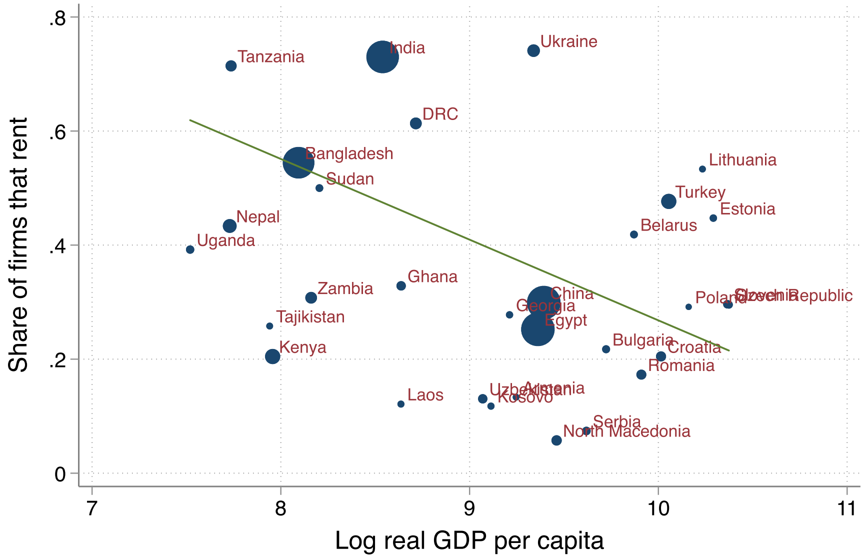

FIGURE A5.—Prevalence of rental markets for capital across countries. Notes: Data: World Bank Enterprise Surveys (WBES) for 2012–2014. Share of firms in each country that reports any rental expenditure on machines/equipment/vehicles, against log real GDP per capita. Countries are weighted by the number of firms in the WBES. We exclude 13 countries with less than 20 firms.

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