Wages and Labor Management in African Manufacturing*

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Abstract

Using matched employer-employee data on 10 African countries, this paper examines the relationship between wages, worker supervision, and labor productivity in manufacturing. Wages increase with firm size for both production workers and supervisors. We develop a two-tier model of supervision that can account for this stylized fact and we fit the structural model to the data. Employee data is used to derive a firm-specific wage premium that is purged of the effect of worker observables. We find a strong effect of both supervision and wages on effort and hence on labor productivity. Labor management in sub-Saharan Africa appears problematic, with much higher supervisor-to-worker ratios than elsewhere and a higher elasticity of effort with respect to supervision than in Morocco.

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1. Introduction

It is widely acknowledged that firms pay different wages, so much so that unemployment is often modeled as a sequential search process for the best wage offer. In particular, large firms are uniformly found to pay higher wages than small firms (e.g. Oi and Idson 1999, Mazumdar and Mazaheri 2002).

Different explanations have been proposed for this state of affairs (e.g. Troske 1999, Bayard and Troske 1999). One category of explanations reverts around the idea that workers differ in dimensions that are hard to measure. Firms employing better workers pay higher wages because their workers are more productive. This, by itself, does not explain why large firms pay more. To account for this, it is possible to assume, as does Stiglitz (1987), that large firms need better workers and consequently screen job applicants and new workers more thoroughly. While the notion that the size-wage differential is driven by unobserved heterogeneity may be intuitively appealing, it does not appear to be supported by the empirical evidence. In recent years a number of data sets have become available that enable researchers to estimate the size-wage effect while controlling for unmeasured heterogeneity in the form of individual fixed effects. Spanning a wide range of countries[1], Brown and Medoff (1989), Criscuolo (2000), Arai (2003), and Soderbom, Teal and Wambugu (2004) all reject the hypothesis that the size-wage effect can be attributed solely to the omission of individual fixed effects. These studies also indicate that the magnitude of the bias from omitting controls for worker heterogeneity is relatively moderate.[2]

Another category of explanation for wage differences across firms focuses on labor management. In order to be productive, workers need to be motivated to exert effort and initiative. Firms can motivate workers in two ways: by supervising the workforce more closely to minimize shirking and idle time; or by paying workers more to increase firm loyalty and the opportunity cost of losing one's job. To motivate workers, there is thus a trade-off between supervision and wages. Because of moral hazard and information processing requirements are more difficult in large and multi-tiered hierarchies, the management and supervision of workers becomes increasingly complex as firm size increases (e.g. Williamson 1975, Itoh

[1] Brown and Medoff: the U.S.; Criscuolo: Germany; Arai: Sweden; Söderbom et al.: Ghana and Kenya.

[2] Using a sample of 60 firms, Reilly (1995) shows that after controlling for computer access the size effect is no longer significant. From this he concludes that the size effect is driven by unobserved human capital. If computer use was responsible for the size effect, then this effect should be absent when computers are not used. Yet firms in our SSA sample display a strong size effect despite hardly ever using computers. More recent studies that control for unobserved heterogeneity in the most robust way – ie by means of fixed effects – all find a size effect.

1991, Meagher 2001). As a result, large firms may choose to motivate their workers through higher wages instead. The intellectual appeal of this explanation comes from its parsimony: it explains wage differentials across firms in a way that also accounts for the empirical relationship between firm size and wages.[3]

This paper revisits these issues using matched employer-employee data in manufacturing. We contrast two mechanisms by which firms seek to motivate their workers: supervision and wages. To capture them, we formulate a two-tier model of supervision in which middle-level managers must be monitored by shareholders. The model predicts that worker supervision falls with firm size while wages rise, a feature consistent with the descriptive analysis of our data. This structural model is then econometrically estimated using data from ten African countries – nine in Sub-Saharan Africa (SSA) and one in North-Africa. Africa is a very suitable test case for a study of the trade-off between supervision and wages. Firstly, supervision rates in Africa appear to be high relative to other parts of the world. Acemoglu and Newman (2002) report averages of the ratio of managerial to production workers in six OECD countries. In no case does this ratio exceed 25%. In contrast, the average supervision ratio is 41% in SSA.[4] Secondly, the wage premium given by large firms relative to small firms is larger in SSA than elsewhere (e.g. Velenchik 1997, Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal and Zeufack 2004). Taken together, these two stylized facts suggest that in Africa labor management problems may indeed be driving part of the wage differences across firms. The model is estimated separately for Morocco and SSA to account for structural differences between the two groups of countries brought to light by the descriptive analysis.[5]

Econometric estimation yields parameter estimates of the structural two-tier supervision model. Estimation is accomplished by solving the theoretical model numerically and iterating on parameter estimates. Results suggest that, at the sample average, the elasticity of worker effort with respect to wage is around 0.45 in SSA and 0.74 in Morocco. In contrast, the elasticity of worker effort with respect to supervision

[3] In a related vein, Garicano and Hubbard (2003) and Garicano and Hubbard (2004) show that hierarchies play an important role in capturing increasing returns.

[4] As noted by Acemoglu and Newman, cross-country comparisons should be interpreted with caution, since the definition of a manager or production worker may vary across countries.

[5] Due to the small size of the valid samples in SSA, we have no choice but to pool the observations across countries. In the analysis, country dummies are use throughout to control for differences in legal institutions and labor market structure.

is around 0.27 in SSA and 0.11 in Morocco. We find a non-negligible trade-off between supervision and wages as alternative ways of motivating workers. At the sample average, a decrease in supervision by 20% reduces worker effort by 6% in SSA and 3% in Morocco, holding everything else constant. To keep effort constant, worker wages must increase by 10-12% in SSA and by 3% in Morocco.

This paper contributes to the literature in various ways. The model and analysis presented here elaborate on a possible explanation for the often observed positive relationship between wages and firm size (Oi and Idson 1999). The fact that wages in SSA increase particularly rapidly with firm size is consistent with our findings that labor management is a more acute problem there. On the empirical side, we use matched employer-employee data covering ten African countries, a part of the world that to date has received little attention (Abowd and Kramarz 1999). Our contribution is also methodological as we combine non-parametric and structural estimation methods to throw light on labor efficiency issues.

The paper is organized as follows. A conceptual framework is introduced in Section 2. A two-tier efficiency wage model is constructed in which middle-rank managers and administrative staff must be monitored by firm owners. The data are presented in Section 3 together with a non-parametric analysis of labor management. Using matched employer-employee data, we find that wages increase with firm size even after we correct for observable human capital. We also find that supervision ratios fall with firm size, a finding contrary to that of Ringuede (1998) for French enterprises. Section 4 estimates a structural efficiency wage model that combines firm level and employee level data. Conclusions appear in Section 5.

2. Conceptual framework

As a basis for our empirical analysis, we construct a two-tiered model of wages and worker supervision. This model nests a number of simpler model as special cases. We begin by presenting the most general model. We then discuss a number of special cases and illustrate how they differ in their predictions regarding wages and supervision. We then describe our testing strategy.

2.1. The general model

We construct a model of firms' labor management decisions. Workers are divided into two categories: production workers (hereafter workers), denoted L, and supervisors, denoted S. Firms choose the number of workers and supervisors they hire. They also set wages w for workers and m for supervisors. The effort provided by workers depend on their wage w and on the extent of supervision p. We write the effort function as:

$$e = (w - x)^c (d + \frac{1}{p})^{-b} \tag{2.1}$$

where x, c, d, and b are parameters, with $c \geq 0$, $b \geq 0$, $d \geq 0$, and $x \geq 0$. A similar effort function is assumed for supervisors:

$$e' = (m - x')^{c'} (d' + \frac{1}{p'})^{-b'} \tag{2.2}$$

where p' measures the extent to which supervisors are themselves supervised by firm owners, and x', c', d', and b' are model parameters.

Equations (2.1) and (2.2) imply that effort is increasing with wage (w and m) and with supervision (p and p'). The choice of this functional form is dictated by several considerations. First, it is sparse in parameters and yet able to deliver results of interest (Stiglitz 1987). Second, it nests a number of interesting special cases. For instance, if $c = 0$ ($b = 0$), effort is unresponsive to wages (supervision). Finally, the effort function derived by Sparks (1986) using an explicit worker dismissal model is a special case of equation (2.1) with $c = b = 0.5$, $x = rV^U$, and $d = 1/2r$ where r is the workers' rate of time preference and V^U is the expected life-time utility from becoming unemployed (see also Ringuede (1998)).[6] Because in Sparks' framework x and x' are interpretable as the income employees receive if they are sacked from their current job, we sometimes refer to these parameters as measuring the 'outside option' of workers and supervisors.

Equations (2.1) and (2.2) are sufficiently general to capture a variety of effects that have been discussed in the literature (e.g. Stiglitz 1987, Oi and Idson 1999, Abowd and Kramarz 1999). The effect of wages on

[6] Sparks uses a slightly different formulation with $(1+\frac{2r}{p})^{\frac{1}{2}}$ as second term. Given that we use a Cobb-Douglas production function, dividing Sparks' second term by $2r$ yields an effort function equivalent to ours, except for a $(2r)^{\frac{1}{2}}$ term in front. The factored out term only affects the constant in the production function and can be ignored in the analysis.

effort may be due to the fear of losing one's job or to the morale-boosting of higher-than-average wages. Supervision effects may due to the probability of dismissal of workers found shirking, as in Shapiro and Stiglitz (1984) and Sparks (1986). It may also be driven by other labor management effects, such as information processing within the firm, the organization of team work, etc (e.g. Itoh 1991, Fudenberg and Tirole 1991, Williamson 1985).

Next we assume that extent of supervision p is proportional to the supervisor per worker ratio, corrected for the effort of supervisors:

$$p = \frac{e'S}{L} \tag{2.3}$$

This implies that the more effort supervisors provide, the more closely monitored workers are, and the more effort is supplied by workers themselves. We apply the same reasoning to the supervision of supervisors, treating the owner or board of directors as one. Consequently, we have:

$$p' = \frac{1}{S} \tag{2.4}$$

Firms are assumed to choose employment levels L and S and remuneration levels w and m so as to maximize profits:

$$\max_{L,S,w,m,p,p'} \; a(eL)^{\beta} - wL - mS$$

subject to equations (2.1), (2.3), (2.2), and (2.4)

where a stands for everything other than labor in the production function. After replacing throughout p and p' by equations (2.3) and (2.4), the first order conditions are:

$$w = ae^{\beta}\beta L^{\beta-1} - a\beta e^{\beta-1} e_p S e' L^{\beta-2} \tag{2.5}$$

$$m = a\beta e^{\beta-1} e_p \left[\frac{e'}{L} + \frac{S}{L} e'_S\right] L^{\beta} \tag{2.6}$$

$$L = a\beta e^{\beta-1} e_w L^{\beta} \tag{2.7}$$

$$S = a\beta e^{\beta-1} e_p S e'_m L^{\beta-1} \tag{2.8}$$

where the derivatives of the effort functions are given by:

$$\begin{aligned}
e_w &= c(w-x)^{c-1}(d+\frac{1}{p})^{-b} \\
e_p &= (w-x)^{c}(d+\frac{1}{p})^{-b-1}\frac{b}{p^2} \\
e'_m &= c'(m-x')^{c'-1}(d'+S)^{-b'} \\
e'_S &= -b'(m-x')^{c'}(d'+S)^{-b'-1}
\end{aligned}$$

2.2. No effort function

To understand the properties of the model, it is useful to proceed step by step and to start from a simplified version with no supervision. Formally, let $c = b = c' = b' = 0$. Consequently, e and e' are constant. In this case, the firm's profit maximization problem boils down to:[7]

$$\max_{L,S\geq 0} a(\bar{e}L)^{\beta} - wL - mS$$

which immediately yields $S = 0$ and the usual first order condition:

$$w = a\beta L^{\beta-1}$$

[7] Since wages have no effect on effort, the firm would naturally wish to set $w = 0$. This unrealistic prediction can be eliminated either by assuming that firms do not set wages, or that, by an arbitrage argument, they must set wages at least equal to wages paid by other employers. In this case, firms choose a wage exactly equal to the going market wage.

where u_w is, as before, a error term. In this simple case, we expect no relationship between w and firm size: on average, all firms pay the same wage, irrespective of size. Moreover, there are no supervisors.

2.3. Efficiency wage model

The standard efficiency wage model without supervision is obtained by assuming that $b = c' = b' = 0$. Profit maximization with respect to L and w yields the usual first order conditions:

$$\begin{aligned} w &= ae^{\beta}\beta L^{\beta-1} \\ L &= a\beta e^{\beta-1}e_w L^{\beta} \end{aligned}$$

which, after straightforward manipulation, yields the standard Solow condition:

$$w = \frac{e_w}{e}$$

Since here e (and thus e_w) only depends on w, the Solow condition implies that all firms pay the same wage, irrespective of size. Sparks (1986) provides behavioral underpinnings for a special case of this model in which $c = 0.5$.

2.4. Supervision by owner

Let us now assume that the effort of workers varies with wage and supervision matters but that all workers are supervised by the firm owner. Formally, this means assuming that $c' = d' = 0$ and $b' = 1$, implying that $e' = 1/S$, and thus that $p = 1/L$. In this case, the optimization model is:

$$\max_{L,S\geq 0,w,m} \quad a(eL)^{\beta} - wL - mS \;\; \text{subject to}$$

$$\begin{aligned} e &= (w-x)^c(d+\frac{1}{p})^{-b} \\ p &= \frac{1}{L} \end{aligned}$$

As in the previous sub-sections, it is optimal to set $S = m = 0$. For the other choice variables, the first order conditions are:

$$
\begin{aligned}
w &= ae^{\beta}\beta L^{\beta-1} - a\beta e^{\beta-1}e_p L^{\beta-2} \\
L &= a\beta e^{\beta-1}e_w L^{\beta}
\end{aligned}
$$

Combining the two first order conditions, we obtain:

$$e - e_p p = we_w \tag{2.9}$$

which can be manipulated to yield an expression for w as a function of p:

$$w = \frac{x(1-b+dp)}{1-b-c+dp-cdp}$$

Totally differentiating with respect to w and p we get:

$$\frac{dw}{dp} = -\frac{bcdx}{[b+(c-1)(1+dp)]^2} \leq 0$$

Since $p = 1/L$, this shows that larger firms in terms of L pay higher wages: workers need to be motivated to exercise more care or effort given that they are monitored less closely. Wages are used to compensate for lower levels of supervision.

2.5. Constant supervisor effort

Next we introduce supervisors but keep e' constant. Formally, this boils down to assuming $c' = b' = 0$, which implies that $e' = 1$. Given this assumption, it makes sense to assume that the wage rate of supervisors is given exogenously.[8] We have:

$$\max_{L,S,w} \; a(eL)^\beta - wL - mS \text{ subject to}$$
$$e = (w-x)^c(d+\frac{1}{p})^{-b}$$
$$p = \frac{S}{L}$$

which can be rewritten more simply as:

$$\max_{L,p,w} \; a(eL)^\beta - wL - mpL \text{ subject to}$$
$$e = (w-x)^c(d+\frac{1}{p})^{-b}$$

since $S = pL$. The first order conditions boil down to:

$$w + pm = ae^\beta \beta L^{\beta-1}$$
$$L = a\beta e^{\beta-1} e_w L^\beta$$
$$mL = a\beta e^{\beta-1} e_p L^\beta$$

In this model, the supervision ratio S/L is constant across firms of different size. Indeed the first order conditions can be manipulated to obtain:

$$m = \frac{e_p}{e_w} \tag{2.10}$$

which establishes a relationship between w and p that does not depend on firm size L. Combining the first two first order conditions, we get:

$$w + pm = \frac{e}{e_w}$$

which sets another relationship between p and w that does not depend on L. Consequently, in this model, p and w are constant across firms. The intuition is that firm can buy the supervision from the market at a constant marginal price.

[8]Or that, by an arbitrage argument, firms have to pay the going market wage for supervisors.

2.6. Constant supervisor wage

Next we consider what happens if supervisor effort varies with the supervision of supervisors by the owner. We continue to assume that m is exogenously given. This means that m is not regarded as a choice variable for the firm. We have:

$$\max_{L,S,w} \; a(eL)^{\beta} - wL - mS \text{ subject to}$$

$$\begin{aligned} e &= (w-x)^{c}(d+\frac{1}{p})^{-b} \\ p &= \frac{e'S}{L} \\ e' &= (m-x')^{c'}(d'+S)^{-b'} \end{aligned}$$

where we have used $p' = 1/S$: supervisors are supervised by the owner. The first order conditions are:

$$\begin{aligned} w &= ae^{\beta}\beta L^{\beta-1} - a\beta e^{\beta-1}e_{p}Se'L^{\beta-2} \\ m &= a\beta e^{\beta-1}e_{p}\left[\frac{e'}{L}+\frac{S}{L}e'_{S}\right]L^{\beta} \\ L &= a\beta e^{\beta-1}e_{w}L^{\beta} \end{aligned}$$

In this model, the effort of supervisors is not constant. Raising the effort of production workers by hiring supervisors has a cost that increases with firm size. This can be seen by manipulating the first order conditions to obtain:

$$\frac{e_{p}}{e_{w}}\left[e'+Se'_{S}\right]=m$$

which is different from our earlier expression (2.10) because of the presence of S. The implication is that the supervision ratio S/L decreases with firm size while wage w increases. This is because the owner finds it difficult to monitor all supervisors, whose effort level drops with firm size. The end result is the same as in the model where the owner monitors everyone directly: the firm trades higher wages for less effective supervision p. The wage m paid to supervisors does not, however, increase with firm size since, in this special case, it is assumed constant.

2.7. The testing strategy

The general model is the same as the model discussed in the previous sub-section, except that we regard m as a choice variable. The only difference with the earlier model is that now m also increases with firm size. The rationale behind this result is that larger firms need more supervisors to monitor their growing workforce but cannot monitor the supervisors as closely. This reduces supervisors' incentives. To compensate, large firms pay higher supervisor wages m to induce more effort. This effect is similar in spirit to the force that affects workers' wage w. This in turn implies that supervision costs increase with firm size. To economize on supervision, large firms lower the supervision ratio S/L. To minimize the negative effect on workers' motivation, they raise the wage w of production workers.

These effects are illustrated on Figures 1 and 2 which show, for some reasonable choice of parameter values, how wages and supervision ratio change with firm size.[9] We see that w and m are increasing in L while S/L is decreasing in L. Larger firms pay higher wages to both supervisors and production workers. At the same time, they monitor production workers less closely. The magnitude of the effect is large but commensurate with what is observed in our data.

To summarize, we have shown that our general model nests a variety of simpler models, including the standard producer model and the efficiency wage model. It can therefore be used as a way of testing the restrictions imposed by simpler models. To this effect, we estimate a five equation model composed of the four first order conditions (2.5) to (2.8) and the production function

$$Q = a(eL)^{\beta} \exp(\varepsilon_q) \tag{2.11}$$

where ε_q is an error term. Observed values of $\widetilde{w}, \widetilde{m}, \widetilde{L}$, and $\widetilde{s}$ are assumed to include measurement error

[9] The Figures are obtained using coefficient values derived from the Sparks model, namely, $c = b = c' = b' = 0.5$, $x = rV^U$, and $d = d' = 1/2r$ where r is the workers' rate of time preference and V^U is the expected life-time utility from becoming unemployed.

so that:

$$\ln \widetilde{w} = \ln w + \varepsilon_w \quad (2.12)$$

$$\ln \widetilde{m} = \ln m + \varepsilon_m \quad (2.13)$$

$$\ln \widetilde{L} = \ln L + \varepsilon_l \quad (2.14)$$

$$\ln \tilde{S} = \ln S + \varepsilon_s \quad (2.15)$$

where w, m, L, and S are the values that solve the system of first order conditions (2.5) to (2.8). The advantage of formulating the error structure using (2.12) to (2.15) is that, from an econometric point of view, the system to be estimated is a reduced form system of non-linear equations, thereby eliminating simultaneity concerns. The system formed by the five equations (2.11) to (2.15) is estimated using non-linear generalized least squares (GLS). The details of the estimation procedure are discussed in the econometric section.

In testing the theory we begin by examining the data for evidence of the kind of patterns predicted by the theory. In particular, we examine whether w and m increase with firm size and whether S/L decreases with firm size. This test is conducted in a non-parametric manner without imposing any restriction on the shape of the relationship. This test serves to pre-validate the model, to avoid 'forcing' on the data a relationship that is not there. We then proceed by estimating the complete model and test the coefficients of the effort functions individually – in particular, we test whether $c = 0$, $b = 0$, $c' = 0$, and $b' = 0$. Indeed we have seen that, when these coefficients are 0, the general model simplifies to one of the special models discussed earlier.

As mentioned in the introduction, there are other possible reasons why large firms pay high wages (e.g. Troske 1999, Bayard and Troske 1999). One reason that has received some attention in the literature is the possibility that large firms employ better workers. Stiglitz (1987), for instance, argues that worker productivity – observed and unobserved – will be correlated with firm size if the returns to better workers are larger in large firms. This is because large firms would either screen workers more effectively at hiring, or dismiss those who prove less productive. As a result of this self-selection process, their workforce may be statistically different from that of smaller firms where worker quality has less impact on firm productivity. The self-selection explanation of the relationship between firm size and wages does not predict any systematic relationship between firm size and supervision ratio. If we find such relationship, it would suggest that other factors are at work, such as the ones discussed here.

There are several reasons why large firms may require better workers. One possibility is that they have complicated equipment that is hard to operate and vulnerable to mishandling. This idea is empirically testable by examining whether firms with a larger capital-labor ratio pay higher wages. In our analysis, we partially control for this possibility by focusing on a subset of industries that share similar capital intensity. Another possibility is that, in large firms, the organization of work is complex and worker discipline is important to achieve coordination. This latter idea is close to our focus, except that we regard worker effectiveness as an action subject to moral hazard instead of as an immutable individual trait.

Given that we do not have panel data on individual workers, we cannot control for unobserved heterogeneity in workers across firms. But we can control for observed heterogeneity. To purge wages from observed differences between workers, we proceed as follows. Let w_{ij} be the wage of worker j in firm i. Observed human capital for this observation is written h_{ij}. We then regress (the log of) w_{ij} on h_{ij} and a firm-level fixed effect ω_i. This is done separately for supervisors and production workers, yielding different $\widehat{\omega_w}$ and $\widehat{\omega_m}$ estimates for each firm. When estimating (2.11) to (2.15), we replace throughout w and m by $\widehat{\omega_w}$ and $\widehat{\omega_m}$. This ensures that our firm-specific wage measure is purged of differences in worker productivity due to observable traits (and unobservable traits correlated with them). The average human capital of the workforce is also included in a to control for its effect on firm productivity.[10]

3. The data

To investigate these labor management issues, we test the model presented in section 2 on matched employer-employee data collected on the manufacturing sector of nine SSA countries and one North-

[10] Underlying this approach is an implicit arbitrage argument by which the individual return to human capital is equal to the associated productivity gain. Put differently, firms are at the margin indifferent between hiring workers with different human capital endowment because the premium paid for additional human capital is equal to the additional output generated. If this arbitrage argument is combined with the assumption that returns to human capital are linear, then the effect of human capital on output can be captured by including in a the average human capital of the workforce – which we do.

African country, Morocco. The data used here have been collected by various teams of researchers. The bulk of the data from SSA was collected as part of the Regional Program for Enterprise Development (RPED), organized by the World Bank, in which samples of approximately 200 randomly selected firms were interviewed in eight countries (Burundi, Cameroon, Cote d'Ivoire, Ghana, Kenya, Tanzania, Zambia, and Zimbabwe). The surveys started with Ghana in 1992, and most other country surveys were initiated in 1993. Firms were re-interviewed three years in a row in most countries; as some firms dropped out of the sample, they were replaced with other firms with similar characteristics.[11] Four sectors of activity were covered: textile and garments; wood products; metal products; and food processing. Firms of all sizes are included except for microenterprises which are excluded.[12] Information is available on a wide range of variables, including sales and output, capital stock, entrepreneur characteristics, employment by occupational category, labor turnover, wages, and conflicts with workers. The RPED data have been extensively analyzed and have greatly improved our understanding of manufacturing in the continent (e.g. Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Oduro, Oostendorp, Patillo, Soderbom, Teal and Zeufack 2000, Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal, Zeufack and Appleton 2000).

In order to form as large a sample as possible on SSA firms, we augment the RPED sample with data from two other sources. First, we add data on Ethiopian manufacturing firms that were collected independently of RPED but using the same questionnaire.[13] Ethiopia was surveyed three times but we only have data for the first year, 1993. Second, we use data from the Kenyan Manufacturing Enterprise Survey (KMES), fielded in 2000 and designed as a follow-up to the last Kenyan RPED survey.[14] This survey generates data for 1998 and 1999.

In addition to our sample from SSA, we have data on one North-African country, namely Morocco. The Moroccan data were collected as part of the Firm Analysis and Competitiveness Surveys (FACS), carried out jointly by the Ministry of Commerce and Industry and the World Bank in 2000. A random

[11] Burundi was surveyed only once due to the rapid deterioration of the political situation following the Rwandan genocide. Cote d'Ivoire was surveyed only twice due to insufficient funding.

[12] The reason is that, in most SSA countries, microenterprises far outnumber other firms (e.g. Daniels 1994, Liedholm and Mead 1999). Sampling randomly from the population of all firms would have yielded samples constituted nearly exclusively of microenterprises.

[13] The Ethiopian survey was coordinated by Taye Mengistae.

[14] The KMES was organized by the Centre for the Study of African Economies, University of Oxford. See Soderbom and Teal (2001) for a report based on these data.

sample 860 firms were interviewed in six towns and seven sectors. Here we only use the 680 sample firms in food processing, textile, and garment to ensure comparability. The Moroccan survey generates data for 1998 and 1999.

After eliminating observations with missing data, we end up with roughly the same number of firms for Morocco and SSA. Given the small size of valid samples for each individual SSA country, we have no choice but to pool the SSA observations. In the subsequent analysis, country dummies are used to control for differences in labor market and legal institutions.

One unusual feature of the data sets is that they all contain matched employer-employee information. At the same time as the firms were surveyed, a sample of workers was chosen from each firm designed to cover the full range of firm employees. The objective was to have up to 10 workers from each firm where firm size allowed. To increase the informational content of the data, the worker sample was stratified according to occupational status. Where there is panel data, samples of workers have been interviewed again in subsequent years, but the identity of the workers differs across survey rounds.[15]

For the purpose of our analysis, workers are divided into three categories: production workers, supervisors, and other staff. Production workers are skilled and unskilled workers on the shop floor, plus technicians and maintenance personnel. These are the workers most directly involved in the production process itself. Supervisors include managers, foremen, and administrative staff. In small and medium-size firms such as the ones in our sample, foremen represent middle-rank management and can thus be counted as part of the management/supervision process. Among our sample firms, the main role of administrative staff is to assist management in gathering and processing information essential to the monitoring of the production process, such as reports, accounts, inventories, time sheets, and the like. For this reason, we count them as part of the supervision personnel of the firm: if the small manufacturers in our sample had fewer employees, they essentially would keep accountants and office staff to the strict minimum – which, in our case, is 0. The 'other staff' category is a residual category that includes commercial staff, trainees, craftsmen, and other support staff. These workers are excluded from either L of S but are included in the production function as part of a (see below).

[15] In all surveys, information on worker identifiers was not collected to protect the confidentiality of workers' responses.

The characteristics of the firms in our pooled sample are summarized in Table 1. Manufacturing firms in SSA are small by international standards. The average level of employment is 106 and the median is 45, a discrepancy consistent with the usual skewed distribution of firm size. Firm size is somewhat larger in our Moroccan sample, with average employment of 169 (median=100). The average of the log value-added per employee corresponds to about US$ 3,000 in levels.

The average supervision ratio, defined as the number of supervisors to the number of production workers, is 0.17 in Morocco and 0.41 in SSA. Medians are 0.07 and 0.23, respectively. The t-test statistic between the two samples is 8.82, which is highly significant. Acemoglu and Newman (2002) report the average ratio of managerial to production countries in six OECD countries. Of the countries considered, the ratio is lowest in Spain (approximately 0.025) and highest in Norway (approximately 0.25), suggesting that the supervision intensity is indeed higher in SSA than in more developed countries. As noted by Acemoglu and Newman, differences in cross-country averages should interpreted with care, since the definition of a manager may vary across countries and/or over time. In any case, the difference between SSA and Morocco, where we know there are at most marginal differences in the job definitions, is striking.

About 17-20 percent of the firms have some foreign ownership, and slightly more than half of the firms are located in the main industrial city (Casablanca for Morocco). Around 10 percent of surveyed managers have only primary education, 43 percent have secondary or professional education, and 44 percent have a university degree. Moroccan managers are, on average, more educated. About a third of the firms employ unionized workers. The distribution across countries is highly non-uniform. The largest sub-Saharan sample is Kenya, followed by Zambia. We lose many observations in Cameroon, Cote d'Ivoire and Ethiopia due to missing data.

In Table 2 we show summary statistics based on the sample of workers. We have complete data on a total of 19,924 production workers and 7,022 supervisors. The average monthly earnings for production workers is US$ 93 in SSA vs. US$ 259 in Morocco. For supervisors earnings are much larger, on average US$ 172 in SSA and 853 in Morocco. A breakdown by country (not shown to save space) reveals that there are substantial differences across countries. For both production workers and supervisors, Tanzania has the lowest median of earnings (US$ 32 and US$ 49, respectively). Incidentally, differentials between countries are often close to differentials in per capita income as reported in the World Development Indicators database.[16]

Production workers have on average eight years of education and seven years of tenure with the present firm. Interestingly, the level of education does not vary much across countries. Morocco, the country in our sample with by far the highest per capita income, ranks second from the bottom in terms of the average level of education of production workers; only Ivory Coast records a lower sample average. Supervisors have on average 12 years of education, and eight years of tenure. While Moroccan production workers are on average less educated than their counterparts in SSA, Moroccan supervisors are better educated. The average age for both categories of workers is close to 35 years. About a fifth of the sample of production workers, and approximately a third of the sample of supervisors, are women.

4. Econometric estimation

We begin our empirical analysis by estimating earnings regressions using the worker data. As explained in Section 2, the purpose of these regressions is to obtain a measure of firm-specific wage premium that is net of observable differences in workforce quality. These firm-specific wage premia are then used as estimates of w_i and m_i. Next, we take a fairly agnostic view at the data, trying to assess whether they exhibit the kind of patterns predicted by the model. This step is done without imposing much structure on the data. Having validated the model, the third step estimates the model directly by applying GLS to the non-linear system (2.11) to (2.15).

4.1. Earnings regressions

The estimated earnings equation takes the form:

$$\log w_{ijt} = \omega_{it} + \theta h_{ijt} + v_{ijt} \tag{4.1}$$

[16] Measured in constant 1995 USD, the per capita GNP in Morocco is about 1350 and in Tanzania about 180, hence yielding a difference of factor 7.4.

where w_{ijt} is the wage of worker j in firm i at time t, h_{ijt} is a vector of human capital characteristics of worker j, ω_{it} is a firm fixed effect allowed to vary over time, and υ_{ijt} is an error term (Abowd and Kramarz 1999). The regression is estimated separately for production workers and supervisors.

Tables 3 and 4 present the results for production workers and supervisors, respectively, both pooled and by sub-sample.[17] Education has a non-linear, convex, effect on earnings, manifesting itself here through the significance of the squared term on education. Since marginal returns of education vary with the level of education, for ease of interpretation we show the marginal returns computed at six and twelve years of education. For production workers, the returns are very low at low levels of education; they are equal to 1.4 per cent at six years of education. At twelve years, the marginal return reverts around 5.5 percent in SSA and 3 percent in Morocco. Marginal returns to education are much higher for supervisors, especially at higher levels of schooling in SSA. This suggests a high demand to highly educated supervisors South of the Sahara.

The age-earnings profile has an inverse U-shape in all cases. The tenure coefficient is positive and significant, indicating that new workers earn less. This feature is consistent with the idea that firms adjust wages to productivity after hiring – either because workers learn on the job and become better, or because firms learn more about their intrinsic ability. It is noted, however, that the reward to tenure is small – typically about one per cent per year for production workers, less for supervisors. The gender dummy is negative in both sub-samples, indicating that women have significantly lower earnings than men with the same observable characteristics.

The firm fixed effects explain much of the wage differences between workers. For the pooled production workers model, for instance, the firm effects alone account for 82 per cent of the explained variation in wages.[18] Some 89 per cent of total wage variation can be explained either by fixed-effects or human capital differences. The importance of firm-level characteristics is at prima facie consistent with our theory, where firms adjust their wages in order to motivate workers to exert a certain level of effort.

[17] In the estimation of the structural model, coefficient estimates by sub-sample are used.
[18] R-squared reported in Tables 3 and 4 refer to within variation, not between or overall.

4.2. Validating the model

Next, we investigate how predicted firm fixed effects $\widehat{\omega}_{it}$ correlate with firm size. The general model presented in Section 2 predicts that large firms pay more to production workers and supervisors and that the wage differential between the two categories also increases with size. We investigate whether these predictions are consistent with our data. To control for individual worker productivity, we do not use actual wages but use $\widehat{\omega}_{it}$ instead.

To check for robustness, we experiment with three different ways of measuring $\widehat{\omega}_{it}$. First we compute firm fixed effects both from pooled and country regressions (Tables 3 and 4). We also estimate earnings regressions without firm-level controls or fixed-effects and take the firm-specific averages of the residuals as an alternative measure of $\widehat{\omega}_{it}$. The reason for doing so is that 'going within' may exacerbate the effects of measurement errors and bias the associated coefficients towards zero (Griliches and Hausman 1986). If this is the case, fixed effects estimates would do a poor job in purging the data from heterogeneity in observable human capital. We then regress the alternative measures of $\widehat{\omega}_{it}$ on various measures of firm size (in logarithms) and a set of country and sector dummies.

Table 5 reports the estimated size coefficients, interpretable as elasticities, and the associated t-values for various permutations. In the top panel of the table, size is measured as the number of production or supervision workers, depending on the earnings function estimated. The size coefficients are about 0.09 for production workers when using the fixed effects estimates and about 0.07 when using firm averages of OLS residuals. For supervisors they are somewhat larger: 0.13 when using fixed effects and 0.12 when based on the OLS residuals. All coefficients are highly significant. The middle panel shows that these results are affected little when we use total employment as size measure instead. In the bottom panel we use the capital stock as final size measure. Coefficients are uniformly smaller, but the size-effect is still highly significant and larger for supervisors than for production workers. The results demonstrate that earnings (purged from observed human capital heterogeneity) increase with firm size. The increase is faster for supervisors than for production workers. Both findings are consistent with the model presented in Section 2. In the rest of the analysis, we use $\widehat{\omega}_{it}$ computed on the basis of Tables 3 and 4.

Figures 3 to 6 show results from a non-parametric analysis of wages and supervision ratio.[19] Figure 3 shows how the (log of the) supervisor-to-worker ratio S/L varies with firm size in the two sub-samples. We observe a strong significant decline between S/L and L in both cases, but S/L in SSA is systematically above that in Morocco. This suggests that the higher supervision ratio observed in Africa is not due to a difference in firm size: SSA has more supervisor per worker at all firm sizes.

Figure 4 depicts the relation between firm size and the firm-specific wage effect $\widehat{\omega}_{it}$ for production workers. Figure 5 shows the corresponding relation for supervisors. In both Figures, regression lines indicate a positive relationship between wages and firm size in both sub-samples, except at either ends of the spectrum where the relationship becomes less precise. All these results are in line with the predictions made by the more general model presented in Section 2. They constitute prima facie evidence that the model is compatible with the data.

In Figure 6 we show how the earnings differential between supervisors and production workers varies with size. When Sparks coefficients of 0.5 are used for c, c', b, and b', it can be shown that the earnings differential between workers and supervisors increases rapidly with size. This need not be the case with other parameter values. Figure 5 shows that in our sample the earnings differential increases slightly with firm size, but the effect is not significant. This constitutes prima facie evidence against Sparks coefficients for the effort functions.

4.3. Structural Estimation

We have seen that the qualitative features of the data are consistent with the supervision model presented in section 2. We are now ready to impose more structure on the data by estimating the model directly. Our aim is to estimate the production function and the first order conditions described in equations (2.11) to (2.15). Our task is to estimate the parameters of the production function plus c, b, x, d, c', x', d', and

[19] Results were obtained using locally weighted regressions based on an Epanechnikov kernel. A 95% asymptotic confidence interval is displayed. It is computed on the basis of the standard error of the constant in locally weighted regressions. The bandwidth is 0.4. We have applied a 5% trimming to eliminate observations that are too unrepresentative. All regressions control for country and sector through first difference.

b'.[20] For estimation purposes, the total factor productivity (TFP) parameter a is expanded into:

$$a = \alpha_0 K^{\gamma} O^{\delta} \exp(\sum_i \lambda_i F_i + \sum_j \theta_j D_j) \tag{4.2}$$

where α_0 is a constant, K is capital stock, O is staff other than production workers and supervisors, F_i is a series of firm characteristics including the average education level and length of tenure of the workforce, the age of the firm, the percentage of foreign ownership, and the location in the capital city. The D_j's are sectoral and country dummies. Country dummies are also included in the effort functions to capture possible differences in legal institutions and unemployment rates, and their disciplining effect on workers. All these variables are regarded as exogenous in the estimation that follows. All Greek letters are parameters to be estimated.

From an econometric point of view, the system formed by equations (2.11) to (2.15) is a non-linear system of reduced form equations. Given the non-linear nature of the model it is not possible to solve for w, m, L, S analytically, and so we nest the solution of the system of first order conditions within the search for parameter estimates. That is, we start from a 'guess' of the parameter vector, and, conditional on these values, solve the first order conditions (2.5) to (2.8) for each observation. We then calculate the residuals by subtracting predicted from actual values, and compute the relevant criterion value. We then update the parameter vector and start the process all over again, provided there is scope for further improvements in the criterion value. If there is not, the search stops.[21] As is always the case in non-linear estimation, multiple local optima are possible. To test for this possibility, we restart the parameter search process from many different starting values; since all searches converge to the same parameter vector, we can safely rule out multiple local optima in our case.

With this methodology, the endogeneity of the choice variables does not result in bias of the parameter estimates.[22] The system of equations can therefore be estimated in the usual manner, i.e. through

[20] In the estimation, the values of c, c', b, d, d', and b' are constrained to be positive. None of the estimated coefficients is at the boundary.

[21] The search for the parameters is accomplished using a combination of a simulated annealing algorithm (to identify a suitable search region) and quasi-Newton algorithm (around the point of convergence). References regarding these algorithms can be found in Judd (1998), pp.113-114 and pp.299-301. Estimation is carried out using the Gauss package. The computational cost of the exercise is high.

[22] In contrast, if we were to estimate equations (2.5) to (2.8) directly we would have to deal with the fact that there are endogenous variables on the right-hand side of these equations. In a previous version of this paper we attempted to do so

generalized least squares (GLS). This is accomplished in two steps: the first step estimates the system assuming a diagonal covariance matrix for the errors. An estimate of the cross-equation covariance matrix of the errors is then obtained from the first step and the system is reestimated with the error covariance matrix. This is equivalent to one-step non-linear seemingly unrelated regressions. Standard errors for parameters are obtained using the outer product of the gradient.

4.4. Results

Estimation results are summarized in Table 6 for Morocco and SSA. Parameter a is time- and country-specific and varies by sector. In the estimation, observations on variables w and m are replaced with $\hat{\omega}_{it}^{w}$ and $\hat{\omega}_{it}^{m}$ for reasons discussed above.

We first discuss the parameters of the production function. There are important similarities and differences between SSA and Morocco. The estimated share of capital is small in both samples: 0.127 in Morocco, 0.284 in SSA. The share of labor is high in Morocco – 0.738 – but low in SSA – 0.328. In both samples, we see that support staff makes an important and significant contribution to output.[23] Coefficients on exogenous TFP shifters are broadly consistent with other work using these data. Firm age is significant in SSA but not in Morocco. Firms with some foreign ownership are more productive in both samples, but the effect is only mildly significant in Morocco. Of the two human capital variables, education has a strong significant effect in both regressions, while job experience – proxied by length of tenure – has the expected sign but is only significant in SSA. Returns to schooling appear to be higher in SSA than in Morocco: one additional year of education for the entire labor force raises output by 8% in SSA vs. 0.9% in Morocco.

Parameters x and x' measure the level of wage above which effort increases. In Sparks (1986), x and x' take a more specific meaning as the measure of workers' income if they are sacked. To facilitate comparison, all estimates are expressed in US$ per year. We find that both x and x' are larger in Morocco than in SSA. This reflects our earlier observation that workers are better paid in Morocco (Figures 4 and 5). We also find large differences across SSA countries, with outside options being much

by using a non-linear instrumental variable GMM estimator, however we found this approach quite unsatisfactory as the results tended to be sensitive to the instrument set and the normalisations.

[23] Parameter δ is the coefficient of log(support staff+1).

larger in Cameroon and Ivory Coast – possibly reflecting the overvaluation of the CFA Franc over the survey period. As anticipated, we find $x' > x$ in all cases: this is consistent with the idea that the outside option of supervisor is larger than that of production workers. The difference between the two is much larger in SSA, however, where x' is roughly ten times x. In contrast, in Morocco x' is only twice x. The theory implies that as the difference between x' and x shrinks, the ratio of supervisors to workers will rise, everything else constant. This is because as x' falls relative to x, it becomes cheaper to motivate production workers via better supervision. Of course, in the data the supervisor-worker ratio is *lower* in Morocco than in SSA. This pattern must therefore be explained by differences in other parameters in the model. Had the relative difference between x' and x been constant across the two samples, there would have been even greater differences in the implied supervisor-worker ratio.

Turning to our main coefficients of interest, we find that, with the exception of d in Morocco, our coefficients c, b, d, c', b' and d' are significantly different from 0. This tends to reject *all* the simpler models discussed in Section 2 in favor of our more general two-tier supervision model.[24] The estimates reported in Table 6 indicate that c, b, c', b' are lower in SSA than in Morocco. This implies that effort, both for supervisors and workers, is less responsive to changes in wages and supervision in SSA than in Morocco.

How effort responds to changes in total factor productivity a is central to our understanding of how the incentive structure faced by supervisors and workers in the firms impacts on various aspects of firm behavior. In the special case of $c = b = c' = b' = 0.5$, our model boils down to a generalized (two-tier) version of the Sparks (1986) model. A special feature of that model is that, in equilibrium, worker and supervisor effort does not vary with exogenous total factor productivity a. In the more general case where c, b, c', b' are not restricted to be equal to 0.5, effort varies with a. Coefficient estimates of c, b, c', b' are all different from 0.5, hence rejecting the generalized Sparks model. We therefore expect effort to vary with productivity, although it is unclear how.

To investigate how differences in firm total factor productivity affect effort, we show in Figure 7 how (the logarithm of) worker effort responds to a change in TFP a.[25] There is a striking difference between

[24] The very low standard errors on these parameters are result in part from the non-linear nature of the model and should not be taken too literally. It is indeed likely that similar – though not identical – predicted behavior would obtain from slightly different combination of values for c, b, c', and b'. But changing only one of these parameters independently from the others dramatically decrease the quality of the fit. This explains the high gradient and hence low standard error.

[25] The Figure is constructing by taking values of $\ln a$ from the country average minus 0.5 to the country average plus 0.5,

the two samples: an increase in TFP has a positive effect on worker effort in Morocco, but a negative effect in SSA. In other words, while the incentive structure in Morocco is such that an increase in TFP leads to more worker effort, the converse is the case in SSA. An immediate implication is that high TFP firms in SSA hire fewer workers and supervisors (and produce less output) relative to what they would have done if the incentive structure had been similar to that in Morocco. Quantitatively, this effect on output is large: an increase in a by 1% increases output by 2.9% in Morocco but only by 1.3% in SSA. This is because a high TFP firm in SSA finds it more difficult than in Morocco to manage and supervise its labor force so as to increase or maintain effort.

To illustrate the effect of supervision and worker incentives on firm behavior, we calculate the relationship between firm size, wages, and supervision implied by estimated parameter values. Results are presented in Figures 8-13. Figure 8 shows the association between wages and employment, as predicted by the model on the basis of estimated parameters. The model manages to mimic the positive association between these two variables that is present in the data (Figure 4). To facilitate interpretation we express this relation in relative terms in Figure 9, for Morocco and three SSA countries (the curves of the remaining SSA countries are positioned between those of Zimbabwe and Cameroon). This graph shows that an increase in employment by 100% is associated with an increase in worker wages by between 7 and 10%.

Figure 10 shows that the there is a positive association between predicted supervision wages and employment (as in Figure 5), and Figure 11 shows that supervision wages increase more rapidly with firm size in Morocco than in SSA. Figure 12 shows the predicted ratio of supervisors to production workers, and clearly the model replicates the pattern observed in the data that the supervision intensity is much lower, on average, in Morocco than in SSA (see Figure 3). Figure 13 shows that the supervision intensity falls more rapidly in Morocco than in SSA: an increase in firm size by 100% in Morocco is associated with a fall in the supervision ratio by 12%.

It should be clear from the above that, in order to grow, firms must address serious incentive problems among production workers and supervisors. Our parameter estimates imply that doubling the number

normalizing initial log effort to zero.

of production workers is associated with an increase in total labor cost per unit of effort (including supervisors' wages) by 9% for Morocco and between 11 and 14% for SSA, depending on the country. This is the penalty large firms have to incur in order to motivate workers and manage a large workforce.

Our results hence show that there are significant differences in the incentive structures across Morocco and SSA, and that these differences are economically important. Taken together, our findings suggest that managing and monitoring workers in SSA is more costly and more problematic than in Morocco. Findings are also consistent with the higher absolute levels of S/L in SSA. This is because supervisors, in spite of costing relatively more to the firm, have a relatively stronger effect on worker effort.

5. Conclusion

In this paper we have examined whether data on manufacturing firms are consistent with a two-tier supervision model of worker effort. We began by constructing a efficiency labor model whereby firms optimally choose their level of supervision and the wage premium they pay their workers and supervisors relative to other firms. This model predicts an increase in wages and a decrease in supervisor-to-worker ratio with firm size. The reason is that supervisors have to be motivated to manage the workforce well.

We then take the model to a data set covering ten African countries. The main difficulty about testing supervision models is that any observed relationship between wages and firm size can potentially be attributed to systematic differences in workers' traits across firms. To minimize this bias, we take advantage of matched worker-employer data to construct a firm-specific wage measure that is purged of all observable differences across workers. As was explained in the paper, this approach does not entirely eliminate the possibility of a selection bias – there might remain systematic differences in unobservable worker traits across firms – but it singularly reduces the likely magnitude of the bias. This is particularly true given that the studied sectors belong to light manufacturing such as garment, textile and food processing. Most surveyed firms use dated equipment for which production work is relatively straightforward. In such an environment, it is doubtful that unobservable worker traits would account for much of the productivity differences across firms.

We begin by testing whether the data is broadly consistent with model predictions. We find that wages increase with firm size for both production workers and supervisors. We also find that the supervision ratio drops dramatically with firm size. Given these encouraging preliminary results, we venture to estimate the structural model itself. To do so, we estimate a system of five non-linear equations by generalized least squares. Results show that workers in SSA are less responsive to monitoring by supervisors than workers in Morocco. This suggests that labor management is more difficult in Africa than elsewhere. This point has already been made by some authors. Using data from manufacturing firms in Cote d'Ivoire, Azam and Lesueur (1997) for instance show that worker supervision is a serious concern among large firms. Many African entrepreneurs indeed complain about the difficulty to manage a large labor force.[26]

According to our estimates, a doubling in the number of production workers is associated with an equilibrium increase in wages of 7% in Morocco and between 7 and 9% in SSA, depending on the country. At the same time, supervisors' wages increase by 22% in Morocco and between 11 and 13% in SSA. A doubling of the number of production workers is also associated with an equilibrium fall in supervision ratio of 12% in Morocco and between 8 and 11% in SSA. As a result of these combined effects, total labor cost per unit of effort (including supervisors' wages) increases by 9% for Morocco and between 11 and 14% for SSA. This is the penalty large firms have to incur in order to motivate workers.

The analysis presented here suggests that labor management is a seriously underestimated problem. This leaves open the question of what type of labor management problems is responsible for our findings. Labor management problems can be divided basically into two broad categories: those due to a poor organization of work that leaves workers idle or unproductive part of the time (task assignment, coordination between workers and production units, information transfer within the firm); and those coming from poor enforcement of labor contracts (shirking, absenteeism, pilferage).[27]

Although the methodology used here cannot distinguish between the two, we can volunteer some thoughts as to where the most promising avenue for future research might be. Presumably, it is easier to organize work within a large firm if workers are well educated and hence can read written instructions and report on their progress. Education may also raise worker discipline through the routine of daily

[26] It has been claimed that managers and workers in African firms often show little loyalty to their employer (Ezeala-Harrison 1991). Pilferage may be a concern too: Fafchamps and Minten (2001) show that 37% of agricultural traders in Madagascar refrain from hiring more employees for fear of employee theft.

[27] In practice, it is often very difficult to distinguish between the two because workers found shirking often seek to blame their idleness on ambiguous or incorrect task assignment.

school attendance throughout adolescence. For these reasons, one may expect countries with low school enrollment rates to experience difficulties running large organizations. Because of the low education level of many SSA countries, it may be tempting to blame labor management problems there on the poor education of the workforce – and hence to call for more investment in education (e.g. Mazumdar and Mazaheri 2002, Strobl and Thornton 2001).

The empirical evidence presented in this paper indirectly militates against this oversimplistic interpretation. First, although the African workforce *in general* is poorly educated, the evidence presented here shows that production workers *in manufacturing* have a fairly high average level of schooling; they certainly are not, as a rule, illiterate. Second, although production workers in our Moroccan sample are less well educated than those in our SSA sample, labor management problems have been shown to be less acute in Morocco. It is therefore at prima facie unlikely that, as is sometimes assumed, labor management problems in African manufacturing arise primarily from the difficulty of organizing a poorly educated manpower.

The explanation must probably be sought elsewhere. One possibility is that the internal organization of labor is difficult in SSA for reasons other than insufficient education, for instance because of frequent machine breakdown, power cut, and input shortages (Fafchamps, Gunning and Oostendorp 2000). It is also conceivable that the enforcement of employment contracts is more problematic in SSA than elsewhere, perhaps because of weak legal institutions.[28] These issues deserve more investigation.

References

Abowd, J. M. and Kramarz, F. (1999), The Analysis of Labor Markets Using Matched Employer-Employee Data., *Handbook of Labor Economics, Volume 3*, O. Ashenfelter and D. Card (edsd.), Elsevier, New York, pp. 2629–710.

[28] Another possibility is that, as discussed in Platteau (1996), the strength of sharing norms in SSA weakens loyalty to employers. Some – admitedly impressionistic – evidence of employer distrust towards employees can for instance be found in the work of Barr and Oduro (2002) who find that Ghanaian workers related to their employers earn a premium and that there is statistical discrimination in favour of inexperienced co-ethnic workers. Fafchamps (2004) reports ample evidence of imperfect enforcement of commercial contracts in SSA.

Acemoglu, D. and Newman, A. F. (2002). "The labor market and corporate structure.", *European Economic Review*, 46:1733–1756.

Arai, M. (2003). "Wages, Profits, and Capital Intensity: Evidence from Matched Worker-Firm Data.", *Journal of Labor Economics*, 21(3):593–618.

Azam, J.-P. and Lesueur, J.-Y. (1997). "Efficiency Wage and Supervision: Theory and Application to the Ivorian Manufacturing Sector.", *Journal of African Economics*, 6(3):445–62.

Barr, A. and Oduro, A. (2002). "Ethnic Fractionalization in an African Labour Market.", *Journal of Development Economics*, 68(2):355–79.

Bayard, K. and Troske, K. R. (1999). "Examining the Employer-Size Wage Premium in the Manufacturing, Retail Trade, and Service Industries Using Employer-Employee Matched Data.", *American Economic Review*, 89(2):99–103.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J. W., Isaksson, A., Oduro, A., Oostendorp, R., Patillo, C., Soderbom, M., Teal, F. and Zeufack, A. (2004). "Risk Sharing in Labour Markets.", *World Bank Economic Review*,, . (forthcoming).

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J.-W., Isaksson, A., Oduro, A., Oostendorp, R., Patillo, C., Soderbom, M., Teal, F., Zeufack, A. and Appleton, S. (2000). "Rates of Return on Physical and Human Capital in Africa's Manufacturing Sector.", *Economic Development and Cultural Change*, 48(4):801–27.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J. W., Oduro, A., Oostendorp, R., Patillo, C., Soderbom, M., Teal, F. and Zeufack, A. (2000), Exports and Firm Level Efficiency in the African Manufacturing Sector. (mimeograph).

Brown, C. and Medoff, J. (1989). "The employer size-wage effect.", *Journal of Political Economy*, 97(5):1027–59.

Criscuolo, C. (2000), *Employer Size-Wage Effect: A Critical Review and an Econometric Analysis*, Dipartimento di Economia Politica, Universita degli Studi di Siena, Siena. (Quaderni No. 277).

Daniels, L. (1994), *Changes in the Small-Scale Enterprise Sector from 1991 to 1993: Results from a Second Nationwide Survey in Zimbabwe*, Gemini Technical Report No. 71, Gemini, Bethesda, Maryland.

Ezeala-Harrison, F. (1991). "An Empirical Framework for the Efficiency-Wage Model: Use of Micro Data for Nigeria.", *Journal of Economic Studies*, 19(3):18–35.

Fafchamps, M. (2004), *Market Institutions in Sub-Saharan Africa*, MIT Press, Cambridge, Mass.

Fafchamps, M., Gunning, J. W. and Oostendorp, R. (2000). "Inventory and Risk in African Manufacturing.", *Economic Journal*, 110(466):861–893.

Fafchamps, M. and Minten, B. (2001). "Property Rights in a Flea Market Economy.", *Economic Development and Cultural Change*, 49(2):229–268.

Fudenberg, D. and Tirole, J. (1991), *Game Theory*, MIT Press, Cambridge, Mass.

Garicano, L. and Hubbard, T. N. (2003), Specialiation, Firms, and Markets: The Division of Labor Within and Between Law Firms. (mimeograph).

Garicano, L. and Hubbard, T. N. (2004), Hierarchies, Specialization, and Increasing Returns to Knowledge: Theory and Evidence from the Legal Services Industry. (mimeograph).

Griliches, Z. and Hausman, J. (1986). "Errors in Variables in Panel Data.", *Journal of Econometrics*, 31:93–118.

Itoh, H. (1991). "Incentives to Help in Multi-agent Situations.", *Econometrica*, 59(3):611–36.

Judd, K. L. (1998), *Numerical Methods in Economics*, The MIT Press., Cambridge Massachusetts.

Liedholm, C. and Mead, D. C. (1999), *Small Enterprises and Economic Development: The Dynamics of Small and Micro Enterprises*, Routledge, London.

Mazumdar, D. and Mazaheri, A. (2002), *Wages and Employment in Africa*, Ashgate, Aldershot, UK.

Meagher, K. J. (2001). "The Impact of Hierarchies on Wages.", *Journal of Economic Behavior and Organization*, 45:441–58.

Oi, W. Y. and Idson, T. L. (1999), Firm Size and Wages., *Handbook of Labor Economics, Volume 3*, O. Ashenfelter and D. Card (edsd.), Elsevier, New York, pp. 2165–2214.

Platteau, J.-P. (1996), Traditional Sharing Norms as an Obstacle to Economic Growth in Tribal Societies., *Technical report*, CRED, Facultés Universitaires Note-Dame de la Paix, Namur, Belgium. Cahiers No. 173.

Reilly, K. T. (1995). "Human Capital and Information: The Employer Size-Wage Effect.", *Journal of Human Resources*, 30(1):1–18.

Ringuede, S. (1998). "An Efficiency Wage Model for Small Firms: Firm Size and Wages.", *Economic Letters*, 59:263–8.

Shapiro, C. and Stiglitz, J. E. (1984). "Equilibrium Unemployment as a Worker Discipline Device.", *Amer. Econ. Rev.*, 74(3):433–444.

Soderbom, M. and Teal, F. (2001), *Trade and Human Capital as Determinants of Growth*, Centre for the Study of African Economies, Oxford University, Oxford. CSAE WP/2001-10.

Soderbom, M., Teal, F. and Wambugu, A. (2004), Unobserved Heterogeneity and the Relation between Earnings and Firm Size: Evidence from Two Developing Countries. (mimeograph).

Sparks, R. (1986). "A Model of Involuntary Unemployment and Wage Rigidity: Worker Incentives and the Threat of Dismissal.", *Journal of Labor Economics*, 4(4):560–81.

Stiglitz, J. E. (1987). "The Causes and Consequences of the Dependence of Quality on Price.", *Journal of Economic Literature*, XXV:1–48.

Strobl, E. and Thornton, R. (2001), *Do Large Employers Pay More in Developing Countries? The Case of Five African Countries*, Department of Economics, University College, Dublin.

Troske, K. R. (1999). "Evidence on the Employer Size-Wage Premium From Worker-Establishment Matched Data.", *Review of Economics and Statistics*, 81(1):15–26.

Velenchik, A. D. (1997). "Government Intervention, Efficiency Wages, and the Employer Size Wage Effect in Zimbabwe.", *Journal of Development Economics*, 53(2):305–338.

Williamson, O. E. (1975), *Markets and Hierarchies: Analysis and Antitrust Implications*, The Free Press, Macmillan, New York.

Williamson, O. E. (1985), *The Economic Institutions of Capitalism*, The Free Press, Macmillan, New York.

TABLE 1
SUMMARY STATISTICS, FIRM LEVEL VARIABLES

	[1] Pooled			[2] Sub-Saharan Africa			[3] Morocco		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Employment	136.93	61.00	214.65	106.16	45.00	213.55	169.06	100.00	211.20
log Value-Added / Employee	8.02	8.10	1.11	7.69	7.76	1.23	8.36	8.31	0.85
log Capital / Employee	8.55	8.56	1.42	8.59	8.74	1.53	8.50	8.32	1.29
log Supervision Ratio	-2.04	-2.03	1.18	-1.42	-1.47	0.95	-2.69	-2.71	1.04
Firm Age / 100	0.18	0.15	0.13	0.20	0.18	0.13	0.16	0.12	0.13
Any Foreign Ownership	0.19			0.17			0.20		
Location in Capital City	0.55			0.52			0.58		
MANED, Primary	0.11			0.11			0.10		
MANED, Secondary / Prof.	0.43			0.60			0.25		
MANED, University	0.44			0.28			0.61		
Kenya	0.20			0.39					
Ivory Coast	0.01			0.01					
Ethiopia	0.01			0.02					
Cameroon	0.01			0.03					
Zambia	0.11			0.21					
Tanzania	0.06			0.12					
Zimbabwe	0.06			0.12					
Ghana	0.05			0.10					
Morocco	0.49						1.00		
Food Processing	0.20			0.26			0.14		
Wood & Furniture	0.13			0.25			0.00		
Textile & Garments	0.56			0.28			0.86		
Metal & Machinery	0.11			0.22			0.00		
Observations	1390			710			680		

TABLE 2
SUMMARY STATISTICS, PRODUCTION WORKER AND SUPERVISOR CHARACTERISTICS

	[1] Pooled			[2] Sub-Saharan Africa			[3] Morocco		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A. Production Workers									
Monthly earnings (USD)	177.9	172.6	147.1	93.1	67.8	88.4	259.2	215.3	146.3
Education (years)	8.4	9.0	4.4	9.5	11.0	3.4	7.3	8.0	5.0
Age	33.5	32.0	9.1	33.4	32.0	9.6	33.7	32.0	8.6
Tenure	7.3	5.0	6.6	7.4	5.0	6.9	7.2	5.0	6.4
Female	0.27			0.12			0.41		
Observations	19924			9755			10169		
B. Supervisors									
Monthly earnings (USD)	375.7	198.6	538.7	171.8	123.8	148.5	852.8	620.5	770.2
Education (years)	12.5	12.0	3.0	11.8	12.0	2.5	14.1	14.0	3.3
Age	36.6	35.0	9.1	36.3	35.0	9.3	37.4	36.0	8.5
Tenure	8.2	6.0	7.2	8.5	6.0	7.6	7.5	6.0	6.2
Female	0.25			0.25			0.25		
Observations	7022			4920			2102		

TABLE 3
EARNINGS REGRESSIONS FOR PRODUCTION WORKERS, WITH FIXED EFFECTS

	[1] Pooled			[2] Sub-Saharan Africa			[3] Morocco		
	Coef.	Std. Err	t-value	Coef.	Std. Err	t-value	Coef.	Std. Err	t-value
Education (years)	-0.012	0.002	-5.440	-0.027	0.004	-6.390	-0.002	0.002	-0.720
$Education^2$ / 100	0.214	0.015	13.900	0.340	0.028	12.070	0.130	0.017	7.540
Age	0.029	0.002	15.440	0.037	0.003	12.550	0.022	0.002	9.270
Age^2 / 100	-0.026	0.002	-10.720	-0.036	0.004	-9.320	-0.018	0.003	-5.770
Tenure (years)	0.009	0.001	14.350	0.007	0.001	7.100	0.010	0.001	13.980
Female	-0.133	0.007	-18.590	-0.161	0.016	-10.020	-0.124	0.007	-17.260
Marginal return at education = 6	0.014			0.014			0.014		
Marginal return at education = 12	0.040			0.055			0.030		
R-squared (within)	0.14			0.13			0.1738		
Observations	19924			9755			10169		

The dependent variable is the logarithm of monthly earnings, expressed in USD.

TABLE 4
EARNINGS REGRESSIONS FOR SUPERVISORS, WITH FIXED EFFECTS

	[1] Pooled			[2] Sub-Saharan Africa			[3] Morocco		
	Coef.	Std. Err	t-value	Coef.	Std. Err	t-value	Coef.	Std. Err	t-value
Education (years)	-0.010	0.011	-0.930	-0.058	0.015	-3.980	0.014	0.018	0.790
$Education^2$ / 100	0.392	0.052	7.480	0.736	0.069	10.660	0.080	0.080	1.010
Age	0.060	0.006	9.550	0.066	0.007	9.950	0.040	0.015	2.700
Age^2 / 100	-0.051	0.008	-6.590	-0.062	0.008	-7.490	-0.020	0.018	-1.090
Tenure (years)	0.003	0.002	1.930	0.004	0.002	2.600	0.010	0.004	2.660
Female	-0.117	0.019	-6.240	-0.090	0.021	-4.250	-0.226	0.037	-6.100
Marginal return at education = 6	0.037			0.030			0.024		
Marginal return at education = 12	0.084			0.119			0.030		
R-squared (within)	0.21			0.27			0.20		
Observations	7022			4920			2102		

The dependent variable is the logarithm of monthly earnings, expressed in USD.

TABLE 5
THE FIRM-SIZE EARNINGS RELATION: RESULTS FROM POOLED REGRESSIONS

Definition Wage Variable*	Size Variable	Coef.	t-value	Size Variable	Coef.	t-value
FE, pooled	log(Prod.work.)	0.090	15.773	log(Supervisors)	0.132	12.922
FE, country-spec.		0.091	15.938		0.133	12.930
OLS, pooled		0.069	13.068		0.123	12.557
OLS, country -spec.		0.068	13.114		0.120	12.438
FE, pooled	log(Employment)	0.096	17.047	log(Employment)	0.105	12.623
FE, country-spec.		0.097	17.281		0.110	13.147
OLS, pooled		0.078	14.939		0.098	12.293
OLS, country -spec.		0.076	14.918		0.098	12.497
FE, pooled	log(Capital)	0.050	14.484	log(Capital)	0.065	12.158
FE, country-spec.		0.051	15.021		0.066	12.223
OLS, pooled		0.035	10.812		0.058	11.306
OLS, country -spec.		0.034	10.927		0.057	11.292

* Note:
FE, pooled = Fixed Effects from Pooled regression;
FE, c-spec. = Fixed Effects from country regressions;
OLS, pooled = Average residual from Pooled regression;
FE, c-spec. = Average residual from country regressions.

TABLE 6
ESTIMATES OF STRUCTURAL PARAMETERS

	[1] Sub-Saharan Africa			[2] Morocco		
	Coef.	Std. Err	t-value	Coef.	Std. Err	t-value
Production Function						
β	0.328	0.018	18.384	0.738	0.033	22.661
γ	0.284	0.011	24.923	0.127	0.012	10.524
Effort Function						
c	0.529	0.028	18.794	0.554	0.095	5.857
b	0.447	0.024	18.277	0.904	0.184	4.903
d	0.022	0.009	2.414	1.491	1.691	0.882
c'	0.369	0.060	6.193	0.600	0.151	3.969
b'	0.466	0.036	12.829	0.702	0.097	7.232
d'	1.226	0.668	1.834	3.017	0.934	3.230
Outside Option*						
Production Workers						
Kenya	43.0	14.5	2.955			
Tanzania	25.0	8.5	2.946			
Ghana	39.3	13.4	2.947			
Zimbabwe	59.1	20.3	2.914			
Zambia	51.6	17.5	2.955			
Ivory Coast	121.1	42.3	2.863			
Cameroon	185.3	63.7	2.908			
Ethiopia	51.9	18.5	2.797			
Burundi	41.5	14.7	2.817			
Morocco				923.1	289.5	3.188
Supervisors						
Kenya	508.2	79.6	6.382			
Tanzania	261.0	39.1	6.680			
Ghana	366.6	59.2	6.197			
Zimbabwe	842.1	134.6	6.258			
Zambia	524.0	81.8	6.408			
Ivory Coast	1294.2	240.1	5.389			
Cameroon	1783.5	292.9	6.088			
Ethiopia	915.0	162.2	5.641			
Burundi	644.1	129.9	4.958			
Morocco				1864.6	285.7	6.526
TFP Shifters						
Average education (years)	0.080	0.015	5.175	0.009	0.003	2.834
Average tenure (year)	0.015	0.006	2.501	0.0004	0.003	0.142
Firm age / 100 (years)	0.445	0.177	2.515	-0.034	0.103	0.327
Any foreign ownership	0.130	0.047	2.801	0.046	0.026	1.801
log (Support staff + 1)	0.240	0.018	13.363	0.145	0.016	8.937
Country effects	Yes					
Year effects	Yes			Yes		

* Expressed as annual value in USD.

Figure 1. Supervision and Firm Size

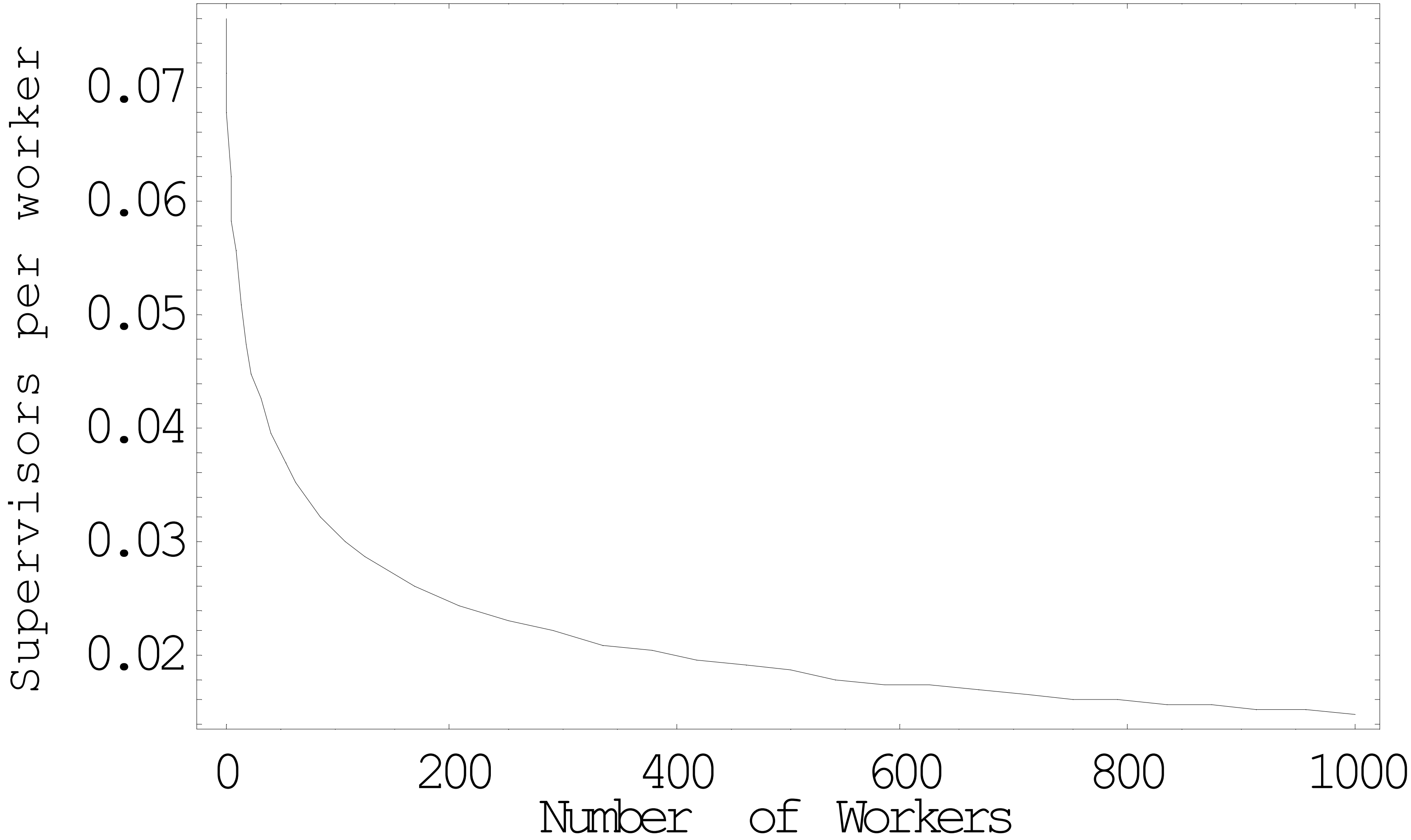
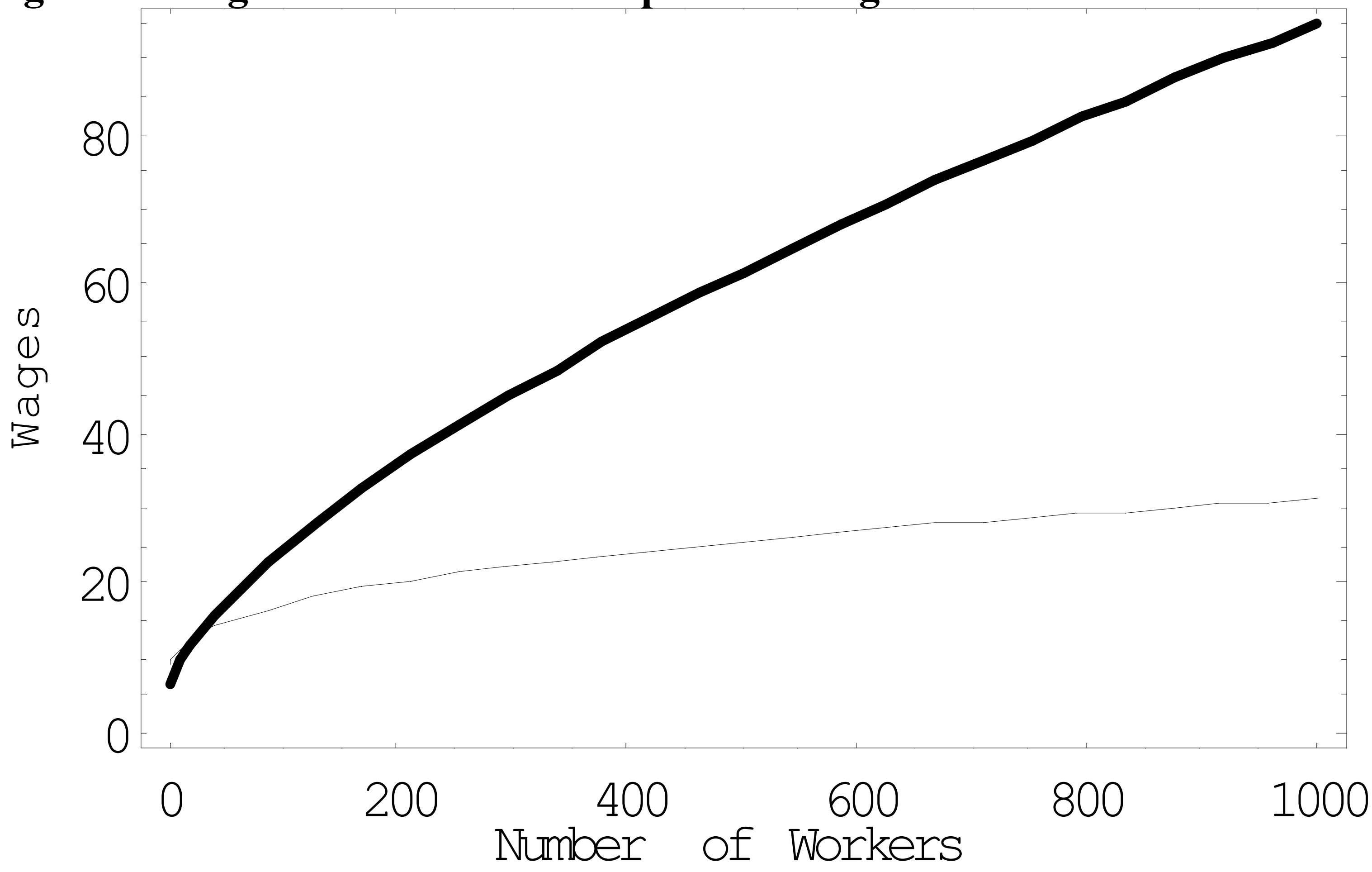


Figure 2. Wages and Firm Size – supervisor wages in bold



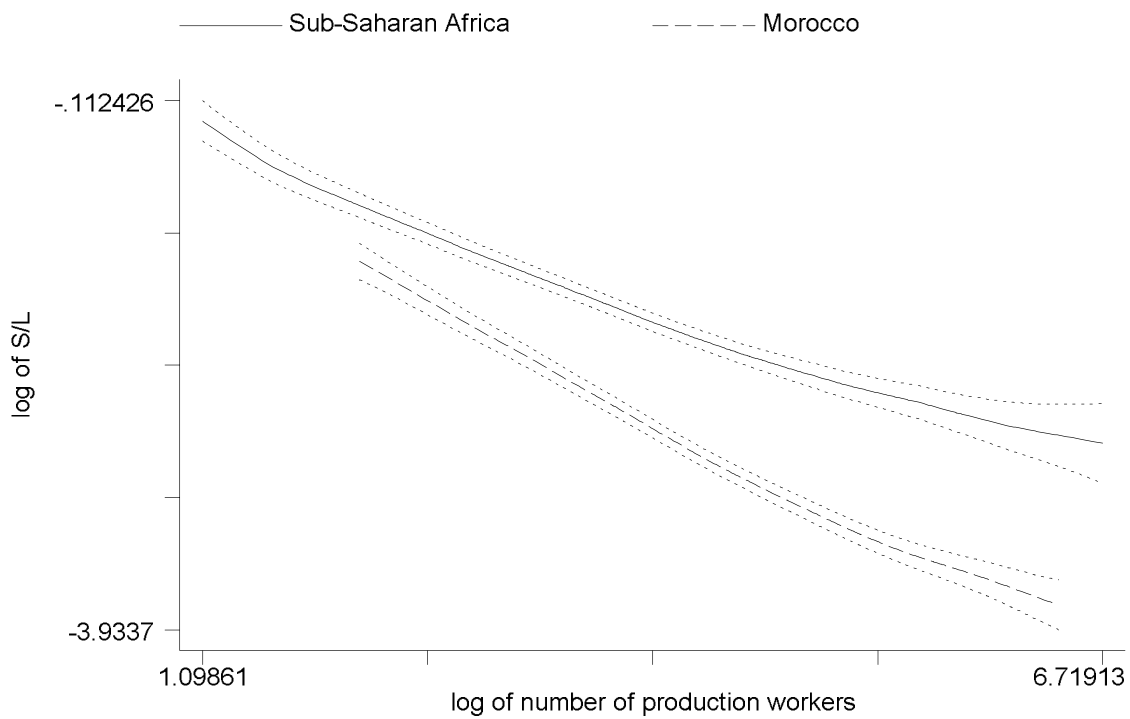


Figure 3. Firm size and supervisor-to-worker ratio

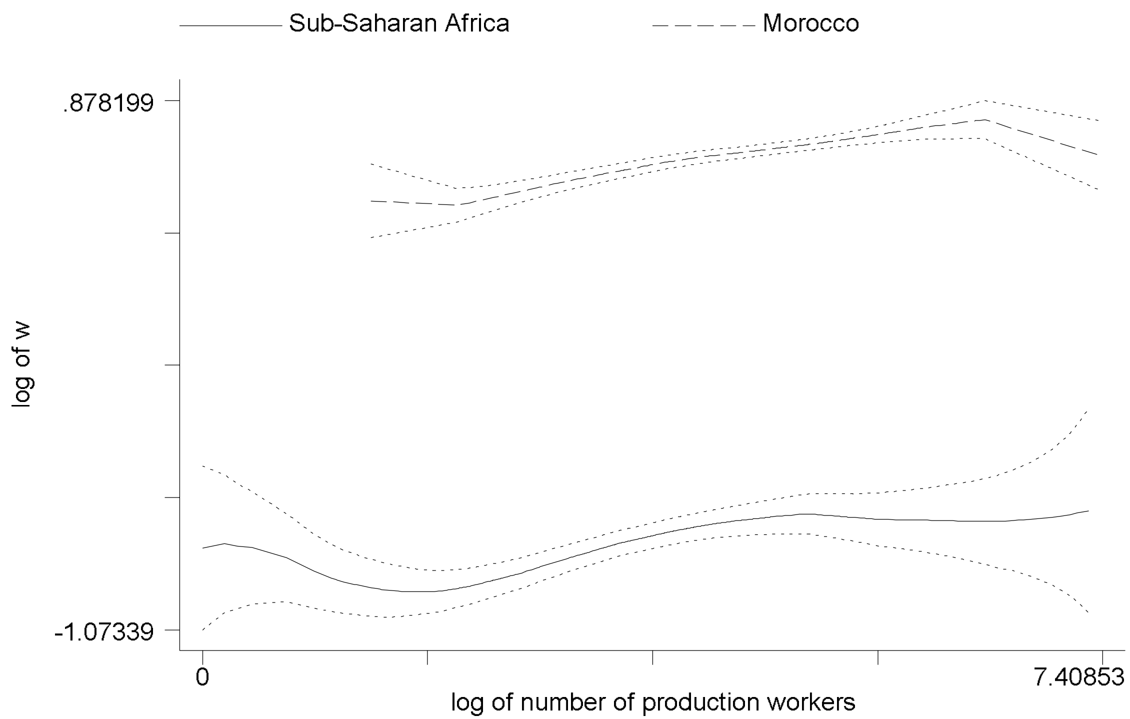


Figure 4. Firm size and production worker wages

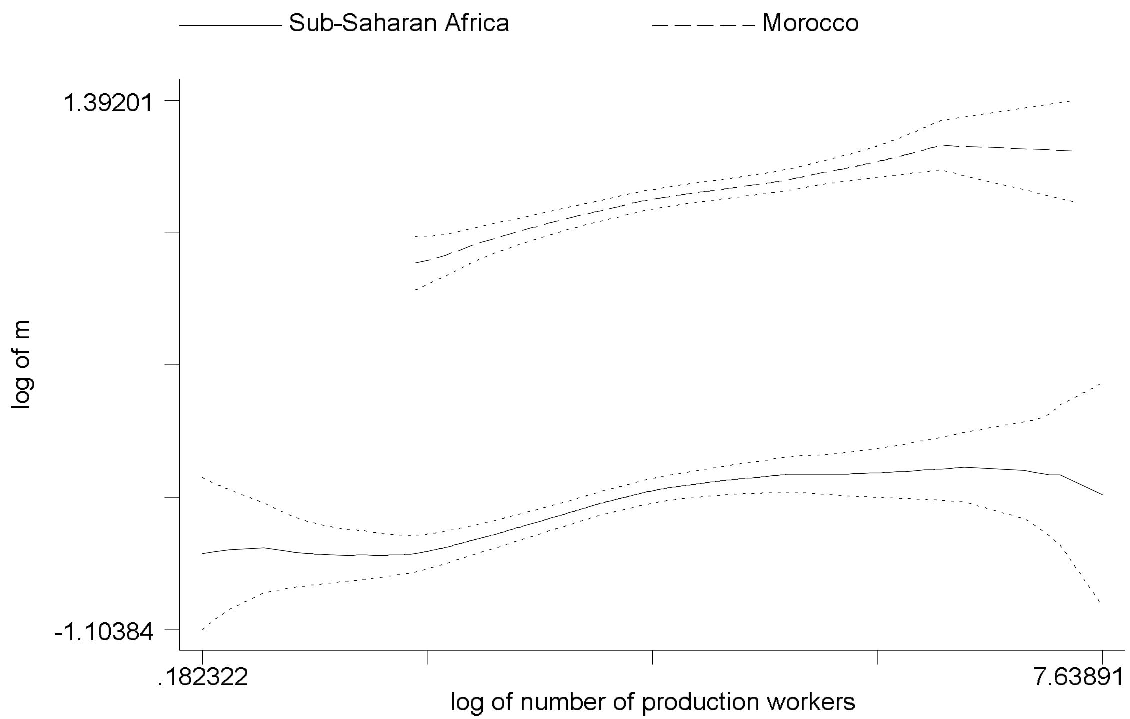


Figure 5. Firm size and supervisor wages

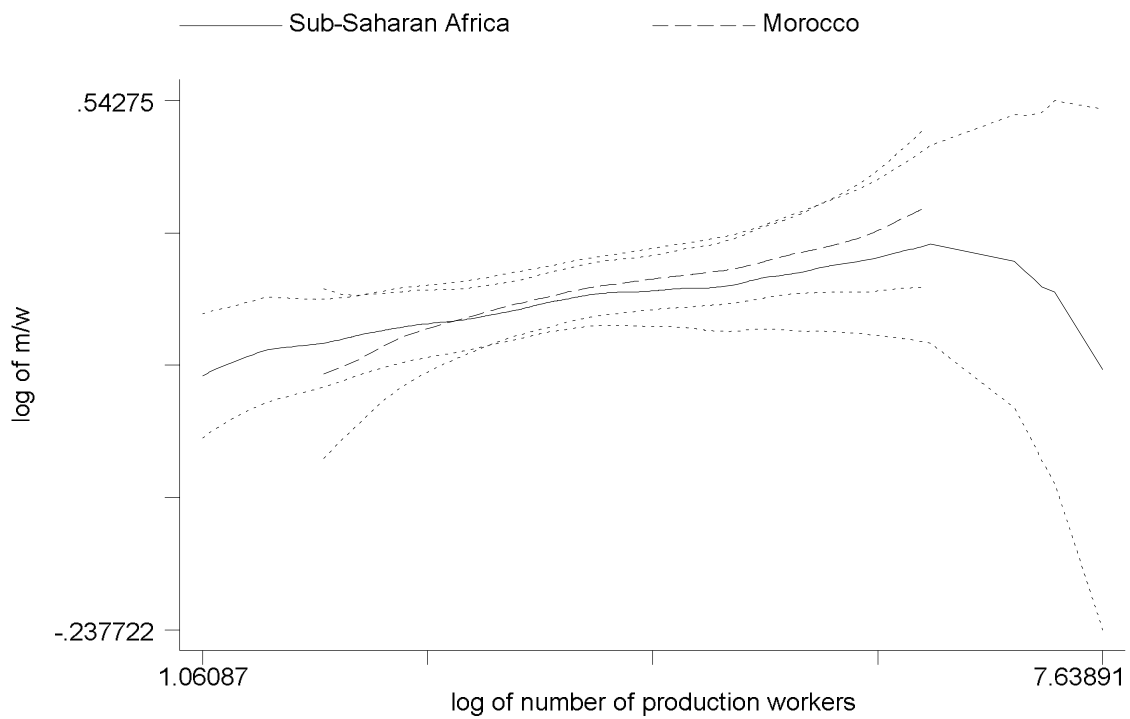
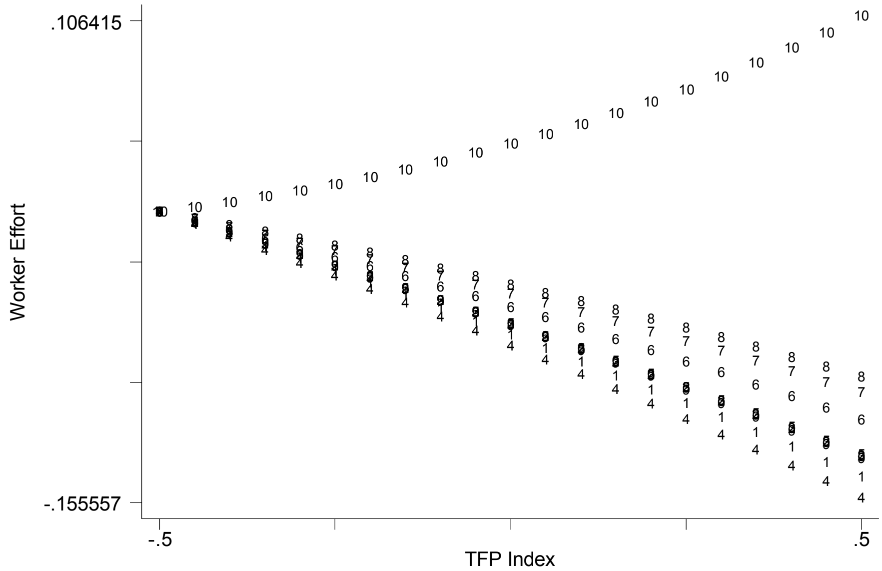


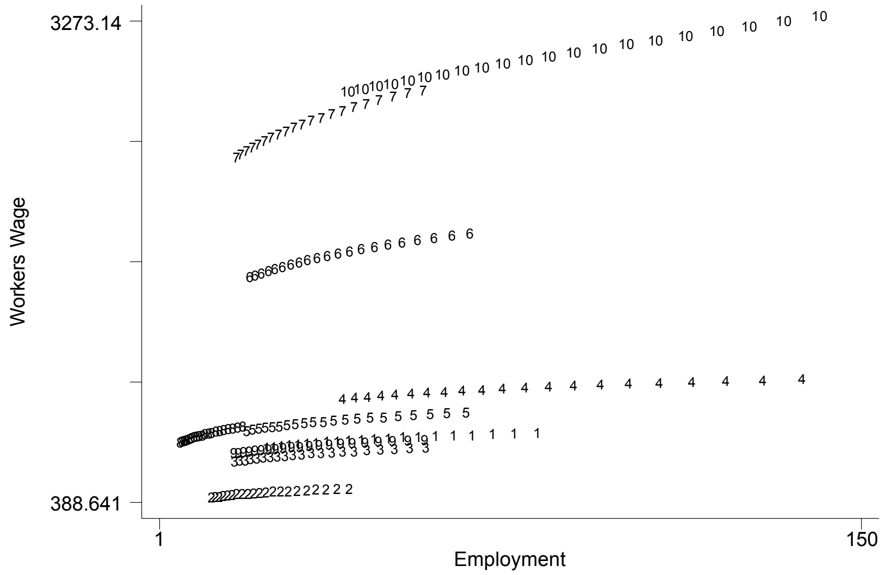
Figure 6. Firm size and supervisor-to-worker wage ratio

Figure 7: Worker Effort and Changes in TFP



Note: The figure shows how worker effort responds to a change in TFP.
Countries:1=Kenya; 2=Tanzania; 3=Ghana; 4=Zimbabwe; 5=Zambia; 6=Ivory Coast; 7=Cameroon; 8=Ethiopia; 9=Burundi; 10=Morocco.

Figure 8: Production Worker Wages and Firm Size



Note: The figure shows predicted wages for production workers and employment by country based on the estimated structural model. The country codes are shown in the notes to Figure 7.

Figure 9: Production Worker Wages and Firm Size

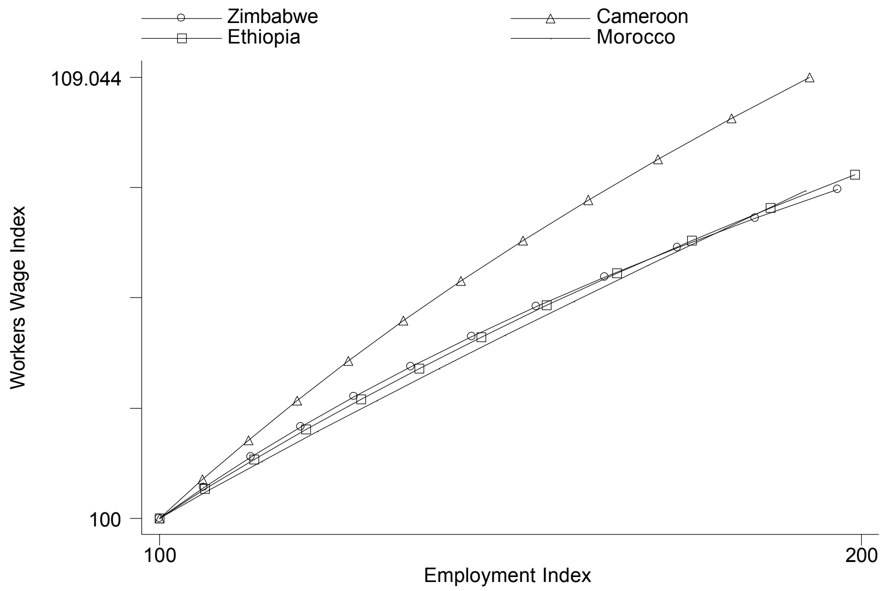
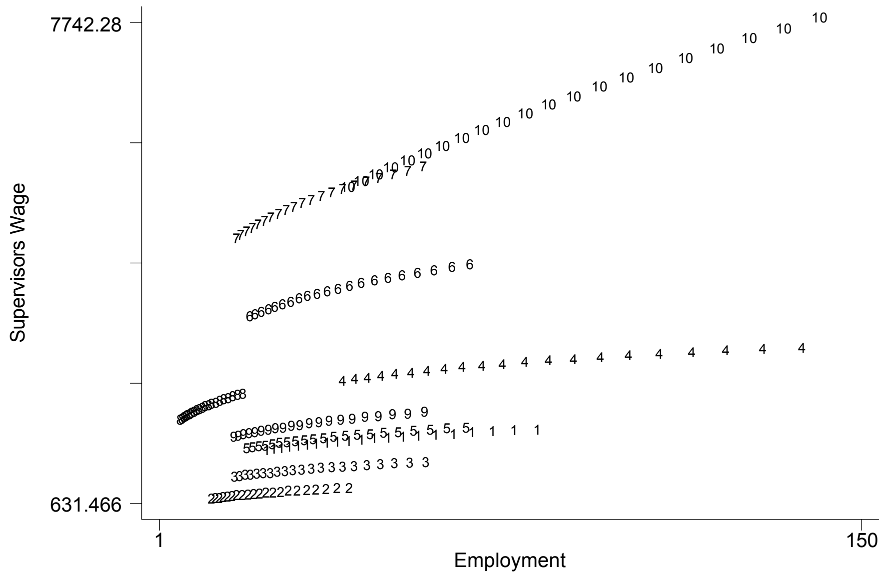


Figure 10: Supervision Wages and Firm Size



Note: The figure shows predicted supervision wages and employment by country based on the estimated structural model. The country codes are shown in the notes to Figure 7.

Figure 11: Supervision Wages and Firm Size

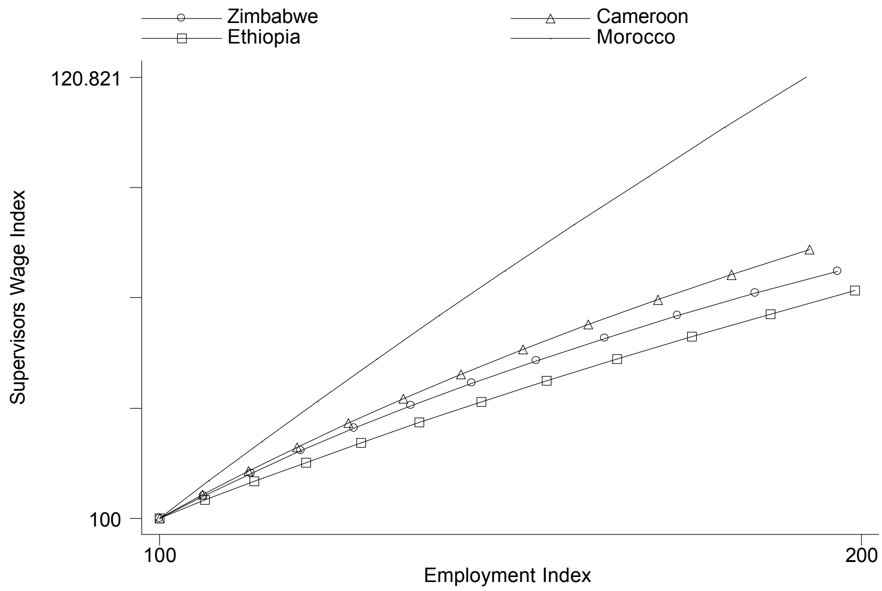
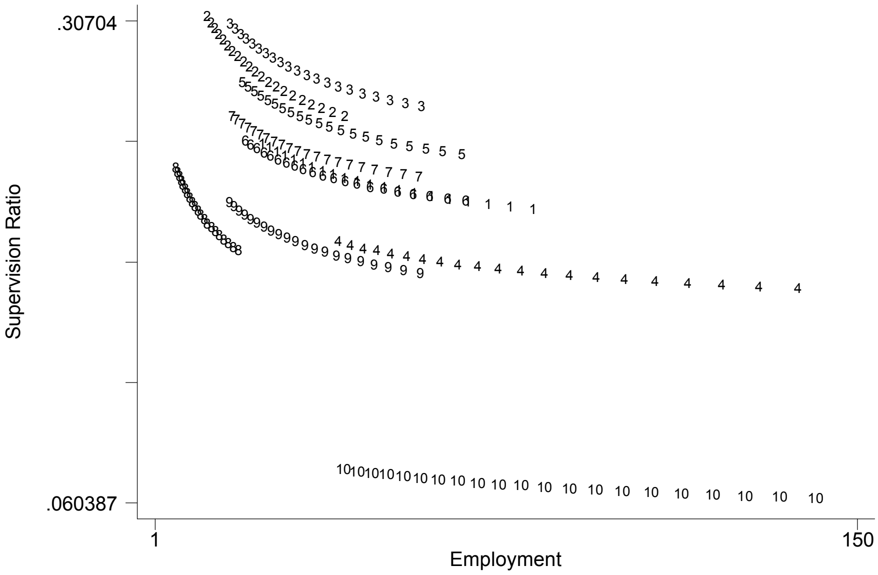


Figure 12: Supervision Ratio and Firm Size



Note: The figure shows predicted supervision ratios and employment by country based on the estimated structural model. The country codes are shown in the notes to Figure 7.

Figure 13: Supervision Intensity and Firm Size