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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 in Morocco and a higher elasticity of effort with respect to supervision.

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1. Introduction

Prosperity varies dramatically across regions of the world. Many economists believe this has to do with differences in the quality of manpower. These beliefs are typically expressed in terms of human capital, that is, of schooling and vocational skills (e.g. Barro & i Martin 1992, Mankiw, Romer & Weil 1992). Countries with uneducated manpower, the story goes, provide low returns on capital and fail to attract foreign investments. As a result, they grow less fast or not at all. The solution is to increase expenditures in education.

Not all economists share these views, however. Economists focusing on sub-Saharan Africa (SSA), for instance, have long noted the lack of relationship between school enrollment rates and economic performance, either across countries or over time (e.g. Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal, Zeufack & Appleton 2000*a*, Teal 2000, Soderbom & Teal 2001). Africa is often characterized by unemployment among school graduates (e.g. Eicher 1985, Serneels 1999). This situation is hard to reconcile with the idea that a shortage of educated manpower is what stifles growth in the continent. If there is something wrong with African manpower quality, it is unlikely to be schooling per se.

An alternative explanation is labor management. During the colonial era, it was customary for authorities to complain about workers' lack of effort. Such claims should be heavily discounted as influenced by the ideology of the time and may have reflected passive resistance to colonialism on the part of workers. Recent evidence is more troubling. It has been claimed that managers and workers in African firms often show little loyalty to their employer (Ezeala-Harrison 1991). Absenteeism is blamed on the 'extended family system' that obliges employees to assist parents in need. Pilferage is a concern too: Fafchamps & Minten (2001) show that 37% of agricultural traders in Madagascar refrain from hiring more employees for fear of employee theft. Using data from manufacturing firms in Cote d'Ivoire, Azam & Lesueur (1997) show that worker supervision is a serious concern among large firms. Breach of employment contract by employers is also mentioned as an endemic problem. Labor management problems need not be due to opportunistic behavior but originate in internal organization difficulties regarding task assignment, coordination between workers and units, and reporting and monitoring. Many African entrepreneurs

indeed complain about the difficulty to manage a large labor force. Could it be that labor management, not education, is the main determinant of labor quality in poor countries with little or no experience in wage employment?

This is not a far-fetched notion. After all, we know that self-discipline and the capacity to obey instructions is one of the skills imparted by education – so much so that employers may pay a premium for workers who obtain their diploma from a regular day school (e.g. Cameron & Heckman 1993, Tyler, Murnane & Willett 2000). Corruption, which is blamed for many of the evils of underdevelopment, is largely a worker discipline problem: if workers followed their job description, there would be much less corruption. Lack of loyalty towards large formal organizations such as states and firms has long been noted and blamed for the prevalence of corruption (e.g. Bayart 1989, Bates 1983, Bauer 1971). As suggested by Platteau (1996), one possible explanation for this state of affairs is the existence in SSA of sharing norms that makes shirking more morally acceptable. Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal & Zeufack (2004) indeed document the prevalence of rent sharing between firms and their workers. Barr & Oduro (2002) find that workers who are related to their employers earn a premium and there is statistical discrimination in favour of inexperienced co-ethnic workers. These findings are consistent with the idea that employers trust relatives more. Taken together, these concerns might help explain why African manufacturing firms remain quite small by international standards: 100 workers on average, excluding enterprises of less than five workers (Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal & Zeufack 2000*b*).

This paper revisits this issue using matched worker-enterprise 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. This structural model is then econometrically estimated using data from nine countries in SSA and one North-African country, Morocco. We think of Morocco as a control case, representing the situation in a middle income country with labor management problems comparable to those encountered in other middle income countries. Descriptive analysis show that worker supervision falls with firm size

while wages rise, which is consistent with our theoretical model.

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 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 & Idson 1999). The fact that wages in Africa increase particularly rapidly with firm size is consistent with the view that labor management is a more acute problem there – possibly because of lower school enrollment rates in the population at large (e.g. Mazumdar & Mazaheri 2002, Strobl & Thornton 2001). If confirmed by subsequent research, this finding has deep implications for our understanding of the early development process. 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 that middle-rank managers and administrative staff must be monitored by shareholders. The data are presented in Section 3 together with a non-parametric analysis of labor management. Using matched worker-employer 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 individual 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:

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

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:

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

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)).¹ 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 & Idson 1999, Abowd & Kramarz 1999). The effect of wages on 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 be due to the probability of dismissal of workers found shirking, as in Shapiro & 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 & 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:

$$p = \frac{e'S}{L} \quad (2.3)$$

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:

$$p' = \frac{1}{S} \quad (2.4)$$

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)

¹Sparks 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.

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:

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

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

$$L = a\beta e^{\beta-1} e_w L^\beta \quad (2.7)$$

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

where the derivatives of the effort functions are given by:

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

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:²

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

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

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

²Since 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:

$$\begin{aligned} &\max_{L, S \geq 0, w, m} a(eL)^\beta - wL - mS \quad \text{subject to} \\ e &= (w - x)^c \left(d + \frac{1}{p}\right)^{-b} \\ p &= \frac{1}{L} \end{aligned}$$

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:

$$e - e_p p = w e_w \tag{2.9}$$

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.³ We have:

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

which can be rewritten more simply as:

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

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

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

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.

³Or 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:

$$\begin{aligned} & \max_{L,S,w} a(eL)^\beta - wL - mS \text{ subject to} \\ e &= (w-x)^c \left(d + \frac{1}{p}\right)^{-b} \\ p &= \frac{e'S}{L} \\ e' &= (m-x')^{c'} (d'+S)^{-b'} \end{aligned}$$

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

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

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:

$$\frac{e_p}{e_w} [e' + S e'_S] = m$$

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.⁴ 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 \tilde{w} , \tilde{m} , \tilde{L} , and \tilde{s} are assumed to include measurement error

⁴The 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:

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

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

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

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

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.

There are other possible reasons why large firms pay high wages (e.g. Troske 1999, Bayard & 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.⁵

3. The data

The ideas presented in the previous section are applicable anywhere. But they are particularly relevant for SSA because of the rampant belief that African workers are less disciplined and harder to manage

⁵Underlying 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.

than, say, East-Asian or Chinese workers. This belief might help explain why international corporations refrain from investing in Africa.

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-African country, Morocco. We think of Morocco as a control case, representing the situation in a middle income country with labor management problems comparable to those encountered elsewhere in the world.

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.⁶ Four sectors of activity were covered: textile and garments; wood products; metal products; and food processing. Large as well as small firms, including informal ones, were included. 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, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal, Zeufack & Appleton 2000*a*, Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal & Zeufack 2000*b*).

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.⁷ Ethiopia was surveyed three times but we

⁶Burundi 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.

⁷The Ethiopian survey was coordinated by Taye Mengistae.

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.⁸ 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 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.

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.⁹

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,

⁸The KMES was organized by the Centre for the Study of African Economies, University of Oxford. See Soderbom (2001) for a report based on these data.

⁹In all surveys, information on worker identifiers was not collected to protect the confidentiality of workers' responses.

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 or S but are included in the production function as part of a (see below).

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 USD 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. We also note that the supervision ratio figures for SSA are higher than for OECD data (Acemoglu & Newman 2000). This is partly because our broad definition of supervision workers includes clerical staff, a difference that is justified by the nature of the firms we investigate. But the difference between SSA and Morocco 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 USD 93 in SSA vs. USD 259 in Morocco. For supervisors earnings are much larger, on average USD 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 (USD 32 and USD 49, respectively). Incidentally, differentials between

countries are often close to differentials in per capita income as reported in the World Development Indicators database.¹⁰

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:

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

¹⁰Measured 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 v_{ijt} is an error term (Abowd & 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.¹¹ 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.¹² 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.

¹¹In the estimation of the structural model, coefficient estimates by sub-sample are used.

¹²R-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 $\hat{\omega}_{it}$ 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 worker productivity effects, we do not use actual wages but use $\hat{\omega}_{it}$ instead.

To check for robustness, we experiment with three different ways of measuring $\hat{\omega}_{it}$. 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 $\hat{\omega}_{it}$. The reason for doing so is that 'going within' may exacerbate the effects of measurement errors and bias the associated coefficients towards zero (Griliches & 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 $\hat{\omega}_{it}$ 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 $\hat{\omega}_{it}$ 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.¹³ 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.

The next step in our analysis is to examine how supervision and wages impact on productivity. Before estimating the structural model directly, we begin with a standard Cobb-Douglas production function to which we add variables that affect workers' effort, namely the supervision ratio and predicted wages. Value-added is the dependent variable. To minimize omitted variable bias, additional controls are included as well, such as firm age and foreign ownership. The regression takes the form:

$$\log q = \log a + \beta_1 \log k + \beta_2 \log L + \beta_3 \log \left(\frac{S}{L} \right) + \beta_4 \widehat{\omega}_w + \beta_5 \widehat{\omega}_m + \varepsilon_q \quad (4.2)$$

¹³Results 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.

OLS estimates of equation 4.2 are shown in Table 6. Predicted wages are shown to have the anticipated positive effect on productivity in some of the regressions. In the sub-Saharan regression, the estimated coefficient on workers' wage is 0.58 and significant at the 1 per cent level. In Morocco, supervisor wage is also significant at the 1 per cent level. In Table 7 we report two-stage least squares results, treating production workers as an endogenous variable. Instruments include lagged total employment (in log), the manager's education, a dummy for whether or not the firm is located in the capital city, and the other exogenous variables in the structural estimation (see below). Most of the coefficients of interest are quite similar between the instrumented and uninstrumented regressions.

4.3. Structural Estimation

We have seen that many of 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 b' .¹⁴ For estimation purposes, parameter a is expanded into:

$$a = \alpha_0 K^\gamma O^\delta \exp\left(\sum_i \lambda_i F_i + \sum_j \theta_j D_j\right) \quad (4.3)$$

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. 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

¹⁴In 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.

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.¹⁵

With this methodology, the endogeneity of the choice variables does not result in bias of the parameter estimates.¹⁶ The system of equations can therefore be estimated in the usual manner, i.e. through 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 8 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.¹⁷ Coefficients on productivity 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,

¹⁵The 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). Estimation is carried out using the Gauss package. The computational cost of the exercise is high.

¹⁶In 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 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.

¹⁷Parameter δ is the coefficient of $\log(\text{support staff}+1)$.

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 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.¹⁸ The estimates reported in Table 8 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

¹⁸The 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.

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 underlying 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 productivity affect effort, we show in Figure 7 how (the logarithm of) worker effort responds to a change in productivity a .¹⁹ There is a striking difference between the two samples: an increase in productivity 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 productivity leads to more worker effort, the converse is the case in SSA. An immediate implication is that high productivity 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 productivity 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 247% is associated with an increase in worker wages by between 12 and 17%, thus implying an average slope between 0.05 and 0.07.

¹⁹The Figure is constructed by taking values of $\ln a$ from the country average minus 0.5 to the country average plus 0.5, normalizing initial log effort to zero.

Figure 10 shows that 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 247% is associated with a fall in the supervision ratio by 19%.

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 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 are consistent with the kind of claims and stories discussed in the introduction: managing and monitoring workers in SSA is more costly and more problematic than in Morocco and, possibly, in other parts of the world. 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 an 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 10 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. Although this approach does not entirely eliminate the possibility of a selection bias – there might remain systematic differences in unobservable worker traits across firms – the approach singularly reduces the likely magnitude of the bias. This is particularly true given that the studied sectors belong to light manufacturing such as garment and textile or food processing. Most surveyed firms use dated equipment for which production work is relatively straightforward. In such an environment, it is unclear why 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. When we regress value added on capital and labor plus wages and the supervisor-to-worker ratio, both are shown to be strongly correlated with productivity.

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 provides some support to the idea that labor management is more difficult in Africa than elsewhere. Why this is the case is unclear and deserves more research.

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 suggest that labor management is a seriously underestimated problem. This might be especially true in Sub-Saharan Africa where manpower has generally spent little time in

school and has not been brought up within the routine of daily school attendance throughout adolescence. What is important to recognize, however, is that the analysis presented here cannot ascertain whether labor management problems come from poor enforcement of labor contracts (shirking, absenteeism, pilferage) or from difficulties in organizing the labor force within the firm (task assignment, coordination between workers and production units, information transfer within the firm).

Given that the workforce in SSA is often illiterate and unfamiliar with the technical intricacies of manufacturing, it seems reasonable to suspect internal organization to be the root of labor management difficulties. Several observations militate against this interpretation. First, production workers in SSA manufacturing have a fairly high average level of education. Second, the manufacturing labor force in our Moroccan sample is less well educated than that of our SSA sample, and yet labor management problems appear less acute in Morocco. To the extent that internal organization difficulties originate in poor education, this does not appear as a complete explanation for the difference between SSA and Morocco. The enforcement of labor contracts seems, a *prima facie*, a more promising avenue of enquiry. It is also conceivable that the internal organization of labor is more difficult in SSA than elsewhere for reasons other than insufficient education, for instance because of frequent machine breakdown, power cut, and input shortages. These issues deserve more investigation.

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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
VALUE-ADDED PRODUCTION FUNCTIONS: OLS ESTIMATES

	[1] Sub-Saharan Africa			[2] Morocco		
	Coef.	Std. Err	t-value	Coef.	Std. Err	t-value
log Capital	0.198	0.034	5.880	0.346	0.034	10.040
log Production workers	0.482	0.050	9.540	0.487	0.040	12.080
log Supervisors	0.358	0.075	4.790	0.124	0.057	2.170
log Support staff	0.175	0.047	3.690	0.183	0.040	4.600
Wage: Production workers	0.580	0.121	4.790	0.124	0.123	1.000
Wage: Supervisors	0.065	0.104	0.630	0.177	0.065	2.740
Average education (years)	0.014	0.036	0.390	0.017	0.009	1.850
Average tenure (year)	0.017	0.012	1.430	-0.009	0.010	0.910
Firm age / 100 (years)	-0.026	0.444	0.060	0.087	0.415	0.210
Any foreign ownership	0.109	0.138	0.790	0.002	0.085	0.030
Ivory Coast	0.833	0.333	2.500			
Ethiopia	-0.196	0.440	0.450			
Cameroon	0.190	0.636	0.300			
Zambia	-0.360	0.210	1.710			
Tanzania	-0.206	0.203	1.020			
Zimbabwe	0.202	0.193	1.050			
Kenya x 1993	-0.171	0.187	0.910			
Kenya x 1994	0.112	0.157	0.720			
Kenya x 1998	-0.202	0.230	0.880			
Kenya x 1999	-0.384	0.175	2.190			
Cameroon x 1993	0.568	0.686	0.830			
Zambia x 1993	0.057	0.216	0.260			
Zambia x 1994	0.082	0.246	0.330			
Tanzania x 1993	-0.797	0.398	2.000			
Tanzania x 1994	-0.085	0.326	0.260			
Zimbabwe x 1993	-0.166	0.118	1.410			
Ghana x 1992	0.292	0.187	1.560			
Morocco x 1999				-0.070	0.038	1.810
Ghana	-0.628	0.179	3.510			
Food	-0.050	0.139	0.360	0.254	0.114	2.230
Wood	-0.385	0.141	2.730			
Textile	-0.266	0.137	1.940			
R-squared	0.78			0.73		
Observations	710			680		

The dependent variable is the logarithm of annual value-added, expressed in USD.
The reported standard errors are robust to heteroskedasticity.

TABLE 7
VALUE-ADDED PRODUCTION FUNCTIONS: IV ESTIMATES

	[1] Sub-Saharan Africa			[2] Morocco		
	Coef.	Std. Err	t-value	Coef.	Std. Err	t-value
log Capital	0.178	0.038	4.720	0.313	0.035	9.020
log Production workers	0.570	0.084	6.800	0.678	0.054	12.550
log Supervisors	0.298	0.085	3.500	0.043	0.067	0.650
log Support staff	0.174	0.048	3.640	0.113	0.047	2.390
Wage: Production workers	0.585	0.121	4.860	0.075	0.128	0.590
Wage: Supervisors	0.059	0.104	0.570	0.150	0.067	2.230
Average education (years)	0.022	0.037	0.600	0.028	0.010	2.710
Average tenure (year)	0.017	0.012	1.410	-0.005	0.011	-0.470
Firm age / 100 (years)	0.006	0.441	0.010	0.157	0.439	0.360
Any foreign ownership	0.103	0.139	0.740	-0.026	0.092	-0.280
Ivory Coast	0.780	0.339	2.300			
Ethiopia	-0.243	0.438	-0.550			
Cameroon	0.167	0.627	0.270			
Zambia	-0.348	0.210	-1.660			
Tanzania	-0.207	0.204	-1.010			
Zimbabwe	0.129	0.202	0.640			
Kenya x 1993	-0.585	0.184	-3.180			
Kenya x 1994	-0.182	0.189	-0.960			
Kenya x 1998	0.096	0.156	0.620			
Kenya x 1999	-0.161	0.239	-0.670			
Cameroon x 1993	-0.375	0.177	-2.120			
Zambia x 1993	0.672	0.688	0.980			
Zambia x 1994	0.068	0.217	0.310			
Tanzania x 1993	0.087	0.246	0.350			
Tanzania x 1994	-0.757	0.400	-1.890			
Zimbabwe x 1993	-0.054	0.325	-0.170			
Ghana x 1992	-0.143	0.117	-1.220			
Morocco x 1999	0.241	0.190	1.270	-0.080	0.039	-2.070
Ghana						
Food	-0.071	0.139	-0.510	0.428	0.115	3.720
Wood	-0.415	0.141	-2.950			
Textile	-0.309	0.138	-2.230			
R-squared	0.73			0.78		
Observations	710			680		

The dependent variable is the logarithm of annual value-added, expressed in USD.

The reported standard errors are robust to heteroskedasticity.

Log Production workers is treated as an endogenous variable. The instruments are: total number of employees in previous period; education of manager or owner; location in capital city; and all exogenous variables in the structural specification.

TABLE 8
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						
<i>c</i>	0.529	0.028	18.794	0.554	0.095	5.857
<i>b</i>	0.447	0.024	18.277	0.904	0.184	4.903
<i>d</i>	0.022	0.009	2.414	1.491	1.691	0.882
<i>c'</i>	0.369	0.060	6.193	0.600	0.151	3.969
<i>b'</i>	0.466	0.036	12.829	0.702	0.097	7.232
<i>d'</i>	1.226	0.668	1.834	3.017	0.934	3.230
Outside Option*						
<u>Production Workers</u>						
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
<u>Supervisors</u>						
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

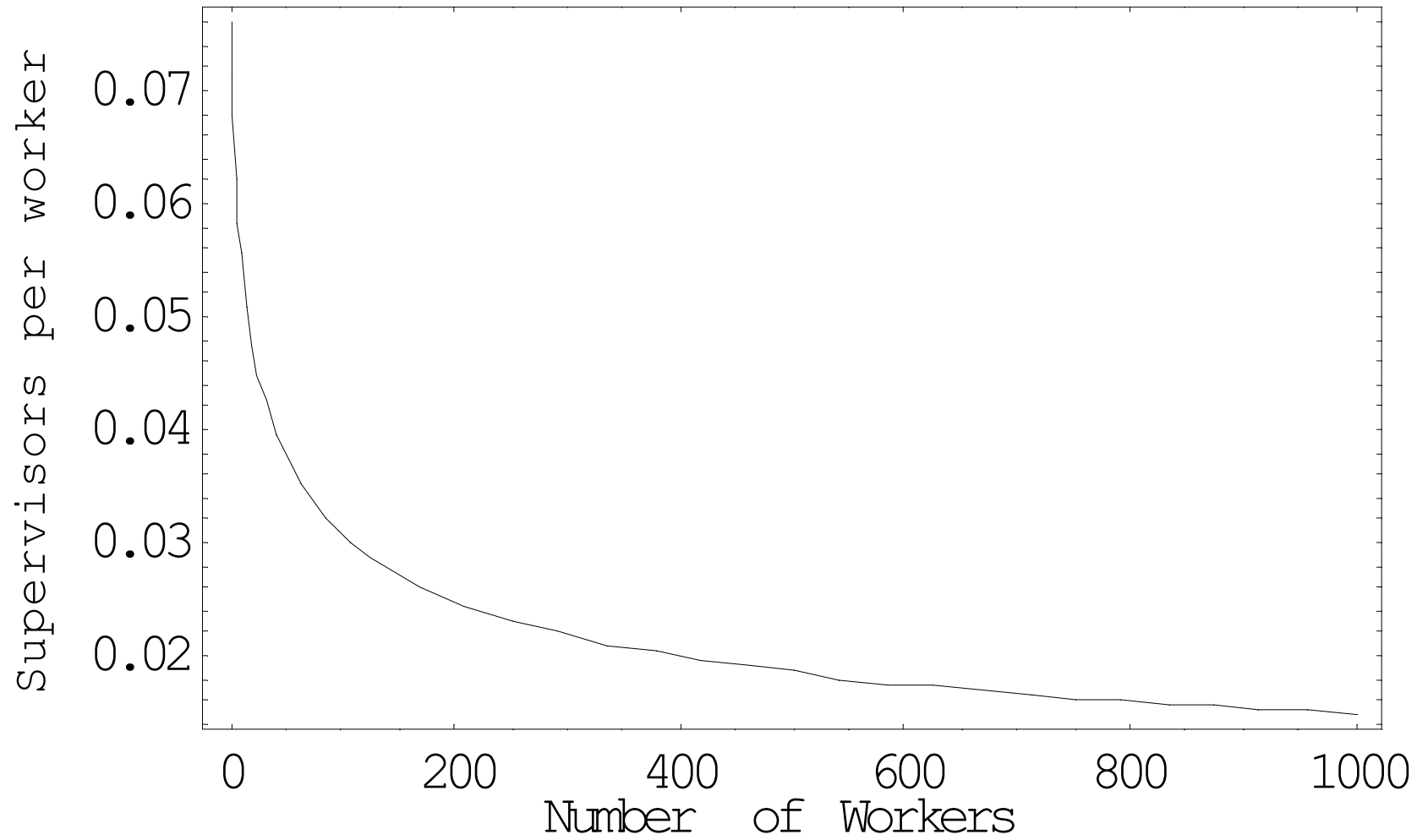
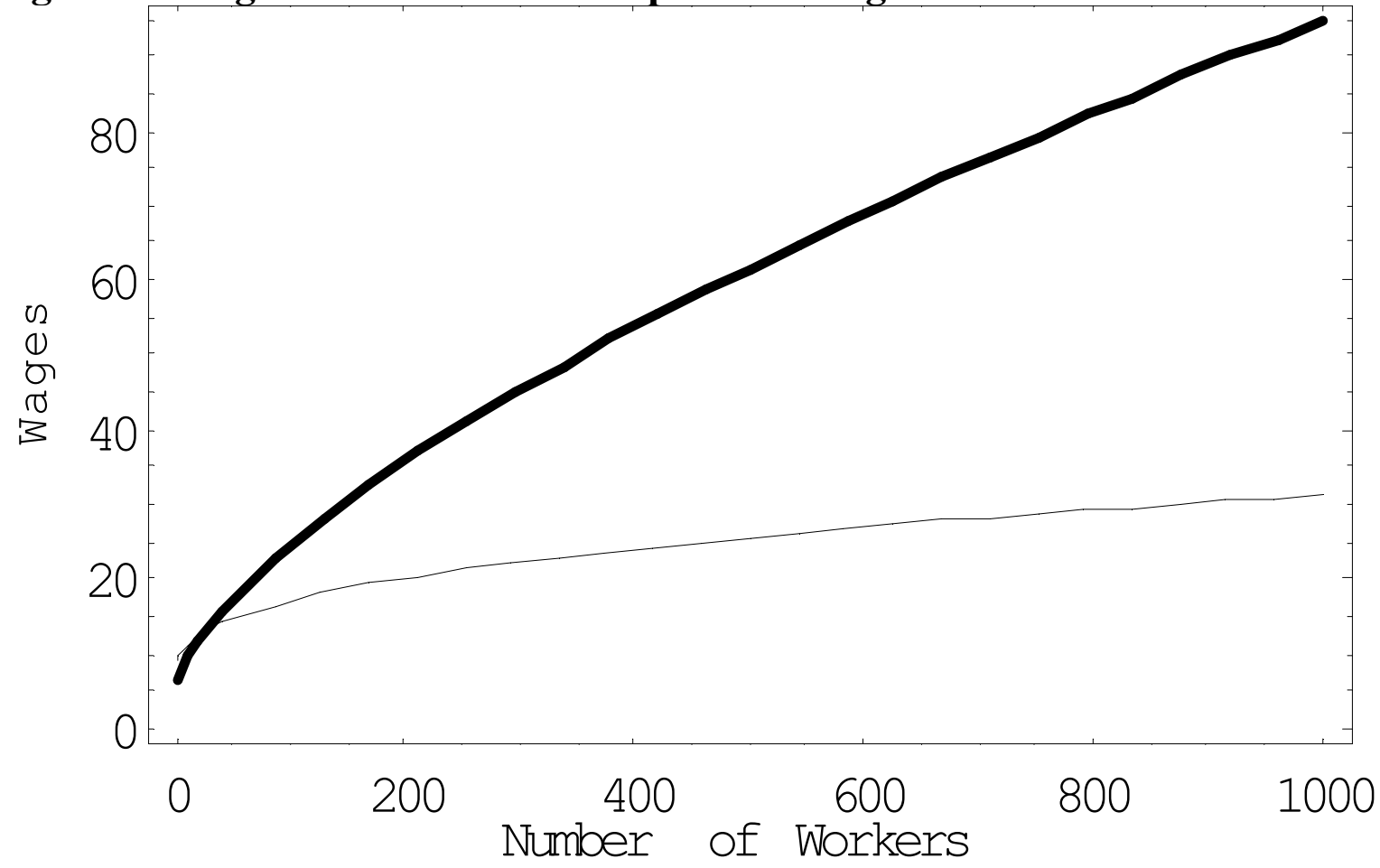


Figure 2. Wages and Firm Size – supervisor wages in bold



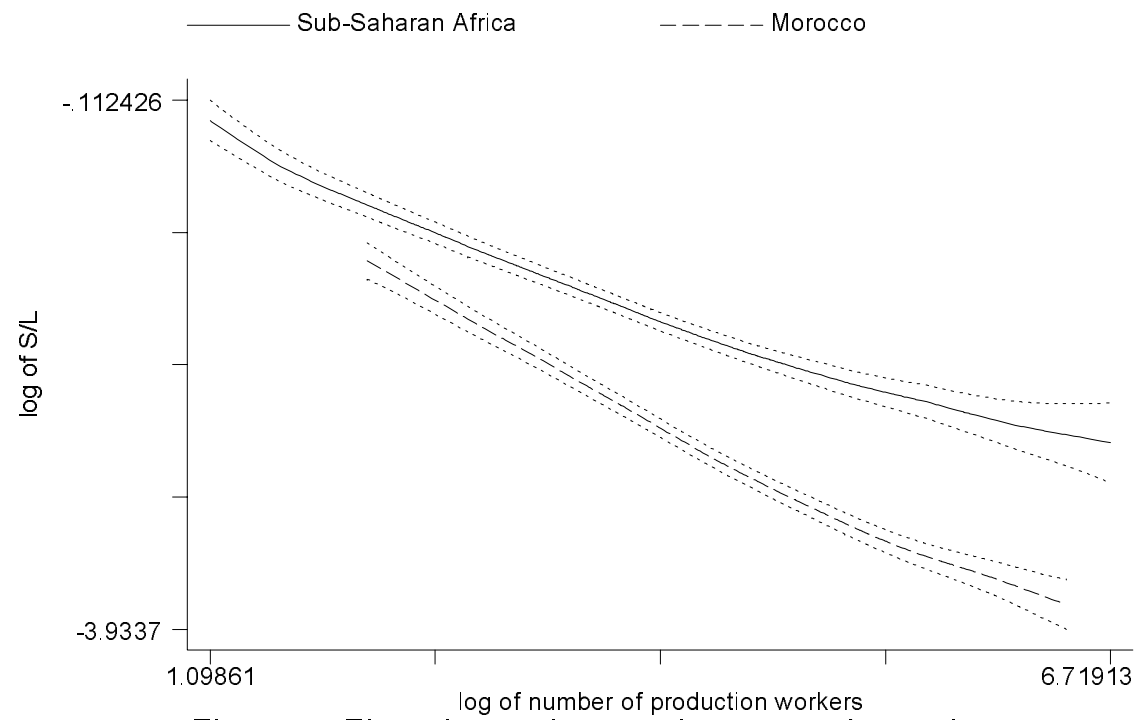


Figure 3. Firm size and supervisor-to-worker ratio

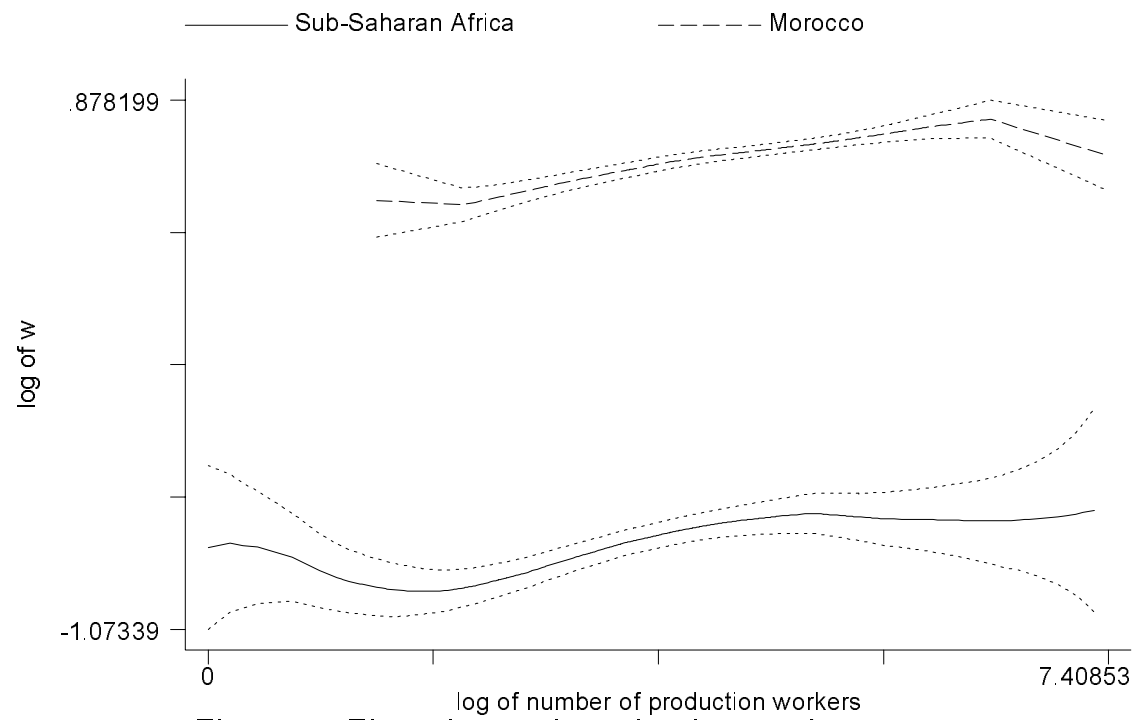


Figure 4. Firm size and production worker wages

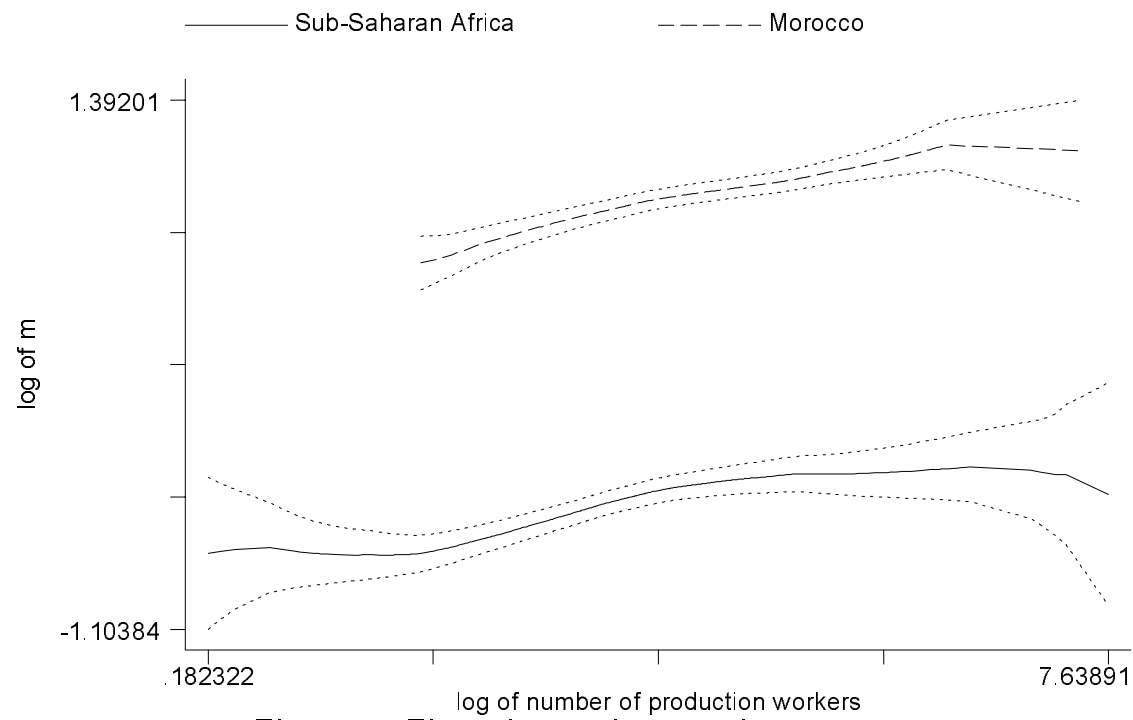


Figure 5. Firm size and supervisor wages

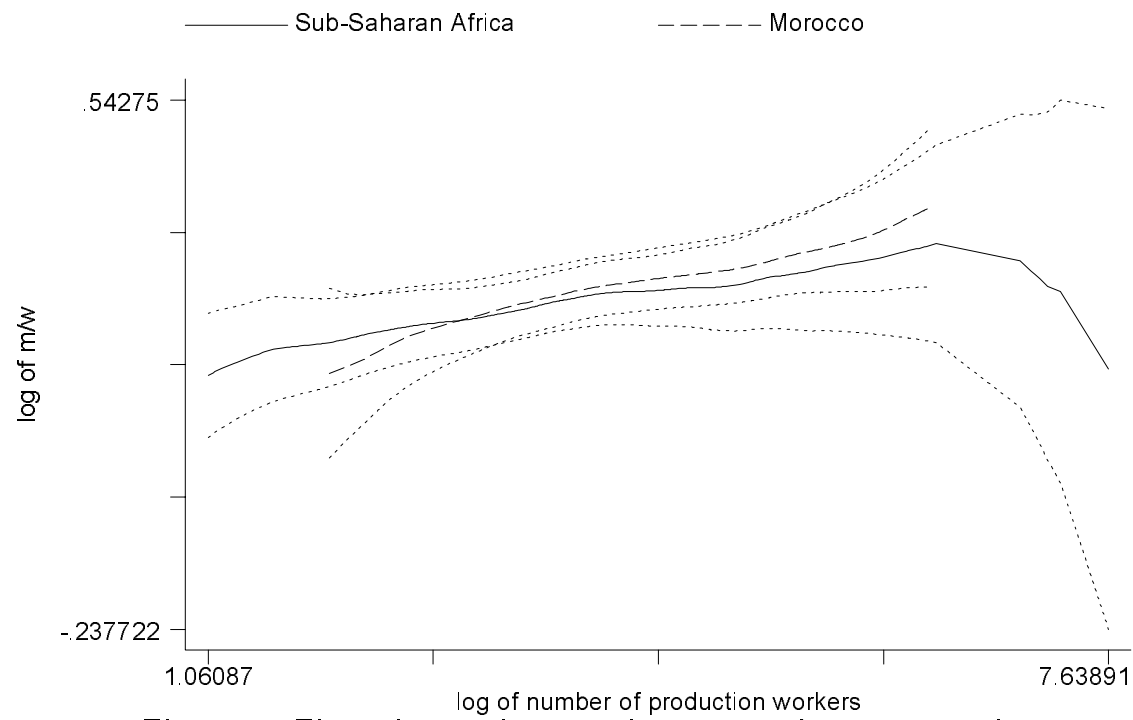
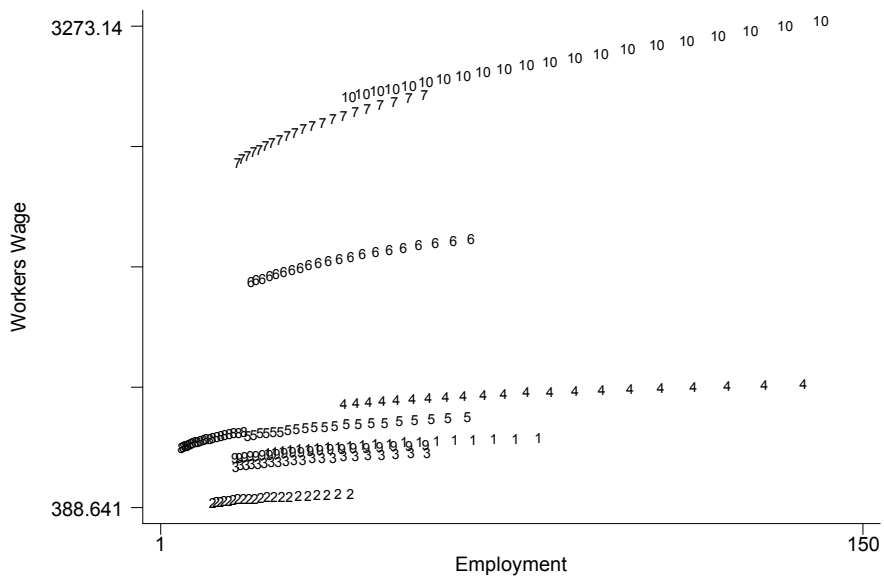


Figure 6. Firm size and supervisor-to-worker wage ratio

Figure 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

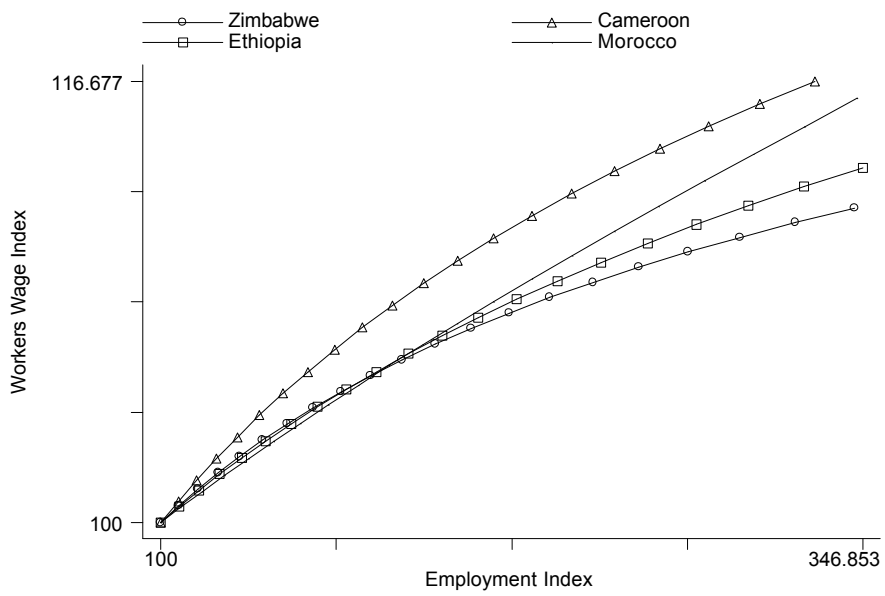
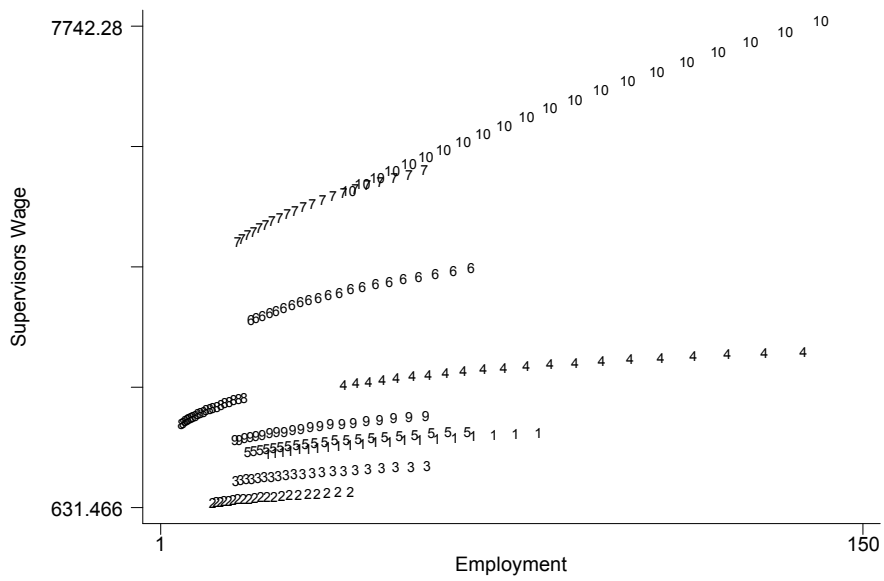


Figure 10: Supervision Wages and Firm Size



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

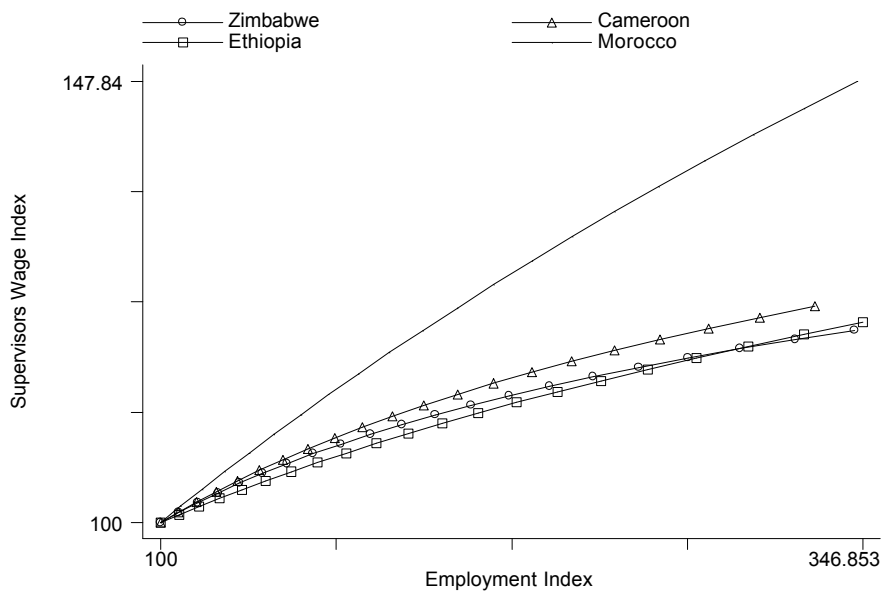
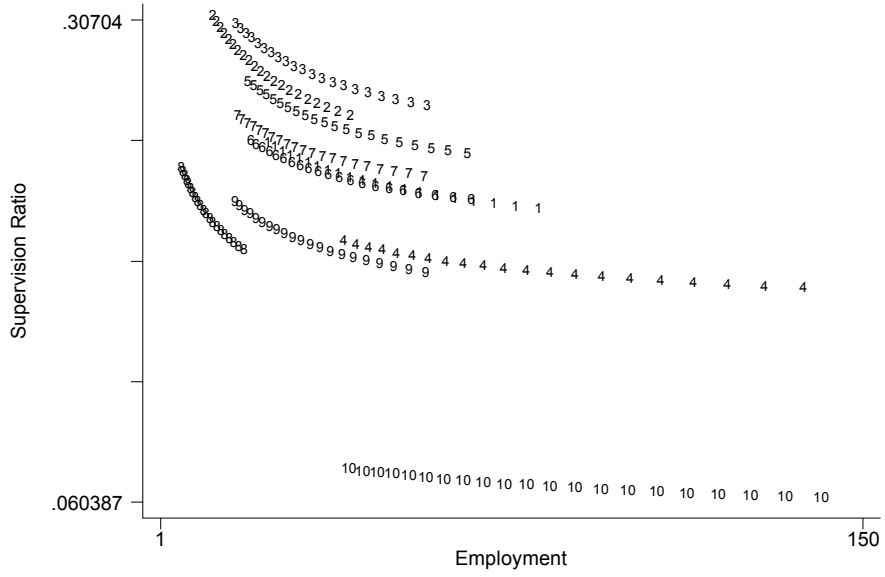


Figure 12: Supervision Ratio and Firm Size



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

