

# Online Appendix to “Measuring Firm-level Inefficiencies in the Ghanaian Manufacturing Sector”

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August 17, 2016

## **Abstract**

This document presents additional results for the paper "Measuring Firm-level Inefficiencies in the Ghanaian Manufacturing Sector." This document is not intended for publication.

# 1 Alternative depreciation rates

The results in the paper followed Bigsten et al. (2005) in assuming a 6% depreciation rate. There are other figures used in the literature: Söderbom and Teal (2004) and Frazer (2005) use 2%, which is also the figure originally used by the survey team in their construction of the capital stock variable. Some of the rates used for other countries are larger (see Schündeln, 2013).

The choice of the depreciation rate matters at several different stages. First, it affects the computed values of firm's capital stock. Second, the capital stock variable in turn affects the production function parameter estimates. Third, the optimal input combination and gap values are affected by both the capital stock and the production function parameters, as well as directly by the chosen depreciation rate.

To check the sensitivity of the findings to alternative depreciation rates, Table 1 presents production function estimates using alternatively a 2% and a 10% depreciation rate. Tables 2 and 3 show the corresponding correlations between input gaps, productivity, and firm characteristics. Remarkably these correlations always follow the same patterns as those discussed in the main text (Table 11).

Table 1: Gross output production function estimates using different depreciation rates

	Food / Bakery / Alcohol			Furniture / Wood		
	(1)	(2)	(3)	(1)	(2)	(3)
Capital	0.124*** (0.015)	0.128*** (0.016)	0.127*** (0.016)	0.047* (0.027)	0.058** (0.027)	0.068** (0.027)
Material	0.818*** (0.026)	0.808*** (0.026)	0.794*** (0.026)	0.829*** (0.041)	0.825*** (0.040)	0.821*** (0.043)
Worker	0.098* (0.051)	0.106** (0.053)	0.123** (0.055)	0.170*** (0.056)	0.165*** (0.055)	0.157*** (0.058)
Age	0.054 (0.038)	0.063 (0.039)	0.073* (0.039)	0.297*** (0.063)	0.283*** (0.061)	0.264*** (0.058)
Returns to scale	1.040	1.042	1.044	1.046	1.048	1.046
p-value	0.081	0.099	0.092	0.077	0.061	0.052
Hansen J statistic	41.373	42.185	43.055	23.742	23.303	22.576
p-value	0.124	0.108	0.092	0.361	0.385	0.426
N	381	381	381	461	461	461
	Garment / Textiles			Machines / Metal		
	(1)	(2)	(3)	(1)	(2)	(3)
Capital	0.086*** (0.018)	0.088*** (0.019)	0.089*** (0.020)	0.163*** (0.048)	0.149*** (0.046)	0.129*** (0.042)
Material	0.698*** (0.028)	0.700*** (0.029)	0.703*** (0.031)	0.808*** (0.040)	0.805*** (0.042)	0.804*** (0.044)
Worker	0.259*** (0.041)	0.250*** (0.043)	0.244*** (0.044)	0.052 (0.083)	0.075 (0.083)	0.101 (0.084)
Age	0.066 (0.050)	0.066 (0.049)	0.057 (0.049)	0.034 (0.040)	0.035 (0.039)	0.032 (0.039)
Returns to scale	1.043	1.038	1.036	1.023	1.029	1.034
p-value	0.175	0.241	0.250	0.580	0.456	0.399
Hansen J statistic	34.793	36.221	36.944	25.751	25.834	25.725
p-value	0.211	0.167	0.148	0.313	0.309	0.314
N	369	369	369	391	391	391

*Notes:* Columns (1), (2), and (3) use depreciation rates of 2, 6, 10 percent, respectively. Gross output (revenues deflated with firm-specific price deflators) production function parameter estimates obtained using the Wooldridge extension of the Levinsohn-Petrin procedure. The estimation controls for three ownership dummies. Robust standard errors clustered at the firm level in parentheses. The specification corresponds to column (4) in Table 5 in the paper (labor is treated as a state variable, exit and material price differences are accounted for). Returns to scale is the sum of the capital, material, and labor coefficients; the corresponding p-value is for the null that the sum of these is equal to 1. Hansen's J statistic is a test of the overidentifying restrictions. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

Table 2: Gap measures, productivity, and firm characteristics using 2 percent depreciation

	Gap for Capital	Gap for Material	Gap for Labor	Productivity
State owned	-0.167 (0.455)	0.290 (0.462)	74.345 (86.754)	0.104 (0.121)
Private Ghanaian	0.172 (0.157)	-0.524 (0.339)	-62.201 (41.487)	-0.148** (0.060)
Dummy for firms with formal loans	-0.207* (0.111)	-0.172 (0.134)	72.647*** (25.402)	-0.017 (0.033)
Dummy for firms with informal loans	0.040 (0.238)	-0.011 (0.129)	-36.890* (21.647)	-0.003 (0.030)
Management workers as a share of all workers	-0.006 (0.019)	-0.020* (0.011)	-2.169 (1.809)	-0.006** (0.003)
Workers' average years of education	-0.095** (0.042)	0.089*** (0.026)	-3.594 (3.998)	0.015** (0.007)
Workers' average age	-0.035*** (0.012)	0.016 (0.011)	0.819 (1.548)	0.001 (0.003)
Unionization	-0.045 (0.174)	0.071 (0.284)	75.871** (37.693)	0.010 (0.052)
Percentage of output exported within Africa	-0.004 (0.002)	-0.005*** (0.002)	0.561 (0.426)	-0.001** (0.000)
Percentage of output exported outside Africa	0.011 (0.017)	-0.008* (0.005)	1.652 (1.059)	-0.001 (0.001)
Percentage of raw materials imported	0.004 (0.002)	-0.003 (0.004)	0.522 (0.680)	-0.000 (0.001)

*Notes:* Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include location, industry, and year indicators. Gaps are computed as described in Section 6.1 in the paper using the gross output production function parameter estimates from Table 5 column (4). Input prices are the firm-level prices observed in the data. Productivity refers to the transmitted component of the productivity term ( $\omega_{it}$ ). All values are in 1991 Ghanaian Cedis.  $N = 1175$ . Estimated gap values were winsorized by 2.5 percent on both tails. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

Table 3: Gap measures, productivity, and firm characteristics using 10 percent depreciation

	Gap for Capital	Gap for Material	Gap for Labor	Productivity
State owned	-0.060 (0.628)	0.314 (0.442)	17.449 (85.661)	0.119 (0.122)
Private Ghanaian	0.315 (0.213)	-0.519 (0.336)	-52.159 (44.310)	-0.127** (0.059)
Dummy for firms with formal loans	-0.428*** (0.156)	-0.171 (0.131)	65.270** (27.020)	-0.022 (0.032)
Dummy for firms with informal loans	0.043 (0.336)	-0.041 (0.126)	-47.744** (21.143)	-0.007 (0.027)
Management workers as a share of all workers	-0.011 (0.027)	-0.018* (0.010)	-1.964 (2.043)	-0.006** (0.003)
Workers' average years of education	-0.148** (0.060)	0.084*** (0.026)	-1.332 (4.075)	0.013** (0.006)
Workers' average age	-0.050*** (0.016)	0.018* (0.011)	-0.963 (1.496)	0.001 (0.002)
Unionization	-0.208 (0.251)	0.048 (0.281)	91.988** (39.001)	0.004 (0.052)
Percentage of output exported within Africa	-0.005 (0.003)	-0.005*** (0.002)	0.444 (0.412)	-0.001** (0.000)
Percentage of output exported outside Africa	0.017 (0.023)	-0.008* (0.005)	1.588* (0.940)	-0.000 (0.001)
Percentage of raw materials imported	0.003 (0.003)	-0.002 (0.004)	0.461 (0.625)	-0.000 (0.001)

*Notes:* Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include location, industry, and year indicators. Gaps are computed as described in Section 6.1 in the paper using the gross output production function parameter estimates from Table 5 column (4). Input prices are the firm-level prices observed in the data. Productivity refers to the transmitted component of the productivity term ( $\omega_{it}$ ). All values are in 1991 Ghanaian Cedis.  $N = 1175$ . Estimated gap values were winsorized by 2.5 percent on both tails. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

## 2 Alternative production functions

I begin by using the same production function specification as in the main text but estimate it using either OLS or OLS with firm and year fixed effects. As in the paper, I estimate a separate production function for each industry. Regressions using the resulting gap measures are presented in Table 4 and 5. A drawback of the OLS estimates is that the capital coefficient can become negative. I find this to be the case for one industry in the sample (machines / metal), and firms in this industry are therefore omitted from the regressions. The qualitative findings on formal loans, human capital and unionization are similar to those discussed in the paper, although some of the coefficients are imprecisely estimated in these regressions.

To relax the Cobb-Douglas assumption on the elasticity of output with respect to individual inputs, I consider a translog specification of the form

$$y_{it} = \sum_j \beta_j x_{it}^j + \sum_{j,k} \beta_{jk} x_{it}^j x_{it}^k + \varepsilon_{it}$$

for firm  $i$  in year  $t$ . The terms  $x^j$  include capital, labor, materials, and the firm's age. In this specification, the elasticity of substitution between inputs is not restricted to be 1. I estimate this specification separately for each industry and include firm and year fixed effects. The regressions in Table 6 use the gap measures resulting from this specification, and confirm the main patterns discussed in the paper.

Table 4: Gap measures, productivity, and firm characteristics using OLS production function estimates

	Gap for Capital	Gap for Material	Gap for Labor	Productivity
State owned	-0.140 (0.288)	-0.027 (0.087)	-58.947 (611.216)	-0.083 (0.144)
Private Ghanaian	0.164 (0.151)	0.008 (0.058)	-17.511 (280.765)	0.021 (0.078)
Dummy for firms with formal loans	-0.176 (0.138)	-0.016 (0.035)	326.197** (142.554)	0.128** (0.053)
Dummy for firms with informal loans	0.206 (0.329)	0.043 (0.041)	-97.724 (116.484)	-0.001 (0.067)
Management workers as a share of all workers	0.012 (0.021)	-0.001 (0.003)	2.084 (11.762)	0.006 (0.004)
Workers' average years of education	-0.064 (0.043)	0.007 (0.006)	-33.651 (29.930)	-0.020** (0.009)
Workers' average age	-0.051*** (0.014)	0.005* (0.003)	-11.400 (8.436)	-0.001 (0.004)
Unionization	-0.021 (0.198)	-0.056 (0.057)	730.702*** (250.458)	0.163* (0.091)
Percentage of output exported within Africa	-0.004 (0.003)	0.000 (0.000)	5.349** (2.284)	0.001 (0.001)
Percentage of output exported outside Africa	0.019 (0.023)	-0.002 (0.001)	13.864** (6.847)	0.006** (0.003)
Percentage of raw materials imported	-0.001 (0.003)	0.001 (0.001)	0.155 (2.702)	0.002* (0.001)

*Notes:* Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include location, industry, and year indicators. Gaps are computed as described in Section 6.1 using OLS gross output production function parameter estimates. Input prices are the firm-level prices observed in the data. Productivity refers to the transmitted component of the productivity term ( $\omega_{it}$ ). All values are in 1991 Ghanaian Cedis. N = 1175. Estimated gap values were winsorized by 2.5 percent on both tails. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

Table 5: Gap measures, productivity, and firm characteristics using OLS production function estimates with firm and year fixed effects

	Gap for Capital	Gap for Material	Gap for Labor	Productivity
State owned	-0.268 (0.246)	0.122 (0.197)	178.982 (250.237)	0.180 (0.233)
Private Ghanaian	0.303 (0.197)	0.084 (0.140)	151.759* (91.181)	0.166 (0.112)
Dummy for firms with formal loans	-0.233* (0.137)	-0.047 (0.093)	82.667* (46.364)	0.142** (0.062)
Dummy for firms with informal loans	0.326 (0.291)	-0.031 (0.081)	-61.576 (49.652)	-0.054 (0.071)
Management workers as a share of all workers	-0.011 (0.025)	0.000 (0.005)	-2.071 (5.267)	-0.002 (0.005)
Workers' average years of education	-0.151*** (0.050)	0.007 (0.012)	-4.619 (10.074)	-0.023* (0.012)
Workers' average age	-0.018 (0.011)	0.005 (0.005)	1.110 (3.587)	0.005 (0.005)
Unionization	-0.273 (0.207)	0.111 (0.143)	126.379 (91.959)	0.177 (0.125)
Percentage of output exported within Africa	-0.003 (0.002)	-0.001 (0.001)	1.573 (1.001)	0.001 (0.001)
Percentage of output exported outside Africa	-0.002 (0.005)	-0.001 (0.003)	2.819 (2.122)	0.004* (0.002)
Percentage of raw materials imported	0.003 (0.003)	0.003 (0.002)	0.297 (0.841)	0.002 (0.002)

*Notes:* Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include location, industry, and year indicators. Gaps are computed as described in Section 6.1 using OLS gross output production function parameter estimates with firm and year fixed effects. Input prices are the firm-level prices observed in the data. Productivity refers to the transmitted component of the productivity term ( $\omega_{it}$ ). All values are in 1991 Ghanaian Cedis. N = 1175. Estimated gap values were winsorized by 2.5 percent on both tails. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.



Table 6: Gap measures, productivity, and firm characteristics using translog production function estimates

	Gap for Capital	Gap for Material	Gap for Labor	Productivity
State owned	-0.094 (0.267)	0.179 (0.146)	233.565 (213.569)	0.051 (0.472)
Private Ghanaian	0.064 (0.117)	0.052 (0.064)	-21.153 (92.673)	0.237 (0.255)
Dummy for firms with formal loans	-0.156 (0.100)	-0.051 (0.047)	97.393** (45.292)	0.186 (0.121)
Dummy for firms with informal loans	0.130 (0.227)	0.015 (0.047)	-1.676 (45.677)	0.024 (0.124)
Management workers as a share of all workers	0.014 (0.016)	0.004 (0.004)	2.305 (4.244)	0.003 (0.011)
Workers' average years of education	-0.055* (0.028)	0.013* (0.007)	-5.496 (9.571)	0.024 (0.022)
Workers' average age	-0.030*** (0.010)	0.002 (0.003)	-0.560 (3.212)	0.013 (0.008)
Unionization	-0.038 (0.149)	0.070 (0.080)	276.998*** (86.290)	0.364** (0.184)
Percentage of output exported within Africa	-0.002 (0.002)	-0.000 (0.001)	2.070** (0.845)	-0.002 (0.002)
Percentage of output exported outside Africa	0.016 (0.016)	-0.002 (0.002)	2.078 (1.923)	0.002 (0.005)
Percentage of raw materials imported	-0.002 (0.002)	0.001 (0.001)	-0.404 (0.713)	0.003 (0.003)

*Notes:* Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include location, industry, and year indicators. Gaps are computed as described in Section 6.1 using the parameters of a translog production function estimated with OLS including firm and year fixed effects. Input prices are the firm-level prices observed in the data. Productivity refers to the transmitted component of the productivity term ( $\omega_{it}$ ). All values are in 1991 Ghanaian Cedis. N = 1175. Estimated gap values were winsorized by 2.5 percent on both tails. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

### 3 Additional tables

Table 7: Underutilization measures and firm characteristics including firm size variables

	Capital	Material	Labor
State owned	-0.852 (1.052)	-0.010 (0.102)	0.040 (0.595)
Private Ghanaian	0.843 (0.553)	-0.104 (0.088)	-0.312 (0.217)
Dummy for firms with formal loans	-0.972** (0.408)	-0.101*** (0.038)	0.363*** (0.140)
Dummy for firms with informal loans	0.394 (1.002)	0.038 (0.058)	-0.155** (0.074)
8-21 employees	0.575 (1.025)	-0.032 (0.060)	-0.010 (0.084)
22-57 employees	-1.933** (0.911)	0.181** (0.078)	-0.114 (0.118)
More than 58 employees	-1.060 (0.906)	0.025 (0.098)	0.191 (0.167)
Management workers as a share of all workers	-0.008 (0.076)	0.002 (0.004)	0.000 (0.011)
Workers' average years of education	-0.244 (0.154)	0.028*** (0.008)	-0.014 (0.014)
Workers' average age	-0.139** (0.059)	0.002 (0.003)	-0.004 (0.006)
Unionization	0.461 (0.750)	-0.061 (0.090)	0.306** (0.149)
Percentage of output exported within Africa	-0.019** (0.009)	-0.001 (0.001)	0.005** (0.002)
Percentage of output exported outside Africa	0.136 (0.136)	-0.003 (0.002)	0.005 (0.003)
Percentage of raw materials imported	0.007 (0.008)	-0.000 (0.001)	-0.000 (0.003)

*Notes:* N = 1299. Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include year, location and industry indicators. Underutilization measures are computed as described in Section 6.1 using the gross output production function parameter estimates from Table 5 column (4) for each industry. All input prices are set equal across firms, equal to the average observed prices in the data. The price of labor is based on wages. All values are in 1991 Ghanaian Cedis. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

Table 8: Marginal value product of capital, conditional on the full production function residual

Parameter estimates	Mean	Median	Std.	10%	90%	N
<i>Firms with formal loans</i>						
Lower bound	0.329	0.055	0.883	0.003	0.725	422
Mean	0.605	0.135	1.471	0.025	1.578	422
Upper bound	0.896	0.211	2.198	0.045	2.301	422
<i>Firms with formal or informal loans</i>						
Lower bound	0.552	0.088	1.282	0.004	1.344	583
Mean	1.036	0.196	2.182	0.031	2.425	583
Upper bound	1.530	0.292	3.215	0.050	3.449	583
<i>All firms</i>						
Lower bound	0.792	0.128	1.501	0.005	2.399	1602
Mean	1.483	0.374	2.596	0.033	4.437	1602
Upper bound	2.195	0.579	3.865	0.054	6.624	1602

*Notes:* The table reports summary statistics for the estimated marginal value product of capital (MVPK) for three groups of firms. MVPK is computed as described in Section 6.1, using estimates from Table 5 column (4) for each industry. In the first column, 'Mean' uses the point estimates for the capital coefficient to compute the MVPK. 'Lower bound' and 'Upper bound' uses, respectively, the lower and upper bound of the 95 percent confidence intervals on the parameter estimate. Estimated MVPK values were winsorized by 2.5 percent on both tails before computing the summary statistics. All values are in 1991 Ghanaian Cedis.

Table 9: Gap measures, productivity, and firm characteristics, conditioning on the full production function residual

	Gap for Capital	Gap for Material	Gap for Labor	Productivity
State owned	-0.546 (0.372)	0.314 (0.351)	21.535 (99.117)	0.080 (0.111)
Private Ghanaian	0.252 (0.210)	-0.139 (0.219)	-57.081 (43.942)	-0.027 (0.051)
Dummy for firms with formal loans	-0.372** (0.154)	-0.141 (0.126)	40.019 (27.798)	0.012 (0.039)
Dummy for firms with informal loans	0.083 (0.327)	0.065 (0.141)	-46.316* (24.227)	0.008 (0.045)
Management workers as a share of all workers	-0.000 (0.026)	-0.002 (0.010)	-1.205 (2.086)	-0.000 (0.003)
Workers' average years of education	-0.176*** (0.068)	0.052** (0.023)	-4.916 (4.532)	-0.002 (0.006)
Workers' average age	-0.052*** (0.018)	0.015 (0.010)	-0.198 (1.789)	0.002 (0.003)
Unionization	-0.056 (0.230)	0.265 (0.212)	100.367** (43.963)	0.062 (0.062)
Percentage of output exported within Africa	-0.006** (0.003)	-0.003* (0.002)	0.456 (0.445)	-0.000 (0.001)
Percentage of output exported outside Africa	0.020 (0.024)	-0.003 (0.004)	1.868 (1.135)	0.001 (0.001)
Percentage of raw materials imported	0.005 (0.004)	0.005 (0.003)	0.416 (0.637)	0.002 (0.001)

*Notes:* Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include location, industry, and year indicators. Gaps are computed as described in Section 6.1 using the gross output production function parameter estimates from Table 5 column (4). Input prices are the firm-level prices observed in the data. Productivity refers to the full production function residual. All values are in 1991 Ghanaian Cedis. N = 1175. Estimated gap values were winsorized by 2.5 percent on both tails. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

Table 10: Gap measures, productivity, and firm characteristics, using an alternative wage measure

	Gap for Capital	Gap for Material	Gap for Labor	Productivity
State owned	-0.148 (0.561)	0.294 (0.452)	-77.639 (86.679)	0.107 (0.123)
Private Ghanaian	0.236 (0.183)	-0.526 (0.336)	-89.334** (39.215)	-0.140** (0.060)
Dummy for firms with formal loans	-0.339*** (0.128)	-0.148 (0.129)	17.753 (24.054)	-0.021 (0.031)
Dummy for firms with informal loans	0.067 (0.279)	-0.068 (0.117)	-44.760** (19.176)	-0.006 (0.028)
Management workers as a share of all workers	-0.010 (0.021)	-0.015 (0.011)	2.979 (2.052)	-0.005* (0.003)
Workers' average years of education	-0.121** (0.048)	0.078*** (0.025)	7.841** (3.221)	0.013** (0.006)
Workers' average age	-0.045*** (0.014)	0.014 (0.010)	1.156 (1.549)	0.000 (0.002)
Unionization	-0.053 (0.209)	0.061 (0.276)	51.345 (32.052)	0.010 (0.051)
Percentage of output exported within Africa	-0.005* (0.003)	-0.005*** (0.002)	0.252 (0.377)	-0.001** (0.000)
Percentage of output exported outside Africa	0.011 (0.020)	-0.006 (0.005)	0.762 (1.314)	-0.000 (0.001)
Percentage of raw materials imported	0.004 (0.003)	-0.002 (0.004)	0.335 (0.623)	-0.000 (0.001)

*Notes:* Each column corresponds to a separate regression with the dependent variable listed in the column heading. Regressions include location, industry, and year indicators. Gaps are computed as described in Section 6.1 using the gross output production function parameter estimates from Table 5 column (4). Input prices are the firm-level prices observed in the data. Productivity refers to the transmitted component of the productivity term ( $\omega_{it}$ ). All values are in 1991 Ghanaian Cedis. N = 1175. Estimated gap values were winsorized by 2.5 percent on both tails. Standard errors clustered by firm in parentheses. \* significant at 10 percent, \*\* significant at 5 percent, \*\*\* significant at 1 percent.

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