

The Implications of Capital-Skill Complementarity in Economies with Large Informal Sectors*

Pedro Amaral
Southern Methodist University

Erwan Quintin
Federal Reserve Bank of Dallas

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Abstract

In most developing nations, formal workers tend to be more experienced, more educated, and earn more than informal workers. These facts are often interpreted as evidence that low-skill workers face barriers to entry into the formal sector. Yet, there exists little direct evidence that such barriers are important. This paper describes a model where significant differences arise between formal and informal workers even though labor markets are perfectly competitive. In equilibrium, the informal sector emphasizes low-skill work because informal managers have access to less outside financing, and choose to substitute low-skill labor for physical capital.

*E-mail: pamaral@mail.smu.edu and erwan.quintin@dal.frb.org. We wish to thank Sangeeta Pratap and Beatrix Paal for helpful discussions, and seminar participants at Southern Methodist University and the University of Montréal. The views expressed herein are those of the authors and may not reflect the views of the Federal Reserve Bank of Dallas or the Federal Reserve System.

1 Introduction

In most developing economies, workers employed in the untaxed, unregulated sector tend to be younger, have less education, and earn less than their counterparts in the formal sector.¹ This is often interpreted as evidence that labor markets are segmented in these nations: barriers to entry, it is conjectured, prevent certain groups of workers from competing for higher paying formal jobs. While this view has become prevalent in the development literature, direct empirical tests of the premise that informal workers would expect higher wages in the formal sector yield mixed results, at best. For instance, Magnac (1991), Maloney (1998), and Pratap and Quintin (2002) find no compelling evidence of segmentation between the formal and the informal sector with data from Colombia, Mexico and Argentina, respectively. Heckman and Hotz (1986) find some evidence of segmentation with data from Panama but, in the same paper, argue that the parametric tests upon which theirs and most segmentation studies are founded are flawed.

Given the lack of strong evidence of segmentation, a natural question to ask is whether, and how, the documented differences in worker characteristics and earnings between sectors can arise in an economy where labor markets are competitive. We answer this question in the context of a dynamic version of the span-of-control model of Lucas (1978), with two types of labor. Agents can transform inputs of physical capital, unskilled and skilled labor into a single consumption good according to a strictly concave technology. Our main technological assumption is that unskilled labor is a better substitute for physical capital than skilled labor.

¹See e.g. Thomas, 1992 or Maloney, 1998.

The hypothesis that capital and skill are complements is supported by most micro-economic studies with data from industrialized countries (see Hamermesh, 1993, for a review.) The few comparable studies for other nations suggest that capital skill complementarity is also the norm in the developing world (see e.g. Zhou, 2001.)

In the model, managers can self-finance part of their capital with savings and can borrow funds from an intermediary. At the end of the period, managers can choose to default on the payment they owe the intermediary. In the informal sector, default carries no direct cost. On the other hand, default is costly for formal managers. As a result, their access to outside financing is better. But unlike informal managers, they are subject to taxation. We show that the most talented managers self-select into the formal sector, and that formal managers operate with more physical capital. In turn, since unskilled labor is a better substitute for physical capital than skilled labor, this implies a greater emphasis on skilled labor in the formal sector, in conformity with the evidence.

While the intuition behind our result is simple, the fact that formal managers operate with more physical capital in equilibrium requires a proof. Indeed, at equal talent, managers with more assets will tend to self-select into the informal sector because their need for outside financing is smaller. For instance, managers wealthy enough to operate without outside funds will always opt for the informal sector. We argue that for a large class of enforcement technologies, formal managers' better access to outside financing dominates the potential effect of heterogenous saving decisions.

That models with endogenous borrowing constraints in the spirit of Kehoe and Levine

(1993) have implications for the organization of production that match documented features of developing nations is well-known (see, for instance, Banerjee and Newman, 1993.) We argue that borrowing constraints have implications for labor markets in developing nations that are also borne out by the evidence. The literature on the importance of contractual imperfections for economic development is motivated by the abundant evidence that property rights are not effectively enforced in developing economies (see e.g. Djankov et al., 2002.) In contrast, the importance of formal barriers to entry into the formal sector, the premise behind the prevalent view of informal economic activities (see e.g. Rauch, 1991 or Fortin et al., 1997), is subject to much debate. Loayza (1996) and Sarte (2000) show that these elusive barriers are not needed to explain the large size of the informal sector in developing nations. Nor are they necessary, we show, to account for key characteristics of labor markets in developing economies.

We also point out that the direct evidence that informal firms tend to rely on self-financed funds much more than formal firms, and that they operate at a markedly lower physical capital to labor ratio (see Thomas, 1992 for a review, or Mansell-Carstens, 1999) is further indication that contractual imperfections are important to understand labor markets in developing nations. Consistency with these facts, and the assumption that labor markets are competitive, separate our model from most existing theories of informal economic activities.

2 Labor markets in developing economies

For concreteness, we will use data from Argentina's permanent household survey between 1993 and 1995 to illustrate several distinguishing features of labor markets in developing economies. The survey is based on bi-annual interviews of a rotating panel of households. It records each household member's basic demographic and employment data, including the revenues and benefits they derive from each of their occupations, as well as the industry classification and employment size of the establishment in which they work.

The data we present below pertains to wage earners in the Buenos Aires area. We discard individuals who claim to work more than 80 hours a week. The resulting sample contains 15,692 observations. We consider workers informally employed if they fail to receive social security coverage in the form of pension contributions and unemployment insurance, two benefits mandated by Argentina's labor laws.² According to this definition, 33% of the wage earners in our sample are informally employed, a large fraction typical of developing economies (See e.g. Schneider et al, 2000.)

The distinguishing characteristics of informal workers in Argentina, shown in table 1 in the appendix, are also typical of developing nations. On average, informal employees are significantly younger, less experienced, and less educated than formal employees. In addition, establishments with 15 employees or fewer account for a significantly higher fraction of employment in the informal sector than in the formal sector.

²Many empirical studies equate informal employment with employment in small establishments. As we will argue below, small establishments emphasize informal employment as we define it. Not surprisingly then, we find that a scale-based definition of informal employment does not alter this section's main results.

As one would expect given those differences, average hourly wages are higher in the formal sector. While it is a common view in the development literature that differences in individual and job characteristics alone cannot account for the magnitude of these earning differences, the evidence on this question is mixed, at best. While several papers find evidence of wage segmentation (see, for instance, Heckman and Hotz, 1986, for Panama, or Pradhan and Van Soest, 1995, for Bolivia), other papers (e.g. Magnac, 1991, for Colombia and Tannen, 1991, for Brazil) find no such evidence. Furthermore, most studies that find some evidence of segmentation rely on strong parametric assumptions that may yield misleading results. As Heckman and Hotz (1986) point out, results are sensitive to the wage equation one chooses to specify, and OLS estimates are biased and inconsistent because individuals may select sectors on the basis of observed and unobserved characteristics that also affect earnings. Pratap and Quintin (2001) partially address those shortcomings by using semi-parametric techniques to compute formal sector premia for various subsamples with the data behind table 1. None of the resulting formal premium estimates proves significantly positive. In summary, existing data provide little evidence that the competitive labor market hypothesis should be rejected. There remains to explain how the differences shown in table 1 can arise in a context where labor markets are competitive. We now provide an answer to this question.

3 The economy

Time is discrete. Every period, a cohort of measure 1 of two-period-lived agents are born. In the first period of their life, agents split their time between unskilled work and education. Denote by $e \in [0, 1]$ the fraction of time they devote to education, so that $(1 - e)$ is the quantity of unskilled labor services they supply. In the second period of their life, agents can supply one of two possible types of labor services: unskilled and skilled. All agents can choose to supply one unit of unskilled labor services. Alternatively, they can supply $ph(e)$ units of skilled labor services, where $h(0) = 0$, h is strictly concave and increasing, while $p \in [0, 1]$ is an agent-specific parameter. Instead of supplying labor services in the second period of their life, agents can choose to become managers. A manager of ability $z \in [0, 1]$ operates a technology that transforms inputs of unskilled labor, l_u , skilled labor, l_s , and physical capital, k , into the unique consumption good according to net schedule $zF(k, l_u, l_s) \equiv z[\min(k, l_s)]^\alpha l_u^\theta$, where $0 < \alpha + \theta < 1$ to allow for managerial profits.³ Physical capital depreciates entirely from one period to the next.

The managerial and education types (p, z) of agents are drawn from a joint distribution μ with finite support. We assume, for simplicity, that agents know their management and education types at the beginning of the first period of their life, and that both characteristics are public information.

³Assuming that the elasticity of substitution between skilled labor and physical capital is 0 simplifies the analysis, but one only needs to assume that this elasticity is lower than the elasticity of substitution between unskilled labor and physical capital.

Managers can operate in one of two sectors: formal or informal.⁴ In the formal sector, profits are taxed at a uniform rate $\tau > 0$. Informal managers, on the other hand, do not pay taxes.⁵ The proceeds from taxation are dissipated.

In both sectors, managers can self-finance part of their physical capital with savings from the first period of their life. They can also borrow some capital from a financial intermediary with access to perfect outside capital markets, where a one-period risk-free security earns net return $r > 0$. Therefore, one should think of our economy as a small, open economy. Managers who borrow funds from the intermediary can choose to default on their debt. When they do so, managers bear a cost proportional to output, which measures the extent to which contracts can be enforced. We show in appendix A.1 that our results hold for a large class of enforcement technologies that includes the specification we use in the exposition.⁶

Private contracts are more difficult to enforce in the informal sector. In fact, for simplicity and without loss of generality, we will set default costs to zero in the informal sector, while default costs are fraction $\eta > 0$ of output in the formal sector. As for preferences, we assume that all agents order lifetime consumption streams, $\{c_1, c_2\}$, according to $U(c_1, c_2) = \log c_1 + \beta \log c_2$ where $\beta > 0$. All our results can be generalized to utility functions of the type $U(c_1, c_2) = \frac{c_1^\gamma}{\gamma} + \beta \frac{c_2^\gamma}{\gamma}$, where γ is in a neighborhood of zero. Naturally, how wide that neighborhood is depends on one's specification of exogenous parameters.

⁴One interpretation for this sector choice is the decision by managers whether or not to legally declare their establishment.

⁵Adding a tax on payroll, on capital, or both, complicates the exposition without altering any of our results.

⁶We do so by showing that lemmas 1 and 2 can be established for a large set of incentive compatibility constraints. None of our other results hinge on the specification of the enforcement technology.

4 Optimal Policies

We focus our attention on equilibria in which wage rates are constant over time. Henceforth, for notational simplicity, we dispense with time subscripts. Denote by w_u and w_s the unskilled and skilled wage rates, respectively. Because we assume that workers can move freely between the formal and informal sectors, these wage rates must be the same in the two sectors. We begin by calculating the income of formal managers as a function of the quantity k of physical capital with which they are able to operate, their managerial ability z , and tax rate τ :

$$\Pi(k, z; \tau) = (1 - \tau) \left[\max_{l_u, l_s \geq 0} zF(k, l_u, l_s) - l_s w_s - l_u w_u - k(1 + r) \right].$$

In an environment with perfect enforcement ($\eta = 1$), formal managers would employ the uniquely defined optimal quantity $k^*(z; \tau)$ of physical capital that solves:

$$\max_{k \geq 0} \Pi(k, z; \tau).$$

But managers have the option to default and debt contracts must be self-enforcing. In other words, the maximum net income of formal managers with ability z and own savings a is:

$$\begin{aligned} V(a, z; \eta, \tau) &= \max_{s \leq a, d \geq 0} \Pi(s + d, z; \tau) \\ \text{s.t.} \quad &\Pi(s + d, z; \tau) \geq \Pi(s + d, (1 - \eta)z; \tau) + d(1 + r) \end{aligned}$$

where s is the amount deposited by the owner with the intermediary, and d is the net loan received by the manager from the intermediary.⁷ The inequality constraint is a standard incentive compatibility constraint: the intermediary will only lend the manager a net amount $d > 0$ such that defaulting is sub-optimal. The left-hand side is the net income for the agent associated with honoring his debt contract, while the right-hand side is the net gain associated with defaulting (by doing so, a manager saves the principal plus the interest due to the intermediary).⁸ Denote by $s(a, z; \eta, \tau)$, $d(a, z; \eta, \tau)$, $l_u(a, z; \eta, \tau)$, and $l_s(a, z; \eta, \tau)$ the solutions to the manager's problem. The following lemma characterizes these policy functions and the corresponding value function. All proofs are in the appendix.

Lemma 1. *For all $z \in [0, 1]$, there exists $a^*(z; \eta, \tau) \leq k^*(z; \tau)$ such that:*

(i) *$V(\cdot, z; \eta, \tau)$, is strictly concave, strictly increasing, and twice continuously differentiable on $[0, a^*(z; \eta, \tau))$, and constant past $a^*(z; \eta, \tau)$;*

(ii) *$s(a, z; \eta, \tau) = a$, on $[0, a^*(z; \eta, \tau))$;*

(iii) *$d(\cdot, z; 0, \tau) = 0$, while $d(\cdot, z; \eta, \tau)$ is strictly increasing and concave on $[0, a^*(z; \eta, \tau))$ for $\eta > 0$;*

(iv) *$s(\cdot, z; \eta, \tau) + d(\cdot, z; \eta, \tau) = k^*(z; \eta, \tau)$ on $[a^*(z; \eta, \tau), +\infty)$.*

⁷The gross loan received by the manager is $s + d$, which corresponds to a tax deduction of $\tau(s + d)(1 + r)$ for depreciation and interest payments.

⁸It is not clear whether formal managers should be able to deduct interest payments $(s + d)r$ from their taxable income subsequent to default. We assume managers can conceal from tax authorities the fact that they have defaulted, which makes for a more compact incentive compatibility constraint. Assuming they cannot do so would amount to subtracting $(s + d)r\tau$ from the right-hand side of the constraint, and would not change any of our results.

The lemma says that the amount that formal managers can borrow rises with their own savings. In rough terms (see the proof in the appendix for details), this is because raising assets weakens the right-hand side of the incentive compatibility constraint by raising the opportunity cost of default. We will now argue that the amount formal managers can borrow also rises with their managerial ability.

Lemma 2. *For all $\eta > 0$ and $a \in [0, a^*(z; \eta, \tau))$, $d(a, \cdot; \eta, \tau)$ is increasing.*

This result is due to the fact that the opportunity cost of default rises with the manager's ability, which should be obvious upon inspection of the incentive compatibility constraint. The ability of managers to borrow, therefore, depends jointly on the savings with which they enter the second period (their assets) and their managerial ability. Managers choose to enter the formal sector when their access to outside financing is sufficient to offset the fact that they become subject to income taxation, i.e. when $V(a, z; 0, 0) < V(a, z; \tau, \eta)$. Intuitively, managers with less assets, all else equal, should be more likely to operate in the formal sector. The following result illustrates this intuition. It says that under certain assumptions on exogenous parameters, an asset threshold separates formal managers from informal managers of a given talent.⁹

Lemma 3. *Assume $\frac{(1-\tau)(1-\theta)}{1-\theta-\alpha} < 1$. Then, for all $z \in (0, 1]$, there exists $a^I(z; \eta, \tau)$ such that managers of ability z operate in the informal sector if and only if $a \geq a^I(z; \eta, \tau)$. Furthermore, a^I rises with z .*

⁹Since this result plays no direct role in the analysis and is only meant to build intuition, we relegated the proof to an appendix available upon request. *For the convenience of the referees, the proof is provided in appendix D in this manuscript.*

Lemmas 1 and 3 are illustrated in figure 1 in the appendix. The maximum profits a formal manager of ability $z_1 > 0$ can generate given their assets (i.e. $V(a, z_1; \eta, \tau)$) are strictly positive at $a = 0$ since $d(0, z_1; \eta, \tau) > 0$, and rise at a decreasing rate until $a = a^*(z_1, \eta, \tau)$. The profits of an informal manager with the same ability start at 0, but rise to a level higher than $V(a^*(z_1, \eta, \tau), z_1; \eta, \tau)$ since $\tau > 0$. Lemma 3 says that when $\frac{(1-\tau)(1-\theta)}{1-\theta-\alpha} < 1$ the two curves cross only once, at $a^I(z_1; \eta, \tau)$, as shown in the figure. The figure also plots the same profits curves for an agent of ability $z_2 > z_1$. The new crossing point moves to the northeast. At equal assets, therefore, managers of higher talent are more likely to operate in the formal sector.

To obtain the result we seek, namely that the formal sector emphasizes skilled labor, we need to argue that formal managers operate with more physical capital than informal managers. This appears intuitively obvious because more talented managers have a greater need for outside financing (their optimal scale of operation is higher) and a better access to it (their opportunity cost of default is higher, as shown in lemma 2) and are therefore more likely to opt for the formal sector. But, as illustrated in lemma 3, agents with more assets, all else equal, are more likely to choose the informal sector since their need for outside financing is smaller. For instance, agents wealthy enough to self-finance their optimal scale of operation will always opt for the informal sector. We will characterize the net result of these potentially conflicting considerations by considering the problem solved by agents in the first period of

their life. Young agents of type (p, z) solve:

$$W(p, z) = \max_{a, e \geq 0} \log c_1 + \beta \log c_2$$

$$\text{where } c_1 = (1 - e)w_u - a$$

$$c_2 = a(1 + r) + \max(w_u, ph(e)w_s, V(a, z; \eta, \tau), V(a, z; 0, 0))$$

We will now show that managers of higher talent are indeed more likely to become formal managers.

Lemma 4. *Given $p \in [0, 1]$ there exist values $\underline{z}(p; \eta, \tau) \leq \bar{z}(p; \eta, \tau)$ such that in the second period of their life agents of type (p, z) become:*

(i) *workers when $z < \underline{z}(p; \eta, \tau)$;*

(ii) *managers in the informal sector when $\underline{z}(p; \eta, \tau) \leq z \leq \bar{z}(p; \eta, \tau)$;*

(iii) *managers in the formal sector when $z > \bar{z}(p; \eta, \tau)$.*

Furthermore, formal managers operate with more capital than informal managers.

The basic intuition for the last, key statement of the lemma is as follows. Consider a given informal manager and a given formal manager. If the formal manager has more assets than the informal manager, they operate with more capital, trivially. Assume then that the informal manager saves more than the formal manager. Then their marginal utility of consumption in the first period must be higher which means (as a necessary condition for optimal saving

behavior, see proof for details) that returns to savings are higher in the second period. In turn, because the production function is strictly concave in physical capital, we show that this implies that informal managers operate a lower capital scale, which is the last item of the lemma.

While each agent's ability thresholds depend on their education type, we now argue that, in equilibrium, formal managers are uniformly more talented than informal managers. This is because once an agent decides to become a manager, their education type no longer affects their choices.

Lemma 5. *Suppose there exist both formal and informal managers. Let \underline{z}_F denote the lowest managerial talent among formal sector managers, and let \bar{z}_I denote the highest managerial talent among informal sector managers, then, $\underline{z}_F \geq \bar{z}_I$.*

In appendix C, we complete our characterization of policy functions by describing the impact of education types on policy functions. Quite intuitively, all else equal, agents with high education types devote more time to education, save less and, therefore, are less likely to become managers in the second period than agents with low education types. We now turn to establishing our main result.

5 Properties of steady state equilibria

A steady state equilibrium is a pair (w_s, w_u) of wage rates and a list of policies for each agent such that 1) policies are optimal for all agents given wage rates in the sense defined in the

previous section, and 2) both labor markets clear. To make this definition more precise, for each $(p, z) \in [0, 1]^2$ denote by $\phi^{p,z}$ the probability distribution such that for all $e \in [0, 1]$, $l_u \geq 0$, and $l_s \geq 0$, $\phi^{p,z}(e, l_u, l_s)$ is the fraction of agents of type (p, z) who choose to devote time e to education in the first period of their life and choose to hire quantities l_u and l_s of unskilled and skilled labor in the second period. Optimality requires that for all $e \in [0, 1]$, $l_u \geq 0$, and $l_s \geq 0$, $\phi^{p,z}(e, l_u, l_s) > 0$ imply that (e, l_u, l_s) is an optimal policy for agent type (p, z) given wage rates. Since workers are indifferent between sectors, labor market clearing only requires that overall demand equal overall supply for each skill level, i.e.:

$$\int_{[0,1] \times \mathbb{R}^2 \times [0,1]^2} l_u d\phi^{p,z}(e, l_u, l_s) d\mu(p, z) = \int_{[0,1] \times \mathbb{R}^2 \times [0,1]^2} (1 - e) d\phi^{p,z}(e, l_u, l_s) d\mu(p, z) + \int_{[0,1]^2} \phi^{p,z}(0, 0, 0) d\mu(p, z) \quad (5.1)$$

$$\int_{[0,1] \times \mathbb{R}^2 \times [0,1]^2} l_s d\phi^{p,z}(e, l_u, l_s) d\mu(p, z) = \int_{[0,1] \times \mathbb{R}^2 \times [0,1]^2} ph(e) d\phi^{p,z}(e, l_u, l_s) d\mu(p, z) \quad (5.2)$$

The right-hand sides of equations (5.1) and (5.2) are the aggregate supply of unskilled and skilled labor, respectively. Indeed, the supply of unskilled labor is the sum of time devoted to work by young agents and the mass of old agents who devoted no time to education in the first period and chose not to become managers (i.e. chose to set $l_u = l_s = 0$.) The supply of skilled labor, on the other hand, is the sum of all returns to education.

The set of optimal policies may not be single-valued for all types, but one easily shows that it is finite. Since μ has finite support by assumption, all integrals in (5.1) and (5.2) are finite sums. This simplifies the proof that a steady state equilibrium exists, which we provide

in the appendix.

Proposition 1. *A steady state equilibrium exists.*

While steady states always exist, we have yet to show that the model can deliver an informal sector commensurate with existing estimates for developing countries. The next result addresses this question.

Proposition 2. *For any $\rho \in [0, 1]$, there is a pair, $(\tau, \eta) \in [0, 1]^2$, of tax and default cost parameters such that a steady state exists in which the informal share of employment is ρ .*

An interesting question is whether a sense exists in which the informal share of employment decreases monotonically with η and rises monotonically with τ .¹⁰ One interpretation of proposition 2 is that one can find a sequence of tax and default cost parameters that generates any rising sequence of informal employment shares. Furthermore, it is easy to show that the sequence of tax and default cost parameters can be set such that the tax rate is non-decreasing while the default cost non-increasing. A stronger monotonicity result requires assumptions that guarantee that steady state equilibria are unique, assumptions which we do not need to obtain the results we are seeking.

The following proposition will enable us to conclude that steady state equilibrium differences between the formal and informal sectors are consistent with the evidence discussed in section 2. It also lists several testable implications which one can use to evaluate the performance of our model.

¹⁰Johnson et al., 1997 and 1998, find that higher tax burdens and a weaker rule of law tend to be associated with large informal sectors.

Proposition 3. *In steady state, formal managers*

(i) are more productive in total factor terms,

(ii) employ more capital, more skilled workers, and more unskilled workers,

(iii) operate at a higher skilled labor to unskilled labor ratio,

(iv) operate at a higher capital to employment ratio,

than informal managers.

The third item is a direct consequence of the fact that unskilled labor is a better substitute for physical capital than skilled labor. It implies that formal workers tend to be older and more educated than informal workers. They also tend to work in larger establishments. In other words, our economy is consistent with the empirical regularities of labor markets in developing nations illustrated in table 1.

What about our model's other predictions? In her comprehensive review of empirical studies of informal sources of financing in developing countries, Mansell Carstens (1995, p65) concludes that "financial intermediation in the strict sense is extremely limited" in the informal sector. In his survey, Thomas (1992, pp64-78) writes "... it is striking how small a role is played by bank credit [in the informal sector] in comparison with the entrepreneur's own savings or informal credits, which usually takes the form of loans from family and friends." This fact is best illustrated by a 1983 study of the informal sector in Lima, Peru sponsored by the International Labor Organization (see Thomas, 1992, for details.) based on 3,000 firms

classified as informal on the basis of their size and sector of operation. In that sample, bank loans accounted for under 2% of overall credit, while own savings accounted for over 80% of overall credit. The study also revealed that almost half of those informal firms operated with under US\$500 of capital per employee. In sharp contrast, 90% of a comparable sample of formal firms operated with over US\$6000 of capital per employee. In summary, the evidence that the access of informal firms to outside sources of funds is limited is compelling, as is the evidence that production is markedly more capital intensive in the formal sector.

6 Conclusion

We have presented a theory of informal economic activities consistent with the main features of labor markets in economies with large informal sectors. We model the cost associated with producing in the informal sector as resulting from a limited access to formal means of contract enforcement. Managers choose to enter the formal sector when their return to outside financing exceeds the additional tax cost they must bear. We show that the most productive managers self-select into the formal sector, and operate a higher physical capital to employment ratio than informal managers, consistently with the evidence. This, in turn, implies that the formal sector emphasizes skilled labor, under the assumption that unskilled labor is a better substitute for physical capital than skilled labor.

The model, therefore, successfully replicates key features of labor markets and the organization of production in developing nations, without resorting to any assumption of formal

barriers to movement between sectors. Combined with the lack of direct evidence that such barriers are important in practice, our results suggest that the leading, dualistic view of labor markets in developing countries should be questioned.

A Proofs for section 4

A.1 Proof of lemma 1

We will show this result for a large class of constraints. Consider the following problem:

$$\begin{aligned} V(a, z; \eta, \tau) &= \max_{s \leq a, d \geq 0} \Pi(s + d, z; \tau) \\ \text{s.t.} \quad &\Phi(s, d, z; \eta, \tau) \geq 0, \end{aligned}$$

where:

Assumption 1. Φ is twice continuously differentiable and concave. Furthermore, $\Phi_1 > 0$, $\Phi_2 < 0$, $\Phi_3 > 0$, and $\Phi_{12} \leq 0$.

Clearly, the enforcement technology we specify in the text leads to incentive compatibility constraint that satisfies assumption 1. The concavity of Φ enables us to use standard tools. The main element of the assumption is that Φ_{12} be negative. Because s and d enter additively the first argument of a concave function (Π), many natural specification of the enforcement technology satisfy that requirement.

Define $a^*(z; \eta, \tau) = \inf\{a : s(a, z; \eta, \tau) + d(a, z; \eta, \tau) = k^*(z; \eta, \tau)\}$ where s and d are the optimal solutions to the general problem stated above. We will show that this level of assets satisfies each item of lemma 1. Part (iv) of the lemma is obvious from the definition of $a^*(z; \eta, \tau)$. Note also that $a^*(z; \eta, \tau) \leq k^*(z; \eta, \tau)$. If $a^*(z; \eta, \tau) = 0$, the lemma holds trivially. So assume an $a > 0$ exists with $a < a^*(z; \eta, \tau)$. First-order conditions for optimization are:

$$\Pi_1(s + d, z; \tau) + \lambda \Phi_2(s, d, z; \eta, \tau) = 0 \tag{A.1}$$

$$\lambda \Phi(s, d, z; \eta, \tau) = 0 \tag{A.2}$$

$$\Pi_1(s + d, z; \tau) + \lambda \Phi_1(s, d, z; \eta, \tau) - \nu = 0 \tag{A.3}$$

$$\nu(a - s) = 0 \tag{A.4}$$

where $\lambda \geq 0$ is the Lagrange multiplier associated with the incentive compatibility constraint, and $\nu \geq 0$ is the multiplier associated with the constraint $s \leq a$. (A.1) and (A.3) imply $\lambda(\Phi_1 - \Phi_2) = \nu$. Hence, since $\Phi_1 \neq \Phi_2$ by assumption 1, $\nu = 0 \implies \lambda = 0$. But $s < a$ implies $\nu = 0$ by (A.4), so that $s < a \implies \lambda = 0$ which is the second item of the lemma.

To show part (iii), note that for constrained agents $\Phi(\cdot, d, z; \eta, \tau) = 0$ in a neighborhood of a . Differentiating w.r.t. a yields $\Phi_1 + \Phi_2 \frac{\partial d}{\partial a} = 0$, hence

$$\frac{\partial d}{\partial a} = -\frac{\Phi_1}{\Phi_2} > 0 \tag{A.5}$$

Differentiating w.r.t. a once more gives

$$\frac{\partial^2 d}{\partial a^2} = -\frac{\Phi_2 \left(\Phi_{11} + \Phi_{12} \frac{\partial d}{\partial a} \right) - \Phi_1 \left(\Phi_{21} + \Phi_{22} \frac{\partial d}{\partial a} \right)}{\Phi_2^2} < 0,$$

as needed for the third item of the lemma.

Finally, to show part (i), first use the envelope theorem to obtain

$$V_1(a, z; \eta, \tau) = \nu > 0.$$

To show strict concavity, note that $V_{11}(a, z; \eta, \tau) = \frac{\partial \nu}{\partial a}$. But, from (A.3),

$$\frac{\partial \nu}{\partial a} = \Pi_{11} \left(1 + \frac{\partial d}{\partial a} \right) + \frac{\partial \lambda}{\partial a} \Phi_1 + \lambda \left(\Phi_{11} + \Phi_{12} \frac{\partial d}{\partial a} \right).$$

By (A.1),

$$\frac{\partial \lambda}{\partial a} = -\frac{\Pi_{11} \left(1 + \frac{\partial d}{\partial a} \right) \Phi_2 - \left(\Phi_{21} + \Phi_{12} \frac{\partial d}{\partial a} \right) \Pi_1}{\Phi_2^2} < 0$$

Together with assumption (1) this implies $\frac{\partial \nu}{\partial a} < 0$, and completes the proof.

A.2 Proof of lemma 2

Differentiating the incentive compatibility constraint w.r.t z yields $\Phi_3 + \Phi_2 \frac{\partial d}{\partial z} = 0$. Thus, $\frac{\partial d}{\partial z} = -\frac{\Phi_3}{\Phi_2} > 0$, as needed.

Remark 1. *Among the lemmas we invoke in the proof of proposition 3, lemmas 1 and 2 are the only results for which the form of the incentive compatibility constraint matters. The fact that lemmas 1 and 2 hold for the wide class of enforcement technologies described in assumption 1 implies, therefore, that proposition 3 holds for all enforcement technologies in that class as well.*

A.3 Proof of lemma 4

The first item of the lemma is obvious, so fix p and assume that z is large enough that an agent of type (p, z) chooses to become a manager. Clearly, those agents devote no time to education in the first period. Let $W_I(z) = \max_{a \in (0, w_u)} \log(w_u - a) + \beta \log[V(a, z; 0, 0) + a(1+r)]$, while $W_F(z) = \max_{a \in (0, w_u)} \log(w_u - a) + \beta \log[V(a, z; \eta, \tau) + a(1+r)]$. That is, $W_F(z)$ is the maximum lifetime utility that an agent of ability z can obtain if she becomes a formal managers, while $W_I(z)$ is the maximum lifetime utility that an agent of ability z can obtain if she becomes an informal manager. An agent of ability z becomes a formal manager when $W_F(z) > W_I(z)$. We will show that $\frac{\partial}{\partial z} W_F(z) > \frac{\partial}{\partial z} W_I(z)$ for all z . One easily shows that $\frac{\partial}{\partial z} W_I(z) = \frac{\beta}{(1-\theta)z}$ for all z . On the other hand, note that after solving for l_u and l_s , $\Pi(k; z, \tau) =$

$(1 - \tau) \left[z^{\frac{1}{1-\theta}} C k^{\frac{\alpha}{1-\theta}} - k(1 + r + w_s) \right]$ where $C > 0$ is a constant independent of z . Therefore, letting \hat{a} denote the optimal saving choice of formal managers of ability z ,

$$\begin{aligned} \frac{\partial}{\partial z} W_F(z) &> \beta \frac{\frac{1-\tau}{1-\theta} z^{\frac{\theta}{1-\theta}} C [\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}}}{(1 - \tau) \left\{ z^{\frac{1}{1-\theta}} C [\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}} - d(\hat{a}, z; \eta, \tau)(1 + r + w_s) \right\}} \\ &> \beta \frac{\frac{1-\tau}{1-\theta} z^{\frac{\theta}{1-\theta}} C [\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}}}{(1 - \tau) z^{\frac{1}{1-\theta}} C [\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}}} \\ &= \frac{\beta}{(1 - \theta)z} \end{aligned}$$

as claimed. The first inequality is strict because we are ignoring the fact that d rises with z , and the fact that interest payments and depreciation are tax deductible. It follows W_F can only cross W_I from below, hence at most once, which is exactly what the second and third item of the lemma claim.

We now show that formal managers operate with more capital than informal managers. Assume first that z is such that $W_F(z) = W_I(z)$. Let a_F and a_I be the corresponding saving choices. If $a_F > a_I$ we are done so assume that $a_F < a_I$. The first order condition for a_I is:

$$\frac{1}{w_u - a_I} = \beta \frac{\alpha}{(1 - \theta)a_I} \quad (\text{A.6})$$

As for a_F , the first order condition implies:

$$\begin{aligned} \frac{1}{w_u - a_F} &> \beta \frac{(1 - \tau) \frac{\alpha}{1-\theta} z^{\frac{1}{1-\theta}} C [a_F + d(a_F, z; \eta, \tau)]^{\frac{\alpha}{1-\theta} - 1}}{(1 - \tau) z^{\frac{1}{1-\theta}} C [a_F + d(a_F, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}} + \tau a(1 + r) - d(a_F, z; \eta, \tau)(1 + r)} \\ &> \beta \frac{\alpha}{(1 - \theta)[a_F + d(a_F, z; \eta, \tau)]}, \end{aligned} \quad (\text{A.7})$$

where the first inequality results from the fact that we are ignoring the positive effect of a_F on d , and the fact that interest payments and depreciation are tax deductible. Because $a_F < a_I$, comparing (A.6) and (A.7) yields, $a_I < [a_F + d(a_F, z; \eta, \tau)]$, which is the desired result for managers whose ability is such that $W_F(z) = W_I(z)$. We need to show that this is also true for managers of higher ability. If formal managers of higher ability have savings in excess of a_I , we are done. In the other case, the same argument as above applies. This completes the proof.

A.4 Proof of lemma 5

A young agent that will become a manager in the second period devotes no time to education. That is, for managers, $e(p, z) = 0$, as first period income is strictly decreasing on e , while e does

not affect second period income for managers, $V(a, z; \eta, \tau)$. Suppose, by way of contradiction, that $\underline{z}_F < \bar{z}_I$. Since second period income, $V(a, z; \eta, \tau)$, is independent of p , assume these two managers have the same p . This is a contradiction of lemma 4, and the result follows.

B Proofs for section 5

B.1 Proof of proposition 1

Denote by $\Phi^{w_u, w_s, p, z}$ the set of measures ϕ with finite support on $[0, 1] \times \mathbb{R}^2$ such that $\phi(e, l^u, l^s) > 0$ implies that e, l^u, l^s is an optimal policy for agent type (p, z) given wage rates $w_u, w_s > 0$. Define ED^u as the mapping which associates with any pair $w_u > 0$ and $w_s > 0$ the set of possible excess demands for unskilled labor, i.e.:

$$ED^u(w_u, w_s) = \left\{ \int [l_u - (1 - e)] d\phi^{p,z} d\mu - \int \phi^{p,z}(0, 0, 0) d\mu \right. \\ \left. : \phi^{p,z} \in \Phi^{w_u, w_s, p, z} \quad \forall (p, z) \in [0, 1]^2 \right\}.$$

Similarly define the set of possible excess demands for skilled labor as:

$$ED^s(w_u, w_s) = \left\{ \int [l_s - ph(e)] d\phi^{p,z} d\mu : \phi^{p,z} \in \Phi^{w_u, w_s, p, z} \quad \forall (p, z) \in [0, 1]^2 \right\}.$$

Note that whenever $w_u > ph(1)w_s$, no agent chooses to devote any time to education and, therefore, $ED^s(w_s, w_u) \subset \mathbb{R}_{++}$. This implies that a value \bar{w}_u exists such that:

$$w_u \geq \bar{w}_u \implies ED^s(w_s, w_u) \subset \mathbb{R}_{++} \text{ or } \{ED^u(w_s, w_u) \cup ED^s(w_s, w_u)\} \subset \mathbb{R}_{--} \quad (\text{B.1})$$

There must then exist \bar{w}_s such that:

$$w_s \geq \bar{w}_s \implies \{ED^u(w_s, w_u) \cup ED^s(w_s, w_u)\} \subset \mathbb{R}_{--} \text{ or } ED^s(w_s, w_u) \subset \mathbb{R}_{--} \quad (\text{B.2})$$

For every $\epsilon > 0$ define the compact set $A_\epsilon = \{w_u, w_s : \epsilon \leq w_u \leq \bar{w}_u \text{ and } \frac{w_u}{ph(1)} \leq w_s \leq \bar{w}_s\}$. Also define the mapping $T^\epsilon : A_\epsilon \longrightarrow 2^{A_\epsilon}$ by

$$T_1^\epsilon(w_u, w_s) = \left\{ w_u + \frac{|\bar{w}_u - w_u| \max\{0, x\} + |w_u - \epsilon| \min\{0, x\}}{1 + |x|} : x \in ED^u(w_s, w_u) \right\}$$

and

$$T_2^\epsilon(w_u, w_s) = \left\{ w_s + \frac{|\bar{w}_s - w_s| \max\{0, x\} + |w_s - \frac{w_u}{ph(1)}| \min\{0, x\}}{1 + |x|} : x \in ED^s(w_s, w_u) \right\}$$

Intuitively, T^ϵ raises wages when excess demands are positive and lowers them otherwise. For each type, the theorem of the maximum implies that the set of optimal policies is non-empty and upper hemi-continuous. Since different agents of a given type may choose different policies, ED^s and ED^u are the finite sums of non-empty, upper hemi-continuous and *convex* correspondences on \mathbb{R}_{++}^2 . In turn, this implies that for all $\epsilon > 0$, T^ϵ is non-empty, upper hemi-continuous and convex. Since A_ϵ is compact for all $\epsilon > 0$, each T^ϵ has at least one fixed point. So let (w_u^n, w_s^n) be a fixed point of $T_n^{\frac{1}{n}}$ for all $n \in \mathbb{N}$ and let (w_u^*, w_s^*) be a limit point of the resulting sequence. We claim that (w_u^*, w_s^*) is a steady state equilibrium pair of wages. By construction of the sequence $T_n^{\frac{1}{n}}$ this will be true provided (w_u^*, w_s^*) is in the interior of $A_0 = \{w_u, w_s : 0 \leq w_u \leq \bar{w}_u \text{ and } \frac{w_u}{ph(1)} \leq w_s \leq \bar{w}_s\}$. By (B.1), $w_u^* < \bar{w}_u$, while (B.2) guarantees that $w_s^* < \bar{w}_s$. We must also have $w_s^* > ph(1)w_u^*$, since otherwise the supply of skilled workers would become vanishingly small as $(w_u^n, w_s^n) \rightarrow (w_u^*, w_s^*)$. So we only need to verify that $(w_u^*, w_s^*) \neq (0, 0)$. But this is the case since for $w_u + w_s$ small enough $ED^s(w_s, w_u)$ and $ED^u(w_s, w_u)$ are contained in \mathbb{R}_{++} . This completes the proof.

B.2 Proof of proposition 2

The informal share of employment in steady state is 1 when $\eta = 0$ but $\tau > 0$, and is 0 when $\eta > 0$ but $\tau = 0$. It suffices, therefore, to show that the informal share of employment given (τ, η) is an upper hemi-continuous, non-empty, convex correspondence. The first two properties follow from the theorem of the maximum. As before, convexity is a consequence of the fact that there are many agents of any given type.

B.3 Proof of proposition 3

Consider steady states where both sectors coexist. (For other steady states, the result holds vacuously.) The first item of the proposition follows directly from lemma 5. Fix p and let $z^* \in [0, 1]$ be such that an agent of ability z^* and education type p generates the same profits in both sectors. We will show, first, that all items of the lemma hold for such agents. Denote by k_I^* and $l_{u,I}^*$ the quantity of physical capital and unskilled labor they choose to employ if they opt for the informal sector, while k_F^* and $l_{u,F}^*$ are the physical capital and unskilled labor they employ if they opt for the formal sector. Lemma 4 implies $k_F^* > k_I^*$, which, in turn, implies that formal managers employ more skilled workers. In fact, denote by

$$E(ph(e)) = \frac{\int_{e>0} ph(e) \phi^{p,z}(e, l_u, l_s) d\mu(p, z)}{\int_{e>0} \phi^{p,z}(e, l_u, l_s) d\mu(p, z)}$$

the average quantity of labor delivered by skilled workers in equilibrium. On average, formal managers of ability z^* employ $\frac{k_F^*}{E(ph(e))}$ skilled workers, while informal managers of ability z^* employ a strictly smaller number $\frac{k_I^*}{E(ph(e))}$ of skilled workers. We have thus shown that the second item of the proposition holds for managers of ability z^* . Turning to the third item, first order conditions for unskilled labor demand in the manager's net income maximization problem in each sector imply:

$$l_{u,F}^* = \left[\frac{z\theta k_F^{*\alpha}}{w_u} \right]^{\frac{1}{1-\theta}} > \left[\frac{z\theta k_I^{*\alpha}}{w_u} \right]^{\frac{1}{1-\theta}} = l_{u,I}^*$$

We will now show that $\frac{k_F^*}{l_{u,F}^*} > \frac{k_I^*}{l_{u,I}^*}$. To see this, note that first order conditions for profit maximization in the two sectors imply

$$\begin{aligned} z^*\theta \left(\frac{k_F^*}{l_{u,F}^*} \right)^\alpha &= w_u l_{u,F}^{*1-\alpha-\theta} \\ &> w_u l_{u,I}^{*1-\alpha-\theta} \\ &= z^*\theta \left(\frac{k_I^*}{l_{u,I}^*} \right)^\alpha \end{aligned}$$

The inequality is due to the fact that $l_{u,F}^* > l_{u,I}^*$. This establishes the second item of the proposition holds for managers of type z^* . As for the last item,

$$\begin{aligned} \frac{l_{u,F}^* + \frac{k_F^*}{E(ph(e))}}{k_F^*} &= \frac{l_{u,F}^*}{k_F^*} + \frac{1}{E(ph(e))} \\ &< \frac{l_{u,I}^*}{k_I^*} + \frac{1}{E(ph(e))} \\ &= \frac{l_{u,I}^* + \frac{k_I^*}{E(ph(e))}}{k_I^*} \end{aligned}$$

as claimed. We have thus demonstrated the result for managers of ability z^* . For managers with managerial ability $z > z^*$, the proposition now follows from lemma 4. This completes the proof

C Characterization of education policy functions

In equilibrium, agents who eventually become managers devote no time to education. As for other agents, standard manipulations of first order conditions imply that the time devoted to education rise with the education type. In fact, a threshold exists such that agents whose

education type exceed that threshold, and those agents only, become skilled workers in the second period. The following lemma records those results. We omit the proof for conciseness.

Lemma 6. *In steady state, for all $z \geq 0$,*

1. $e(p, z)$ rises with $p \in [0, 1]$, while $a(p, z)$ decreases with p ;
2. There exists $\underline{p} \in [0, 1]$ such that $p > \underline{p} \implies e(p) > 0$ and $p < \underline{p} \implies e(p) = 0$.

D Proof of lemma 3

Fix z . Clearly, $V(0, z; 0, 0) < V(0, z; \eta, \tau)$, while $V(k^*(z; 0), z; 0, 0) > V(k^*(z; 0), z; \eta, \tau)$. Therefore, $V(\cdot, z; 0, 0)$ and $V(\cdot, z; \eta, \tau)$ must cross. We will show that they cross exactly once. Let \hat{a} be such that $V(\hat{a}, z; 0, 0) = V(\hat{a}, z; \eta, \tau)$, i.e,

$$\Pi(\hat{a}; z, 0) = \Pi(\hat{a} + d(\hat{a}, z; \eta, \tau), z; \tau) = (1 - \tau)\Pi(\hat{a} + d(\hat{a}, z; \eta, \tau); z, 0) \quad (\text{D.1})$$

Our first goal is to bound $\frac{\partial d(\hat{a}, z; \eta, \tau)}{\partial a}$. Since d is concave in a by lemma 1, we will bound $\frac{\partial d(0, z; \eta, \tau)}{\partial a}$. Recall that $\Pi(k; z, \tau) = (1 - \tau) \left[z^{\frac{1}{1-\theta}} C k^{\frac{\alpha}{1-\theta}} - k(1 + r + w_s) \right]$ where $C > 0$ is a constant independent of z . In particular,

$$\Pi(d(0, z; \eta, \tau), z; \tau) - \Pi(d(0, z; \eta, \tau), (1-\eta)z; \tau) < (1-\tau) \left[z^{\frac{1}{1-\theta}} - ((1-\eta)z)^{\frac{1}{1-\theta}} \right] C d(0, z; \eta, \tau)^{\frac{\alpha}{1-\theta}}$$

The incentive compatibility constraint now implies

$$X \equiv (1 - \tau) \left[z^{\frac{1}{1-\theta}} - ((1 - \eta)z)^{\frac{1}{1-\theta}} \right] C d(0, z; \eta, \tau)^{\frac{\alpha}{1-\theta} - 1} > (1 + r) \quad (\text{D.2})$$

But, (A.5) and (D.2) now yield $\frac{\partial d(0, z; \eta, \tau)}{\partial a} = \frac{\frac{\alpha}{1-\theta} X}{1+r-\frac{\alpha}{1-\theta} X} < \frac{\alpha}{1-\theta-\alpha}$. Therefore,

$$\begin{aligned} V_1(\hat{a}, z; \eta, \tau) &= (1 - \tau)\Pi_1(\hat{a} + d(\hat{a}, z; \eta, \tau); z, 0) \left(1 + \frac{\partial d(\hat{a}, z; \eta, \tau)}{\partial a} \right) \\ &< \frac{(1 - \tau)(1 - \theta)}{1 - \theta - \alpha} \Pi_1(\hat{a} + d(\hat{a}, z; \eta, \tau); z, 0) \\ &< \Pi_1(\hat{a}; z, 0) = V_1(\hat{a}, z; 0, 0) \end{aligned}$$

where the last inequality is due to the fact that $(1 - \tau) \frac{1-\theta}{1-\theta-\alpha} < 1$. This implies that $V(\cdot, z; 0, 0)$ can only cross $V(\cdot, z; \eta, \tau)$ from below, and, therefore, can only cross it once. To obtain the second item of the lemma, note that by the envelope theorem,

$$\Pi_2(\hat{a}; z, 0) = \frac{1}{1 - \theta} z^{\frac{\theta}{1-\theta}} C \hat{a}^{\frac{\alpha}{1-\theta}}$$

while

$$\Pi_2(\hat{a} + d(\hat{a}, z; \eta, \tau); \eta, \tau) > (1 - \tau) \frac{1}{1 - \theta} z^{\frac{\theta}{1-\theta}} C[\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}}$$

To obtain the second item of the lemma it then suffices to show that:

$$\hat{a}^{\frac{\alpha}{1-\theta}} < (1 - \tau)[\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}} \quad (\text{D.3})$$

To see that this is the case, let $\lambda_I = \frac{z^{\frac{1}{1-\theta}} C \hat{a}^{\frac{\alpha}{1-\theta}}}{\hat{a}(1+r+w_s)}$ and $\lambda_F = \frac{z^{\frac{1}{1-\theta}} C [\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}}}{[\hat{a} + d(\hat{a}, z; \eta, \tau)](1+r+w_s)}$. Then,

$$\begin{aligned} \Pi(\hat{a}, z, 0) &= z^{\frac{1}{1-\theta}} C \hat{a}^{\frac{\alpha}{1-\theta}} \left(1 - \frac{1}{\lambda_I}\right) \\ &= \Pi(\hat{a} + d(\hat{a}, z; \eta, \tau), z; \tau) \\ &= (1 - \tau) z^{\frac{1}{1-\theta}} C [\hat{a} + d(\hat{a}, z; \eta, \tau)]^{\frac{\alpha}{1-\theta}} \left(1 - \frac{1}{\lambda_F}\right) \end{aligned}$$

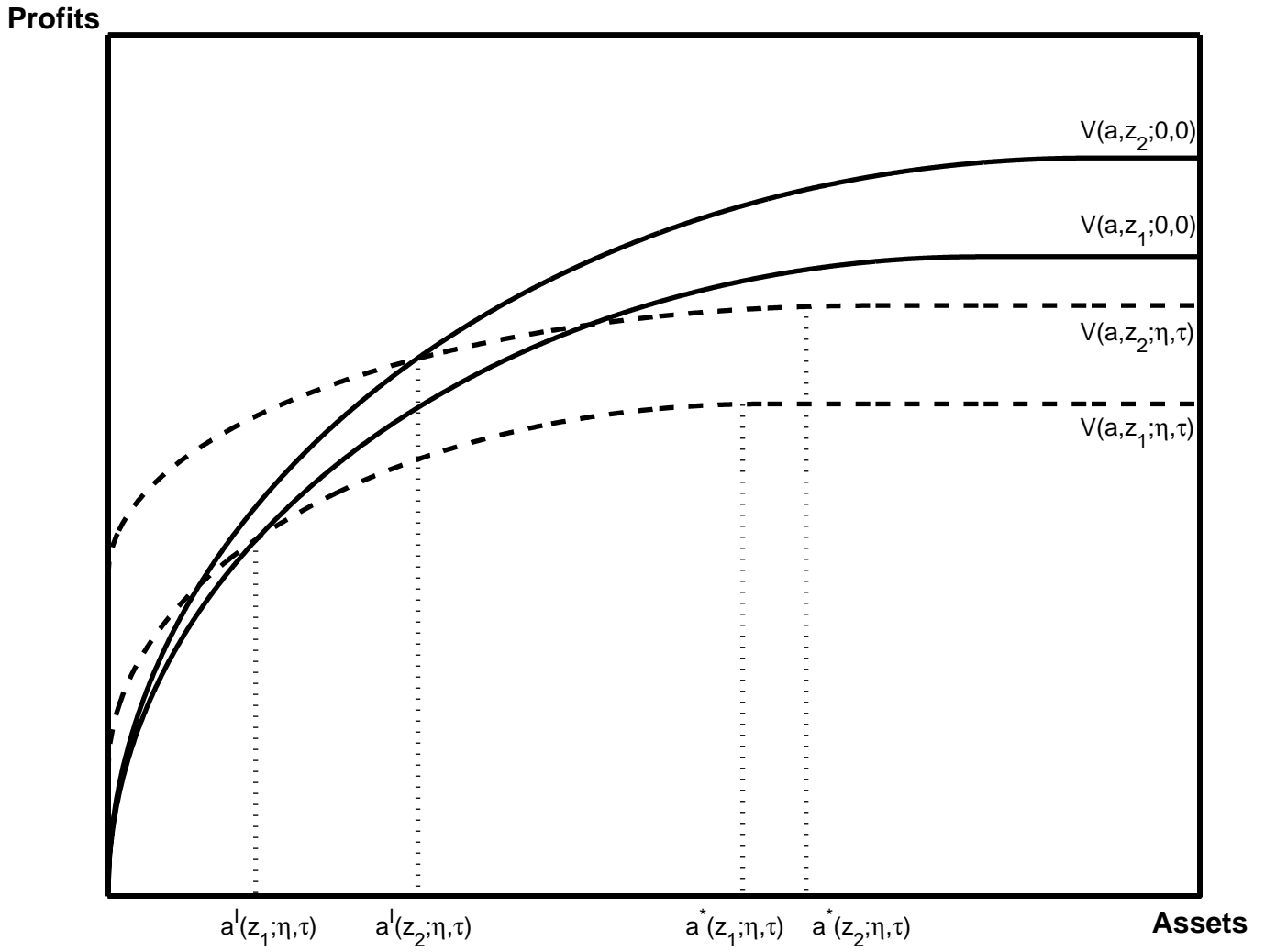
Since $\lambda_F < \lambda_I$, condition (D.3) follows, which completes the proof.

E Tables and figures

Table 1: Average characteristics of employees, Argentina, 1992-94

| | Formal sector | Informal sector | T-statistic |
|---|---------------|-----------------|-------------|
| Observations | 10010 | 5682 | |
| Average age in years | 37.32 | 33.45 | 17.44 |
| Average tenure in years | 7.88 | 3.42 | 35.14 |
| Percent of workers with tertiary education | 19.92 | 11.00 | 15.49 |
| Percent of workers in plants with 15 employees or fewer | 79.29 | 30.34 | 69.20 |
| Average gross hourly earnings | 4.43 | 3.32 | 16.90 |

Figure 1: Profits in the two sectors when $\frac{(1-\tau)(1-\theta)}{1-\theta-\alpha} < 1$



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