

Why do more productive firms pay workers more? Evidence from Egypt

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International
Journal of
Manpower

101

Received 20 June 2025
Revised 20 December 2025
Accepted 4 February 2026

Abstract

Purpose – This paper aims to investigate the wage-productivity relationship at the firm level in Egypt. It quantifies the relative role of factors related to the use of efficiency wages (paying higher than market wages to improve worker quality, effort and retention) on the part of employers versus ones associated with rent sharing (sharing profits due to market power) in the context of imperfectly competitive product markets.

Design/methodology/approach – The paper uses the 2017/18 Egypt Economic Census firm-level data to estimate multivariate regressions quantifying the relationship between wages and productivity, as well as what firm, industry and worker characteristics mediate that relationship. Analyses use a Shapley decomposition to estimate the relative contributions of imperfect competition versus efficiency wage explanations.

Findings – Results indicate that the positive wage-productivity association is more so due to the use of efficiency wages by employers, but imperfect competition still plays an important role.

Originality/value – Understanding the drivers of the wage-productivity relationship is critical for designing effective economic policy in Egypt and other low- and middle-income countries. The findings indicate increasing competition among firms and addressing incentive and information issues are therefore both important components to creating a more dynamic labor market and efficient economy.

Keywords Wages, Productivity, Firms, Egypt

Paper type Research article

1. Introduction

Despite the prediction of the classical competitive model of the labor market that worker wages should not be tied to productivity at the firm level, empirical studies generally show that wages are positively correlated with productivity. A meta-analysis estimates the wage elasticity of production at 0.325 (Peach and Stanley, 2009). This paper examines why more productive firms pay their workers more using data from Egypt. Specifically, by analyzing the drivers of the wage-productivity nexus, it quantifies the relative roles of efficiency wages in labor markets and imperfect competition in product markets.

Efficiency wages occur when workers' productivity depends on the real wage paid by the firm. Such a productivity-wage relationship may exist when there is imperfect information about worker quality or worker effort, when there are costs associated with worker turnover, or when higher wages raise worker morale and thus their productivity (Bryson *et al.*, 2011; Yellen, 1984). Alternatively, firms may be operating in imperfectly competitive product markets, such that they earn excess profits and can potentially share some of this "rent" via workers' wages (Monteiro *et al.*, 2011; Parente and Prescott, 1999).

Thus, efficiency wages and rent-sharing in imperfectly competitive markets are alternative explanations for why more productive firms may pay their workers more

JEL Classification — D22, D24, J31

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Funding: The authors acknowledge the support of the Economic Research Forum under the "Egypt Labor Demand Project."



International Journal of Manpower
Vol. 47 No. 10, 2026
pp. 101-132
Emerald Publishing Limited
e-ISSN: 1758-6577
p-ISSN: 0143-7720
DOI 10.1108/IJM-06-2025-0488

(Barth *et al.*, 2016). We distinguish between these two explanations by examining the characteristics of firms, industries and workers that mediate the wage-productivity nexus in Egypt. Characteristics related to potential rent-sharing include the degree of concentration in the firm's industry, as well as capital per worker, the legal form, and the formality of the firm. Characteristics related to potential efficiency wages include the use of skilled labor, the extent of training and supervision, incentive structures, and features such as firm size and age. We associate these characteristics with either efficiency wage or imperfect competition explanations as a way to determine the relative importance of each. Accordingly, our research questions are:

- (1) In which firms (old, high-skilled, highly concentrated, etc.) is the wage/productivity relationship particularly strong?
- (2) What are the relative roles of imperfect competition versus efficiency wage explanations in understanding the wage-productivity nexus in Egypt?

Egypt is an interesting setting to examine these questions. Almost two-thirds of overall employment and 78% of private wage employment in Egypt was informal in 2023 (Assaad and Mahmoud, 2024). Furthermore, nearly 60% of employment in private establishments, which are the focus of this paper, is in establishments of fewer than 25 workers (Assaad and Mahmoud, 2024). This predominance of small firms and employment informality suggests that strong social ties may exist between employers and their workers, leading to some willingness on the part of employers and workers to share risks in the face of fluctuating economic conditions, which may take the form of wage flexibility (Riveros and Bouton, 1994). Moreover, social bonds between workers and employers could potentially reduce worker mobility and turnover, thus allowing a link between wages and productivity.

Despite the overall predominance of small firms, some industries are dominated by a few large firms due to barriers to entry linked to cronyism and political connections, leading to a substantial degree of market power and the possibility of rent sharing (Artuç and Saleh, 2025; Diwan *et al.*, 2014). Besides the presence of a few very large firms, firm formality is costly and far from universal in Egypt, implying substantial barriers to entry for formal firms and, thus, the potential for them to reap economic rents (Krafft *et al.*, 2024).

The link between wages and productivity has been under-researched in Egypt due to data limitations and is generally understudied in developing countries [1]. Although linked employer-employee data is not available in Egypt, we use the Economic Census firm-level data from 2017/18, which includes detailed establishment-level characteristics as well as aggregate wage data for broad categories of workers, to estimate multivariate regressions quantifying the relationship between wages and productivity, as well as what firm, industry, and worker characteristics mediate that relationships. We use a Shapley decomposition to estimate the relative contributions of imperfect competition versus efficiency wage explanations. Shapley decomposition allows us to systematically quantify the contribution of individual or a group of potentially-correlated explanatory variables to the goodness of fit of a regression model. This approach avoids the arbitrariness associated with the stepwise introduction of various explanatory variables (Israeli, 2007). We find that while efficiency wages explain slightly more of the wage-productivity linkage, imperfect competition also plays a substantial role.

2. Literature review

2.1 Economic theory on wages and productivity

The basic idea of efficiency wage models is that workers' productivity depends on the wage they are paid. Firms may thus be able to increase profits by paying a wage that is above the market-clearing wage. Underlying the efficiency wage explanation are theoretical models that

posit heterogeneous workers and firms undertaking assortative matching. Efficiency wages therefore arise because there are labor market frictions, as well as principal-agent problems, in a context with imperfect information (Bryson *et al.*, 2011; Kaas and Kircher, 2015). Four specific explanations have been provided for this link between workers' productivity wages, namely: (1) imperfect information about worker quality (Weiss, 1980), (2) difficulty in monitoring worker effort (Antonietti *et al.*, 2017), (3) to reduce costs due to worker turnover (Stiglitz, 1974), and (4) to improve worker loyalty, morale and workplace culture (Akerlof, 1982).

The alternative explanation of the productivity-wage relationship is the degree of competition in labor and product markets. Either workers or firms could be acting in an imperfectly competitive market (McDonald and Solow, 1981; Parente and Prescott, 1999). For example, returns to scale may not be constant; this may be due to policies that make formality and thus greater scale more costly, or because formality (and access to formal credit) substantially raises productivity (McKenzie and Sakho, 2010). When firms are facing an imperfectly competitive market, they can capture rents, and may share these rents with workers (Monteiro *et al.*, 2011; Parente and Prescott, 1999). On the worker side, unions may affect productivity or rent-sharing (Budd *et al.*, 2014).

Empirical evidence on the wages and productivity link tends to focus on testing one hypothesis or one possible mediator at a time, such as research on why there is a firm size, wages, and productivity relationship (Heyman, 2007; Schmidt and Zimmermann, 1991). However, the relative roles of these myriad factors in determining wages have not been quantified and doing so can shed light on important aspects of wage-setting. We quantify the importance of efficiency wage (labor market) and imperfect competition (product market) explanations of the wage-productivity link for Egypt.

2.2 Labor markets in Egypt

Egypt is an ideal developing-country case study for assessing the relative roles of imperfect competition and efficiency wage explanations for the wage-productivity relationship. Lack of competition and informality are issues for Egypt's firms, as achieving formality has been identified as a challenge linked with corrupt practices (Diwan *et al.*, 2014; Fakh and Ghazalian, 2015). A focus on credentials over skills, as well as labor market mismatch, are key issues in Egypt (Assaad *et al.*, 2018), which may make worker quality difficult to observe on hire and contribute to efficiency wages. Despite repeated waves of economic reform, employment creation in Egypt is disconnected from typical markers of productivity (Krafft, 2024). Egypt remains stuck in a primarily labor-absorbing paradigm, with a large and growing informal sector but little structural change (Assaad *et al.*, 2020). Improving our understanding of the functioning of such labor markets is critical to understanding why Egypt and similar developing countries are unable to close the income gap with developed countries (Johnson and Papageorgiou, 2020).

3. Data

3.1 Survey and sample

The analysis uses the Egypt Economic Census of 2017/2018 (EC 2018) data (OAMDI, 2022) [2]. Although officially called a census, the data are in fact a sample [3]. We restrict our working sample to private sector establishments outside of agriculture. Private non-agricultural employment within establishments made up 33% of total employment in Egypt in 2018 [4].

While larger firms and certain sectors are universally included in the EC 2018 data, smaller firms in some sectors are randomly sampled. Weights are included to make the data nationally representative of establishments and account for the sampling design. Additionally, researchers are given access to only a 50% random sub-sample of the firms in the data,

covering 170,330 unique firms (establishments). We exclude firms that did not pay any wages in 2017/18 ($N = 50,634$ establishments) [5] or have negative value added (production) (a further $N = 6,911$ establishments) from our analyses [6]. We exclude public sector establishments ($N = 1,318$) and the few ($N = 3,263$) agricultural establishments. This ultimately results in a working sample of 108,204 firms.

We also draw on the Egypt Labor Market Panel Survey (ELMPS) 2018 data (OAMDI, 2019) [7] to merge in information on the industry-region-firm size level on workers' characteristics, such as whether workers received training or their average educational level in the relevant cell. We merge data for an equivalent sub-sample from the ELMPS: wage workers in private sector non-agricultural establishments [8].

Although linked employer-employee data are ideal to examine the link between wages and firm-level productivity, such data is not available in Egypt. Instead, we use aggregated wages for broad categories of workers at the establishment level, which limits our ability to observe differences in worker quality across establishments. We address this by linking data from the Economic Census 2018 to that of the ELMPS 2018, which has substantially more details about worker quality. Because these data are not linked at the firm level but at the level of industry-region-firm size cells, there may be further unobserved heterogeneity in worker quality within these cells. If higher-skilled workers tend to sort to more productive firms within the cells, the relationship between wages and productivity could potentially be biased upward.

3.2 Key variables: productivity and wages

The firm-level data allow us to quantify production and thus productivity, both in terms of value added per worker [9] (Y/L) and in terms of total factor productivity (TFP)—the residual after accounting for capital [10] and labor inputs. We estimate both Cobb-Douglas and translog specifications of TFP [11] and test the sensitivity of our results to the definition of productivity used. All three of these quantities are measures of firm productivity, or average worker productivity, not the productivity of specific, individual workers.

Cash wages, in-kind benefits, and social security payments are available in the EC 2018. We therefore present results for three measures of compensation: (1) cash wages, (2) total compensation (cash wages + social insurance + in-kind benefits) and (3) “formality adjusted” wages. “Formality adjusted” wages are calculated by doubling cash wages for formal workers, operationalized here as those who work for firms that pay social insurance, to reflect total compensation. The doubling is based on an estimate (Assaad, 1999) that total compensation for formally employed workers is about 1.9 times their wages [12]. All measures of compensation were available in 2018 Egyptian pounds and are measures of average annual compensation per wage worker.

3.3 Factors that may mediate the wage-productivity relationship

We are interested in understanding which factors link wages and productivity based on sharing of rents in imperfectly competitive markets and efficiency wages. In classifying variables as related to either imperfect competition or efficiency wages, we draw on the literature, with references in this section provided after the description of each variable that support our classification. To assess imperfect competition, we calculate concentration ratios (in percentage terms, based on the share of the four largest firms in the total value added in the two-digit industry), along with the Herfindahl-Hirschman Index (HHI, scaled from 0, perfect competition, to 10,000, perfect monopoly) (Diwan and Haidar, 2021). Firm formality (commercial registration or paying social insurance) may also be a relevant dimension of imperfect competition and is included in our estimation (Ulyssea, 2018). We also include log capital per worker as a measure of imperfectly competitive markets (McAfee et al., 2004) [13]. All of these measures are from the EC 2018 data. On the labor supply side of imperfectly competitive markets, we include a measure from the ELMPS on unionization (percentage of

workers in that industry-region-firm size cell that are unionized) (Budd *et al.*, 2014). Another aspect of competition is the legal structure of the firm (Salim *et al.*, 2025) [14].

Firm size (categorically) and firm age (categorically) are included as potential mediators of efficiency wages, addressing incentive issues in start-ups or supervision/shirking in different firm sizes (Boadway and Tremblay, 2003; Oi and Idson, 1999). Since many of the efficiency wage explanations center around issues of incentives and monitoring or shirking (Antonietti *et al.*, 2017), we merge data on the pay and incentive structure for workers from the ELMPS 2018. The measures include the percentage of workers with piece-rate wages, the percentage of workers with incentive pay or bonuses, and the percentage of workers that have temporary contracts, permanent contracts or no contracts at all. Supervision, including the percentage of workers who are supervisors and the number of employees they supervise is also an important aspect of examining shirking and is incorporated from the ELMPS 2018 as well at the industry-region-firm-size level.

Since turnover, and the costs of retraining, are an important explanation for efficiency wages (Stiglitz, 1974), we merge data at the industry-region-firm size level on mean tenure, namely the length of employment in years (to date), as a measure of turnover. We also merge in data on the percentage of workers who undertake training, the length of training (in weeks), the percentage with training that is employer-provided, and the percentage with training that is paid for by the employer. Since the level of skill is likely to affect the costs of turnover, and also directly affect wages, we include several measures of skill. Worker quality is also one potential driver of efficiency wages (Weiss, 1980), and while some aspects are observable, others may be unobservable (or correlated with observable ones) and contribute to efficiency wages. We calculate the percentage of workers in blue collar and white-collar occupations (the omitted category being professionals), and the percentage of workers reporting their job requires different education levels (basic, secondary, or higher education, with less than basic being omitted). We measure the percentage reporting specific skills required for jobs, such as literacy, math, computer, technical, and physical skills [15]. We also incorporate average test scores of workers in preparatory (lower secondary) exams as a measure of worker quality [16]. We expect that in industry-region-firm size cells where workers are more skilled, trained, or educated, turnover will be more expensive and therefore higher-productivity firms in these cells will pay efficiency wages to attract and retain the best workers. All continuous explanatory variables are standardized (mean of zero and standard deviation of one) in order to estimate the main effects of productivity at mean levels and to facilitate comparisons of different factors.

4. Methods

We initially present a descriptive analysis of the patterns of productivity and wages, their dispersion, and their relationship across firms. We present these descriptive relationships using local polynomials (local mean smoothing) with Epanechnikov kernels using the rule-of-thumb bandwidth estimator and present 95% confidence intervals around those estimates as well.

Our multivariate analyses are based on ordinary least squares regressions with various measures of compensation as the dependent variable. The key explanatory variables are productivity, either log average labor productivity (Y/L) or the Cobb-Douglas or translog TFP. Since TFP is itself estimated, we bootstrap the standard errors for our regression models (including for Y/L for comparability) [17]. We present our models, below, for compensation as average wages and productivity as, generically, “TFP.” The methods are identical for the various measures of compensation and productivity. Initially, we estimate a very simple model:

$$\ln(w_f) = \beta_0 + \beta_1 \text{TFP}_f + u_f \quad (1)$$

where w_f is the average wage per wage worker in firm f . Since TFP is productivity, β_1 is the relationship between wages and productivity. Specifically, $100 * \beta_1$ is the percentage change in wages for a standard deviation increase in productivity.

Our first research question investigates which firms have a particularly strong wage/productivity relationship. To answer this question, we add a series of controls (X_{jf}) to our model and then interact these with productivity:

$$\ln(w_f) = \beta_0 + \beta_1 TFP_f + \sum_j \beta_j X_{jf} + \sum_j \delta_j X_{jf} * TFP_f + u_f \quad (2)$$

Now β_1 is the relationship between wages and productivity for the reference firm, β_j are the main effects of firm characteristics on wages, and δ_j are the coefficients on the interactions. These interactions provide tests of specific mediators.

Since we are estimating a large number of main effects and interactions, standard errors may be inflated by multi-collinearity. We are also effectively conducting multiple hypothesis tests on our many coefficients. To simultaneously address both these issues, as well as summarize our multitude of results, we calculate Shapley decompositions of the R-squared for Eq. (2). [18] The Shapley decomposition can be used to quantify the contribution of individual variables or groups of potentially correlated variables to the model R-squared, while avoiding the arbitrariness of sequentially entering explanatory variable in a stepwise manner (Israeli, 2007). We assess the contributions of: (1) the main effect of productivity, (2) the main effects of imperfect competition variables, (3) the main effects of efficiency wage variables, (4) the interactions of imperfect competition variables with productivity, and (5) the interactions of efficiency wage variables with productivity [19]. The main effects control for the effects of the various groups of explanatory variables on wages, as well as for the main effect of productivity on wages, but the interactions allow us to gauge how the wage-productivity relationship varies with firm characteristics, which is the main objective of this paper.

All of these estimated relationships are associations. In the absence of panel data, we are unable to estimate causal models linking wages to productivity. Associations could be confounded by both reverse causality and unobserved heterogeneity. For example, it may be that imperfectly competitive, higher productivity firms share their rents with workers. Alternatively, it may be that higher wages attract more skilled workers who are more productive. Or some third, unobserved characteristics of the workers or the firms, perhaps some unobserved dimension of worker quality or variations in firm recruiting practices, may link the two measures. Although only associations can be observed, *which* associations hold can shed light on the potential reasons for the linkages.

5. Results

5.1 Relationship between compensation and productivity

We first assess the relationship across the different compensation and productivity measures in Figure 1. Wages per worker increase with value added per worker (productivity), at least up to a certain point, before leveling off at high levels of productivity. Essentially the same pattern holds for all three measures of compensation. There are similar patterns by the different TFP measures. Both, but especially the more flexible translog model, show wages declining a bit at high productivity levels. This decline may be due to the particular combinations of labor and capital used in high-productivity firms. Hereafter, we present figures for our preferred measure of productivity, the translog TFP. The TFP measure of productivity is preferred because it has accounted for capital as well as labor (unlike value added per worker) and the translog specification is preferred for its additional flexibility, which improves model fit.

To assess the strength of the relationship between compensation and productivity, we estimate a model with only compensation and productivity measures (Equation (1)). Figure 2 shows the results of these models, in terms of the coefficients on productivity and their

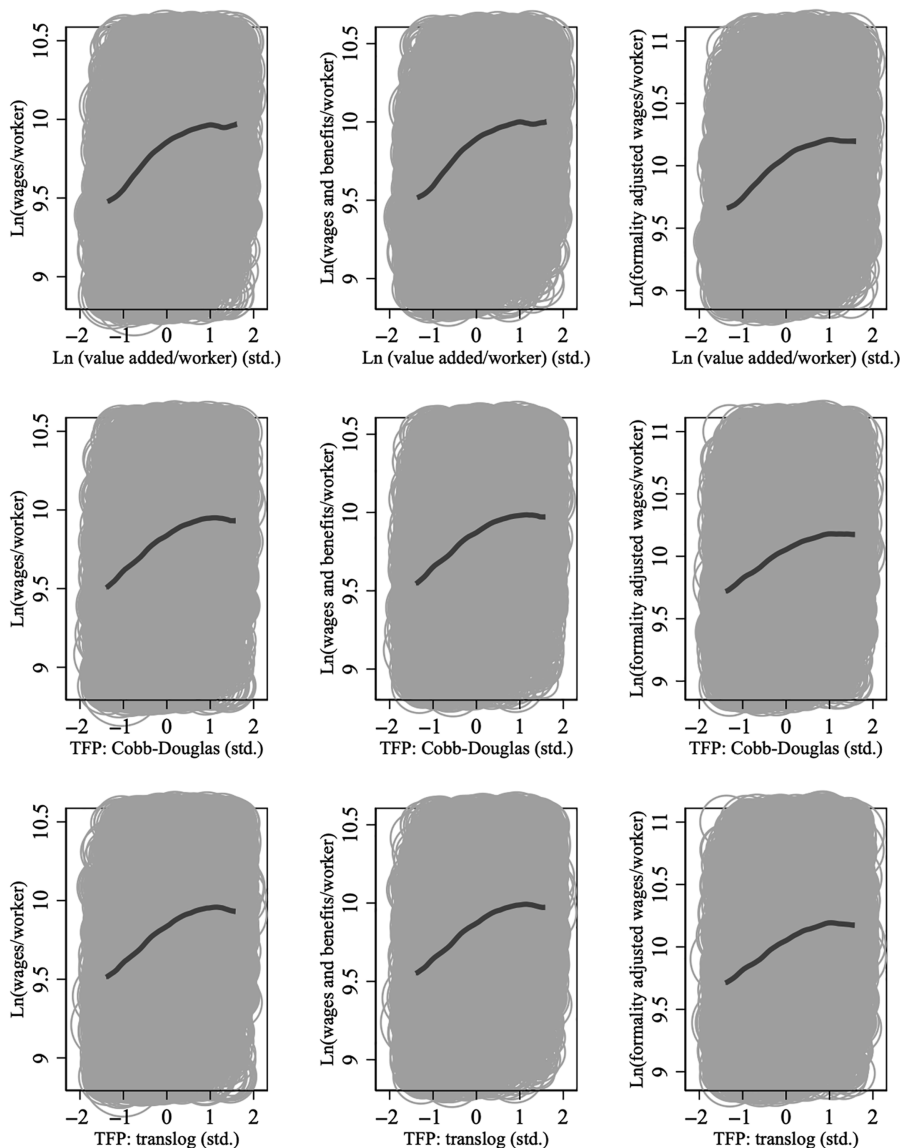


Figure 1. Relationship between compensation and productivity, by measures of compensation and productivity. Note(s): Circles are weighted observations. Lines denote local polynomial and 95% confidence interval. Data visualization restricted to 5th-95th percentile of distribution for each variable. Source: Authors' calculations based on EC 2018

confidence intervals. All are significantly different from zero. Coefficients are largest for adjusted wages, indicating the strongest relationship. The coefficients for standardized log value added per worker all fall in the range of 0.211–0.231, meaning that a one standard deviation increase in productivity is associated with a 21.1–23.1% increase in compensation. The coefficients for the TFP measures fall between 0.215 and 0.276, meaning that a standard deviation increase in TFP is associated with a 21.5–27.6% increase in compensation [20].

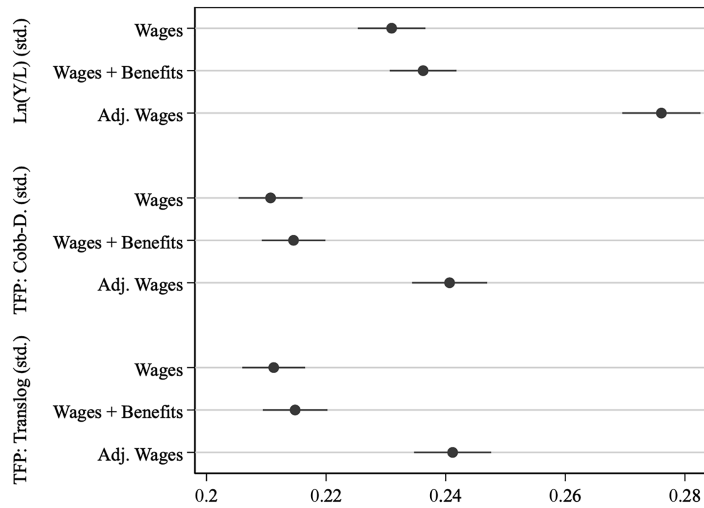


Figure 2. Coefficients and 95% confidence intervals for models containing only measures of compensation and productivity. Note(s): Lines denote 95% confidence intervals from bootstrapped standard errors. Source: Authors' calculations based on EC 2018

Overall, the results across measures of compensation are similar enough that, hereafter, we focus on results related to wages.

5.2 Multivariate models of the relationship between compensation and productivity

The correlation between wages and productivity could be due to differential worker quality. To test this possibility, in the [Appendix](#), in [Table A1](#) we present regressions for the relationship between wages and productivity after accounting for worker composition using ELMPS 2018 data as described above. The coefficient on productivity remains quite similar, in the 0.21–0.28 range, as in the bivariate [Figure 2](#). We further add controls for firm characteristics in the [Appendix](#) in [Table A2](#). The coefficient on productivity remains large (0.20–0.22) and significant.

Hereafter, we focus on the coefficients of the interaction terms between productivity and firm/industry characteristics to determine how the relationship between wages and productivity varies across these characteristics. Since the results are generally similar for different measures of productivity and different measures of compensation, we limit ourselves to discussing the results of the relationship between wages per worker and TFP: translog, mentioning when the results differ substantially across other specifications. The full regression results for all nine combinations of the different measures of compensation and productivity are shown in the [Appendix](#) in [Table A3](#). We present the interactions of groups of coefficients for our preferred specification in figures. The main effect of productivity is 0.277 in the TFP: translog and wages specification; for the reference firm, wages increase 27.7% when TFP increases by one standard deviation. This estimate is somewhat higher than for the simple correlation due the fact that our reference firm type (as defined by the omitted categories for each variable) has a stronger wage-productivity relationship than the average.

[Figure 3](#) shows the interactions with measures of imperfect competition. More capital-intensive firms have a weaker link between wages and productivity than more labor-intensive firms. The desire to retain more of the benefits of higher productivity for the owners of capital appears to more than offset any effects of reduced competition. The relationship between wages and productivity is significantly weaker in formal firms compared to informal firms.

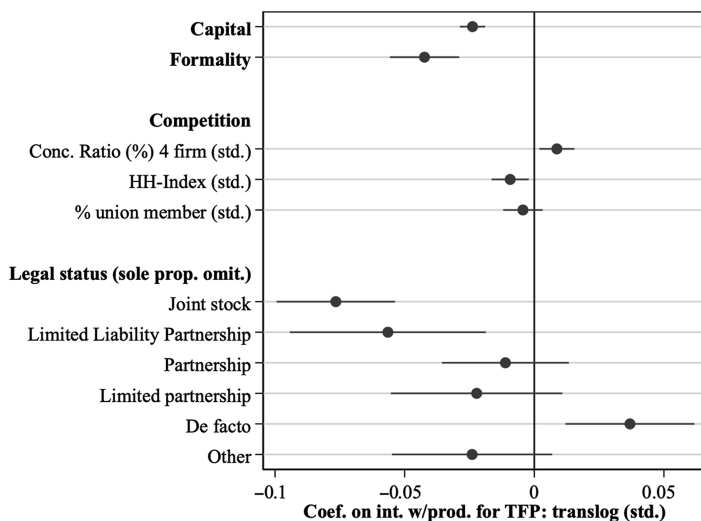


Figure 3. Capital, formality, competition and legal status: Coefficients of interaction terms with productivity and 95% confidence intervals for model using TFP: translog as a measure of productivity. Note(s): Lines denote 95% confidence intervals. Source: Based on full regression models in [Table A3](#)

As shown in [Table A3](#) in the [Appendix](#), the elasticity of wages per worker to productivity as measured by TFP: translog is reduced by 4 percentage points for formal firms relative to the 28% for the reference (informal) firm. This result could be explained by the closer and more tight-knit social relations between owners and workers in informal firms, which could lead to more profit-sharing or risk-sharing behavior on the part of owners. This explanation would make it compatible with the more sociological efficiency wage theories that emphasize worker morale and workplace culture. Alternatively, informal firms may face less rigid wage structures and be able to adjust wages in the face of economic shocks more readily.

The wage-productivity nexus's relationship with the degree of competition in an industry suggests potential rent sharing. For market power as measured by the concentration ratio of the top 4 firms, the interaction is positive and significant. A one standard deviation increase in the concentration ratio increases the wage-productivity elasticity by 0.9 percentage points. However, as measured by the HHI, greater market power is in fact associated with a (usually) significantly weaker relationship between wages and productivity. This suggests that oligopoly, in particular, as measured by the concentration ratio, more so than the distribution in market power among firms outside the top four (as measured by the HHI), leads firms to share their rents. Unionization does not significantly mediate the wage-productivity relationship. Our expectation was that more complex (and thus less competitive) legal structures would have a stronger relationship between wages and productivity. The results are otherwise; stock and limited liability (the latter only sometimes significant) structures have a weaker relationship between wages and productivity than sole proprietorships, while de facto legal structures have a stronger relationship. Sole proprietorships could have more informed managers, due to their simpler structure, who are better able to identify and reward productivity. They could also have stronger more personalized social ties with workers, leading to greater acceptance of risk-sharing.

[Figure 4](#) shows the degree to which the relationship between wages and productivity is associated with firm size and firm age, potential drivers of efficiency wages related to incentives or supervision. The link between wages and productivity is strongest for the youngest firms (0–3 years, the reference category). Workers in new (“start-up”) firms may be

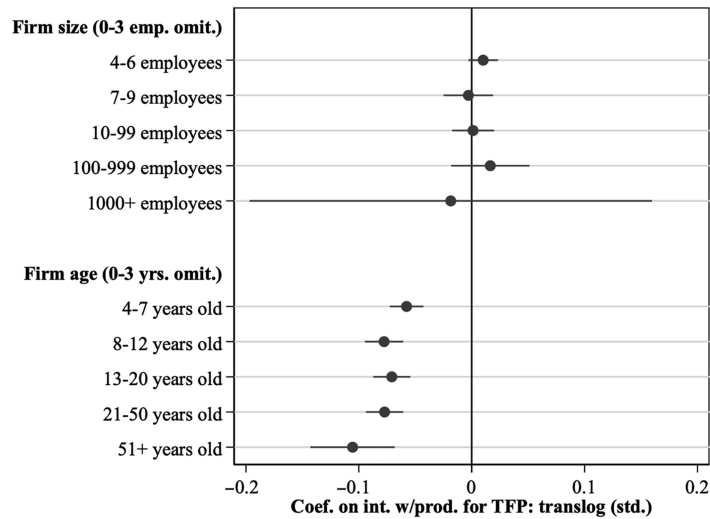


Figure 4. Firm size and firm age: coefficients of interaction terms with productivity and 95% confidence intervals for model using TFP: translog as a measure of productivity. Note(s): Lines denote 95% confidence intervals. Source: Based on full regression models in [Table A3](#)

incentivized or rewarded with higher wages for firm success. Firm size does not mediate the wage-productivity relationship.

We now move to how the relationship between wages and productivity varies by the characteristics of the workforce. These characteristics are measured at the industry-region-firm size cell level. As shown in [Figure 5](#), industries where workers have higher test scores (an indication of worker quality) do not have a differential productivity-wage link. In some of the specifications, there is a significantly stronger wage-productivity nexus when jobs require basic or secondary education. Jobs that require math skills or in some specifications physical skills have a weaker wage-productivity link. There are thus countervailing patterns for skills than education requirements. It is possible that it is differences in ability across workers in the same firm or across workers in the same industry that matter more for efficiency wages rather than the inter-industry differences in education or skills that we measure here. Occupations are associated with differential linkages between wages and productivity, with a much weaker relationship for white collar (5.3 percentage point reduction in elasticity) and especially blue-collar workers (6.6 percentage point reduction) compared to professional/managerial workers, suggestive of efficiency wages for professional/managerial workers.

[Figure 6](#) summarizes the differences in the wage-productivity nexus by variations across industries in experience, training, incentives, and monitoring. There are significantly weaker associations for firms where workers have longer tenure or where training was lengthier. These results do not support a wage-productivity link due to the labor turnover model, where high-productivity employers pay efficiency wages to reduce labor turnover when that turnover is costly to employers. However, it may be the case that industries with longer tenure are less concerned about worker turnover, and that more training means workers are more specialized and less likely to leave. Payment systems (paid by piece and paid bonus/incentives) are significantly and positively related to the wage-productivity nexus, consistent with incentive and monitoring dimensions of the efficiency wage hypothesis. More temporary or permanent contracts also more strongly link wages and productivity than no contracts. In most specifications, a higher share of supervisors weakens the wage-productivity relationship, suggesting supervision may substitute for efficiency wages.

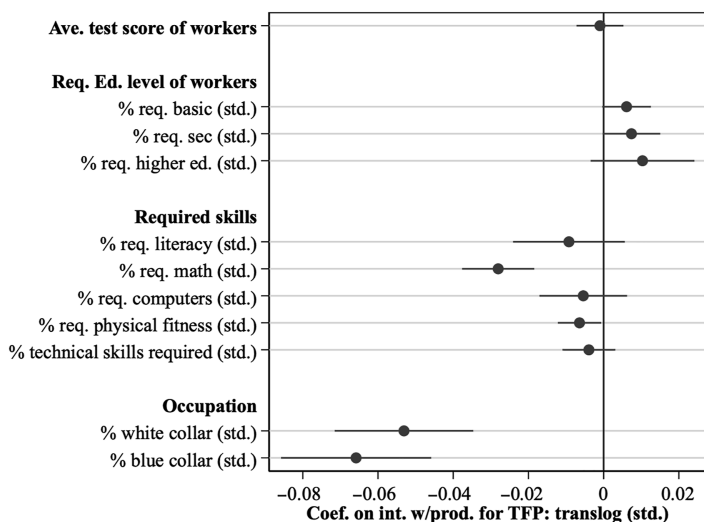


Figure 5. Worker test scores, education requirements, required skills and occupations: Coefficients of interaction terms with productivity and 95% confidence intervals for model using TFP: translog as a measure of productivity. Note(s): Lines denote 95% confidence intervals. Source: Based on full regression models in [Table A3](#)

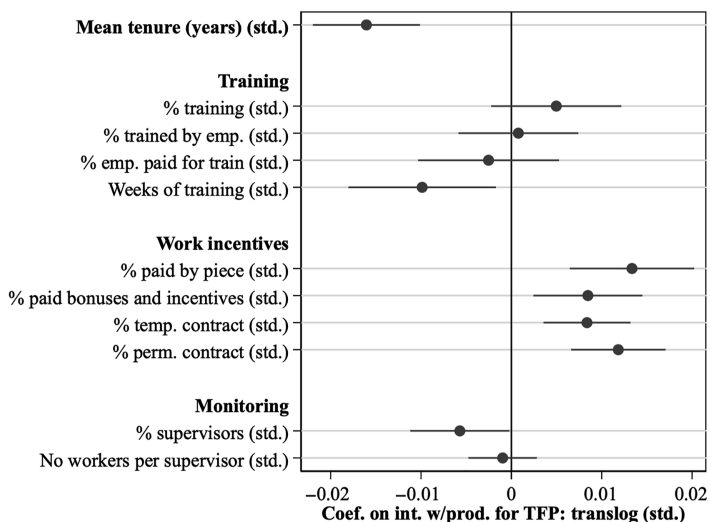


Figure 6. Worker experience, training, incentives and monitoring: Coefficients of interaction terms with productivity and 95% confidence intervals for model using TFP: translog as a measure of productivity. Note(s): Lines denote 95% confidence intervals. Source: Based on full regression models in [Table A3](#)

While the preceding results have demonstrated, in line with the literature, that there are roles for both efficiency wages and imperfect competition, we now turn to the question of their relative roles in the wage-productivity link. In [Table 1](#) we present the Shapley decomposition, showing the percentage of the R-squared that comes from the productivity main effect, imperfect competition or efficiency wage main effects, and their interactions with

Table 1. Shapley decomposition (percentage of R-squared) for full regression models

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
Prod. main effect	28.9 (0.3)	26.0 (0.3)	25.0 (0.3)	28.2 (0.3)	25.1 (0.3)	24.0 (0.3)	20.3 (0.2)	17.2 (0.2)	16.1 (0.2)
Imperf. comp. main effects	17.1 (0.3)	22.0 (0.6)	25.3 (0.6)	18.3 (0.3)	23.6 (0.5)	27.2 (0.5)	30.1 (0.5)	35.7 (0.5)	38.6 (0.5)
Effic. wage main effects	10.6 (0.3)	12.4 (0.3)	13.4 (0.3)	10.7 (0.3)	12.8 (0.3)	13.7 (0.3)	16.9 (0.2)	19.5 (0.2)	20.5 (0.2)
Imperf. comp. int. with prod.	20.7 (0.3)	18.6 (0.3)	17.0 (0.3)	20.6 (0.3)	18.3 (0.3)	16.6 (0.3)	16.2 (0.2)	13.5 (0.2)	12.0 (0.2)
Effic. wage int. with prod.	22.7 (0.3)	20.9 (0.3)	19.3 (0.3)	22.2 (0.3)	20.2 (0.3)	18.5 (0.3)	16.4 (0.2)	14.2 (0.2)	12.9 (0.2)
<i>N</i>	108,195	108,195	108,195	108,195	108,195	108,195	108,195	108,195	108,195
<i>R</i> -squared	0.293	0.290	0.291	0.307	0.305	0.306	0.353	0.352	0.352

Note(s): All shares significantly different from zero, significance not shown

Source(s): Based on full regression models in [Table A3](#)

productivity. All shares were significantly different from zero, based on the bootstrapped standard errors. Efficiency wage interactions are generally larger than those for imperfect competition, although less so for formality adjusted wages. For example, in our preferred specification they explain 19.3% of the variation in wages. Imperfect competition interactions are still quite important, at 17.0%. Despite our array of interactions, there also remains a sizeable productivity main effect of 25.0% for the reference type of firm. Efficiency wage main effects (which also include worker quality) explain 12.4% of wages, compared to 25.3% for imperfect competition main effects. This pattern holds true across specifications. Overall, efficiency wages play a slightly larger role in explaining the wage-productivity link, but imperfect competition remains important.

6. Discussion and conclusions

In this paper we analyzed which firm characteristics are associated with the wage-productivity nexus and how these relationships reflect either efficiency wages or imperfect competition. We find that new firms have a stronger wage-productivity nexus, consistent with efficiency wage theory, since newer firms would want to incentivize employees to contribute to the start-up success by setting up reward systems that tie pay to firm performance.

In terms of the characteristics of the workforce, there is a stronger wage-productivity link for firms with professional/managerial workers than white- or blue-collar workers, suggestive of efficiency wages. There is some evidence that firms with more educated workers have a stronger link as well, but the opposite is true for math and physical fitness skills. It may be that the latter skills are more basic and substitutable and hence efficiency wages are not required. Contrary to efficiency wage theories, wage-productivity links were weaker with longer tenure and more weeks of training. Work incentives and contracts did, however, link wages and productivity, in line with efficiency wages, and supervision may have substituted for the need for efficiency wages, weakening the link.

Our results on mediators for wage-productivity links are also consistent with models of imperfect competition, when rents may be shared with workers. Firms in less competitive industries, especially oligopolies, as indicated by the top four firm's concentration ratio (but not the HHI), have a stronger wage productivity nexus. When rents exist because of oligopolies, owners may share these rents with their workers. However, we also find that capital-intensive firms have a weaker wage-productivity nexus, suggesting that when higher productivity is due to capital investments, there is less rent-sharing. One somewhat unexpected finding is that formal firms are less likely to link wages and productivity than informal firms. One explanation for this finding is that owners and workers in informal firms are more likely to have strong social ties based on kinship; ties that may foster greater sharing of risks and rewards, along the lines of the more sociological efficiency wage explanations. Alternatively, informal forms may be more readily able to adjust wages in response to productivity differentials or shocks (Riveros and Bouton, 1994). Overall, while our results support both efficiency wage (labor market) and imperfect competition (product market) explanations of the wage-productivity link, efficiency wages explain slightly more of this linkage.

6.1 Limitations

A potential limitation of our results is our inability to properly correct for worker quality across different kinds of firms due to the limited information we have about workers in the firm-level data. We have attempted to address this by correcting for industry-region-firm size level worker characteristics, but this is insufficient if there is sorting of higher quality workers to more productive firms within an industry. The main way to properly control for worker quality is to have linked firm-worker data, which is not available in Egypt. Our classifications, although they draw on the literature, reflect subjective decisions about which variables represent efficiency wages and which imperfect competition. For instance, firm formality may

relate to for degree of competition, but may also indicate the existence of enduring social ties between owners and workers in informal firms that could result in risk sharing that mimics efficiency wages.

Our results are based on association rather than causal inference. Factors that could confound causal interpretation include reverse causality and unobserved heterogeneity of both workers and firms. However, our paper is the first, to our knowledge, to try to quantify the relative roles of efficiency wages and imperfect competition in the wage-productivity link. An important area for future research is undertaking similar work in other settings.

6.2 Policy implications

These findings have important implications for policymakers working to improve the functioning of the economy and labor markets in Egypt and globally. The results on incentives and contracts indicate the importance of policies that allow firms to incentivize and compensate workers, such as Egypt's introduction of flexible labor regulations in 2003, which also helped incentivize hiring workers formally (Wahba and Assaad, 2017). Additional innovations may further increase the scope for efficiency wages that incentivize and reward productivity, such as the introduction, in 2025, of an hourly minimum wage (Chen and Edin, 2002; Daabas, 2025). The labor law might be further amended to increase the scope of pay-for-performance schemes, which can be impactful but must be carefully designed (Miller and Babiarz, 2013). Repeated increases in the minimum wage in Egypt (Daabas, 2025) may limit the scope for such incentives beyond the fixed wage.

Information frictions around worker quality may also be behind efficiency wages. Interventions, such as reference letters or skills certifications, can help overcome information frictions (Abel *et al.*, 2020; Bassi and Nansamba, 2021). Addressing labor regulations and skills mismatch issues may be particularly pertinent throughout the Middle East and North Africa region, where these two constraints are most frequently reported by firms (Dibeh *et al.*, 2019; Fakh and Ghazalian, 2015).

Past research in Egypt has underscored that growth has been jobless (Assaad and Mahmoud, 2024), while politically connected firms earn rents and reduce job creation (Artunç and Saleh, 2025; Diwan *et al.*, 2014). Our results suggest that particularly oligopolistic rents are shared with workers. These oligopolies may earn particularly high rents but also be uniquely harmful to developing countries' economies (Beirne and Kirchberger, 2020). Policies that increase competition, for instance simplifying taxation and reducing barriers to entry and formality (Fajnzylber *et al.*, 2011), may stimulate competition and labor demand simultaneously, which will be beneficial for both the economy as a whole and workers specifically.

Data availability

The ELMPS and Economic Census data are publicly available from the Economic Research Forum at www.erfdataportal.com.

Code availability

Code for the final, published version will be made available on one of the author's websites: <https://carolinekrafft.com/publications/>

Acknowledgments

The authors appreciate the comments of "Egypt Labor Demand Project" workshop participants and Bob Rijkers on earlier paper drafts. The authors appreciate the research assistant of Sarah Wahby in updating the results for the 2017/18 Economic Census.

Table A1. Regressions with worker quality main effects only

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog
<i>Prod.</i>	0.229*** (0.003)	0.209*** (0.003)	0.210*** (0.003)	0.235*** (0.003)	0.213*** (0.003)	0.214*** (0.003)	0.276*** (0.003)	0.242*** (0.003)	0.242*** (0.003)
<i>% req. literacy (std.)</i>	-0.012 (0.006)	-0.010 (0.006)	-0.011 (0.006)	-0.008 (0.006)	-0.006 (0.006)	-0.008 (0.006)	0.014 (0.008)	0.017* (0.008)	0.015* (0.008)
<i>% req. math (std.)</i>	0.014** (0.004)	0.016*** (0.005)	0.017*** (0.004)	0.014*** (0.004)	0.016*** (0.005)	0.017*** (0.004)	0.025*** (0.005)	0.028*** (0.005)	0.030*** (0.005)
<i>% req. computers (std.)</i>	-0.024*** (0.006)	-0.017** (0.006)	-0.017** (0.006)	-0.026*** (0.006)	-0.019** (0.006)	-0.019** (0.006)	-0.046*** (0.007)	-0.036*** (0.007)	-0.036*** (0.007)
<i>% req. physical fitness (std.)</i>	-0.014*** (0.003)	-0.018*** (0.003)	-0.018*** (0.003)	-0.012*** (0.002)	-0.016*** (0.003)	-0.015*** (0.003)	-0.009** (0.003)	-0.014*** (0.003)	-0.013*** (0.003)
<i>% technical skill required (std.)</i>	0.003 (0.003)	0.002 (0.003)	0.003 (0.003)	0.004 (0.003)	0.003 (0.003)	0.004 (0.003)	-0.007* (0.004)	-0.008* (0.004)	-0.007 (0.004)
<i>Job ed. req. (% less than basic omit.)</i>									
<i>% req. basic (std.)</i>	-0.031*** (0.003)	-0.038*** (0.003)	-0.037*** (0.003)	-0.030*** (0.003)	-0.037*** (0.003)	-0.036*** (0.003)	-0.037*** (0.003)	-0.045*** (0.004)	-0.045*** (0.004)
<i>% req. sec (std.)</i>	0.000 (0.003)	0.001 (0.004)	0.001 (0.004)	-0.001 (0.003)	-0.000 (0.003)	-0.001 (0.003)	-0.012** (0.004)	-0.011** (0.004)	-0.011** (0.004)
<i>% req. higher ed. (std.)</i>	0.016* (0.007)	0.014* (0.007)	0.015* (0.007)	0.015* (0.006)	0.013* (0.007)	0.014* (0.007)	0.012 (0.008)	0.009 (0.008)	0.010 (0.009)
<i>Prep. test score (std.)</i>	0.003 (0.003)	0.000 (0.003)	0.001 (0.003)	0.001 (0.003)	-0.002 (0.003)	-0.001 (0.002)	-0.022*** (0.003)	-0.025*** (0.003)	-0.024*** (0.003)
<i>Occup.: % prof./man. omit.</i>									
<i>% white collar (std.)</i>	0.005 (0.010)	0.008 (0.011)	0.012 (0.010)	0.002 (0.009)	0.006 (0.010)	0.010 (0.010)	-0.039*** (0.011)	-0.033** (0.012)	-0.029* (0.012)
<i>% blue collar (std.)</i>	0.040*** (0.010)	0.049*** (0.011)	0.052*** (0.010)	0.036*** (0.009)	0.046*** (0.010)	0.049*** (0.010)	0.013 (0.011)	0.026* (0.012)	0.030* (0.012)

(continued)

Table A1. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog
<i>% Training (std.)</i>	-0.003 (0.004)	-0.003 (0.004)	-0.004 (0.003)	-0.005 (0.003)	-0.004 (0.004)	-0.005 (0.004)	-0.010* (0.005)	-0.010* (0.005)	-0.010* (0.005)
<i>% trained by emp. (std.)</i>	-0.021*** (0.005)	-0.024*** (0.006)	-0.026*** (0.006)	-0.022*** (0.005)	-0.025*** (0.005)	-0.026*** (0.006)	-0.004 (0.006)	-0.008 (0.007)	-0.010 (0.007)
<i>% emp. paid for train (std.)</i>	0.032*** (0.006)	0.040*** (0.006)	0.042*** (0.006)	0.035*** (0.006)	0.043*** (0.006)	0.045*** (0.006)	0.031*** (0.007)	0.041*** (0.008)	0.043*** (0.007)
<i>Weeks of training (std.)</i>	-0.014*** (0.003)	-0.018*** (0.003)	-0.017*** (0.003)	-0.015*** (0.003)	-0.018*** (0.003)	-0.017*** (0.003)	-0.032*** (0.004)	-0.036*** (0.004)	-0.035*** (0.003)
<i>Mean tenure (years) (std.)</i>	0.042*** (0.003)	0.039*** (0.003)	0.040*** (0.003)	0.037*** (0.003)	0.035*** (0.002)	0.035*** (0.002)	0.010*** (0.003)	0.007* (0.003)	0.008** (0.003)
<i>Constant</i>	9.785*** (0.002)	9.785*** (0.002)	9.785*** (0.002)	9.821*** (0.002)	9.821*** (0.002)	9.821*** (0.002)	10.009*** (0.003)	10.009*** (0.003)	10.009*** (0.003)
<i>N (Obs.)</i>	108,197	108,197	108,197	108,197	108,197	108,197	108,197	108,197	108,197
<i>R-sq.</i>	0.234	0.200	0.201	0.244	0.207	0.207	0.211	0.166	0.166

Note(s): * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
 Bootstrapped standard errors (500 repetitions) in parentheses
Source(s): Authors' calculations based on EC 2018; ELMPS 2018

Table A2. Regressions with worker quality and firm characteristics main effects only

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog
<i>Prod.</i>	0.207*** (0.003)	0.199*** (0.003)	0.199*** (0.003)	0.209*** (0.003)	0.200*** (0.003)	0.200*** (0.003)	0.220*** (0.003)	0.211*** (0.003)	0.211*** (0.003)
<i>Firm size (1–3 omit.)</i>									
4–6 employees	0.115*** (0.005)	0.127*** (0.005)	0.120*** (0.005)	0.109*** (0.005)	0.122*** (0.005)	0.114*** (0.005)	0.153*** (0.006)	0.166*** (0.006)	0.158*** (0.006)
7–9 employees	0.170*** (0.009)	0.192*** (0.010)	0.182*** (0.010)	0.164*** (0.010)	0.187*** (0.010)	0.176*** (0.010)	0.241*** (0.011)	0.265*** (0.012)	0.253*** (0.012)
10–99 employees	0.146*** (0.009)	0.183*** (0.010)	0.181*** (0.010)	0.142*** (0.009)	0.180*** (0.010)	0.177*** (0.010)	0.236*** (0.011)	0.276*** (0.011)	0.273*** (0.011)
100–999 employees	0.141*** (0.026)	0.224*** (0.027)	0.290*** (0.028)	0.181*** (0.027)	0.265*** (0.027)	0.332*** (0.032)	0.233*** (0.028)	0.322*** (0.029)	0.392*** (0.029)
1,000+ employees	0.342*** (0.101)	0.470*** (0.105)	0.641*** (0.099)	0.406*** (0.093)	0.534*** (0.095)	0.707*** (0.100)	0.385*** (0.104)	0.520*** (0.099)	0.702*** (0.102)
<i>Firm age (0–3 years omit.)</i>									
4–7 years old	0.064*** (0.005)	0.065*** (0.006)	0.064*** (0.005)	0.065*** (0.005)	0.065*** (0.005)	0.064*** (0.005)	0.081*** (0.007)	0.081*** (0.007)	0.080*** (0.007)
8–12 years old	0.087*** (0.006)	0.087*** (0.006)	0.086*** (0.007)	0.090*** (0.006)	0.091*** (0.006)	0.090*** (0.006)	0.122*** (0.007)	0.123*** (0.008)	0.122*** (0.007)
13–20 years old	0.082*** (0.007)	0.083*** (0.007)	0.083*** (0.007)	0.089*** (0.007)	0.090*** (0.006)	0.090*** (0.007)	0.140*** (0.008)	0.141*** (0.008)	0.141*** (0.008)
21–50 years old	0.095*** (0.007)	0.096*** (0.007)	0.097*** (0.007)	0.105*** (0.007)	0.106*** (0.007)	0.107*** (0.007)	0.173*** (0.009)	0.173*** (0.009)	0.174*** (0.009)
51+ years old	0.096*** (0.018)	0.096*** (0.018)	0.098*** (0.019)	0.112*** (0.018)	0.112*** (0.018)	0.114*** (0.018)	0.191*** (0.023)	0.191*** (0.023)	0.193*** (0.022)
<i>Formality</i>	−0.054*** (0.005)	−0.053*** (0.005)	−0.055*** (0.005)	−0.017*** (0.005)	−0.016*** (0.005)	−0.018*** (0.005)	0.263*** (0.005)	0.263*** (0.005)	0.261*** (0.006)

(continued)

Table A2. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog
<i>Conc. Ratio (%) 4 firm (std.)</i>	-0.006 (0.003)	-0.006 (0.003)	-0.003 (0.003)	-0.007* (0.003)	-0.006* (0.003)	-0.004 (0.003)	-0.012** (0.004)	-0.012** (0.004)	-0.009* (0.004)
<i>HH-Index (std.)</i>	0.009** (0.003)	0.009** (0.003)	0.007* (0.003)	0.010** (0.003)	0.010** (0.003)	0.008* (0.003)	0.016*** (0.004)	0.016*** (0.004)	0.014*** (0.004)
<i>Capital per worker (std.)</i>	0.027*** (0.002)	0.080*** (0.003)	0.080*** (0.003)	0.028*** (0.002)	0.081*** (0.003)	0.081*** (0.003)	0.038*** (0.003)	0.095*** (0.003)	0.095*** (0.003)
<i>% union member (std.)</i>	0.017*** (0.004)	0.017*** (0.004)	0.017*** (0.004)	0.018*** (0.004)	0.018*** (0.004)	0.018*** (0.004)	0.011** (0.004)	0.011** (0.004)	0.011* (0.005)
<i>% req. literacy (std.)</i>	-0.042*** (0.006)	-0.043*** (0.007)	-0.044*** (0.006)	-0.039*** (0.006)	-0.039*** (0.006)	-0.041*** (0.006)	-0.022** (0.007)	-0.022** (0.008)	-0.024** (0.007)
<i>% req. math (std.)</i>	0.035*** (0.005)	0.036*** (0.005)	0.037*** (0.005)	0.035*** (0.004)	0.035*** (0.004)	0.036*** (0.004)	0.046*** (0.005)	0.046*** (0.005)	0.047*** (0.005)
<i>% req. computers (std.)</i>	-0.005 (0.006)	-0.005 (0.006)	-0.004 (0.006)	-0.008 (0.006)	-0.008 (0.006)	-0.008 (0.006)	-0.037*** (0.007)	-0.038*** (0.007)	-0.037*** (0.007)
<i>% req. physical fitness (std.)</i>	-0.011*** (0.003)	-0.011*** (0.003)	-0.011*** (0.003)	-0.009*** (0.003)	-0.009*** (0.003)	-0.008** (0.003)	-0.004 (0.003)	-0.004 (0.003)	-0.004 (0.003)
<i>% technical skill required (std.)</i>	0.003 (0.003)	0.003 (0.003)	0.003 (0.003)	0.003 (0.003)	0.003 (0.003)	0.003 (0.003)	-0.012** (0.004)	-0.012** (0.004)	-0.011** (0.003)
<i>Job ed. req. (% less than basic omit.)</i>									
<i>% req. basic (std.)</i>	-0.029*** (0.003)	-0.029*** (0.003)	-0.028*** (0.003)	-0.027*** (0.003)	-0.028*** (0.003)	-0.027*** (0.003)	-0.029*** (0.003)	-0.029*** (0.004)	-0.028*** (0.004)
<i>% req. sec (std.)</i>	-0.008* (0.004)	-0.008* (0.004)	-0.008* (0.004)	-0.010** (0.004)	-0.010** (0.004)	-0.010** (0.004)	-0.030*** (0.004)	-0.030*** (0.004)	-0.030*** (0.004)
<i>% req. higher ed. (std.)</i>	-0.018* (0.008)	-0.018* (0.007)	-0.018* (0.008)	-0.019** (0.007)	-0.019** (0.007)	-0.019** (0.007)	-0.024** (0.008)	-0.024** (0.008)	-0.024** (0.008)

(continued)

Table A2. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog
<i>Prep. test score (std.)</i>	0.017*** (0.003)	0.017*** (0.003)	0.018*** (0.003)	0.015*** (0.003)	0.015*** (0.003)	0.017*** (0.003)	0.008* (0.003)	0.008* (0.003)	0.009** (0.003)
<i>Occup.: % prof./man. omit.</i>									
<i>% white collar (std.)</i>	0.017 (0.011)	0.016 (0.011)	0.017 (0.011)	0.018 (0.010)	0.017 (0.010)	0.018 (0.010)	0.005 (0.012)	0.004 (0.012)	0.005 (0.012)
<i>% blue collar (std.)</i>	0.041*** (0.011)	0.040*** (0.011)	0.040*** (0.011)	0.042*** (0.010)	0.041*** (0.010)	0.041*** (0.010)	0.052*** (0.012)	0.052*** (0.012)	0.052*** (0.012)
<i>% Training (std.)</i>	-0.023*** (0.003)	-0.023*** (0.003)	-0.024*** (0.004)	-0.024*** (0.003)	-0.025*** (0.004)	-0.025*** (0.004)	-0.033*** (0.004)	-0.033*** (0.004)	-0.033*** (0.004)
<i>% trained by emp. (std.)</i>	-0.015** (0.006)	-0.015** (0.005)	-0.016** (0.006)	-0.016** (0.006)	-0.016** (0.005)	-0.017** (0.006)	-0.003 (0.006)	-0.003 (0.006)	-0.003 (0.006)
<i>% emp. paid for train (std.)</i>	0.025*** (0.006)	0.026*** (0.006)	0.026*** (0.006)	0.026*** (0.006)	0.027*** (0.006)	0.027*** (0.006)	0.010 (0.007)	0.010 (0.007)	0.010 (0.006)
<i>Weeks of training (std.)</i>	0.002 (0.003)	0.002 (0.004)	0.003 (0.004)	0.002 (0.003)	0.002 (0.004)	0.003 (0.003)	-0.001 (0.004)	-0.001 (0.004)	0.000 (0.004)
<i>Mean tenure (years) (std.)</i>	0.040*** (0.003)	0.040*** (0.003)	0.040*** (0.003)	0.037*** (0.003)	0.037*** (0.003)	0.037*** (0.003)	0.021*** (0.003)	0.021*** (0.003)	0.022*** (0.003)
<i>% paid by piece (std.)</i>	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)	0.009** (0.003)	0.009** (0.003)	0.009** (0.003)
<i>% paid bonuses and incentives (std.)</i>	-0.024*** (0.003)	-0.025*** (0.003)	-0.024*** (0.003)	-0.025*** (0.003)	-0.025*** (0.003)	-0.024*** (0.003)	-0.018*** (0.003)	-0.018*** (0.003)	-0.018*** (0.003)
<i>% temp. contract (std.)</i>	0.029*** (0.003)	0.029*** (0.003)	0.029*** (0.003)	0.029*** (0.003)	0.029*** (0.003)	0.029*** (0.003)	0.031*** (0.003)	0.031*** (0.003)	0.031*** (0.003)
<i>% perm. contract (std.)</i>	-0.006* (0.003)	-0.006* (0.003)	-0.006* (0.003)	-0.004 (0.003)	-0.004 (0.003)	-0.003 (0.003)	0.005 (0.003)	0.006 (0.003)	0.006* (0.003)
<i>Legal status (sole prop. omit)</i>									

(continued)

Table A2. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L) (std.)	TFP: Cobb- Douglas	TFP: Translog
Joint Stock	0.252*** (0.015)	0.257*** (0.016)	0.276*** (0.015)	0.293*** (0.015)	0.298*** (0.014)	0.317*** (0.014)	0.523*** (0.015)	0.528*** (0.016)	0.548*** (0.015)
Limited Liability Partnership	0.183*** (0.022)	0.186*** (0.021)	0.189*** (0.022)	0.227*** (0.023)	0.231*** (0.022)	0.234*** (0.022)	0.444*** (0.022)	0.447*** (0.023)	0.451*** (0.023)
Partnership	0.006 (0.011)	0.008 (0.011)	0.008 (0.011)	0.018 (0.011)	0.020 (0.010)	0.020* (0.010)	0.050*** (0.013)	0.052*** (0.012)	0.053*** (0.013)
Limited Partnership	-0.017 (0.018)	-0.015 (0.018)	-0.010 (0.019)	0.012 (0.017)	0.014 (0.017)	0.020 (0.019)	0.121*** (0.021)	0.123*** (0.021)	0.129*** (0.021)
<i>De facto</i>	0.025* (0.011)	0.026* (0.010)	0.025* (0.010)	0.032** (0.010)	0.033** (0.010)	0.031** (0.010)	0.041*** (0.012)	0.042*** (0.012)	0.040** (0.013)
Other	-0.218*** (0.026)	-0.219*** (0.025)	-0.225*** (0.025)	-0.214*** (0.025)	-0.215*** (0.025)	-0.221*** (0.025)	-0.319*** (0.029)	-0.320*** (0.030)	-0.327*** (0.027)
% supervisors (std.)	0.036*** (0.003)	0.037*** (0.003)	0.037*** (0.003)	0.036*** (0.003)	0.036*** (0.002)	0.036*** (0.002)	0.036*** (0.003)	0.036*** (0.003)	0.036*** (0.003)
No. workers per supervisor (std.)	-0.000 (0.002)	-0.000 (0.002)	0.000 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.005* (0.002)	-0.005* (0.003)	-0.005* (0.002)
Constant	9.723*** (0.005)	9.716*** (0.005)	9.720*** (0.005)	9.732*** (0.005)	9.726*** (0.005)	9.729*** (0.005)	9.693*** (0.005)	9.686*** (0.006)	9.690*** (0.006)
N	108,195	108,195	108,195	108,195	108,195	108,195	108,195	108,195	108,195
R.-sq.	0.272	0.271	0.272	0.287	0.286	0.287	0.340	0.339	0.339

Note(s): * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Bootstrapped standard errors (500 repetitions) in parentheses

Source(s): Authors' calculations based on EC 2018; ELMPS 2018

Table A3. Full regression models (main effects and interactions)

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
<i>Prod. Main effect</i>	0.286*** (0.008)	0.276*** (0.008)	0.277*** (0.008)	0.289*** (0.008)	0.278*** (0.008)	0.279*** (0.007)	0.286*** (0.008)	0.283*** (0.009)	0.282*** (0.008)
<i>Interactions with productivity</i>									
<i>Formal # prod.</i>	-0.044*** (0.007)	-0.042*** (0.007)	-0.042*** (0.007)	-0.045*** (0.007)	-0.043*** (0.007)	-0.043*** (0.007)	-0.017* (0.008)	-0.025*** (0.008)	-0.024** (0.007)
<i>Conc. Ratio (%) 4 firm (std.) # prod.</i>	0.010** (0.003)	0.010** (0.004)	0.009* (0.003)	0.010** (0.003)	0.010** (0.003)	0.009** (0.003)	0.012*** (0.003)	0.011** (0.003)	0.010** (0.004)
<i>HH-Index (std.) # prod.</i>	-0.009** (0.003)	-0.009* (0.004)	-0.009* (0.004)	-0.010** (0.003)	-0.010** (0.003)	-0.010** (0.003)	-0.010** (0.004)	-0.010** (0.004)	-0.010* (0.004)
<i>Capital per worker (std.) # prod.</i>	-0.026*** (0.003)	-0.025*** (0.002)	-0.024*** (0.002)	-0.025*** (0.003)	-0.024*** (0.003)	-0.023*** (0.003)	-0.024*** (0.003)	-0.023*** (0.003)	-0.021*** (0.003)
<i>% union member (std.) # prod.</i>	-0.002 (0.004)	-0.004 (0.004)	-0.004 (0.004)	-0.002 (0.004)	-0.004 (0.004)	-0.004 (0.004)	-0.002 (0.004)	-0.003 (0.004)	-0.003 (0.005)
<i>Legal status (sole prop. omit)</i>									
<i>Joint Stock # prod.</i>	-0.052*** (0.012)	-0.066*** (0.012)	-0.077*** (0.012)	-0.044*** (0.012)	-0.059*** (0.011)	-0.071*** (0.012)	-0.056*** (0.013)	-0.056*** (0.012)	-0.062*** (0.012)
<i>Limited Liability Partnership # prod.</i>	-0.043* (0.019)	-0.050* (0.020)	-0.056** (0.019)	-0.032 (0.020)	-0.039* (0.019)	-0.046* (0.019)	-0.020 (0.020)	-0.011 (0.020)	-0.014 (0.020)
<i>Partnership # prod.</i>	-0.026* (0.012)	-0.015 (0.014)	-0.011 (0.012)	-0.024 (0.012)	-0.013 (0.013)	-0.009 (0.012)	-0.011 (0.015)	0.003 (0.014)	0.007 (0.015)
<i>Limited Partnership # prod.</i>	-0.028 (0.018)	-0.024 (0.016)	-0.022 (0.017)	-0.026 (0.017)	-0.022 (0.016)	-0.020 (0.016)	-0.026 (0.018)	-0.016 (0.017)	-0.014 (0.016)
<i>De facto # prod.</i>	0.039** (0.013)	0.035** (0.013)	0.037** (0.013)	0.040** (0.013)	0.037** (0.014)	0.038** (0.013)	0.061*** (0.015)	0.061*** (0.015)	0.063*** (0.015)
<i>Other # prod.</i>	-0.022 (0.017)	-0.023 (0.016)	-0.024 (0.016)	-0.020 (0.016)	-0.022 (0.015)	-0.023 (0.015)	-0.004 (0.017)	-0.003 (0.016)	-0.003 (0.016)

(continued)

Table A3. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
<i>Firm size (1–3 omit.)</i>									
<i>4–6 employees # prod.</i>	0.012 (0.007)	0.011 (0.007)	0.010 (0.007)	0.011 (0.006)	0.009 (0.007)	0.009 (0.007)	0.009 (0.007)	0.004 (0.007)	0.003 (0.008)
<i>7–9 employees # prod.</i>	–0.010 (0.012)	–0.006 (0.011)	–0.003 (0.011)	–0.007 (0.012)	–0.004 (0.012)	–0.000 (0.011)	–0.005 (0.012)	–0.005 (0.012)	–0.004 (0.012)
<i>10–99 employees # prod.</i>	0.000 (0.009)	–0.000 (0.009)	0.001 (0.009)	0.001 (0.009)	0.000 (0.009)	0.002 (0.009)	–0.007 (0.010)	–0.009 (0.010)	–0.010 (0.010)
<i>100–999 employees # prod.</i>	0.043*** (0.016)	0.037* (0.017)	0.016 (0.018)	0.046*** (0.017)	0.040* (0.017)	0.017 (0.020)	0.007 (0.017)	–0.002 (0.018)	–0.020 (0.019)
<i>1,000+ employees # prod.</i>	0.165*** (0.047)	0.154** (0.058)	–0.019 (0.091)	0.162*** (0.047)	0.150* (0.060)	–0.026 (0.084)	0.136** (0.048)	0.125* (0.059)	–0.031 (0.086)
<i>Firm age (0–3 years omit.)</i>									
<i>4–7 years old # prod.</i>	–0.059*** (0.008)	–0.057*** (0.007)	–0.058*** (0.008)	–0.061*** (0.008)	–0.058*** (0.008)	–0.059*** (0.007)	–0.061*** (0.008)	–0.060*** (0.009)	–0.060*** (0.009)
<i>8–12 years old # prod.</i>	–0.080*** (0.009)	–0.077*** (0.009)	–0.078*** (0.009)	–0.080*** (0.009)	–0.078*** (0.009)	–0.078*** (0.009)	–0.090*** (0.009)	–0.091*** (0.010)	–0.091*** (0.010)
<i>13–20 years old # prod.</i>	–0.073*** (0.009)	–0.071*** (0.008)	–0.071*** (0.008)	–0.074*** (0.009)	–0.071*** (0.008)	–0.071*** (0.008)	–0.085*** (0.009)	–0.084*** (0.010)	–0.083*** (0.010)
<i>21–50 years old # prod.</i>	–0.075*** (0.008)	–0.074*** (0.009)	–0.077*** (0.008)	–0.076*** (0.009)	–0.076*** (0.009)	–0.078*** (0.008)	–0.088*** (0.010)	–0.090*** (0.010)	–0.091*** (0.010)
<i>51+ years old # prod.</i>	–0.109*** (0.020)	–0.102*** (0.018)	–0.106*** (0.019)	–0.111*** (0.018)	–0.105*** (0.018)	–0.108*** (0.019)	–0.132*** (0.020)	–0.132*** (0.020)	–0.133*** (0.020)
<i>% req. literacy (std.) # prod.</i>	–0.003 (0.007)	–0.009 (0.008)	–0.009 (0.008)	–0.002 (0.007)	–0.008 (0.007)	–0.008 (0.007)	0.001 (0.008)	–0.002 (0.008)	–0.002 (0.008)
<i>% req. math (std.) # prod.</i>	–0.028*** (0.005)	–0.027*** (0.005)	–0.028*** (0.005)	–0.028*** (0.005)	–0.028*** (0.005)	–0.028*** (0.005)	–0.029*** (0.005)	–0.030*** (0.005)	–0.031*** (0.005)

(continued)

Table A3. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
<i>% req. computers (std.) # prod.</i>	-0.006 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.006 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.012 (0.007)	-0.012 (0.007)	-0.012 (0.007)
<i>% req. physical fitness (std.) # prod.</i>	-0.005 (0.003)	-0.006* (0.003)	-0.006* (0.003)	-0.004 (0.003)	-0.006* (0.003)	-0.006* (0.003)	-0.007* (0.003)	-0.009** (0.003)	-0.009** (0.003)
<i>% technical skill required (std.) # prod.</i>	-0.002 (0.004)	-0.004 (0.004)	-0.004 (0.004)	-0.001 (0.004)	-0.003 (0.004)	-0.003 (0.004)	-0.004 (0.004)	-0.006 (0.004)	-0.006 (0.004)
<i>Job ed. req. (% less than basic omit.) % req. basic (std.) # prod.</i>	0.007 (0.004)	0.006 (0.003)	0.006 (0.003)	0.008* (0.003)	0.007* (0.003)	0.007* (0.003)	0.007 (0.004)	0.007 (0.004)	0.007 (0.004)
<i>% req. sec (std.) # prod.</i>	0.005 (0.004)	0.007 (0.004)	0.007 (0.004)	0.006 (0.004)	0.008* (0.004)	0.008* (0.004)	0.008 (0.005)	0.010* (0.004)	0.010* (0.004)
<i>% req. higher ed. (std.) # prod.</i>	0.010 (0.007)	0.011 (0.007)	0.010 (0.007)	0.011 (0.007)	0.011 (0.007)	0.010 (0.007)	0.016* (0.008)	0.016* (0.008)	0.015 (0.008)
<i>Prep. test score (std.) # prod.</i>	-0.003 (0.003)	-0.001 (0.003)	-0.001 (0.003)	-0.004 (0.003)	-0.002 (0.003)	-0.001 (0.003)	-0.005 (0.003)	-0.005 (0.003)	-0.004 (0.003)
<i>Occup.: % prof./man. omit. % white collar (std.) # prod.</i>	-0.054*** (0.009)	-0.052*** (0.009)	-0.053*** (0.009)	-0.054*** (0.009)	-0.051*** (0.009)	-0.052*** (0.009)	-0.055*** (0.010)	-0.051*** (0.010)	-0.052*** (0.010)
<i>% blue collar (std.) # prod.</i>	-0.069*** (0.010)	-0.065*** (0.010)	-0.066*** (0.010)	-0.069*** (0.010)	-0.065*** (0.010)	-0.066*** (0.010)	-0.066*** (0.011)	-0.064*** (0.011)	-0.064*** (0.011)
<i>% Training (std.) # prod.</i>	0.006 (0.003)	0.005 (0.004)	0.005 (0.004)	0.005 (0.004)	0.004 (0.004)	0.004 (0.004)	0.002 (0.004)	0.002 (0.004)	0.002 (0.004)
<i>% trained by emp. (std.) # prod.</i>	0.003 (0.003)	0.000 (0.003)	0.001 (0.003)	0.001 (0.003)	-0.001 (0.003)	-0.000 (0.003)	-0.003 (0.004)	-0.003 (0.004)	-0.002 (0.004)
<i>% emp. paid for train (std.) # prod.</i>	-0.004 (0.004)	-0.002 (0.004)	-0.003 (0.004)	-0.003 (0.004)	-0.001 (0.004)	-0.001 (0.004)	0.001 (0.004)	0.001 (0.004)	-0.000 (0.004)

(continued)

Table A3. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
<i>Weeks of training (std.) # prod.</i>	-0.013** (0.004)	-0.010* (0.004)	-0.010* (0.004)	-0.012** (0.004)	-0.008 (0.004)	-0.008 (0.004)	-0.010* (0.005)	-0.008 (0.005)	-0.008 (0.005)
<i>Mean tenure (years) (std.) # prod.</i>	-0.015*** (0.003)	-0.015*** (0.003)	-0.016*** (0.003)	-0.014*** (0.003)	-0.014*** (0.003)	-0.015*** (0.003)	-0.015*** (0.003)	-0.015*** (0.003)	-0.016*** (0.003)
<i>% paid by piece (std.) # prod.</i>	0.014*** (0.003)	0.013*** (0.003)	0.013*** (0.004)	0.014*** (0.003)	0.013*** (0.003)	0.013*** (0.003)	0.011** (0.004)	0.009* (0.004)	0.010** (0.004)
<i>% paid bonuses and incentives (std.) # prod.</i>	0.008** (0.003)	0.008** (0.003)	0.008** (0.003)	0.007* (0.003)	0.008** (0.003)	0.008** (0.003)	0.006* (0.003)	0.007* (0.003)	0.007* (0.003)
<i>Contract: % no contract omit. % temp. contract (std.) # prod.</i>	0.007** (0.002)	0.008** (0.002)	0.008*** (0.002)	0.007** (0.002)	0.008** (0.002)	0.008** (0.003)	0.007** (0.003)	0.006* (0.003)	0.007* (0.003)
<i>% perm. contract (std.) # prod.</i>	0.012*** (0.002)	0.012*** (0.003)	0.012*** (0.003)	0.012*** (0.003)	0.012*** (0.003)	0.011*** (0.003)	0.011*** (0.003)	0.011*** (0.003)	0.011*** (0.003)
<i>% supervisors (std.) # prod.</i>	-0.009*** (0.003)	-0.006* (0.003)	-0.006* (0.003)	-0.009*** (0.003)	-0.006* (0.003)	-0.006* (0.003)	-0.005 (0.003)	-0.004 (0.003)	-0.003 (0.003)
<i>No. workers per supervisor (std.) # prod.</i>	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	0.000 (0.002)	-0.000 (0.002)	-0.000 (0.002)
<i>Main effects</i>									
<i>Formal</i>	-0.061*** (0.005)	-0.058*** (0.005)	-0.060*** (0.005)	-0.024*** (0.005)	-0.021*** (0.005)	-0.023*** (0.005)	0.258*** (0.006)	0.259*** (0.005)	0.257*** (0.005)
<i>Conc. Ratio (%) 4 firm (std.)</i>	-0.008* (0.003)	-0.008* (0.004)	-0.006 (0.003)	-0.009** (0.003)	-0.009** (0.003)	-0.007* (0.003)	-0.014*** (0.004)	-0.014*** (0.004)	-0.012** (0.004)
<i>HH-Index (std.)</i>	0.009** (0.004)	0.009** (0.004)	0.007* (0.003)	0.011*** (0.003)	0.010** (0.003)	0.009** (0.003)	0.017*** (0.004)	0.016*** (0.004)	0.015*** (0.004)
<i>Capital per worker (std.)</i>	0.027*** (0.002)	0.081*** (0.003)	0.079*** (0.003)	0.027*** (0.002)	0.082*** (0.003)	0.080*** (0.003)	0.038*** (0.003)	0.095*** (0.003)	0.093*** (0.003)

(continued)

Table A3. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
<i>% union member (std.)</i>	0.015*** (0.004)	0.015*** (0.004)	0.015*** (0.003)	0.016*** (0.003)	0.016*** (0.004)	0.016*** (0.004)	0.008 (0.004)	0.008 (0.004)	0.008 (0.004)
<i>Legal status (sole prop. omit)</i>									
Joint Stock	0.325*** (0.020)	0.328*** (0.019)	0.352*** (0.018)	0.357*** (0.019)	0.362*** (0.017)	0.388*** (0.017)	0.601*** (0.021)	0.595*** (0.019)	0.616*** (0.019)
Limited Liability Partnership	0.217*** (0.023)	0.218*** (0.022)	0.225*** (0.022)	0.251*** (0.022)	0.254*** (0.021)	0.261*** (0.021)	0.455*** (0.023)	0.452*** (0.021)	0.457*** (0.022)
Partnership	0.011 (0.010)	0.010 (0.011)	0.010 (0.010)	0.023* (0.010)	0.022* (0.011)	0.022* (0.010)	0.053*** (0.013)	0.053*** (0.012)	0.054*** (0.012)
Limited Partnership	0.001 (0.022)	-0.003 (0.019)	0.002 (0.020)	0.029 (0.021)	0.025 (0.018)	0.030 (0.020)	0.137*** (0.025)	0.132*** (0.021)	0.138*** (0.022)
<i>De facto</i>	0.033*** (0.010)	0.035*** (0.010)	0.033** (0.011)	0.040*** (0.010)	0.041*** (0.010)	0.040*** (0.010)	0.049*** (0.012)	0.052*** (0.013)	0.050*** (0.012)
Other	-0.179*** (0.033)	-0.181*** (0.033)	-0.186*** (0.033)	-0.176*** (0.034)	-0.178*** (0.034)	-0.184*** (0.034)	-0.255*** (0.037)	-0.258*** (0.037)	-0.266*** (0.037)
<i>Firm size (1-3 omit.)</i>									
4-6 employees	0.114*** (0.005)	0.126*** (0.005)	0.116*** (0.005)	0.108*** (0.005)	0.121*** (0.005)	0.110*** (0.005)	0.152*** (0.006)	0.165*** (0.006)	0.154*** (0.006)
7-9 employees	0.171*** (0.009)	0.191*** (0.009)	0.176*** (0.010)	0.165*** (0.009)	0.185*** (0.010)	0.170*** (0.009)	0.240*** (0.012)	0.263*** (0.011)	0.247*** (0.012)
10-99 employees	0.145*** (0.009)	0.176*** (0.010)	0.163*** (0.009)	0.141*** (0.009)	0.172*** (0.009)	0.160*** (0.009)	0.236*** (0.011)	0.269*** (0.011)	0.257*** (0.011)
100-999 employees	0.080** (0.025)	0.179*** (0.026)	0.225*** (0.030)	0.114*** (0.023)	0.218*** (0.027)	0.269*** (0.030)	0.202*** (0.025)	0.290*** (0.027)	0.333*** (0.029)
1,000+ employees	0.096 (0.099)	0.331*** (0.088)	0.514*** (0.121)	0.164 (0.094)	0.400*** (0.081)	0.586*** (0.108)	0.175 (0.104)	0.398*** (0.096)	0.588*** (0.110)

(continued)

Table A3. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
<i>Firm age (0–3 years omit.)</i>									
4–7 years old	0.056*** (0.006)	0.060*** (0.005)	0.058*** (0.005)	0.056*** (0.006)	0.061*** (0.006)	0.059*** (0.005)	0.072*** (0.006)	0.076*** (0.006)	0.075*** (0.006)
8–12 years old	0.082*** (0.006)	0.085*** (0.006)	0.084*** (0.006)	0.086*** (0.006)	0.088*** (0.006)	0.088*** (0.006)	0.118*** (0.007)	0.121*** (0.007)	0.120*** (0.007)
13–20 years old	0.078*** (0.007)	0.080*** (0.007)	0.080*** (0.007)	0.086*** (0.007)	0.087*** (0.007)	0.087*** (0.007)	0.137*** (0.008)	0.139*** (0.008)	0.139*** (0.008)
21–50 years old	0.089*** (0.007)	0.091*** (0.007)	0.092*** (0.007)	0.099*** (0.007)	0.101*** (0.007)	0.102*** (0.007)	0.167*** (0.008)	0.169*** (0.009)	0.170*** (0.009)
51+ years old	0.081*** (0.019)	0.083*** (0.020)	0.084*** (0.018)	0.097*** (0.019)	0.099*** (0.019)	0.100*** (0.018)	0.174*** (0.022)	0.175*** (0.023)	0.177*** (0.021)
% req. literacy (std.)	-0.045*** (0.006)	-0.045*** (0.006)	-0.047*** (0.007)	-0.041*** (0.006)	-0.041*** (0.006)	-0.043*** (0.006)	-0.023** (0.007)	-0.024** (0.008)	-0.026*** (0.007)
% req. math (std.)	0.033*** (0.004)	0.033*** (0.004)	0.034*** (0.004)	0.032*** (0.004)	0.033*** (0.004)	0.034*** (0.004)	0.043*** (0.005)	0.044*** (0.005)	0.045*** (0.005)
% req. computers (std.)	-0.009 (0.006)	-0.009 (0.006)	-0.008 (0.006)	-0.013* (0.006)	-0.013* (0.006)	-0.012* (0.006)	-0.042*** (0.007)	-0.043*** (0.007)	-0.042*** (0.007)
% req. physical fitness (std.)	-0.014*** (0.003)	-0.015*** (0.003)	-0.014*** (0.003)	-0.011*** (0.003)	-0.012*** (0.003)	-0.012*** (0.003)	-0.006* (0.003)	-0.007* (0.003)	-0.007* (0.003)
% technical skill required (std.)	0.002 (0.003)	0.003 (0.003)	0.003 (0.003)	0.002 (0.003)	0.003 (0.003)	0.003 (0.003)	-0.012*** (0.004)	-0.011** (0.004)	-0.011*** (0.003)
<i>Job ed. req. (% less than basic omit.)</i>									
% req. basic (std.)	-0.028*** (0.003)	-0.028*** (0.003)	-0.028*** (0.003)	-0.027*** (0.003)	-0.027*** (0.003)	-0.026*** (0.003)	-0.028*** (0.003)	-0.029*** (0.003)	-0.028*** (0.004)
% req. sec (std.)	-0.001 (0.004)	-0.001 (0.004)	-0.002 (0.004)	-0.003 (0.004)	-0.004 (0.004)	-0.004 (0.004)	-0.024*** (0.004)	-0.024*** (0.004)	-0.024*** (0.004)

(continued)

Table A3. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
% req. higher ed. (std.)	-0.013 (0.007)	-0.013 (0.007)	-0.013 (0.007)	-0.013 (0.007)	-0.013 (0.007)	-0.013 (0.007)	-0.019* (0.008)	-0.019* (0.008)	-0.019* (0.008)
<i>Prep. test score (std.)</i>	0.016*** (0.003)	0.016*** (0.003)	0.017*** (0.003)	0.015*** (0.003)	0.014*** (0.003)	0.016*** (0.003)	0.007* (0.003)	0.008* (0.003)	0.009** (0.003)
<i>Occup.: % prof./man. omit.</i>									
% white collar (std.)	0.011 (0.010)	0.012 (0.009)	0.013 (0.009)	0.013 (0.009)	0.013 (0.009)	0.015 (0.010)	-0.002 (0.010)	-0.001 (0.011)	0.001 (0.010)
% blue collar (std.)	0.034*** (0.010)	0.035*** (0.009)	0.036*** (0.010)	0.035*** (0.010)	0.036*** (0.009)	0.038*** (0.010)	0.044*** (0.010)	0.045*** (0.011)	0.047*** (0.011)
% Training (std.)	-0.021*** (0.004)	-0.020*** (0.004)	-0.021*** (0.004)	-0.022*** (0.003)	-0.022*** (0.004)	-0.022*** (0.004)	-0.030*** (0.004)	-0.030*** (0.004)	-0.030*** (0.004)
% trained by emp. (std.)	-0.014* (0.005)	-0.013* (0.005)	-0.014** (0.005)	-0.014** (0.005)	-0.014** (0.005)	-0.015** (0.006)	0.000 (0.006)	-0.001 (0.006)	-0.002 (0.006)
% emp. paid for train (std.)	0.027*** (0.006)	0.027*** (0.006)	0.027*** (0.006)	0.028*** (0.005)	0.028*** (0.006)	0.028*** (0.006)	0.011 (0.006)	0.011 (0.006)	0.012 (0.007)
Weeks of training (std.)	-0.002 (0.003)	-0.002 (0.003)	-0.001 (0.003)	-0.002 (0.003)	-0.002 (0.003)	-0.001 (0.003)	-0.005 (0.004)	-0.005 (0.004)	-0.004 (0.004)
Mean tenure (years) (std.)	0.038*** (0.003)	0.038*** (0.002)	0.038*** (0.003)	0.035*** (0.003)	0.035*** (0.003)	0.035*** (0.003)	0.020*** (0.003)	0.020*** (0.003)	0.020*** (0.003)
% paid by piece (std.)	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)	0.003 (0.003)	0.003 (0.003)	0.003 (0.003)	0.010** (0.003)	0.010** (0.003)	0.010** (0.003)
% paid bonuses and incentives (std.)	-0.028*** (0.003)	-0.027*** (0.003)	-0.026*** (0.003)	-0.028*** (0.003)	-0.027*** (0.003)	-0.026*** (0.003)	-0.021*** (0.003)	-0.020*** (0.003)	-0.019*** (0.003)
<i>Contract: % no contract omit.</i>									
% temp. contract (std.)	0.030*** (0.003)	0.032*** (0.003)	0.031*** (0.003)	0.030*** (0.003)	0.032*** (0.003)	0.031*** (0.002)	0.033*** (0.003)	0.035*** (0.003)	0.034*** (0.003)

(continued)

Table A3. Continued

	Ln(wages/worker)			Ln(wages and benefits/worker)			Ln(formality adjusted wages/worker)		
	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog	ln (Y/L)	TFP: Cobb- Douglas	TFP: Translog
% perm. contract (std.)	-0.004 (0.003)	-0.003 (0.003)	-0.002 (0.003)	-0.001 (0.002)	-0.000 (0.003)	0.000 (0.003)	0.008** (0.003)	0.009** (0.003)	0.009** (0.003)
% supervisors (std.)	0.036*** (0.003)	0.036*** (0.003)	0.036*** (0.002)	0.036*** (0.002)	0.035*** (0.002)	0.035*** (0.002)	0.035*** (0.003)	0.035*** (0.003)	0.035*** (0.003)
No. workers per supervisor (std.)	0.001 (0.002)	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.005 (0.002)	-0.005* (0.002)	-0.005* (0.002)
Constant	9.746*** (0.005)	9.728*** (0.005)	9.733*** (0.005)	9.755*** (0.005)	9.738*** (0.005)	9.742*** (0.005)	9.713*** (0.005)	9.697*** (0.005)	9.702*** (0.005)
N (obs.)	108,195	108,195	108,195	108,195	108,195	108,195	108,195	108,195	108,195
R-sq.	0.293	0.290	0.291	0.307	0.305	0.306	0.353	0.352	0.352

Note(s): * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Bootstrapped standard errors (500 repetitions) in parentheses

Source(s): Authors' calculations based on EC 2018; ELMPS 2018

Notes

1. The only other study on the wage-productivity relationship in Egypt covered 1914 to 1961 and found wages are related to seasonal demand for agricultural labor (Hansen, 1966).
2. An earlier version of the paper (Krafft and Assaad 2018) used the 2012/13 Egypt Economic Census.
3. The sampling frame is all non-government establishments identified in the 2017 General Population and Establishments Census. Businesses outside of establishments (for example, most construction, transportation, and agriculture) are not included in the sample. Although government establishments are not included, some state-owned enterprises are included in the sampling frame.
4. Authors' calculations from Egypt Labor Market Panel Survey (2018).
5. A number of firms are self-employment or have only unpaid workers.
6. One concern with this approach would be that excluding those with zero or negative value-added biases the relationship and affects generalizability. Although we cannot estimate the logged correlation with zero and negative value added, we checked the correlation between the non-logged value added per worker and non-logged wages per wage worker when those firms with zero or negative value added were included (0.097) and excluded (0.102), suggesting the results are similar and likely generalizable.
7. See Krafft *et al.* (2021) for more information on the ELMPS.
8. We use four regions: (1) Greater Cairo (2) Alexandria and Suez Canal (3) Lower Egypt and (4) Upper Egypt. We follow ELMPS firm size categories: 1–4 employees, 5–24 employees, 25–99 employees, and 100+ employees. We use the lowest one or two-digit level of industry classification, firm size, and region combination that has at least 3 observations to merge in characteristics from the ELMPS. Some of the smaller activities were aggregated even at the one-digit level. If there were not three observations in the two-digit industry, firm size, and region cell, we first reverted to a cell without firm size, then a cell without firm size or region, then the one-digit industry, and lastly the grand mean (continuing through this sequence only until a cell with at least three observations).
9. We include in our measure of workers (L) both paid and unpaid workers.
10. Since we use logs, which would evaluate zero capital as missing, we replace reports of zero capital with one Egyptian pound of capital.
11. In estimating TFP, in both the translog and Cobb-Douglas specifications, we use log value added as the dependent variable. The explanatory variables in the Cobb-Douglas specification are log labor (number of workers) and log capital (value in Egyptian pounds). The translog specification adds the interaction between log labor and log capital to the Cobb-Douglas specification. The translog also adds the squares of log labor and log capital, for a more flexible functional form. TFP is then calculated as the residual from the estimated Cobb-Douglas or translog model.
12. Informal workers' wages are retained as observed in the "formality adjusted" measure.
13. Capital per worker could also, potentially, be related to efficiency wages in cases where there is high capital per worker due to expensive equipment, where worker errors could be damaging and costly (Katz, 1986).
14. We use the classification provided in EC 2018: sole proprietorship (the reference category), joint stock company, limited liability partnership, partnership, limited partnership, de facto company, and other.
15. Skill and education requirements could also relate to whether a worker is well-matched given the common issue of labor market mismatch (Assaad *et al.*, 2018). This would, however, still be a case of efficiency wages if so, in that wages and productivity are related to worker quality via match.
16. Because of an issue in how this question was asked in 2018, we use the 2012–2018 panel to get data on preparatory test scores from 2012 for 2018 workers.
17. We do not cluster our standard errors since sampling was not clustered.
18. We use the STATA module shapley2 (Juarez, 2012).

19. The contributions are calculated marginally, that is, by eliminating the variables in a particular group and calculating the R-squared with versus without that group. Since marginal contributions are driven by orderings when variables are correlated (as they are in this case), the Shapley decomposition uses all possible orderings of removal and calculates the average contribution (Shorrocks, 2013).
20. The wage elasticity of production is 0.614, higher than estimates correcting for publication bias (0.325) but similar to uncorrected estimates (0.625) (Peach and Stanley, 2009).

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