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Modern Value Chains and the Organization of Agrarian Production

Heath Henderson and Alan G. Isaac*

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Abstract

Empirical studies of agrarian production in developing countries often find that smallholders possess a productivity advantage over larger farms. Eswaran and Kotwal (1986) famously derive this inverse farm-size/productivity relationship from the structure of agrarian production. The focal prediction of their model is that, in otherwise equivalent economies, a more egalitarian land distribution raises both output and producer welfare. The traditional (spot) procurement system implicit in the Eswaran and Kotwal model, however, diverges fundamentally from modern (contractual) procurement practices. We therefore develop a new model of agrarian production in order to determine whether the introduction of a modern value chain alters the welfare effects of land redistribution. In our model, the inverse farm-size/productivity relationship persists, but we find that a more egalitarian land distribution leads to nonmonotonic changes in producer welfare. We also find that the introduction of a modern sector can harm the laboring classes.

JEL classification: Q15, C63, 013, Q13, D23

* Henderson: Drake University, College of Business and Public Administration, Aliber Hall, Des Moines, IA, 50311. Tel: +1 515 271 2898. Email: heath.henderson@drake.edu. Isaac (corresponding author): American University, Department of Economics, Kreeger Hall, Washington, DC, 20016. Tel +1 202 885 3770. Email: aisaac@american.edu. Senior authorship is equally shared; authors are listed in alphabetical order. Computing resources used for this work were provided by the American University High Performance Computing System, which was funded in part by the NSF (BCS-1039497). We give special thanks to Paul Winters for his comments and suggestions.

1 Introduction

Population growth, rising incomes, and continued urbanization are increasing food demand in developing economies. Accordingly, FAO (2011) predicts that food prices will become substantially higher and more volatile unless global agricultural production nearly doubles by mid-century. Due to continuing land scarcity, lackluster productivity growth, and little remaining farm price repression, the policy options for increasing agricultural production in developing countries are limited. However, due to the often-observed productivity advantage of small-scale agricultural producers in developing countries, redistributive land reform has been proposed not only as a means to increase equity and reduce poverty, but also as a means to improve agricultural productivity (Eswaran and Kotwal, 1986; Lipton, 2009; Keswell and Carter, 2014).[1]

Eswaran and Kotwal (1986, hereafter EK) famously predict that, in otherwise equivalent economies, more egalitarian land distributions raise output and improve producer welfare. Adopting their terminology, EK's key result is that greater "equity" also improves "efficiency." As a model of modern agrarian economies, however, the EK model has a substantial shortcoming: each producer faces a single output market, which is implicitly an informal spot market. Barrett et al. (2012) show that, for many developing countries, this institutional arrangement is no longer descriptive. The growth of export horticulture, the diffusion of supermarkets, and the proliferation of grades and standards have led to the modernization of agricultural value chains. Contract farming has become central to modern procurement systems, but scale-biased participation raises questions as to the contemporary policy relevance of redistributive measures.

We therefore re-examine the equity-efficiency relationship in a model better suited to the new agricultural economy. Specifically, we extend the EK model by adding a modern agricultural value chain, as described by Barrett et al. (2012). While the inverse farm-size/productivity relationship persists in our model, we find that a more egalitarian land distribution leads to nonmonotonic changes in key model outcomes (e.g., producer welfare). That is, due to the scale-biased nature of modern values chains, a more egalitarian distribution of landholdings eventually diminishes producer welfare, creating an "equity-efficiency" tradeoff in the distribution of land. Our results thus suggest that the case for redistributive measures has been weakened by the emergence of modern agricultural value chains.

While we believe our model advances the understanding of land inequality in developing countries, our results also contribute to the literature on the welfare effects of modern value chains. A substantial literature has emerged examining the effects of contract farming on farm productivity (Neven et al., 2009; Rao, Brümmer, and Qaim, 2012), household incomes (Miyata, Minot, and Hu, 2009; Michelson, 2013), and

[1] Lipton (2009, p.328) defines redistributive land reform as "legislation intended and likely to directly redistribute ownership of, claims on, or rights to current farmland, and thus to benefit the poor by raising their absolute and relative status, power, and/or income, compared with likely situations without the legislation."

labor markets (Neven et al., 2009; Rao and Qaim, 2013). However, this literature is largely empirical and experiences identification issues due to selection bias in contract participation. Our theoretical approach offers new insights. For example, we find that the labor-market effects of the modern value chain depend crucially on the extent of land inequality. In particular, at lower levels of inequality the modern sector is associated with decreasing wage rates, which can adversely affect laboring classes.

In what follows, section 2 provides relevant background information, section 3 presents our model of the new agricultural economy, section 4 discusses our results and sensitivity analysis, and section 5 concludes.

2 Background

This section comprises two short and fairly independent subsections. The first subsection discusses EK in the context of the empirical and theoretical work on the relationship between farm size and productivity. The second subsection motivates our theoretical model by considering the recent restructuring of global agri-food systems and the rise of modern value chains.

2.1 Farm Size and Productivity

Empirical studies of agrarian production in developing countries have historically found that smallholders possess a productivity advantage over larger farms. The Indian Ministry of Food and Agriculture's *Studies in the Economics of Farm Management* was among the first to document an inverse relationship between farm size and land productivity (Sen, 1962). In the 1970s and 1980s, a number of influential cross-country studies observed this inverse relationship across Africa, Asia, and Latin America (Barraclough, 1973; Berry and Cline, 1979; Cornia, 1985). More recent empirical studies have investigated the relationship between farm size and profitability, and have also found a robust negative relationship (van Zyl, Binswanger, and Thirtle, 1995; Heltberg, 1998; Deininger, Zegarra, and Lavadenz, 2003).[2]

Labor market imperfections have occupied a central role in the leading explanations of the inverse relationship.[3] In his "dual labor cost theory," Sen (1966) contended that there exists a gap between the real cost of labor in peasant farming and the market wage rate. Since capitalist farms face higher equilibrium labor costs, peasant farms use labor more intensively and witness greater land productivity. Bhagwati and

[2] Other widely-cited empirical studies include Yotopoulos and Lau (1973), Carter (1984), Bhalla and Roy (1988), Assunção and Braido (2007), and Barrett, Bellemare, and Hou (2010). While a number of the empirical studies have been challenged as reflecting statistical artifacts, these challenges have in turn been challenged. See, for example, Carter (1984), Barrett, Bellemare, and Hou (2010), and Carletto, Savastano, and Zezza (2013). For detailed reviews of the controversy, see Binswanger, Deininger, and Feder (1995) and Eastwood, Lipton, and Newell (2010).

[3] A number of other explanations have been put forth (e.g., decreasing returns to scale, land quality heterogeneity, and differential responses to uncertainty), but much of the empirical work supports the labor market imperfections hypothesis (Barraclough, 1973; Berry and Cline, 1979; Carter, 1984; Cornia, 1985; Binswanger, Deininger, and Feder, 1995; van Zyl, Binswanger, and Thirtle, 1995; Heltberg, 1998; Deininger, Zegarra, and Lavadenz, 2003). See Henderson (2015) for a detailed review of the literature.

Chakravarty (1969), however, found that the inverse relationship persists when examining only capitalist farms. Further, Feder (1985) argued that multiple factor market imperfections must be present to generate a systematic relationship between farm size and productivity. Building on the "dual labor cost theory," EK incorporated such considerations into their influential theoretical model of the inverse relationship.

Drawing on the seminal work of Roemer (1982), EK developed a single-period model of class formation in an agrarian economy characterized by labor-market and credit-market imperfections. In the model, hired labor requires supervision due to moral hazard, and access to credit largely depends on the amount of land an agent owns. In the presence of these imperfections, EK found land-to-labor ratios to be increasing in land endowments, creating an inverse relationship between land productivity and ownership landholdings. Correspondingly, EK demonstrated that a more egalitarian distribution of land ownership increases aggregate agricultural production, enhances overall welfare, and reduces poverty. Even the landless were found to benefit from redistributive measures, due to increased labor demand and a corresponding rise in wages.

EK assume that each producer faces a single output market, which is implicitly an informal spot market. The recent radical restructuring of global agri-food systems raises important questions about this assumption, since such traditional (spot) procurement systems diverge fundamentally from modern (contractual) procurement practices. Specifically, economies of scale in finance and access to capital imply scale-variant grower capacity to meet the demands of modern value chains. Further, scale-invariant contract-related transaction costs suggest that larger-scale private trading and marketing could reduce costs (Collier and Dercon, 2009). As discussed in the next subsection, scale-biased participation in modern contractual farming arrangements may alter predictions about the welfare benefits from redistributive land reform.

2.2 Modern Value Chains

Since the early 1980s, global agri-food systems have undergone a continual and fundamental transformation, especially in developing countries. Developments on the demand side (e.g., rising incomes and increasing urbanization) and supply side (e.g., foreign direct investment and changing technology) stimulated growth in export horticulture, the dissemination of supermarkets, and the proliferation of grades and standards (McCullough, Pingali, and Stamoulis, 2008; Reardon, Timmer, and Berdegué, 2008; Eastwood, Lipton, and Newell, 2010). The diffusion of supermarkets has been particularly dramatic. For example, Reardon and Berdegué (2002) found that supermarket shares in Latin America increased from 10–20 percent of national retail sales in 1990 to 50–60 percent by 2000. Reardon et al. (2003) observed comparable patterns in eastern and southeastern Asia (e.g., Taiwan, the Philippines, and the Republic of Korea) as well as southern and eastern Africa (e.g., South Africa and Kenya). Dries, Reardon, and Swinnen (2004) documented similar changes in central and eastern Europe (e.g., Czech Republic, Hungary, and Poland).

Traditional wholesalers and brokers in developing nations typically rely on informal, spot transactions. However, the restructuring of agricultural output markets has commonly supported the augmented quality standards of downstream entities (e.g., supermarkets and export firms) through parallel modern procurement systems (McCullough, Pingali, and Stamoulis, 2008; Reardon et al., 2009). These parallel systems often include specialized wholesalers, centralized rather than per-store procurement, the standardization and harmonization of product and delivery attributes, and a reliance on contract farming (Reardon et al., 2003; Reardon, Timmer, and Berdegué, 2008; Barrett et al., 2012). The modern-sector prevalence of contract farming diverges fundamentally from traditional-sector practices.[4] Empirical studies of the effects of such arrangements suggest that they can raise grower welfare and enhance rural development by increasing productivity, profitability, and employment.[5] However, in many scenarios these gains appear quite limited (Singh, 2002; Sivramkrishna and Jyotishi, 2008; Escobal and Cavero, 2011; Barrett et al., 2012).

Two common features of contractual farming arrangements can limit producer gains: the monopsony power of procuring firms, and the exclusion of smaller-scale producers. Contract farming in developing-country agriculture is frequently characterized by monopsonistic or oligopsonistic competition: a single large buyer (or possibly a few buyers) chooses the terms (e.g., prices, quantities, or quality) of contracts available to numerous sellers. The rapid consolidation of supermarkets in developing countries is illustrative. In Latin America, on average approximately two-thirds of the supermarket sector is controlled by the top five chains, with some particularly high concentrations in Central America (Reardon and Berdegué, 2002).[6] Similar patterns have been documented in Africa, Asia, as well as central and eastern Europe (Neven et al., 2009; Hu et al., 2004; Dries, Reardon, and Swinnen, 2004). This consolidation of downstream segments raises concerns that the potential benefits of contract farming are restricted by asymmetric power in the negotiation of contractual terms (Sivramkrishna and Jyotishi, 2008).

Additional concerns arise as agro-industrial firms often eschew contracting with smaller-scale, less capital-intensive producers (Barrett et al., 2012). In Africa, such exclusion has been observed in Ghana (Trienekens and Willems, 2007), Kenya (Rao and Qaim, 2011), Senegal (Maertens and Swinnen, 2009), South Africa (Trienekens and Willems, 2007), and Uganda (Bolwig, Gibbon, and Jones, 2009). Asian examples include China (Stringer, Sang, and Croppenstedt, 2009), India (Singh, 2002), and Indonesia (Simmons, Winters, and Patrick, 2005). In Latin America, exclusion has been documented in Brazil (Farina, 2002), Costa Rica

[4]Singh (2002, p. 1621) defines contract farming as "a system for the production and supply of agricultural produce under forward contracts, the essence of such contracts being a commitment to provide an agricultural commodity of a type, at a time and a price, and in the quantity required by a known buyer."

[5]See, for example, Warning and Key (2002), Simmons, Winters, and Patrick (2005), Bolwig, Gibbon, and Jones (2009), Minten, Randrianarison, and Swinnen (2009), and Miyata, Minot, and Hu (2009).

[6]In Guatemala, Costa Rica, and El Salvador these figures reach as high as 99, 96, and 85 percent, respectively.

(Alvarado and Charmel, 2002), Guatemala (Hernández, Reardon, and Berdegué, 2007), Mexico (Key and Runsten, 1999), Nicaragua (Michelson, Reardon, and Perez, 2011), and Peru (Escobal and Cavero, 2011). A few studies document cases of smallholder *inclusion*, but this is rare and usually reflects special circumstances. For example, outside assistance is occasionally provided to a procuring firm or contracted producers as a result of partnerships between public-sector and private-sector stakeholders, as has been observed in Kenya, South Africa, Thailand, and Zimbabwe (Boselie, Henson, and Weatherspoon, 2003).

Scale-biased participation can arise from scale-variant grower capacity to meet requisite standards or scale-invariant contract-related transaction costs. Scale-variant capacity to meet modern-sector standards can be understood in terms of grower-side incentives and constraints. On the one hand, most costs associated with modern-sector production are fixed and "up front." Examples include the cost of information search (e.g., learning to grow crops of the desired shape, flavor, or variety), physical capital investment (e.g., irrigation technology), certification (e.g., EurepGAP/GLOBALGAP), and collective action (e.g., forming producer cooperatives).[7] On the other hand, benefits generally accrue post-harvest. The principal motivation for selling in high-value markets is the ultimate receipt of output price premiums, which may arise from product quality differences, compliance incentives, or the ability to capture a greater part of the marketing margin (Minten, Randrianarison, and Swinnen, 2009; Neven et al., 2009).[8] Producers often require credit to overcome this temporal mismatch, but cash-strapped smallholders typically have limited access to formal and informal lending institutions (Stiglitz and Weiss, 1981; Carter, 1988; Santos and Barrett, 2011).

Scale-biased participation also arises from contract-related transaction costs, which can be understood in terms of procurer-side incentives. An agro-industrial firm pursues contractual farming arrangements in order to minimize transaction, production, and management costs across available alternatives (Herath and Weersink, 2009). Predominant costs include the search for prospective growers, the screening of those growers, the negotiation of contracts, the transfer of goods, services, or property rights, the monitoring of grower behavior, and the enforcement of the terms of the contract (Key and Runsten, 1999). These costs are largely independent of the scale of the grower, thereby creating an incentive for the procuring firm to increase the average scale of contracted producers. Procurer-side incentives can therefore be a critical determinant of grower contracting opportunities (Key and Runsten, 1999; Simmons, Winters, and Patrick, 2005).

In summary, this subsection has reviewed a number of "stylized" facts about agricultural value chains in developing economies. First, modern value chains commonly exist in parallel to traditional channels. Second, modern channels are frequently characterized by monopsonistic procurers. Third, in order to reap

[7]See Key and Runsten (1999) on information costs, Farina (2002) on irrigation technology, Ashraf, Giné, and Karlan (2009) and Asfaw, Mithöfer, and Waibel (2010) on certification, and Blandon, Henson, and Cranfield (2009) on producer cooperatives.

[8]Other benefits include reduced risk and variability as modern-sector output prices can be considerably less volatile (Michelson, Reardon, and Perez, 2011), and resource provision as agro-industrial firms commonly offer specialized inputs (e.g., seeds, fertilizers, pesticides, etc.) to overcome issues associated with thin or missing markets (Key and Runsten, 1999).

the benefits of modern-sector participation (e.g., output price premiums), prospective growers typically must bear the burden of substantial fixed costs—an obstacle that credit-constrained smallholders find difficult to overcome. Finally, downstream entities in the modern sector typically incur fixed contract-related transaction costs in return for the timely delivery of a quality product. In the next section, we incorporate such stylized facts into a theoretical model of a modern agricultural economy.

3 A New Model of Agrarian Production

Recall that EK predict that egalitarian land distributions enhance productivity and welfare. However, the EK model lacks a modernized value chain, which raises questions about its contemporary policy relevance. In this section, we introduce our model of agrarian production, which seeks to remedy this shortcoming. The model has two types of agents: a single monopsonistic procurer, and N producers. Section 3.1 provides a detailed discussion of procurer behavior, section 3.2 describes producer behavior, and section 3.3 outlines our computational implementation and presents our baseline parameterization of the model.

3.1 Procurer Behavior

The procurer is a modern, profit-maximizing processor or distributor of agricultural commodities. While the procurer is a price taker in world markets, it has monopsony power locally where it purchases output from contracted growers. We consider a stylized version of the procurer's optimization problem where real procurer profits are

$$\Pi(\rho) = (P - \rho) \cdot Q_M(\rho) \tag{1}$$

and where P is the relative world price (i.e., the procurer's selling price), ρ is the relative procurement price, and Q_M is the contracted quantity for the modern sector.[9] So $(P - \rho) \cdot Q_M$ is real net revenue generated by procurement and distribution.

Prices are relative to the output price in traditional markets. With ρ as its choice variable, the procurer seeks a constellation of contracted growers that maximizes profits. A profit maximum will be characterized by $\rho \in [1, P]$, because procurer profits are zero for $\rho \leq 1$ or $\rho \geq P$. If $\rho \leq 1$ there is no output price premium, so all producers will forego any contractual farming arrangements and produce for the traditional sector. If $\rho \geq P$ the procurer does not find it profitable to contract any producers.

[9]Here we ignore contract-related transaction costs faced by the procurer; this does not alter our core results. We also assume that ρ is uniform across contracted producers—a reasonable assumption, since procuring firms conventionally pay uniform prices (Sivramkrishna and Jyotishi, 2008). To illustrate, although Campbell's briefly offered seven different types of contracts in Mexico in the mid-1980s, its array of different procurement prices was short-lived. Implementation was costly, and the firm was pressured by other plants to adopt constant and uniform pricing (Key and Runsten, 1999).

Since producers are attracted to the modern sector by the price premium, Q_M depends on ρ. Suppose for one moment that $Q_M(\rho)$ were increasing at $\rho = 1$, concave, and differentiable. Then the procurer's problem would have an analytical solution, satisfying the first-order necessary condition

$$(P - \rho) \cdot Q'_M(\rho) = Q_M(\rho) \tag{2}$$

This says that, at the profit maximizing ρ, the profit from marginal procurement must just offset the cost of paying all growers a higher price.

Unfortunately, there is no simple analytic solution to the procurer problem. One issue is that the response of Q_M to ρ is mediated through factor market adjustments: when the procurer sets ρ, producer incentives change, and this causes adjustments in factor markets that affect supply to the procurer. A more fundamental problem arises as producers decide discretely whether to participate or not. Given a finite set of producers, small changes in ρ can cause discrete changes in supply. In order to overcome these issues, we adopt a computational approach. We compute a general equilibrium where the producer's choice of ρ is optimal for the prevailing factor prices, which in turn are an equilibrium response to ρ. (For details, see our online supplementary appendix.)

3.2 Producer Behavior

Producers in an agricultural region are price takers and utility maximizers. They are heterogeneous: they differ in the quantity of land owned, and some are landless. Let N_0 and N_1 be the number of landless and land-owning agents, so the total number of producers is $N = N_0 + N_1$. The region has H (abstract) units of land, which are homogeneous in quality. Land ownership is Pareto distributed with equality index $\delta \in (0, 1]$, and $\bar{h}_i$ is the resulting land endowment of producer i.[10] By increasing δ, we can explore the effect of more egalitarian distributions of landholdings on the model outcomes.

Producers derive utility from real income (Y) and time reserved for non-market activities (t_r). For brevity, we will refer to t_r as leisure time. All our functional forms come directly from EK, so we have

$$U(t_r, Y) = D\sqrt{t_r} + Y \tag{3}$$

[10] Since $\delta = (1 - \text{Gini})/(1 + \text{Gini})$, this is equivalent to parameterizing by the Gini coefficient of inequality. Since we have a finite number of producers, we use a discrete analog to the continuous Lorenz curve used by EK. The Lorenz curve associated with the Pareto distribution can be written as $F(p) = 1 - (1-p)^\delta$ where $0 < \delta \leq 1$ and p is the cumulative proportion of ranked landowners. In the discrete case, let $p_i = i/N_1$ $(i = 1, \ldots, N_1)$ and set the cumulative land share of producers that own no more land than the i-th landowner to $F(p_i) = 1 - (1 - p_i)^\delta$. Let $\bar{h}_i$ be the land endowment of producer i, sorted by size. Since $\bar{h}_i/H = F(p_i) - F(p_{i-1})$ and $p_i - p_{i-1} = 1/N_1$, we have $\bar{h}_i/H = \big(1 - (i-1)/N_1\big)^\delta - \big(1 - i/N_1\big)^\delta$. Complete distributional equality (among the landed) arises when δ is unity.

where D is a positive parameter. Our characterization of producers follows the EK model, with one exception: producers may now choose to produce for the modern sector. Each producer optimizes their utility by choosing among three activities: pure agricultural laborer, traditional-sector producer, or modern-sector producer (i.e., contract farming). A producer's utility will be maximal over these alternatives:

$$U^* = \max \{U^*_{PL}, U^*_{TS}, U^*_{MS}\} \tag{4}$$

where U^*_{PL}, U^*_{TS}, and U^*_{MS} denote maximal utility as a pure laborer, traditional-sector producer, or modern-sector producer. The payoff in each activity is influenced by the producer's land endowment, factor prices, and ρ.

Consider first the pure agricultural laborer, who derives income solely from wage labor and rents derived from letting out any land owned. Accordingly, we have $Y = w\,t_w + v\,\bar{h}$ where w is the real wage, t_w is time spent on wage labor, v is the real rental rate for land, and $\bar{h}$ is the amount of land owned. We normalize to unity the total time available, so for the pure agricultural laborer we have $t_r = 1 - t_w$. The pure agricultural laborer can therefore be characterized by the maximand $D\sqrt{1 - t_w} + wt_w + v\bar{h}$, subject to a nonnegativity constraint on t_w. When wages are too low to justify wage labor (i.e., $w < D/2$), we have a corner solution at $t^*_w = 0$. Otherwise, this problem has a unique maximizer, $t^*_w = 1 - D^2/(4w^2)$. We can then substitute t^*_w into the maximand to find U^*_{PL}.

The alternative to pure agricultural labor is agricultural production for sale either into the traditional value chain or into the modern value chain. The optimization problems facing the prospective modern-sector and traditional-sector producers are exceedingly similar, so we discuss both problems in parallel. The objective of each producer type is to maximize utility subject to time and working-capital constraints.[11]

Both land and labor are required for agricultural production. Production technology for a single producer is

$$q = A\sqrt{h\ (t_h + L)} \tag{5}$$

where q is producer output, A is a positive productivity parameter, h is operational landholdings, t_h is own labor applied to the operational landholdings, and L is hired labor. Taking into account possible land leasing and labor market participation, real income is

$$Y = pq + w(t_w - L) + v(\bar{h} - h) - K \tag{6}$$

[11] As argued by EK, the constraints are directly influenced by two market "failures" ubiquitous in developing country agriculture: a labor market imperfection deriving from the incentive for hired labor to shirk, which necessitates supervision and thereby influences time allocation; and a credit market imperfection deriving from the requirement of collateral, which means that a producer's access to working capital depends on the quantity of land owned. (See section 2.1.)

where p is the output price received by the producer and K is the fixed cost of production. Recalling (3), the maximand for each producer type can therefore be written as follows:

$$U(t_r, Y) = D\sqrt{t_r} + pq + w(t_w - L) + v(\bar{h} - h) - K \tag{7}$$

with the appropriate (traditional or modern sector) substitutions made for p and K.

As in section 3.1, we normalize the output price in traditional spot markets to unity, and ρ is the relative output price paid by the procurer to modern-sector producers. Fixed costs also differ between sectors: we let K_T and K_M denote the fixed costs of participating in the traditional and modern sectors. Based on the discussion in section 2.2, modern-sector producers incur larger fixed costs in order to receive the output price premium, so $K_M > K_T$. In sum, $(p, K) = (\rho, K_M)$ for a modern-sector producer, while $(p, K) = (1, K_T)$ for a traditional-sector producer.

Regarding the time constraint, in addition to the three uses of time defined above (t_r, t_h, and t_w), hired labor requires time t_s for supervision. Naturally, all four uses of time must be nonnegative and all uses of a producer's time must sum to the total available (which is normalized to unity):

$$t_r + t_h + t_w + t_s = 1 \tag{8}$$

Supervision time is a function of hired labor: $t_s = s_1 L + s_2 L^2$, where $s_1 > 0$ and $0 < s_2 < 1$.[12] With respect to the working-capital constraint, working capital is required to hire labor and rent land. Collateral-based access to working capital ($\bar{B}$) depends linearly on the amount of land that a producer owns: $\bar{B} = \phi + \theta\bar{h}$, where the parameters ϕ and θ are nonnegative. We can then write the working-capital constraint as follows:

$$v(h - \bar{h}) + w(L - t_w) \leq \bar{B} - K \tag{9}$$

(with the appropriate substitution made for K depending on the production sector). All working-capital outlays are incurred at the beginning of the production period.

Given the definition of the utility function and constraints, we can represent the producer's constrained

[12] Again, all functional forms are from EK. These functional forms embody standard assumptions. For example, the production function is linear homogeneous, strictly concave, and twice-continuously differentiable. Similarly, the supervision function is strictly convex and twice-continuously differentiable. The conventional justification for this strict convexity is that it ensures a finite farm size despite the linear homogeneity of the production function. The restriction $s_1 < 1$ is needed for hired labor to ever be profitable.

Table 1: EK's Capital Constrained Class Structure

Class	Characteristics	Working Capital (B)
LC (laborer-cultivator)	$t_w > 0,\ t_h > 0,\ L = 0$	$0 \leq B < B_1$
SC (self-cultivator)	$t_w = 0,\ t_h > 0,\ L = 0$	$B_1 \leq B < B_2$
SM (small capitalist)	$t_w = 0,\ t_h > 0,\ L > 0$	$B_2 \leq B < B_3$
LG (large capitalist)	$t_w = 0,\ t_h = 0,\ L > 0$	$B \geq B_3$

optimization problem with the following Lagrangian:[13]

$$\begin{aligned}\mathcal{L}(t_r, t_h, t_w, L, h, \lambda, \mu) =& D\sqrt{t_r} + pA\sqrt{h\,(t_h + L)} + w(t_w - L) + v(\bar{h} - h) - K \\ &+ \lambda\left[\bar{B} - w(L - t_w) - v(h - \bar{h}) - K\right] \\ &+ \mu\left[1 - t_r - t_h - t_w - s_1 L - s_2 L^2\right]\end{aligned} \tag{10}$$

recalling that $(p, K) = (\rho, K_M)$ for a modern-sector producer and $(p, K) = (1, K_T)$ for a traditional-sector producer. EK analyze this optimization problem in detail.[14]

Define $B \equiv \bar{B} + v\bar{h} - K$. EK show that the unique solution to (10) can be parameterized by B. Table 1 presents the EK solution for four possible modes of production, separated by three critical values of B. Being a pure laborer is always a reserve option, if cultivating is not preferable. As in EK, agents in our model choose traditional-sector production over pure laboring if $U^*_{TS} > U^*_{PL}$. Given that we also include a modern sector, however, our agents will seek contractual farming arrangements if $U^*_{MS} > \max\{U^*_{PL}, U^*_{TS}\}$. If a producer wishes to participate in the modern sector but the procurer does not offer a contract, the producer will choose the next best alternative.[15]

3.3 Implementation and Baseline Parameterization

We implement our model as an agent-based computational model.[16] Agent-based methods allow very general representations of agent heterogeneity (Epstein and Axtell, 1996), and in our model producer-level variation

[13]For compactness, we suppress the nonnegativity constraints on the components of time use.

[14]An operating producer cannot have $t_h = 0$ and $L = 0$ since labor is an essential production input. Additionally, t_w and L cannot both be positive: since the effective cost of hired labor exceeds the market wage (because it must be supervised), a producer who hires workers will not also provide wage labor. However, it is possible that both $t_w > 0$ and $t_h > 0$, since a producer may also provide some wage labor.

EK assume that the capital constraint always binds on cultivators. This is a very strong assumption as it can force producers to use unwanted working capital and can thereby impose suboptimally high levels of production or an inappropriate abandonment of cultivation. While EK needed this assumption for tractability of their simulation approach, our agent-based approach allows us to discard it.

[15]This will not happen in our baseline parameterization, but it can happen if the procurer incurs contract-related transaction costs from producer participation.

[16]Agent-based models often discard optimization and equilibrium in favor of simple behavioral rules and disequilibrium dynamics, but ours does not: we adhere as closely as possible to the original EK model. Our implementation is in Python. This choice is incidental to our research program, but Python has found wide use in scientific programming (Langtangen, 2012). Our implementation depends on the `gridworld` agent module (Isaac, 2011), the `numpy` and `scipy` numerical libraries (Oliphant, 2007; van der Walt, Colbert, and Varoquaux, 2011), and charts generated by Matplotlib (Hunter, 2007). For details, see the source code in our supplementary online appendix.

in landholdings is fundamental. An additional computational payoff to the use of agents is that each agent can autonomously optimize based on its particular state, constraints, and goals. In our model, producers have the same goals (i.e., utility functions), but since land is used as collateral, they face substantial constraint heterogeneity. It is not obvious how one could correctly handle these constraints without agent-based methods.[17]

Figure 1 presents an activity diagram of the steps followed to generate the model outcomes. This algorithm is executed once for each considered value of δ, from the least to the most equal distribution of land.[18] The core component of the set-up phase is the distribution of land to producers, based on δ. Land ownership influences the factor demands and supplies of producers. Accordingly, we then find the general equilibrium for the given δ.[19] In a general equilibrium, the relative procurement price (ρ) must maximize the monopsonistic procurer's profits at the current factor prices, while those factor prices must be the market clearing prices when growers face that procurement price.[20] Finally, we record the model outcomes associated with the general equilibrium.

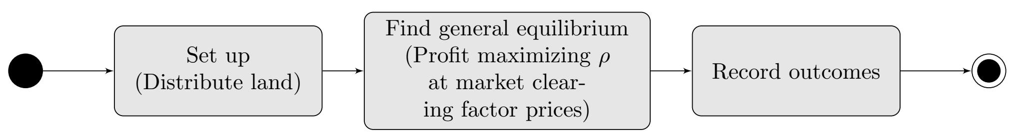

Figure 1: Agent-Based Model Structure

We track a variety of aggregate outcomes for producers, including welfare, output, the poverty rate, the proportion in each activity, the proportion in each agricultural class, and the land use of each agricultural class. Our reported utility and output aggregates are means across all producers, unless otherwise noted. (This allows ready comparisons with scenarios involving variations in the number of producers.) The poverty rate is constructed as the proportion of producers with income below the EK poverty line. We also track outcomes for the procurer, including the procurement price, output procured, and total profit.

[17]For example, EK achieve tractability in their simulations by assuming the working-capital constraint always binds, but it does not.

[18]In the five-fold categorization of developing countries of Lipton (2009), the average Gini for the 19 countries in his most unequal groups (groups I and II) can be computed as 0.82, using his data. Using the relationship that $\delta = (1 - \text{Gini})/(1 + \text{Gini})$, this is equivalent to a δ value of approximately 0.10. (The Gini coefficients used in the calculation correspond to Lipton's most recent data, which spans the years 1990-2005.) We therefore select this as our initial (most unequal) δ value, and we repeatedly increment δ by 0.01 as long as $\delta < 1$ (the limiting case being complete equality).

[19]Since our model implementation is agent-based, we are able to use the exact solution for each agent, including careful attention to the constraints facing each agent and the possibility of corner solutions. Each agent computes its unconstrained optimum. If its constraints bind, it computes a constrained optimum. We code analytical solutions to (10). The analytical solution for the working-capital-constrained large capitalist proves surprisingly complicated. For details, see the source code in our supplementary appendix.

[20]For any given ρ, factor-market clearing is achieved when factor prices (v, w) produce zero excess demand in the land-rental and wage-labor markets. As usual, we find this by numerical search. We use the `fsolve` function from SciPy's `optimize` module. SciPy is a widely-used scientific programming library for Python; `fsolve` is just a wrapper around MINPACK's hybrd and hybrj algorithms. Since $\rho \in (1, P)$, we use a bracketing-interval solver to find the procurer's profit-maximizing ρ (with underlying factor-market clearing). For details, see the source code in our supplementary appendix.

Baseline parameter values are listed in Table 2, and most come directly from EK. One new parameter is required by our use of agent-based methods: the number of producers (N). EK distributed producers along a continuum, while an agent-based implementation must specify the population size. Two more parameters are introduced when we add a modern value chain: the fixed costs of participation in the modern sector (K_M), and the procurer's sales price (P). Table 2 additionally includes a few derived values, which are chosen to mimic EK to the extent possible. The number of landless is determined by p_0, which corresponds to the proportion landless in EK (see their Figure 2). Total arable land is similarly chosen to match their relationship between landless producers, landholders, and the quantity of arable land.

Table 2: Baseline Parameterization

Parameter	Description	Value
	Parameters from EK	
A	production function productivity ($A\sqrt{h\ (t_h + L)}$)	5.0
D	sub-utility of leisure ($D\ \sqrt{t_r}$)	0.1
s_1, s_2	labor-supervision costs ($s_1 L + s_2 L^2$)	0.3, 0.01
ϕ, θ	land-based working capital ($\phi + \theta\bar{h}$)	0.0, 1.0
p_0	proportion of agents without land	0.33
povertyline	poverty line	1.3
K_T	producer's fixed cost (traditional sector)	0.50
	New Parameters	
N	number of producers	250
K_M	producer's fixed costs (modern sector)	0.75
P	sale price of procurer	3.5
	Derived Values	
N_0	number of landless producers	$p_0 \cdot N$
N_1	number of land-owning producers	$N - N_0$
H	total arable land	$N_1/2 + N_0$

EK did not calibrate their model, and it would be counterproductive for our project to attempt a full calibration. Our goal is to explore how adding a modern value chain alters the predictions of the EK model. Accordingly, we must adhere as closely as possible to the original model, which implies reliance on the EK parameters. Of course, the EK model lacks a modern sector. Therefore, our baseline values for the modern-sector parameters are roughly informed by empirical studies. For example, Michelson (2013) conducted a supermarket supplier census in Nicaragua and found 244 current suppliers. We set $N = 250$ in the baseline. To cite another example, Schipmann and Qaim (2011) compared product prices across retail outlets in Thailand and found that modern retailer prices ranged from 40 to 340 percent higher than traditional wet markets. We set $P = 3.5$ in our baseline parameterization.[21] While our choices are intended to be reasonable, we will show that our results are robust to deviations from our particular parameterization

[21] See Minten and Reardon (2008) for further evidence on price differences between traditional and modern retailers. We did not find empirical evidence to inform the baseline for K_M, but it is constrained by two requirements: it must be greater than K_T or we would not see a traditional sector, and it must not be so large that the modern sector disappears.

by supplementing our baseline results with a sensitivity analysis.[22]

4 Results and Sensitivity Analysis

This section comprises three subsections. The first subsection presents some core results from our baseline simulations. The second subsection explores the heterogeneous welfare effects consequent to the introduction of a modern sector. In particular, we highlight the role that general-equilibrium effects play in determining landless producer welfare outcomes. Finally, the third subsection provides a sensitivity analysis, showing that our core results are robust to deviations from the baseline parameterization.

4.1 Baseline Results

In the absence of a modern value chain, our baseline model collapses to an agent-based version of the EK model, and our simulation results for this case are therefore very similar to theirs. For example, EK's illustration of land-use patterns (in their Figure 2) can be compared with the first subfigure in our Figure 2, which illustrates producer outcomes in the absence of a modern sector. (When comparing figures, note that the range for δ differs slightly.) Our figure is qualitatively very similar to the EK results.[23] At high levels of inequality (low δ), large capitalist farming dominates—one thinks of South and Central America. But as the distribution of landholdings becomes more equitable, small capitalist enterprises prevail—one thinks of East and Southeast Asia. As is evident from our second subfigure in Figure 2, this pattern of land use is quite robust to the introduction of the modern sector.

Figure 3 offers a different perspective on the effect of land redistribution on the class structure of the resulting economy. (We find this result to be insensitive to the absence or presence of a modern sector, so we only illustrate the latter case.) The figure is a stacked-bar chart, the height of which is the total population of producers, so for a given δ the relative height of the colored bars illustrates the proportion of producers in each class. We use darker colors for less capital-constrained production activities. White therefore represents the pure agricultural laborer (PL), light gray the laborer-cultivator (LC), gray the self-cultivator (SC), dark gray the small capitalist (SM), and black the large capitalist (LG). Clearly the distribution of land has large effects on the class structure of production. As the distribution becomes more egalitarian, the

[22]Effectively we have two baseline parameterizations: one for the traditional economy (the EK model), and one (with three additional parameters) for our modern economy. For compactness usually we refer to both as the baseline parameterization.

[23]Our agent-based results allow a slightly more prominent role for self-cultivators (SC), since our simulation includes a check for whether or not the working-capital constraint binds. The EK simulations were not agent-based. Instead, they assumed a continuum of producers and generated simulation results by approximating the implied integrals. For reasons of tractability, the EK simulations imposed continual binding of the working-capital constraint. This can force overuse of working capital. In our agent-based implementation, we allow each individual producer to determine whether or not the working-capital constraint is binding.

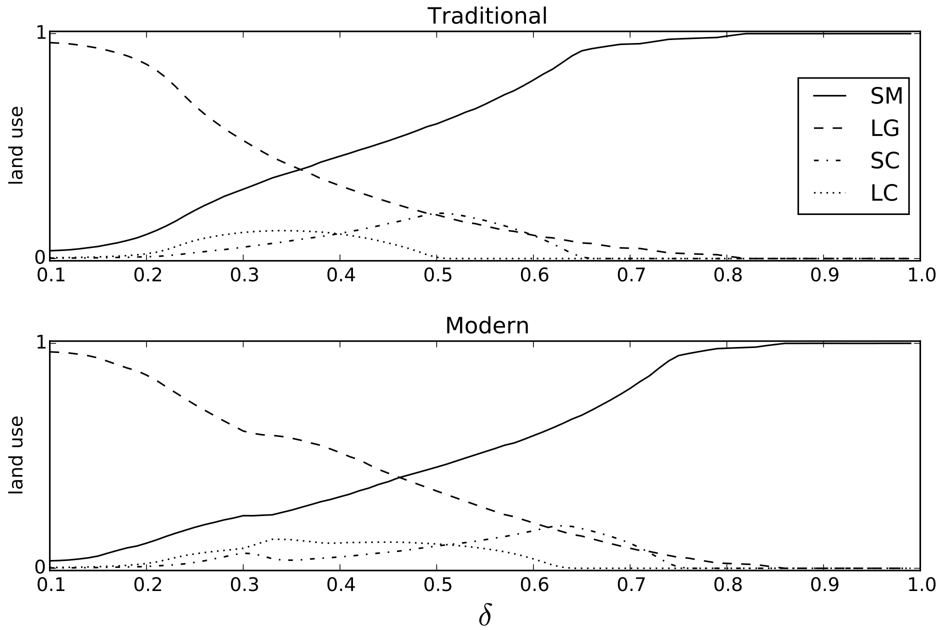

Figure 2: Agrarian Land Use (Traditional vs. Modern)
Land use, which is the proportion of land operated by each class, transitions from being dominated by large capitalists to being dominated by small capitalists as the distributional parameter δ increases. The traditional economy has no modern sector. Depicted classes: laborer-cultivator (LC), self-cultivator (SC), small capitalist (SM), and large capitalist (LG). Parameterization: baseline.

producer population transitions from primarily laboring to primarily cultivating, and small capitalists come to dominate production. Comparing Figures 2 and 3, we see that even when large capitalists dominate land use, they are a small proportion of all cultivators. In contrast, when small capitalists dominate land use, they constitute the bulk of all cultivators.

Despite the small impact of the modern sector on land-use patterns and the class composition of agrarian production, modern-sector participation is substantial. We document this in Figure 4. This figure is another stacked-bar chart, displaying the proportion of producers in each sector for each level of δ. We use white bars for pure agricultural laborers, gray for cultivators that remain in the traditional sector, and dark gray for cultivators that produce for the modern sector. As the distribution of land becomes more egalitarian, an increasing number of producers can surmount the fixed cost of modern-sector participation, and the modern sector slowly replaces the traditional sector.

EK emphasize that equilibrium in their model involves a misallocation of resources. While the optimal land-to-labor ratios are constant for cultivators with $B < B_1$, they are strictly increasing for $B \geq B_1$.[24] Since cultivators set the marginal rate of substitution of land for labor equal to the relative effective factor

[24] See Table 1. This is not true when the capital constraint does not bind, but EK assume that it always binds.

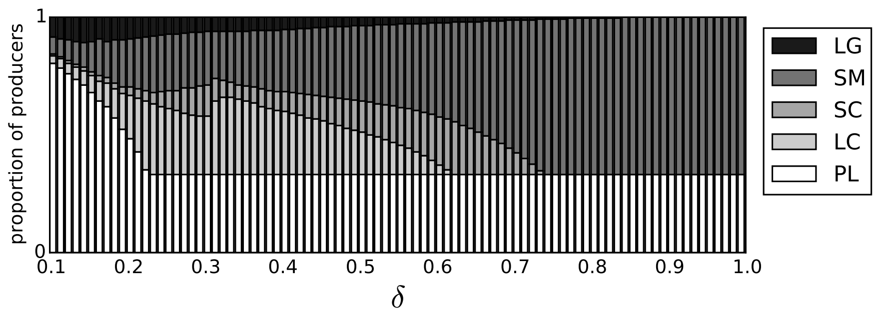

Figure 3: Class Structure and Land Distribution
As δ increases, producers transition from primarily laboring to primarily cultivating, and small capitalists come to dominate production. Depicted classes: pure agricultural laborer (PL), laborer-cultivator (LC), self-cultivator (SC), small capitalist (SM), and large capitalist (LG). Parameterization: baseline.

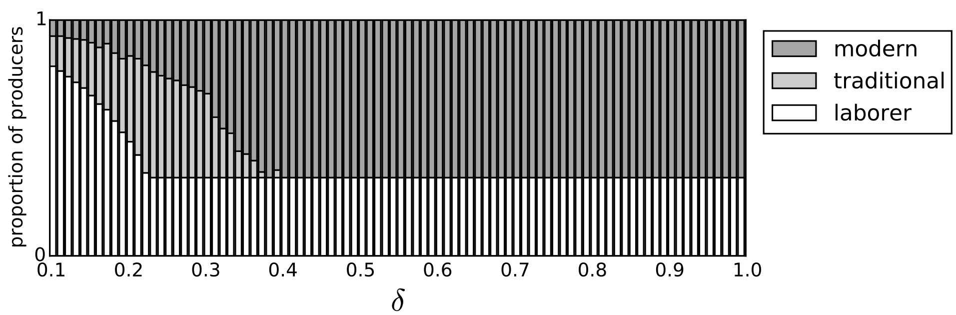

Figure 4: Sector Participation and Land Distribution
Increases in distributional equality (δ) are associated with fewer pure laborers and more modern sector producers. Traditional sector production vanishes beyond intermediate values of δ. Parameterization: baseline.

costs, increases in B beyond B_1 induce a bias toward land use. This is because the effective cost of labor increases as producers optimally consume less leisure (which raises the price of own labor) and hire more wage labor (which raises the marginal supervision cost). Average land productivity is therefore decreasing in B. The EK model thereby offers an explanation of the inverse farm-size/productivity relationship, discussed in section 2.1. For the same reasons, the model implies that land redistribution can raise total agricultural output and improve average producer welfare.

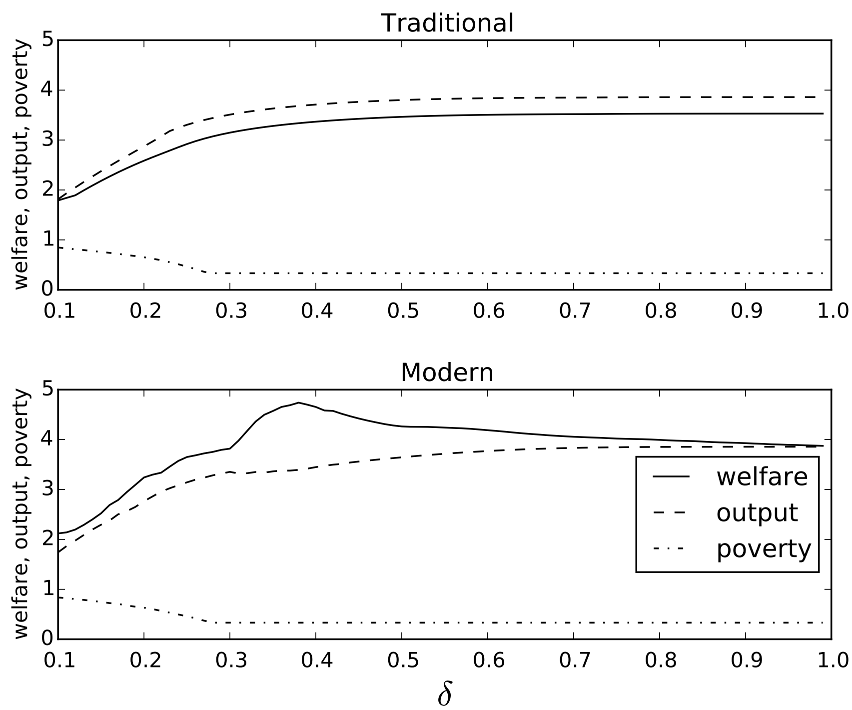

Figure 5: Producer Outcomes (Traditional vs. Modern)
A nonmonotonic relationship between the distributional parameter δ and producer welfare arises with the addition of the modern sector. Parameterization: baseline.

Figure 5 illustrates our results for producer output, welfare, and poverty. The first subfigure illustrates the outcomes for the traditional model, which has no modern sector. The second subfigure illustrates the outcomes for our new model of agrarian production, which includes a modern sector. (In both cases, we use the baseline parameter values, discarding the modern-sector parameters when simulating the traditional model.) The presence of the modern sector has small effects on output and poverty, but it has substantial effects on average producer welfare. While the introduction of a modern sector increases producer welfare for every value of δ, the relationship between welfare and δ is distinctly nonmonotonic. This relationship is of particular interest as a counterpoint to EK, who find that "an increase in the distributional parameter δ ... causes an increase in social welfare ... a direct consequence of the inverse relationship between farm size and land productivity" (Eswaran and Kotwal, 1986, p. 494). From a policy perspective, our result suggests that land redistribution can become counterproductive beyond a certain point.

It is not surprising that the welfare premium associated with the introduction of the modern sector increases as participation in that sector increases. Revisiting Figure 4, we see that participation peaks near $\delta = 0.4$, which is close to the welfare peak. For a given producer to incur the costs of participating in the modern sector, production must be sufficiently large for the associated price premium to offset those costs. High inequality (low δ) is associated with the existence of few farms large enough to justify participation in the modern sector. As the land distribution becomes more egalitarian, more producers can participate in the modern sector. Interestingly, however, as the distribution of land becomes more egalitarian, producer welfare eventually declines. One reason for this is that, when many producers have shifted to the modern sector at higher levels of land equality, the procurer can use a lower price premium (ρ) to draw marginal production into the modern sector. (A fuller explanation requires an exploration of factor-price movements, which we provide in section 4.2.)

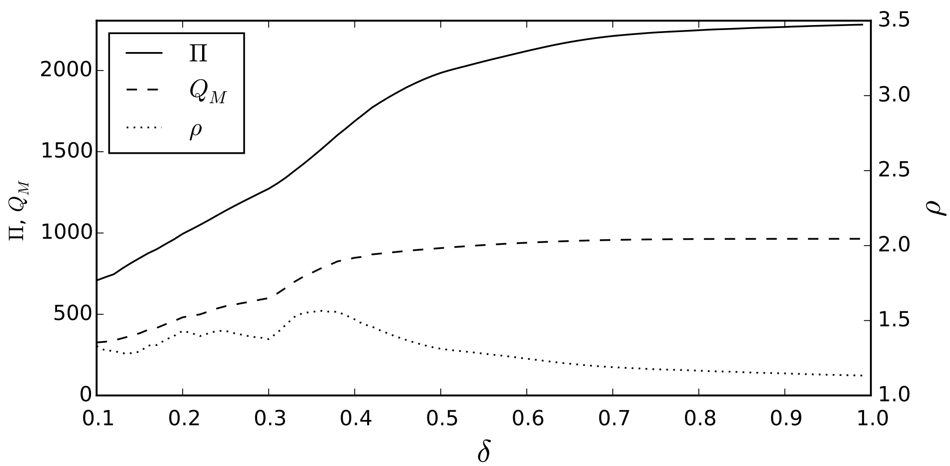

Figure 6: Aggregate Procurer Outcomes
Variations in distributional equality (δ) affect the procurer's optimal procurement price (ρ) and thereby procurer purchases (Q_M) and profits (Π). Purchases and profits are increasing in δ, especially at low δ. Parameterization: baseline.

Figure 6 depicts the procurer outcomes as a function of the distribution of land. The optimal procurement price (ρ) peaks near $\delta = 0.4$, again coinciding with the peak of the modern-sector welfare curve. Further increases in δ produce a reduction in the procurement price; effectively, these increases in δ induce a shift in the supply to the modern-sector. Procurer purchases (Q_M) and profit (Π) rise further and eventually level off. The monotonic relationship between Π and δ contrasts starkly with the nonmonotonic equity-welfare relationship observed in the producer outcomes. These results are robust to changes in the parameter values. In particular, we find qualitatively similar results for large changes in the procurer's output price. (See the online supplementary appendix.)

4.2 Landless Welfare

While the overall welfare effects of a modern sector are of substantial interest, the distribution of welfare changes is also a primary concern (Neven et al., 2009; Rao and Qaim, 2013). Therefore, we now explore the effects on the welfare of landless producers. This exploration leads to a consideration of the factor-market adjustments implied by the introduction of a modern sector. These general-equilibrium adjustments affect landless producers in ways that may sometimes appear counterintuitive. In this secton, we explain how landless producers may be harmed by the introduction of a modern sector. This provides a key insight into the nonmonotonicity result of the previous section.

We begin our exploration with Figure 7, which depicts the effects of the modern sector on landless welfare. At each configuration (δ) of the distribution of land, we show the percentage change in the average welfare of landless agents that is induced by the introduction of a modern sector. It is evident that the modern-sector effect on landless welfare depends on the distribution of land. With high land inequality (low δ), landless producers experience a small welfare improvement with the arrival of a modern sector. But given an egalitarian land distribution (high δ), the effect of the modern sector on the welfare of the landless is substantially negative. This negative effect may appear counterintuitive: how can the addition of a modern sector (with implied higher producer prices) harm the landless? Changes in the equilibrium wage provide the key.

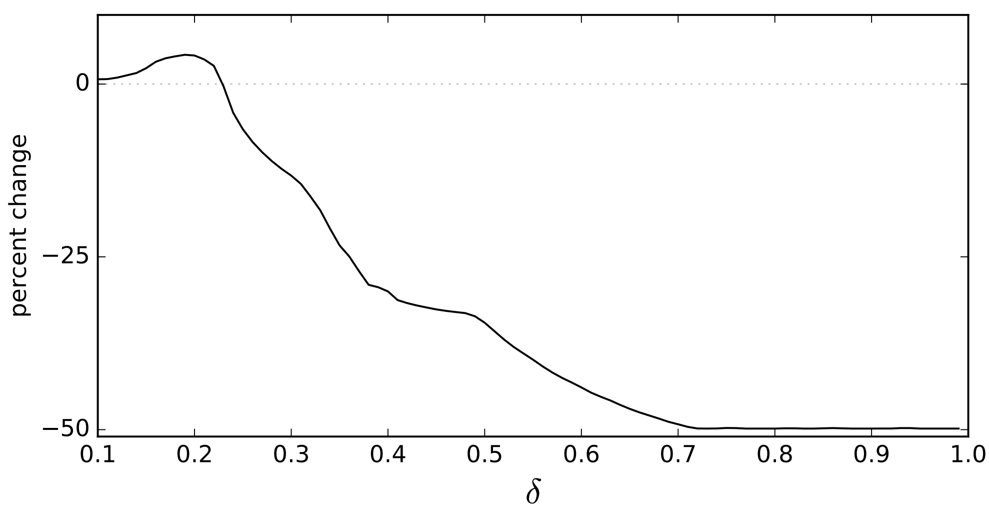

Figure 7: Landless Welfare: Effect of a Modern Sector
At high levels of inequality (low δ), introduction of a modern sector improves landless welfare outcomes. At low levels of inequality (high δ), introduction of a modern sector diminishes landless welfare outcomes. Parameterization: baseline.

Figure 8 illustrates the modern-sector effects on the equilibrium price and quantity in the labor and land markets. At high levels of land inequality (low δ), introducing the modern sector tends to increase factor prices. This is perhaps the expected result: the introduction of a modern sector paying a price premium increases factor demand. However, at low levels of land inequality (high δ), the introduction of a modern sector depresses factor prices. Comparing Figure 7 with Figure 8, we see that the changes in the equilibrium wage correspond directly to the previously discussed welfare changes.

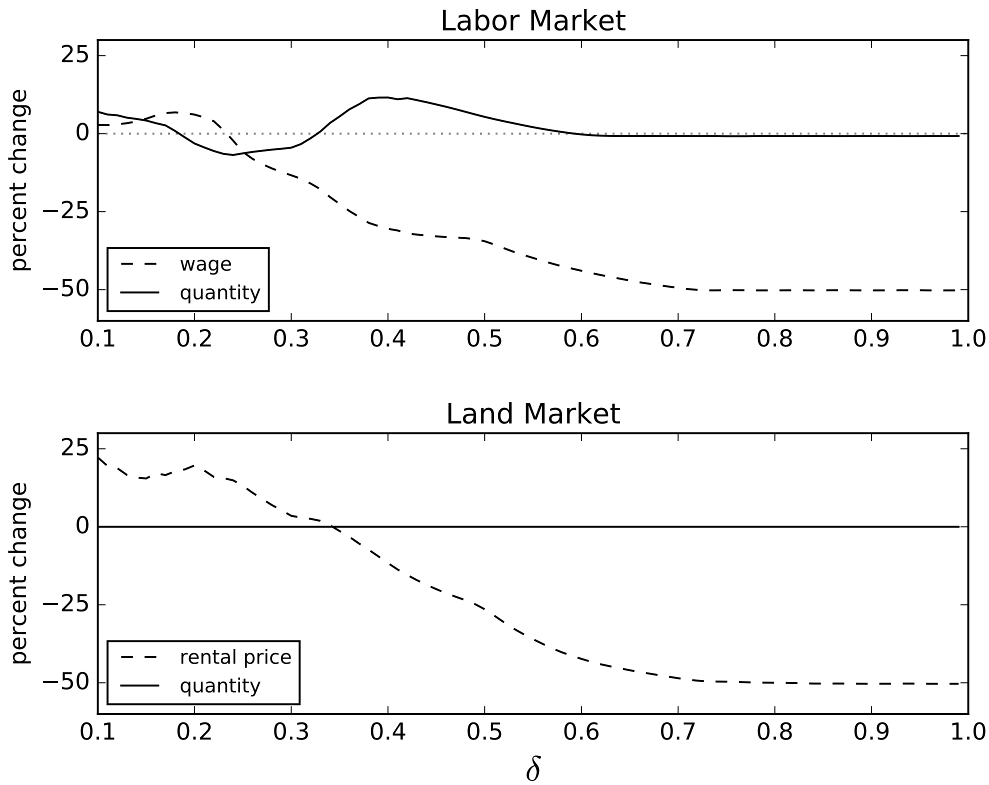

Figure 8: Factor Market Outcomes: Effects of Modern Sector
At high levels of inequality (low δ), the introduction of the modern sector increases equilibrium prices in both factor markets. For low levels of inequality (high δ), introducing the modern sector tends to decrease the equilibrium prices. Parameterization: baseline.

To understand why we observe such movements in equilibrium factor prices, recall that producers must incur a fixed cost to participate in the modern sector. Producers face the working-capital constraint summarized by (9). When producers pay higher fixed costs, they have fewer resources for factor payments. When land inequality is high (at low δ), large landholders are the only participants in the modern sector. (Recall Figure 4.) Their participation costs are small relative to their size. When land inequality is low (at high δ), many landholders can participate in the modern sector. However, their participation costs drain working capital from the economy and thereby drive down factor prices.[25]

Figure 5 shows that the net welfare effect of the modern sector is positive. However, introducing a modern sector has heterogeneous welfare effects on producers. The presence of a modern sector is typically welfare enhancing for landed producers, but the effect on landless producers depends critically on the extent of land inequality. For the reasons discussed above, egalitarian land distributions tend to be associated with decreasing equilibrium wage rates, which lowers the welfare of the landless. It follows that general equilibrium factor-price adjustments underpin the nonmonotonic relationship depicted in Figure 5. In particular, when the distribution of land among landed producers is more egalitarian, losses by the landless tend to decrease the overall welfare premium.

4.3 Sensitivity Analysis

We have found that the welfare-monotonicity prediction of the EK model is undermined when we add a modern sector to the model. Until now, however, our demonstration applies only to the baseline parameterization. While it is interesting to produce a specific parameter set that undermines their prediction, a robust result would be much more interesting. This section therefore provides a sensitivity analysis.

Recall that our new model of agrarian production requires three new parameters: N, P, and K_M. Also recall that our goal is to show that—on its own—the emergence of a modern sector undermines EK's focal prediction. While we must therefore use EK's parameters whenever possible, a sensitivity analysis for the new parameters remains desirable. In what follows, we report select sensitivity analyses for the three new parameters. (Additional sensitivity analysis is provided in a supplementary appendix.)

The number of producers (N): The EK model worked with a continuum of agents, but our agent-based implementation must specify the number of agents. However, we appropriately scale the available land so that land per producer always matches the EK specification (see Table 2). This ensures that our results are comparable over a wide range of values for N. We consider large variations in the number of producers (i.e., halving or doubling). Here we simply state that, as expected, these variations have negligible effects.

The procurer's sales price (P): Halving and doubling this price relative to the baseline naturally has large effects on procurer profitability. A higher external price also encourages the procurer to bid for more output, so the sales price can have important effects on producer welfare. This is illustrated in Figure 9. At the low sales price depicted in the first subfigure, we can barely perceive the nonmonotonic equity-welfare relationship, but it remains. At the high sales price depicted in the second subfigure, it is prominent. Since

[25] This argument implies that relaxing the working capital constraint should mitigate the downward pressure (at egalitarian land distributions) on factor prices. Increases in θ have exactly this effect. Another implication is that if we rank agents by landholdings and consider two adjacent agents, one participating in the traditional sector and the other in the modern sector, the modern-sector agent should tend to have lower factor inputs. This is also the case.

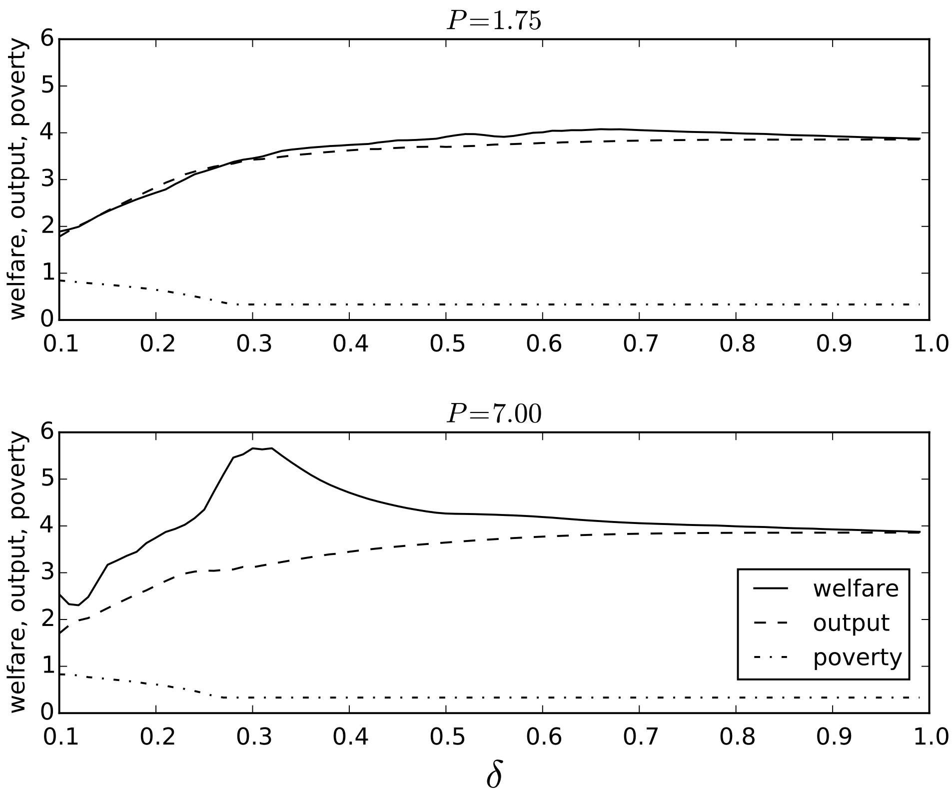

Figure 9: Welfare Effects of Changing P

At a low procurer sales price (P), the nonmonotonic equity-welfare relationship remains, but is barely detectable. At a high procurer sales price, the relationship is more pronounced.

the procurer can offer very little price premium when its sales price is low, these results are also expected.

The cost of modern-sector participation (K_M ***)***: Recalling (6), we expect to observe that K_M is a key determinant of the desirability of modern-sector participation. One way to illustrate this sensitivity is offered in Figure 10, which varies K_M from a low of 0.60 to a high of 1.50. As expected, an increase in K_M produces a decrease in modern-sector participation. With high enough K_M, one can drive out the modern sector altogether. Conversely, as K_M falls toward K_T, eventually all cultivators will prefer to produce for the modern sector.

We might expect that higher participation costs will not only lower modern-sector participation, but will also imply lower welfare payoffs to producers. However, the situation is more complicated: a lower participation cost is unambiguously better for any single producer, ceteris paribus, but participation costs have general equilibrium effects. Figure 10 showed us that participation in the modern sector falls as K_M rises. However, an increase in K_M works against the monopsony power of the procurer, as higher ρ is required to draw forth the same level of production. This provides a gain to intramarginal producers. As illustrated in Figure 11, the gain may be large enough to raise average producer welfare.

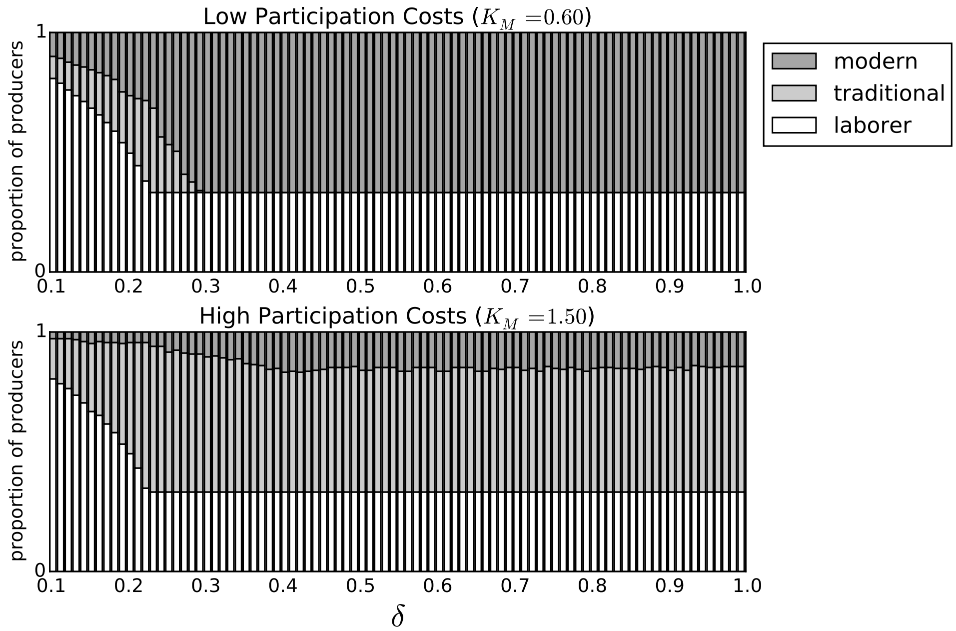

Figure 10: Producer Sectors (Low vs. High Participation Costs)
Higher participation costs (K_M) diminish modern-sector participation, especially when the land distribution is very unequal (low δ). The proportion of pure laborers is unaffected by participation costs.

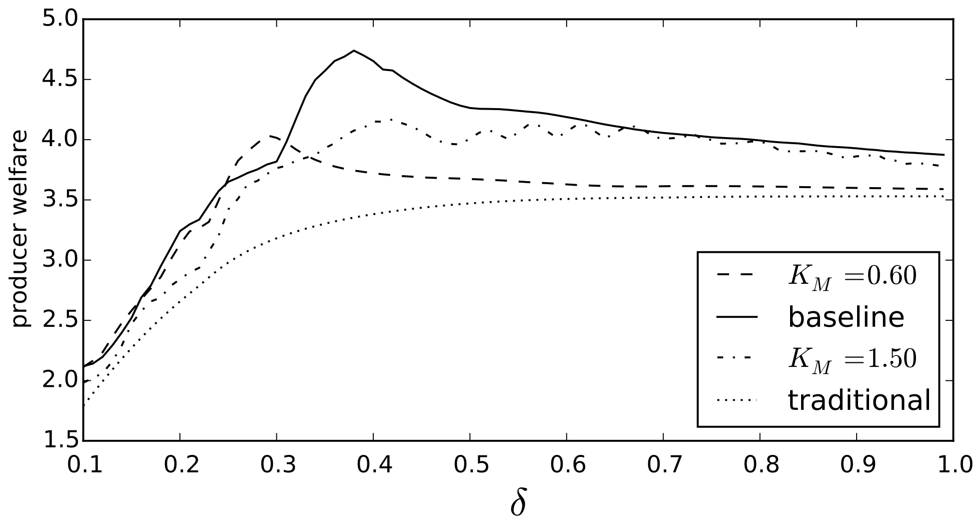

Figure 11: K_M and Producer Welfare
The relationship between modern-sector participation costs (K_M) and mean producer welfare is complex. Even with substantial variation in K_M, however, no monotonic equity-welfare relationship is recovered.

5 Summary and Conclusion

Empirical evidence suggests that smaller-scale producers have historically possessed a productivity advantage in labor-abundant agrarian economies. In this context, researchers have argued that redistributive land reform may improve agricultural productivity and improve welfare, in addition to increasing equity and reducing poverty. Dietary diversification, foreign direct investment, and changing technology have, however, recently induced fundamental changes in agricultural value chains in developing countries. Furthermore, the associated development of modern procurement systems has led to the imposition of quality standards that credit-constrained, small-scale producers typically find difficult to meet. This radical restructuring of global agri-food systems raises questions as to whether such redistributive measures continue to possess welfare-enhancing potential.

In response to the pervasive growth of high-value markets, we re-examine the production and welfare consequences of the distribution of agricultural landholdings. To this end, we extend the influential theoretical work of Eswaran and Kotwal (1986). The EK model famously predicts that a more egalitarian distribution of landholdings will increase aggregate output and welfare. However, the model has a substantive shortcoming: the absence of a modern agricultural value chain. We use our new model of agrarian production, which includes a modern sector, to re-examine the implications of more egalitarian distributions of agricultural landholdings. The inverse farm-size/productivity relationship persists in our model, but EK's core welfare prediction is undermined. In our model, the response of producer welfare to more egalitarian agricultural landholdings is nonmonotonic. Past a certain point, a more egalitarian distribution of landholdings diminishes producer welfare. From a welfare perspective, redistributive measures may indeed be counterproductive.

Our finding of a nonmonotonic welfare-equity relationship arises because of the direct and indirect effects of modern value chains. The direct effects are the product of scale-biased participation in the modern sector. For a given producer to incur the additional costs of participating in the modern sector, output must be sufficiently large for the associated price premium to offset those costs. High levels of inequality are therefore associated with the existence of few producers large enough to justify participation in the modern sector. When the land distribution is more egalitarian, modern-sector participation is then naturally higher. Interestingly, with more modern-sector participants, the procurer's profit-maximizing procurement price can decline, lowering the welfare of intramarginal producers. This is supported by important indirect effects: factor-market adjustments to the presence of a modern sector.

We find that labor-market responses to the addition of a modern sector depend crucially on the extent of land inequality, and greater equality is eventually associated with decreasing equilibrium wages. This occurs because many capital-constrained producers finance modern-sector participation via reduced demand or increased supply of labor. Wage declines harm the laboring classes. Under more egalitarian land distributions, the welfare loss for the landless can outweigh any gains accruing to land owners.

We show that the interaction of these direct and indirect effects undermines EK's welfare-monotonicity prediction. Showing this in a single scenario is enough to caution policy makers against uncritical reliance on the EK prediction, but we provide more than that. Our sensitivity analysis shows that our result is quite robust. Accordingly, for countries with a reasonably well-developed modern sector, we claim to have overturned the EK prediction of a monotone response of welfare to land equality. Related to this, the landless are harmed by the introduction of a modern sector whenever the concentration of land ownership is low.

We believe that our model of agrarian production advances the understanding of developing agrarian economies. Nevertheless, it has important limitations that suggest directions for additional research. It is a static general-equilibrium model, and accordingly it assumes perfect contractual compliance. Barrett et al. (2012) suggest numerous considerations for a more detailed treatment of contracting between procurers and producers. Informational asymmetries between contracting parties and costly contractual enforcement create space for breach of contract. A procurer may delay or default on the final payment, inappropriately reject product, or lower the procurement price post-harvest. Producers may refrain from adhering to the agreed upon production schedule, engage in side-selling, or fail to make timely product deliveries of sufficient quantity and quality. Contractual breakdown has clear short-run consequences (e.g., payment default). Additionally, there are many possible long-run consequences (e.g., delisting underperforming producers). Handling these appropriately may require the development of an apt repeated game. Such considerations may qualify or amplify our results, and we hope to explore them in future research.

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