I   Online Appendix

ARE SMALL FIRMS LABOR CONSTRAINED?
EXPERIMENTAL EVIDENCE FROM GHANA
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I.I   Identification

Appendix Tables 1 and 2 list each probability distribution group. The notation in the first column is a number for each apprentice who listed that firm. The number itself is the number of firms that apprentice listed. So the first row, "3" includes firms listed by a single apprentice who listed three firms. The fifth row, "2,3" includes firms listed by two apprentices, one who listed two firms and one who listed three firms. The second column of these tables includes the number of firms facing each probability distribution. The remaining columns display the probability distributions themselves on the left (P(T=X)) and the realized treatment probabilities within that group (T=X), in bold on the right. Realized treatment assignments are random, generated by a random computer number generator, within each probability distribution group.

I.II   Survey Data

All survey questions and strategies were extensively piloted. Because Ghana has eleven government-sponsored languages and the sample spans 32 districts and all 10 regions, the surveys were printed in English and translated on the spot. Surveyors had with them simple dictionaries developed specifically to assist in the correct translation of important questions/words.

Following **?**, the revenues and profits questions in each firm survey were as follows:

"What were the TOTAL SALES from your business LAST MONTH?"

"What was the total INCOME the business earned LAST MONTH after paying all expenses including wages of employees, but not including any INCOME you paid yourself. That is, what were the PROFITS of your business LAST MONTH?"

Capital stock data in the baseline survey was collected in seven categories: land, building(s), furniture, machinery and equipment, tools, inventory, and any other assets, only the last five of which were included in the second follow up survey. Craft-specific pictorial aids were used to assist survey respondents in including capital stock by category.

Apprentice cognitive tests include the Ravens matrices group B, a commonly used measure of abstract cognitive ability. It is a series of 12 patterns, each with a missing piece. The respondent chooses from six options which piece fits the pattern for each of the 12 patterns. The Digit Span Recall test is a working memory test, in which surveyors read out a number or series of numbers and respondents repeat the numbers. The number of digits increases over time so that later questions are more difficult than earlier ones. The oral English vocabulary test includes fifteen English words and possible synonyms for those words, and asks respondents to choose the synonym. We created the math test ourselves via survey piloting, and it consists of four word problems that require critical thinking and the use of simple arithmetic.

We use ten statements from the Rosenberg Self-Esteem psychometric, measured on a four-point Likert scale from strongly agree to strongly disagree. We include eight statements from the Rotter Locus of Control psychometric, likewise measured on a four-point Likert scale from strongly

agree to strongly disagree. High self-esteem and an external locus of control are considered high non-cognitive ability.

I.III Longer Run Findings

Data for longer run findings comes from two additional survey rounds conducted at approximately 1 year and 2 years after the start of employment. These follow up surveys included the same measures of revenues, profits, and labor inputs as the first two follow up rounds, as well as the same capital stock measures included in the second follow up survey. As is the case with the first two rounds, all financial variables, including wages, profits, revenues, and assets have been deflated to April 2013 Ghana Cedi, and the top 0.5% of levels are winsorized.

Unfortunately, the interpretation of longer run findings is complicated by a layered experimental study that provided cash payments to firm owners training program apprentices just before the third follow up survey and again a few months before the fourth follow up survey. In December 2014, firm owners received 100 GHC per program apprentice currently working from the research team. In September of 2015, firm owners whose apprentices had participated in craftsmanship exams in August of 2015 received a payment from the research team that varied by the performance of the apprentice on the craftsmanship exam and averaged another 100 GHC. These payments were not anticipated by firm owners or apprentices (or our government partners) and thus should not contaminate the prior rounds.

The cash payments were correlated with each firm's original number of assigned apprentices, and collinear with take up as of round 3. Consequently, rounds 3 and 4 potentially obscure treatment effects from the apprentice placement experiment and findings from the later rounds must be interpreted with caution. Indeed, breaking findings out by round in Table A5, there is evidence to support this caution. We observe a temporary capital stock increase per randomly assigned program apprentice of 15% in round 3, consistent with effects being driven by the design of the layered study.

Table A5 also displays firm size estimates pooled across all four rounds and individually by round. One key takeaway is that many program apprentices remained in sample firms into the fourth round, as point estimates on program apprentices working in sample firms are stable across rounds. A second observation of note is that the number of paid workers is significantly larger in treatment firms in round 4. This finding could be driven by program apprentices receiving promotions, by new hiring prompted by cash infusions from the layered experiment that began in December 2014, or by changes in the structure of the business associated with profit increases over the earlier rounds.

Table A6 replicates our main firm output findings, again pooled across four rounds and separately by round. Profit effects are statistical zeros in both Rounds 3 and 4. We note that pooled across all four rounds, level point estimates are positive and IHS are statistically different from zero. A final object of interest in Table A6 is rising wages over rounds, consistent with our qualitative understanding of this labor market. This finding is also consistent with rising worker productivity over time or with workers taking home a rising share of the rents generated by their efforts.

In Table A7, we adjust profits in Rounds 3 and 4 for returns on capital grants at 5% per month, where capital grants in Round 3 are 100 GHC for each working program apprentice at the time of the Round 3 survey deflated to April 2013 Ghana Cedis and capital grants in Round 4 are capital grants in Round 3 plus 100 GHC for each working program apprentices at the time of the Round 4 survey deflated to April 2013 Ghana Cedis. All point estimates fall slightly, as would be expected. Again, the point estimates in Round 3 and 4 are not statistically different from zero and the pooled point estimates are positive.

I.IV Spillovers

As in all RCTs, firms assigned one or more apprentices receive that assignment at the expense of firms assigned zero apprentices. The first hint that spillovers are not driving our results is the simple fact that the saturation of the craft market in this study, both in terms of firms and apprentices in each district and trade, is quite limited. In a separate study, we collected a census of all garment making firm owners in Hohoe District, one of our study districts. That census identified 1,026 garment making firm owners in the district in February 2014. Firm owners from 35 of these firms attended the matching meeting. If this single district and trade is representative, which we believe it is, the share of the market participating in this study is relatively marginal.

As another attempt to address the question of spillovers, Appendix Table A8 conducts spillover analysis using the subset of 25 districts (of 32) in our data for which we have GPS data. We find no significant point estimates on the number of program apprentices assigned to other firms in the sample and trade within 1, 3, or 5 kilometers, conditional on total firms within the sample and trade in those distances. Our main point estimates on treatment are relatively stable and significant in IHS specifications.

I.V Qualitative Support for the Model

Several sources of information are available to provide descriptive and observational support for the structure of the model: the series of questions included in firm baseline surveys to quantify insights from early qualitative interviews with firms owners, information on applicants to the apprenticeship from the apprentice baseline surveys, and information on revenues and wages paid to program apprentices from the follow up surveys. We consider two primary metrics of apprentice ability as candidate proxies for θ, both drawn from the apprentice baseline surveys: a normalized cognitive ability index and a normalized non-cognitive ability index.[1]

Considering first the model set up, we assume that workers know their type, but that firm owners do not observe worker type. Searching for evidence that workers know their type, we consider information from the apprentice baseline survey on expected earnings conditional on completing (and not completing) a program apprenticeship. Appendix Table 9 shows cognitive and non-cognitive ability indices predict higher expected earnings conditional on completing a program apprenticeship and larger returns to completing a program apprenticeship, consistent with our model assumption that workers have information about their type. Drawing on the subset of survey questions from the baseline survey which asked firm owners to articulate their sense of the baseline labor market, one of these questions was intended to understand whether firm owners have perfect information about worker ability. Only 7% of firm owners report that they can intuit or evaluate worker type immediately. Another 22% say it takes a month, 14% that it takes two months, 30% that it takes three months, and 18% that it takes six months. Qualitatively, firm owners agree with our model that worker ability is not immediately observable to hiring firm owners.

The model set up also assumes search and training costs incurred at hiring are large, and potentially prohibitively large. Perhaps the question most closely tied to search costs asks about the learning curve between hiring and workers productively contributing to the profits of the firm. 71% of firm owners think it takes at least three months for apprentices to add to the profits of the business; 45% of firm owners think it takes at least six months. Costs incurred to move apprentices

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[1]Unfortunately, we do not have detailed ability information for apprentices other than program apprentices working in sample firms, either at baseline or in the first two follow up surveys, and do not have wage data on non-program apprentices in the follow up surveys. Consequently, we rely on ability and wage patterns from data on program apprentices.

along the learning curve in the early months of employment are candidate pieces of the overall fixed search and training cost in the model. A second piece of descriptive information on search costs considers the following counterintuitive pair of findings: 96% of firms in the sample state that they would like to grow their businesses (by hiring more apprentices) and 47% cite access to labor as the key constraint to growth (second only to finance), but only 37% have ever actively tried to advertise job postings for apprenticeship positions. Though we have limited information on other search strategies, it appears that simply posting a vacancy is considered unlikely to garner a suitable new apprentice, and alternative institutional centers for vacancy posting are lacking.

Turning to the wage contract, the key piece of qualitative evidence that we gathered from early survey piloting interviews was that firm owners explain the entrance fee as a screening mechanism. In the firm baseline survey, we quantified that observation. When asked the main reason apprentices are normally required to pay an entrance fee at the start of an apprenticeship, 85% of firm owners cite a desire to force apprentices to signal investment in the apprenticeship as the impetus for the fee. Apprentices who signaled they are "serious" by paying the entrance fee would be better able and more motivated to learn.

We model worker ability as predicting firm revenues, as the worker's contribution to the firm is a function of worker ability, something we can search for in the follow up data. The second piece of the wage contract is that wages are paid as a share of revenues. This model choice comes from qualitative observations in the field and from correlations in the baseline data, but is also something that can be found in the follow up data. Finally, if ability and revenues are correlated and revenues and wages are correlated, we should expect ability and wages to be correlated as well. In the firm baseline survey, 80% of firm owners say they pay higher wages to better performing apprentices, but we can also search for evidence in our data. Appendix Table 10 presents correlations between revenues, program apprentice wages, and our two measures of apprentice ability in the sample of program apprentices reported working in sample firms in our two follow up surveys. Consistent with our model and our qualitative understanding of the baseline labor market, wages and revenues are correlated, revenues and cognitive ability are correlated, and cognitive ability and wages are correlated. We find no evidence that non-cognitive ability is correlated with either wages or firm revenues.

Table A1: **Identification: Probability Distributions of Treatment Assignments - Part A**

	#	P(T=0)	T = 0	P(T=1)	T = 1	P(T=2)	T = 2	P(T=3)	T = 3	P(T=4)	T = 4	P(T=5)	T = 5	P(T=6)	T = 6	P(T=7)	T = 7
3	110	0.67	**0.65**	0.33	**0.35**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2	85	0.50	**0.49**	0.50	**0.51**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4	69	0.75	**0.79**	0.25	**0.21**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
5	41	0.80	**0.80**	0.20	**0.20**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,3	34	0.33	**0.32**	0.50	**0.50**	0.17	**0.18**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2	31	0.25	**0.20**	0.50	**0.48**	0.25	**0.32**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
6	19	0.83	**0.79**	0.17	**0.21**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,2	18	0.00	**0.00**	0.50	**0.44**	0.50	**0.56**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,3	16	0.00	**0.00**	0.67	**0.81**	0.33	**0.19**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,3	16	0.44	**0.44**	0.44	**0.44**	0.11	**0.12**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,3,3	16	0.30	**0.31**	0.44	**0.38**	0.22	**0.31**	0.04	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,4	15	0.38	**0.34**	0.50	**0.53**	0.13	**0.13**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,4	14	0.50	**0.22**	0.42	**0.64**	0.08	**0.14**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,3,4	13	0.33	**0.46**	0.44	**0.31**	0.19	**0.23**	0.03	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,2,2,2	10	0.03	**0.00**	0.16	**0.00**	0.31	**0.50**	0.31	**0.30**	0.16	**0.10**	0.03	**0.10**	0.00	**0.00**	0.00	**0.00**
4,5	10	0.60	**0.40**	0.35	**0.60**	0.05	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,2	9	0.13	**0.11**	0.38	**0.56**	0.38	**0.11**	0.13	**0.22**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,2,2	9	0.06	**0.11**	0.25	**0.44**	0.38	**0.34**	0.25	**0.00**	0.06	**0.11**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,3	8	0.17	**0.13**	0.42	**0.37**	0.33	**0.25**	0.08	**0.25**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
8	7	0.88	**0.86**	0.13	**0.14**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,4,4	7	0.38	**0.29**	0.44	**0.43**	0.17	**0.28**	0.02	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,5	7	0.53	**0.43**	0.40	**0.57**	0.07	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
5,6	7	0.67	**0.71**	0.30	**0.29**	0.03	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,1,3	6	0.00	**0.00**	0.00	**0.00**	0.67	**0.67**	0.33	**0.33**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,4,5	6	0.40	**0.33**	0.43	**0.17**	0.15	**0.50**	0.02	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
6,6	6	0.69	**0.83**	0.28	**0.17**	0.03	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,3,4,4	5	0.19	**0.20**	0.41	**0.00**	0.30	**0.80**	0.09	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,4,4,4	5	0.28	**0.40**	0.42	**0.20**	0.23	**0.20**	0.06	**0.20**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,4	5	0.56	**0.60**	0.38	**0.40**	0.06	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,4,5	5	0.45	**4.00**	0.41	**0.40**	0.13	**0.20**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,9	5	0.67	**0.40**	0.31	**0.60**	0.03	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
13	4	0.92	**0.75**	0.08	**0.25**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,1,4	4	0.00	**0.00**	0.00	**0.00**	0.75	**0.75**	0.25	**0.25**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,2,2,2	4	0.00	**0.00**	0.13	**0.25**	0.38	**0.25**	0.38	**0.50**	0.13	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,5	4	0.20	**0.00**	0.45	**0.75**	0.30	**0.25**	0.05	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,4,9	4	0.50	**0.50**	0.40	**0.50**	0.10	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,6	4	0.63	**0.75**	0.33	**0.25**	0.04	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,1,1,1,2	3	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.50	**0.67**	0.50	**0.33**	0.00	**0.00**	0.00	**0.00**
1,1,1,2,2	3	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.25	**0.00**	0.50	**0.33**	0.25	**0.67**	0.00	**0.00**	0.00	**0.00**
1,1,2,2	3	0.00	**0.00**	0.00	**0.00**	0.25	**0.67**	0.50	**0.33**	0.25	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,2,2	3	0.00	**0.25**	0.25	**0.33**	0.50	**0.33**	0.25	**0.33**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,2,3	3	0.00	**0.00**	0.33	**0.33**	0.50	**0.67**	0.17	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,3,3	3	0.00	**0.00**	0.44	0.33	0.44	0.67	0.11	0.00	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,2,2,3	3	0.04	**0.00**	0.19	**0.67**	0.33	**0.00**	0.29	**0.33**	0.13	**0.00**	0.02	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,2,3	3	0.08	**0.33**	0.29	**0.00**	0.38	**0.00**	0.21	**0.67**	0.04	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,4	3	0.19	**0.00**	0.44	**0.67**	0.31	**0.33**	0.06	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,3,3,4	3	0.17	**0.00**	0.39	**0.67**	0.32	**0.00**	0.11	**0.33**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,4,6	3	0.31	**0.33**	0.48	**0.33**	0.19	**0.33**	0.02	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**

Table A2: **Identification: Probability Distributions of Treatment Assignments - Part B**

	#	P(T=0)	**T = 0**	P(T=1)	**T = 1**	P(T=2)	**T = 2**	P(T=3)	**T = 3**	P(T=4)	**T = 4**	P(T=5)	**T = 5**	P(T=6)	**T = 6**	P(T=7)	**T = 7**
2,5	3	0.40	**0.67**	0.50	**0.33**	0.10	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,3,3,3,4	3	0.15	**0.00**	0.35	**0.33**	0.32	**0.67**	0.15	**0.00**	0.03	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**
3,3,4,4	3	0.25	**0.33**	0.42	**0.34**	0.26	**0.33**	0.07	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,5,8	3	0.47	**0.67**	0.42	**0.33**	0.11	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,4,4,5,6	3	0.28	**0.33**	0.41	**0.00**	0.23	**0.67**	0.07	**0.00**	0.01	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**
4,4,5,6	3	0.38	**0.00**	0.42	**0.34**	0.17	**0.33**	0.03	**0.33**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,5,5	3	0.48	**0.33**	0.40	**0.67**	0.11	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,6,6	3	0.52	**0.67**	0.38	**0.33**	0.09	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,7	3	0.64	**0.67**	0.32	**0.33**	0.04	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
5,6,6	3	0.56	**0.67**	0.36	**0.00**	0.08	**0.33**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,1,2,2,4	2	0.00	**0.00**	0.00	**0.00**	0.19	**0.50**	0.44	**0.50**	0.31	**0.00**	0.06	**0.00**	0.00	**0.00**	0.00	**0.00**
1,1,2,3,3,3,3	2	0.00	**0.00**	0.00	**0.00**	0.10	**0.00**	0.30	**0.50**	0.35	**0.50**	0.20	**0.00**	0.06	**0.00**	0.01	**0.00**
1,2,2,3	2	0.00	**0.00**	0.17	**0.00**	0.42	**0.50**	0.33	**0.00**	0.08	**0.50**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,2,4	2	0.00	**0.00**	0.38	**0.50**	0.50	**0.50**	0.13	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,3,4,4	2	0.00	**0.00**	0.38	**0.50**	0.44	**0.50**	0.17	**0.00**	0.02	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,3,5	2	0.00	**0.00**	0.53	**0.50**	0.40	**0.00**	0.07	**0.50**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,4,4	2	0.00	**0.00**	0.56	**0.50**	0.38	**0.50**	0.06	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
1,5,5,6	2	0.00	**0.00**	0.53	**0.50**	0.37	**0.50**	0.09	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,2,2,2,2,2	2	0.01	**0.00**	0.05	**0.00**	0.16	**0.00**	0.27	**0.00**	0.27	**0.50**	0.16	**0.50**	0.05	**0.00**	0.01	**0.00**
2,2,2,3,3	2	0.06	**0.00**	0.22	**0.50**	0.35	**0.50**	0.26	**0.00**	0.10	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,3,3,3,3,4	2	0.04	**0.00**	0.16	**0.50**	0.29	**0.50**	0.23	**0.00**	0.16	**0.00**	0.09	**0.00**	0.01	**0.00**	0.01	**0.00**
2,2,3,4	2	0.13	**0.00**	0.35	**0.50**	0.35	**0.50**	0.15	**0.00**	0.02	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,2,6	2	0.21	**0.50**	0.46	**0.50**	0.29	**0.00**	0.04	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,3,4,4,5	2	0.15	**0.50**	0.36	**0.00**	0.32	**0.00**	0.14	**0.50**	0.03	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**
2,3,4,5	2	0.20	**0.50**	0.42	**0.50**	0.29	**0.00**	0.08	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,3,6	2	0.28	**0.00**	0.47	**0.50**	0.22	**0.50**	0.03	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
2,5,13	2	0.37	**0.50**	0.49	**0.50**	0.13	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,3,3,3	2	0.20	**0.00**	0.40	**0.50**	0.30	**0.00**	0.10	**0.50**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,3,3,3,3	2	0.13	**0.00**	0.33	**0.00**	0.33	**0.50**	0.16	**0.00**	0.04	**0.00**	0.01	**0.50**	0.00	**0.00**	0.00	**0.00**
3,3,3,4	2	0.22	**0.00**	0.41	**0.50**	0.28	**0.50**	0.08	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,4,10	2	0.45	**0.50**	0.43	**0.00**	0.12	**0.50**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,7,7	2	0.49	**0.50**	0.41	**0.50**	0.10	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
3,9	2	0.59	**0.50**	0.37	**0.50**	0.04	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,4,4	2	0.42	**0.50**	0.42	**0.50**	0.14	**0.00**	0.02	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,4,4,9	2	0.38	**0.50**	0.42	**0.50**	0.17	**0.00**	0.03	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
4,9,13	2	0.62	**0.50**	0.33	**0.00**	0.05	**0.50**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
6,6,7,9	2	0.53	**0.50**	0.37	**0.50**	0.09	**0.00**	0.01	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
Average	8.88	0.30	**0.33**	0.34	**0.34**	0.22	**0.23**	0.09	**0.08**	0.04	**0.03**	0.02	**0.02**	0.00	**0.00**	0.00	**0.00**

Table A3: **Attrition In Rounds 3 and 4**

	(1) =1 if Surveyed in Round 3	(2) =1 if Surveyed in Round 4	(3) =1 if Surveyed in Any of Four Rounds	(4) =1 if Profits Non-Missing in Round 3	(5) =1 if Profits Non-Missing in Round 4	(6) =1 if Profits Non-Missing in Any of Four Rounds
No Controls						
Treatment Apprentices	-0.03***	0.00	0.00	-0.03**	-0.01	0.00
	(0.01)	(0.01)	(0.00)	(0.01)	(0.02)	(0.00)
With Controls						
Treatment Apprentices	-0.01	0.02	-0.00	-0.03	-0.01	-0.00
	(0.02)	(0.02)	(0.00)	(0.02)	(0.02)	(0.01)
Observations	755	755	755	755	755	755
Mean of Dep Variable	0.94	0.83	0.99	0.87	0.76	0.98

Notes: Regressions in Panel A exclude all controls and show raw differences in participation in surveys by treatment, where treatment is defined as number of apprentices assigned to the firm. Regressions in Panel B include dummies for district, trade, and all probability distributions over treatment intensity represented in the data, mirroring our preferred specification throughout. The mean of the dependent variable is reported for firms assigned zero apprentices.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4: **Treatment Effects on Revenues and Profits: Test of Linearity**

	(1)	(2)	(3)	(4)	(5)
					Program
	Profits	IHS	Revenues	IHS	Apprentice
	(GHC)	Profits	(GHC)	Revenues	Wages (GHC)
Treatment Assignment = 1	16.82	0.11	15.25	0.10	14.49***
	(32.63)	(0.07)	(79.08)	(0.06)	(2.67)
Treatment Assignment = 2	137.02**	0.34***	64.91	0.23***	22.05***
	(51.05)	(0.10)	(80.00)	(0.08)	(6.30)
F test of linearity	0.19	0.41	0.81	0.75	0.27
Observations	1195	1195	1195	1195	1195
Mean of Dep Variable T=0	401.08	6.12	736.24	6.68	1.13

Notes: These specifications pool data from the first two follow up surveys and exclude firms assigned more than two apprentices. Regressions include round fixed effects, district fixed effects, trade fixed effects, and dummies for each probability distribution. Regressions in Columns (1) through (4) include baseline values of the dependent variable. Profits are self-reports of all sales less all expenses (including the wage bill) in the reported month. Profits, sales, and wages are in April 2013 Ghana Cedis, when 1 US dollar was equivalent to 1.95 Ghana Cedis. The top 0.5% of profit and sales observations have been winsorized. Standard errors in parentheses are clustered at the district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5: **Treatment Effects on Labor and Capital Inputs Across Rounds**

| | Take Up | | Other Labor Inputs | | | Capital | |
	(1) Program Apprentices	(2) Total Workforce	(3) Other Apprentices	(4) Paid Workers	(5) Firm Owner Hours/Week	(6) Capital Stock (GHC)	(7) IHS Capital Stock
Four Pooled Rounds							
Treatment Apprentices	0.44***	0.54***	0.15	0.09	-0.19	291.51	0.07
	(0.05)	(0.12)	(0.09)	(0.05)	(0.66)	(207.35)	(0.04)
Observations	2628	2628	2632	2632	2624	1983	1983
Mean of Dep Variable T=0	0.07	3.18	2.34	0.55	51.71	3250.36	8.22
Round 1							
Treatment Apprentices	0.41***	0.48***	0.05	0.09	-0.41		
	(0.06)	(0.16)	(0.09)	(0.07)	(1.03)		
Observations	630	630	630	630	630		
Mean of Dep Variable T=0	0.03	3.15	2.43	0.58	55.65		
Round 2							
Treatment Apprentices	0.53***	0.66***	0.24	0.05	0.10	171.95	0.05
	(0.05)	(0.19)	(0.19)	(0.08)	(0.96)	(242.01)	(0.04)
Observations	685	685	685	685	682	674	674
Mean of Dep Variable T=0	0.09	3.21	2.41	0.52	51.44	2712.45	8.10
Round 3							
Treatment Apprentices	0.40***	0.35*	0.11	0.02	0.51	510.67	0.15**
	(0.07)	(0.19)	(0.14)	(0.11)	(0.93)	(343.12)	(0.05)
Observations	685	685	686	686	681	678	678
Mean of Dep Variable T=0	0.09	3.43	2.26	0.68	51.89	3698.14	8.36
Round 4							
Treatment Apprentices	0.41***	0.62***	0.18	0.16***	-0.95	98.42	0.01
	(0.07)	(0.16)	(0.13)	(0.06)	(1.27)	(262.82)	(0.07)
Observations	628	628	631	631	631	631	631
Mean of Dep Variable T=0	0.08	2.89	2.26	0.41	47.91	3312.94	8.20

Notes: Regressions include round fixed effects, district fixed effects, trade fixed effects, and dummies for each probability distribution. Columns (2) through (7) include the baseline value of the dependent variable. Program apprentices are apprentices placed with these firms by the experimental program. Total workforce includes program apprentices and all other non-owner labor. *Paid Workers* is a Ghanaian colloquialism for workers who have already completed an apprenticeship, though both apprentices and paid workers receive wages. Capital Stock was collected in rounds 2 through 4, excludes land and buildings, and is in April 2013 Ghana Cedis, when 1 US dollar was equivalent to 1.95 Ghana Cedis. The top 0.5% of capital stock observations have been winsorized. Standard errors in parentheses are clustered at the district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6: **Treatment Effects on Revenues and Profits Across Rounds**

	(1)	(2)	(3)	(4)	(5)
					Program
	Profits	IHS	Revenues	IHS	Apprentice
	(GHC)	Profits	(GHC)	Revenues	Wages (GHC)
Four Pooled Rounds					
Treatment Apprentices	19.71	0.09*	24.31	0.09**	15.13***
	(11.97)	(0.04)	(26.73)	(0.04)	(2.42)
Observations	2457	2457	2457	2457	2457
Mean of Dep Variable T=0	370.24	6.00	705.29	6.64	1.62
Round 1					
Treatment Apprentices	38.38	0.12**	56.00	0.08*	12.26***
	(27.34)	(0.05)	(62.96)	(0.04)	(4.39)
Observations	605	605	605	605	605
Mean of Dep Variable T=0	478.75	6.28	919.63	6.89	0.70
Round 2					
Treatment Apprentices	51.18**	0.12**	59.87*	0.11**	11.59***
	(22.54)	(0.05)	(32.52)	(0.04)	(2.21)
Observations	652	652	652	652	652
Mean of Dep Variable T=0	328.68	5.96	565.29	6.48	1.52
Round 3					
Treatment Apprentices	-13.29	0.01	-51.08	0.01	15.91***
	(32.54)	(0.07)	(57.00)	(0.06)	(3.39)
Observations	629	629	629	629	629
Mean of Dep Variable T=0	423.49	6.23	833.81	6.89	2.63
Round 4					
Treatment Apprentices	17.97	0.11	66.79	0.19**	18.91***
	(28.22)	(0.08)	(63.27)	(0.08)	(6.22)
Observations	571	571	571	571	571
Mean of Dep Variable T=0	244.25	5.48	493.48	6.27	1.53

Notes: Regressions include round fixed effects, district fixed effects, trade fixed effects, and dummies for each probability distribution. Regressions in Columns (1) through (4) include the baseline value of the dependent variable. Profits are self-reports of all sales less all expenses (including the wage bill) in the reported month. Profits, sales, and wages are in April 2013 Ghana Cedis, when 1 US dollar was equivalent to 1.95 Ghana Cedis. The top 0.5% of profit and sales observations have been winsorized. Standard errors in parentheses are clustered at the district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7: **Long Term Treatment Effects Adjusted for Capital Grants**

	Four Rounds Pooled		Round 3		Round 4	
	(1)	(2)	(3)	(4)	(5)	(6)
	Profits	IHS	Profits	IHS	Profits	IHS
	(GHC)	Profits	(GHC)	Profits	(GHC)	Profits
Treatment Apprentices	18.29	0.07	-15.69	-0.01	14.77	0.07
	(11.97)	(0.04)	(32.40)	(0.07)	(28.46)	(0.10)
Observations	2457	2457	629	629	571	571
Mean of Dep Variable T=0	369.90	5.99	422.93	6.22	243.44	5.48

Notes: Regressions include round fixed effects, district fixed effects, trade fixed effects, and dummies for each probability distribution. Regressions in Columns (1) through (4) include the baseline value of the dependent variable. Standard errors in parentheses are clustered at the district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A8: **Spillovers**

	(1) Profits (GHC)	(2) IHS Profits	(3) Revenues (GHC)	(4) IHS (Revenues
Treatment Apprentices	27.99	0.15**	55.91	0.13**
	(18.66)	(0.06)	(46.88)	(0.05)
Program Apprentices Assigned within 1km	1.78	-0.02	7.87	-0.02
	(13.99)	(0.02)	(26.53)	(0.03)
Number Firms within 1km	4.56	0.02	2.24	0.03
	(10.06)	(0.03)	(16.22)	(0.03)
Observations	975	975	975	975
Mean of Dep Variable	394.64	6.07	743.08	6.65
Treatment Apprentices	34.31	0.14**	60.96	0.12*
	(21.60)	(0.06)	(48.44)	(0.06)
Program Apprentices Assigned within 3km	9.58	-0.03	11.53	-0.04
	(19.04)	(0.03)	(32.84)	(0.03)
Number Firms within 3km	-5.54	0.03	-5.24	0.03
	(13.77)	(0.03)	(22.18)	(0.02)
Observations	975	975	975	975
Mean of Dep Variable	394.64	6.07	743.08	6.65
Treatment Apprentices	34.09	0.14**	66.34	0.11*
	(22.64)	(0.06)	(49.58)	(0.06)
Program Apprentices Assigned within 5km	8.82	-0.03	18.34	-0.04
	(18.93)	(0.03)	(31.81)	(0.03)
Number Firms within 5km	-7.14	0.03	-10.79	0.03
	(13.06)	(0.02)	(21.04)	(0.02)
Observations	975	975	975	975
Mean of Dep Variable	394.64	6.07	743.08	6.65

Notes: Regressions include round fixed effects, district and trade fixed effects, dummies for each probability distribution, and baseline values of the dependent variable. Profits are self-reports of all sales less all expenses (including the wage bill) in the reported month. Profits and sales are in April 2013 Ghana Cedis, when 1 US dollar was equivalent to 1.95 Ghana Cedis. The top 0.5% of profit and sales observations have been winsorized. *Number of firms within x km* includes firms in the effective sample within a x km radius, by trade, pooling the three skilled construction trades to match the implementation of the matching meetings. *Program Apprentices Assigned within x km* is the total number of program apprentices assigned to firms in the sample within that range and matching meeting trade group. Seven of 32 districts are missing a large share of GPS observations due to connectivity issues in the field and thus all firms from those districts are excluded from these regressions. Standard errors in parentheses are clustered at the district level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A9: **Correlations - Expected Earnings and Ability Indices**

	(1) Expected Wages (GHC) if Complete Apprenticeship	(2) Implied Perceived Return to Apprenticeship (GHC)
Cognitive Index z-score	10.98*	5.76*
	(5.58)	(3.12)
Non-Cognitive Index z-score	10.81*	4.46
	(5.86)	(4.26)
Observations	2280	2277
Mean of Dep Variable	156.95	49.30

Notes: Outcomes and regressors come from the apprentice baseline survey. Regressions include district and trade fixed effects. *Expected Wages* and *Implied Perceived Returns* are in April 2013 Ghana Cedis, when 1 US dollar was equivalent to 1.95 Ghana Cedis. *Implied Perceived Returns* is constructed as the difference between expected wages conditional on completing an apprenticeship and expected wages conditional on not completing an apprenticeship. The cognitive index includes performance on a Ravens test, a Digits Forward test, an English vocabulary test, and a math word problem test. The non-cognitive index includes a Rotter Locus of Control measure and a Rosenberg self-esteem measure. Both indices are normalized sums of the normalized scores on each of the individual tests.

Table A10: **Correlations Relevant to Model**

	Revenues (GHC)	Wages (GHC)	Cognitive Index z-score	Non-Cognitive Index z-score
Revenues (GHC)	1.00			
Wages (GHC)	0.21***	1.00		
Cognitive Index z-score	0.07**	0.10***	1.00	
Non-Cognitive Index z-score	0.02	0.01	0.07*	1.00

Notes: The correlation matrix includes data from the first two follow up surveys. Revenues and wages are in April 2013 Ghana Cedis, when 1 US dollar was equivalent to 1.95 Ghana Cedis. The top 0.5% of revenues have been winsorized. The cognitive index includes performance on a Ravens test, a Digits Forward test, an English vocabulary test, and a math word problem test. The non-cognitive index includes a Rotter Locus of Control measure and a Rosenberg self-esteem measure. Both indices are normalized sums of the normalized scores on each of the individual tests.

Figure A1: **Sample Districts.** The map highlights the 32 sample districts included in the study, which include Kumasi Metropolitan and Accra Metropolitan, the two largest urban centers. The sample also includes many very rural (and poor) districts. The government program was slated to take place in about half of the districts in Ghana, and the evaluation districts are a population weighted random subset of those.
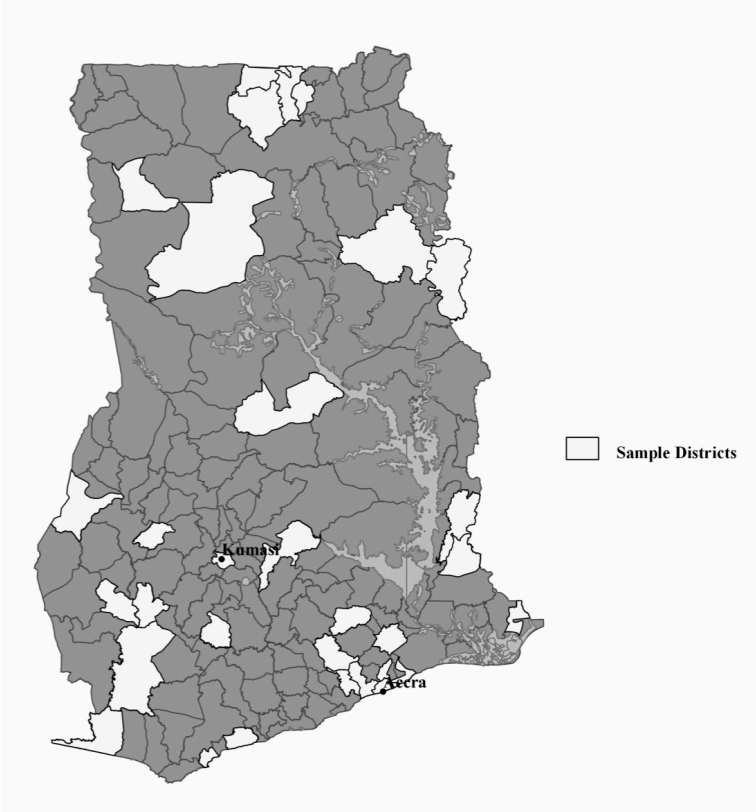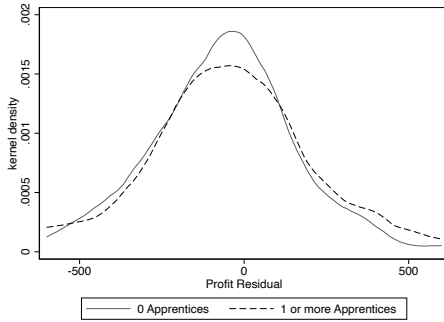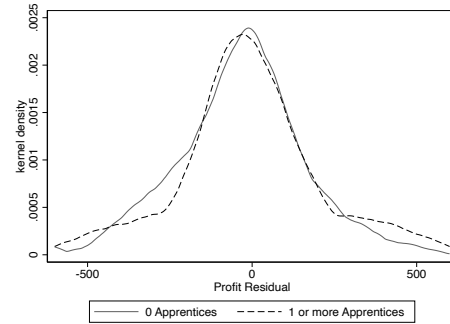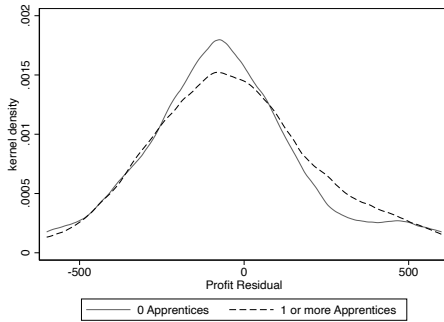
(a) Rounds 1 and 2 Pooled p = .18
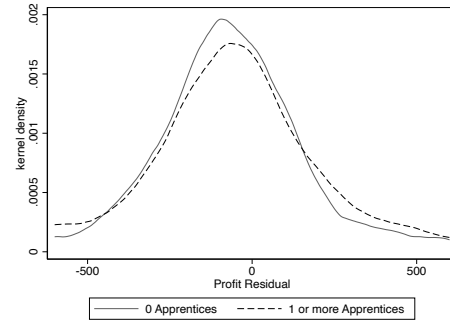
(b) Four Rounds Pooled p = .09
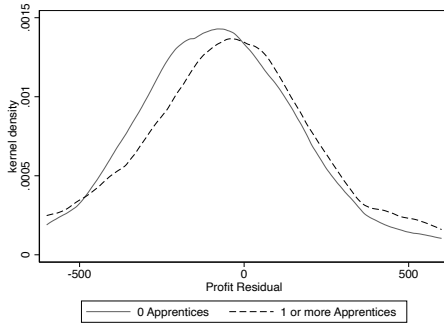
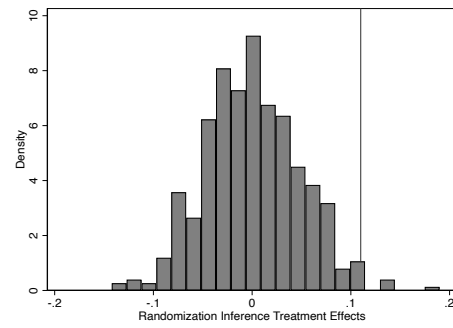(c) Round 1 p = .35

(d) Round 2 p = .48

(e) Round 3 p = .63
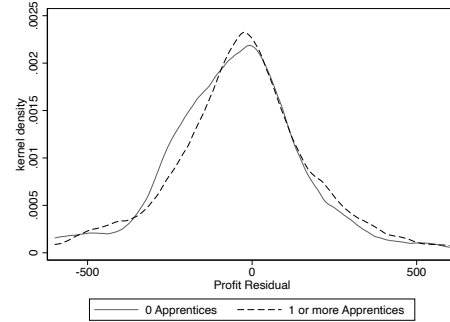
(f) Round 4 p = .58

Figure A2: **Residual Profit Distributions** Residual profits are estimated by regressing winsorized profits on round fixed effects, district fixed effects, trade fixed effects, dummies for each probability distribution, and the baseline value of the dependent variable. Firms assigned any positive number of apprentices are lumped together to make the distributions easier to visualize. P-values from a Kolmogorov-Smirnov test of the equality of distributions are reported for each sub-figure.
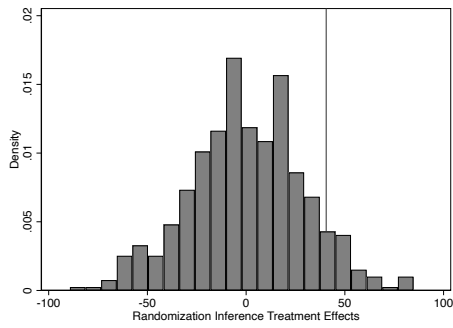
(a) Profits (GHC), RI p-value = .09   (b) IHS Profits, RI p-value = .01

Figure A3: **Randomization Inference** Simulated treatment effects come from 500 simulated treatment assignments (measured as number of simulated assigned apprentices), following the apprentice-level randomization procedure. Profits are self-reports of all sales less all expenses (including the wage bill) in the reported month and are in April 2013 Ghana Cedis, when 1 US dollar was equivalent to 1.95 Ghana Cedis. The top 0.5% of profit observations have been winsorized.