PIGGY-BACK EXPORTING, INTERMEDIATION, AND THE DISTRIBUTIONAL GAINS FROM TRADE IN AGRICULTURAL MARKETS

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ABSTRACT. When the world price of a crop increases, how do the incomes of the crop's farmers in a developing country change? This paper investigates the distributional gains stemming from changes in agricultural world prices. Agricultural markets in developing countries are often characterized by the presence of a large number of small farmers who sell their produce to one or few big companies with significant monopsony or oligopsony power. We develop a flexible theoretical framework that captures this market structure and allows us to examine the impact of international trade on the incomes of small farmers, agribusiness and intermediaries in developing countries. Using household-level evidence from Kenya, we empirically study the magnitude of the trickle-down effect of world price changes on the incomes of small farmers. Small farmers benefit from quality spillovers when selling through agribusinesses, but they receive 30% to 48% lower trickle down of world price changes from agribusinesses compared with intermediaries.

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1. Introduction

Starting in the 1980s, several developing countries have moved to a more internationally open regime with reduced tariffs and non-tariff barriers as part of a series of unilateral, multilateral, and regional trade liberalisations. Trade liberalisations were seen as a means to boost economic growth, raise living standards and mitigate poverty. Inevitably, gains from trade were not equally distributed, and winners and losers were likely to emerge from the wide wave of liberalization.

A large theoretical and empirical literature has examined the gains from international trade to producers and consumers. In this paper, we seek to study in particular the gains from trade accruing to small farmers in developing countries, many of whom live close to subsistence levels. Much of the early theoretical literature has assumed, for simplicity, that agricultural markets are perfectly competitive. While this might be a good approximation for the characterization of trade in international product markets, there are important departures from perfect competition that need to be taken into account in assessing the distributional gains from trade. In particular, four observations substantiate the need for a departure. First, several agricultural markets are characterized by the presence of a large number of small farmers together with few big agribusinesses with monopsony (or oligopsony) power in the domestic market. Second, small producers often engage in piggy-back exporting, that is, the sale of produce by small farmers to agribusinesses, or sell part of their produce through intermediaries. Third, small farmers have low bargaining power in their relationship with agribusiness firms. Fourth, only a small fraction of the change in a crop's international world price trickles down to small farmers growing that crop. (We discuss these regularities in detail in the next section.) Our paper develops a flexible theoretical framework that captures this complex market structure and can be used to study the effects of globalization and changes in global commodity prices on farmers' incomes and welfare.

The modelling framework incorporates two key features. The first is the inability of small farmers to supply directly to the world market. The second feature is their reliance on either imperfectly competitive intermediaries or piggy-back exporting through agribusinesses in order to sell their produce to the world market. The inability of farmers to ship directly can be caused by a number of potential

obstacles that increase the fixed cost of exporting, including, among others, lack of marketing knowledge, credit market imperfections, and information barriers (Allen, 2014; Ashraf et al., 2009; Burke, 2014). The reliance on either intermediaries or piggy-back exporting through big producers is a way of circumventing these high transaction costs of exporting. The lack of competition among intermediating exporters in developing economies is also well-documented and arises due to factors such as access to social networks and geographical remoteness, among others (Barrett and Mutambatsere, 2008; Bardhan, 1980). Finally, the presence of big farmers or agribusinesses producing and buying from small farmers for world export, though often glossed over in the literature, is a common feature in agricultural markets. Interestingly, policymakers in Africa are currently introducing new legislations for seeds, land, contract enforcement, and taxes to ease consolidation and operation of large commercial farms, which will pave the way for a bigger share of large agribusinesses (Unctad, 2009; Provost et al., 2014; Provost and Kabendera, 2014; Carr, 2013).

In our model, farming requires land and capital inputs that are in limited supply, at least in the short run (e.g., packaging facilities, infrastructure). Intermediaries provide farmers with the capital inputs needed to ship the farmer's export crops to the world market. There is a finite number of monopsonistic agribusinesses that own big farms and also have the ability to ship the export crop to the world market. These agribusinesses have technical knowledge of farming, and when a farmer supplies her produce to an agribusiness, she earns a relationship-specific income. This captures the joint investment made to ensure quality standards to satisfy requirements in export markets. The agribusiness enjoys monopsony power in its relationship with the farmer. The farmer, however, has the ability to resort to intermediaries or to farm a subsistence crop, and these factors determine the reservation prices of the farmer. The presence of agribusiness matters for the incomes of small farmers in two ways. First, agribusinesses can potentially raise the productivity of small farmers through knowledge and technical transfers. Second, agribusiness operations require capital inputs for production and exports, resulting in a link between farmers, intermediaries and agribusiness through the capital input market. Within this setting, we determine the gains from trade to farmers and examine how the presence of intermediaries and

large agribusinesses affects the extent to which changes in world prices trickle down to small farmers.

We show that higher international prices for the export crop increase the gross revenue from exports but put pressure on the price of capital inputs as investments into exporting rise. These two forces have competing effects on how much small farmers can expect to share in the gains from higher international prices. If farmers can deflect some of their export crops to competing intermediaries, they get a part of the higher export revenue through competition among intermediaries. Farmers, however, suffer declining returns on their subsistence production as prices of capital inputs rise from increased investment. This weakens the ability of farmers to negotiate a better price for their export crops from their agribusiness buyers. At one extreme, farmers receive the full benefit of higher world prices if they have access to intermediaries that compete with each other by making bids for the farmer's export crop. At the other extreme, farmers experience a decline in earnings, which happens when they are locked into binding relationships with their intermediaries (say, due to lack of timely access to other intermediaries or exclusive contract farming). In the absence of other avenues to sell their export crop, farmers receive lower prices from agribusinesses because the farmer's alternative cropping option in this case gives lower returns. Farmers suffer a fall in their bargaining power and receive lower earnings from their export crops despite a rise in export revenues for their intermediaries. We model these two competing forces flexibly, and discuss the economic channels underlying the resulting relationship between farmers' earnings from export crops, the prices of capital inputs, the value of subsistence production, and the world prices for export crops.

The model underscores the important role played by the distribution of land ownership, the supply elasticity of capital inputs, and the scale of agribusiness firms in determining the extent to which world price increases trickle down to the incomes of farmers. The trickle-down effect rises with the farmers' ability to divert sales from agribusinesses to intermediaries outside the relationship. The share that farmers get from these intermediaries in turn rises with greater competition among intermediaries and with greater equality in land ownership. When farmers are more constrained in their ability to divert sales to intermediaries, they must rely on diverting the land

to subsistence crops and the trickle-down effect depends on alternative cropping options. The trickle-down effect falls with greater reliance on capital inputs in the production of the subsistence crop. As the production and exports of agribusinesses expand, their capital investments rise. This raises the rental rate of capital which makes farming of the subsistence crop more costly and also makes entry of firms into intermediation more costly. Farmers lose out to agribusinesses due to this pressure on capital resources.

The paper connects to a growing literature that has focused on the gains from trade in settings with imperfect competition. On the theoretical side, early work has examined how the Stolper Samuelson theorem is altered in the presence of a monopsony (Feenstra, 1980; Markusen and Robson, 1980; McCulloch and Yellen, 1980; Bhagwati et al., 1998). Recent contributions have focused on some of the microfoundations for market power. In particular, Antràs and Costinot (2011) and Chau et al. (2009) focus on search and matching frictions that confer market power to intermediaries, while Bardhan et al. (2013) stress reputational rents in the intermediation. A related theoretical literature has examined oligopsony power in intermediates and final goods markets (Devadoss and Song, 2006; Raff and Schmitt, 2005; Eckel, 2009; Bernard and Dhingra, 2015). Our main theoretical contribution is to embed key structural characteristics of smallholder farming. Rogers and Sexton (1994) explain that the structural characteristics of agricultural markets give rise to unique modeling issues relative to the analysis of seller market power in industry studies. On the empirical side, most of the extant work has focused on imperfections in the product markets and the gains from trade for consumers rather than producers (e.g., Atkin and Donaldson (2012)). In an informative study on producers, Balat et al. (2009) find that access to local markets makes it more likely for farmers to plant export crops and this helps in reducing poverty at the household level. Our paper seeks to systematically study how small producers of export crops might be affected by globalization and changes in world export prices, when they face monopsony power in the domestic market. While the focus of our paper is small producers in developing countries, possibly among the poorest in the world, some of the issues we analyze are also present in other markets and in more developed economies. They can speak to

a broader theme on the distribution of gains from trade that has taken centre stage in the aftermath of the financial crisis.

The rest of the paper is organized as follows. Section II discusses the motivating evidence and the related literature. Section III presents the model and discusses its implications. Section IV presents concluding remarks.

2. Empirical Motivation

In this section, we discuss the main empirical observations motivating the model.

1. Several agricultural markets are characterized by the presence of a large number of small farmers together with few big agribusinesses with monopsony (or oligopsony) power in the domestic market.

The assumption of a large number of small farmers with no bargaining power and the presence of large agribusinesses and intermediaries with market power is consistent with the industrial organization of agriculture in developing countries. Lowder et al. (2014) demonstrate that out of a sample covering about 80 percent of the world's farms as well as about 80 percent of the world's population, 72 percent of the farms are smaller than one hectare in size; 12 percent are 1 to 2 hectares in size and 10 percent are between 2 and 5 hectares. Only 6 percent of the world's farms are larger than 5 hectares. Assuming this average is representative of the land distribution worldwide, they estimate that there are more than 410 million farms less than 1 hectare in size and more than 475 million small farms that are less than 2 hectares in size.

Specific case studies confirm these estimates. Whitfield (2012) documents that at its peak, the Ghanian pineapple export industry consisted of 12 large farms (of 300-700 hectares), 40 medium farms (of 20-150 hectares) and 10,000 smallholders with acreage less than 10 hectares. Smallholders transacted with large agribusinesses with almost non-existent bargaining power (Fold and Gough, 2008). Based on interviews of the Kenyan horticulture producers, Jaffee and Masakure (2005) finds that smallholders accounted for 27 percent of fresh vegetable exports, medium and large-scale growers accounted for 29 percent, and farms leased or owned by export companies accounted for the remaining 44 percent of vegetable exports. The distribution of

farm acreage and sales is characterized by the coexistence of a large number of small farmers together with a small number of large producers.

2. Small farmers often engage in piggy-back exporting or resort to intermediaries in order to export their produce

Small producers often carry out either piggy back exporting - sell their produce through large agribusinesses - or sell of part of their produce through intermediaries. Since market reforms in many developing countries in the 1980s and 1990s, the rise of supermarket chains, agro-industrialization, and export oriented outgrower schemes, there has been a substantial increase in production of export crops in developing countries (Barrett and Mutambatsere, 2008). This has increased contract farming and outgrower schemes between agro-industrial firms and farmers in developing countries.

Examples of these new relationships include small farmers that engage in contract farming of tea in Kenya, tobacco production for the British American Tobacco company (Minot, 2011), contract farming in Senegalese groundnut production (Warning and Key, 2002), vegetable farming for European supermarkets by farmers in Madagascar (Minten et al., 2009), production for supermarket supply chains in Latin America, Asia and Africa (Reardon and Timmer, 2007), commercial farming of export crops in Kenya and commercial farming of cash crops like sugar, cotton and tea in Europe and Central Asia (Robbins and Ferris, 2003). These studies show that agro-industrial firms and large commercial farms typically provide inputs to small farmers in the form of expertise, seeds, credit, etc. As they sell to export markets with higher quality standards, they also provide small farmers with technical assistance to meet these higher quality standards and to comply with sanitary requirements involved in export sales. Increased industrialization of agricultural markets has integrated markets which were fragmented, encouraged product diversification through differentiation, and provided opportunities for value addition and technology transfer (Barrett and Mutambatsere, 2008).

The rise of agribusiness is viewed as part of a broader trend towards globalization in agriculture (Simmons, 2002). Runsten (1994) documents that since 1989, there has been a range of contracts between Mexican farmers and agribusinesses for the production of high-value crops (such as strawberries, melons and frozen vegetables)

that are exported to the United States. Goodman and Watts (1997) find a similar trend in contract farming and multinational agribusiness activity in pineapple and banana farming in Central America for exports to the United States and Europe.

3. Small farmers often have low bargaining power in their relationship with exporters.

One consequence of the skewed distribution of farm production and the complex arrangements with agribusinesses is that small farmers have low bargaining power relative to their exporters. Barrett and Mutambatsere (2008) argue that while industrialization of agricultural markets provides small farmers with access to export markets and technical assistance, it reduces their bargaining power in negotiating contract conditions. There is growing concern that these developments might lead to a dual structure in farming with small farmers that have little market access and few large farmers and oligopsonistic multinationals that have the scale and capital to market their produce. Increasingly, contracts are being negotiated bilaterally between an individual farmer and an agribusiness firm, rather than through collective bargaining by farmer associations with government parastatals. Contract farming might also narrow markets outside the contract as farm resources are diverted towards contract production (Simmons, 2002). This would increase prices of local farm inputs and increase barriers to exit from contracts through higher costs of accessing outside markets, sunk relationship-specific investments and over-reliance on cash crops during food shortages (Key and Runsten, 1999).

Case studies provide evidence for some of these concerns. Warning and Key (2002) look at melon cultivation in Senegal. They document that small farmers had negotiated a fixed price for their produce. But when there was a glut in supply, the contracting firm did not return to purchase the melons and farmers lost out as spot market prices fell dramatically. Likulunga (2005) looks at cotton farming in Zambia where agribusiness firms paid farmers a lower price (in local currency) than that agreed at the time of making the contract as, in the firm's view, the price was tied to the dollar. The study argues that improving the flow of market information and market trends could improve the negotiating position of farmers. Mitra et al. (2013)

conduct an experimental study of West Bengal potato farmers to study this phenomenon. Potato traders earn on average at least 50 to 60 per cent of the farm-gate price. When potato farmers in randomly selected villages were provided daily price information from neighboring wholesale markets, there was no significant average impact on these margins. In villages located in market areas with low wholesale prices in 2008, traded quantities as well as farm-gate prices fell significantly as a result of the information interventions. The opposite happened in villages with high wholesale prices. They take this as evidence of ex post bargaining in which the trader makes a take-it-or-leave-it price offer to the farmer after observing the wholesale price, and the farmer responds with a quantity that he wishes to sell. The only outside option farmers have is to thereafter take their produce to a local market and sell to a different trader who will also resell it in the wholesale market.

4. Only a small fraction of the change in a crop's international world price trickles down to small farmers growing that crop.

It is well-known that export price increases have very low trickle down effects on the prices that farmers receive for their produce. For instance, McMillan et al. (2003) claim that no more than 40 to 50 percent of the increase in cashew export prices in the 1990s went to farmers in Mozambique. Fafchamps and Hill (2008) examine the transmission of international coffee prices to Ugandan Robusta growers. They find that when the export price of Ugandan coffee increased in 2002-03, wholesale prices rose, but the gap between wholesale and farm-gate prices widened. Looking at local maize markets in Ghana, Badiane and Shively (1998) find that the degree of pass-through of price changes in the central market (caused by production changes resulting from policy reforms) to local market prices is as low as 0.27 and 0.54 for Bolgatanga and Makola. Bolgatanga is further away from the central market and has a lower quality of infrastructure, compared to Makola.

To add to this evidence, we also investigated the extent of pass-through in Uganda, using farmer-level panel data from the Living Standards Measurement Study (LSMS) surveys over three annual spells (2009, 2010, and 2011). The results are summarized in Table 1, which shows the results from regressions of (log) farmer income on (log)

TABLE 1. Response of Farmer's Income to World Prices in Uganda, by crop

	Beans	Maize	Banana	Coffee
	(1)	(2)	(1)	(2)
Log of World Price	0.165**	0.356**	0.419***	0.881***
	(0.0820)	(0.1380)	(0.0929)	(0.2430)
Household FE	yes	yes	yes	yes
	1,367	1,489	1,274	1,054
R^2	0.009	0.013	0.035	0.029
Number of Household FE	916	984	707	614

Notes: The table reports results from regressions of total household income from each crop on the world price of the crop, using farm-level data from four crops in Uganda. ** 5%, *** 1% levels of significance.

world prices for four crops, beans, maize, banana, and coffee.[1] Doubling of world prices leads to an average increase in farmers' income ranging from 16 to 88 percent, depending on the crop.

The model we present next will be consistent with these facts, and will attempt to shed light on the causes for the differences and relatively small trickle-down effects.

3. A Model of Agricultural Production and Trade

In this section, we develop a model to capture what appear to be recurrent features of agriculture in less developed countries. The first feature is the inability of small farmers to supply directly to the world market. The second feature is their reliance on either imperfectly competitive intermediaries or piggy-back exporting through agribusinesses in order to sell their produce to the world market. In an open economy setting, the model will seek to understand how changes in global demand affect the income received by small and large scale farmers, as well as intermediaries.

[1]Both farmers' income and world prices are measured in U.S. dollars. The choice of country and crop was dictated by the availability of data. (For these crops we observe more than 100 farmers over time.) LSMS cover other countries and crops but only in Uganda were we able to identify a critical number of farmers-crops observations in repeated spells.

We consider a small open economy that takes world prices for its exports as given. The model economy consists of Farmers who are unable to export directly, Agribusinesses, which farm and have access to export markets, and Intermediaries, who do not farm but have access to the world market for the export crop. The environment is characterized as follows. There is a continuum of farmers, each endowed with a unit of land on which they can grow the export crop. Farmers can ship this crop through intermediaries or through agribusinesses to the world market. There is a finite number of intermediaries, who have the capital inputs needed to ship the export crop to the world market. Intermediaries are oligopsonistic in their purchases from farmers, but take world prices p_w (net of export costs) as given. There is a finite number of agribusinesses that own big farms and also have the ability to ship the export crop to the world market. Intermediaries and agribusinesses draw on a fixed stock $\bar{K}$ of capital for marketing the export crops. We will first describe the operation of farmers, then intermediaries, and finally, agribusinesses. Next, we will determine the equilibrium prices and earnings.

3.1. **Description of the Economy.** We start with a description of the production and distribution operations of farmers, intermediaries and agribusinesses.

3.1.1. *Farmers.* There is a continuum of farmers who have linear utility for a numeraire good and maximize farm earnings. A farmer can grow a units of the export crop, where a is drawn from a productivity distribution $G(a)$. Alternatively, each farmer can grow s units of a subsistence crop on her land. Let p_h denote the given price of the subsistence crop. Then farmers earn $p_h s$ from the subsistence crop.

If the farmers choose to grow the export crop, they cannot sell directly to world markets and must go through intermediaries or agribusinesses to export. This assumption is motivated by the vast literature in agricultural economics, surveyed in Barrett (2008), which finds that smallholders face high transaction costs in selling their crops to export markets. They lack the productive assets, access to technologies, and infrastructure needed to produce a marketable surplus, and must rely on intermediaries or agribusinesses to access markets. For instance, Fafchamps and Hill (2008) find that only 15 per cent of Ugandan coffee growers travel to nearby markets to sell their produce and the others sell through traders due to high costs

of transportation. Farmers access world markets through their intermediaries or agribusinesses. An intermediary pays the farmer a price p for her export crop and the farmer earns pa by selling through intermediaries.

If a farmer chooses to sell through an agribusinesses, she must engage in relationship-specific investments to grow crops of a desired level of quality for the world market. The farmer's earnings from the agribusiness will depend on the options available outside the relationship. Our focus is on understanding the role of agribusinesses in trickle down of world prices to small farmers, so we will assume that the export crop and its sale through agribusinesses is viable for some farmers and detremine the earnings of farmers across its different options.

3.1.2. *Intermediaries.* There is a finite number N of identical intermediaries who do not farm and compete for the export crops produces by small farmers as Cournot oligopsonists. Intermediaries have identical intermediation productivity of $m \in (0, 1)$. When the world price is p_w, the intermediary receives $p_w m$ and pays the farmer p. The inverse of the intermediation productivity $1/m$ acts like an iceberg trade cost for the exporter to ship to the world market.

Intermediary i's profit from exporting x_i units of the export crop is $\pi_i = (p_w m - p)x_i$. Intermediaries can export as long as they pay an entry cost of f units of capital. Let r denote the rental rate of capital. Then free entry into intermediation implies that the expected profits from intermediation are driven down to the entry costrf.

3.1.3. *Agribusinesses.* There is a fixed number M of identical agribusiness firms who produce b units of the export crop and have the ability to access world markets. Each agribusiness has an intermediation productivity m_b with $1 > m_b \geq m > 0$. Agribusinesses make capital investments to increase the quality of their produce. By investing q units of capital, the agribusiness increases its effective units of export crops from b to $bq^\beta > b$ for $\beta \in (0, 1)$.

An agribusiness invests in its relationship with farmers and shares its technical knowledge with them. This increases the quality of the farmer's produce from a to $\delta a > a$. But selling these higher quality export crops outside of the relationship requires the small farmers to spend θ units of capital. For instance, higher quality produce may require specialized transport facilities which the farmer must pay for

if her relationship with the agribusiness breaks down. To model this as flexibly as possible, we assume the farmer's outside option gives her $\delta pa - \theta r$. The parameter δ reflects the quality gains from the technical knowledge or inputs provided by the agribusiness. It increases the revenue that the farmer would earn if she sold her produce to intermediaries in the event of a breakdown of the relationship with her agribusiness. The parameter θ captures the extent to which marketing higher quality crops entails capital investments such as own local transport to get to the market, specialized refrigerated trucks to carry the higher quality produce or increased credit costs when outside of a relationship with the agribusiness.

Let $T(a, b)$ denote the payment to farmer a from agribusiness b. Then agribusiness b earns a profit of :

$$\pi_b = p_w m_b b q^{\beta} - rq + \int 1_{a \text{ meets } b}(p_w m_b \delta a - T(a, b))dG(a).$$

The agribusiness pays each farmer her reservation value to ensure farmers do not divert the crops outside of the relationship. The farmer receives $T(a, b) = \delta pa - \theta r$, and the next subsection discusses how this determines the choices that farmers make to grow and sell crops.

3.2. **Market Equilibrium.** Having described the three types of agents in the economy, we determine the cropping choices of farmers, and then discuss how much they earn from intermediaries and agribusinesses.

3.2.1. *Farmer Decisions of Crops and Sales.* A farmer has three choices: grow the subsistence crop and earn $p_h s$, grow the export crop and sell through an intermediary to earn pa, or grow the export crop and sell through an agribusiness to earn $\delta pa - \theta r$. Farmers choose the option that gives them the highest farm earnings. Farmers with the lowest levels of export crop productivity ($a < p_h s/p \equiv a_s$) grow the subsistence crop. Farmers with the highest levels of export productivity ($a > \theta r/(\delta - 1)p \equiv a_l$) grow the export crop and sell through an agribusiness. These farmers have the scale of production to take advantage of the quality spillovers from the agribusiness. They can pay the capital investments needed in the event of a disagreement with the agribusiness. Farmers with medium productivity levels of $p_h s/p \leq a \leq \theta r/(\delta - 1)p$ choose to grow the export crop and sell through intermediaries. Having determined

the supply of crops from farmers, we proceed to determining the payments made for the export crops.

3.2.2. *Intermediary Prices.* The total supply of the export crop to intermediaries is $X_I = \int_{a_s}^{a_l} a dG(a)$. For simplicity, we assume a Pareto productivity distribution, $G(a) = 1 - (a_{\min}/a)^k$ with $a \geq a_{\min} > 0$ and $k \geq 1$. A fall in the Pareto shape parameter k captures an increase in inequality (as measured by the Gini index for land productivity). Using the Pareto distribution, intermediaries procure $X_I = \sum_i x_i = \frac{k}{k-1} a_{\min}^k \left[a_s^{-k+1} - a_l^{-k+1}\right]$ units of the export crop.

Intermediary i chooses his quantity x_i of export crops to maximize $\pi_i = (p_w m - p)\, x_i$. Intermediaries are Cournot oligopsonists and take into account how their quantity choices impact the price of the export crop. The own price impact of purchases by an intermediary is $dp/dx_i = p/X_I(k-1)$, holding fixed the purchases of other intermediaries, x_{-i}. From the FOC for profit maximization, the optimal purchase of an intermediary is $x_i = (p_w m - p)(k-1)X_I/p$. In a symmetric equilibrium, intermediaries have identical sales, with $x_i = X_I/N$ and the optimal price paid by the intermediary is

$$p = \frac{N(k-1)}{N(k-1)+1} p_w m. \tag{3.1}$$

Under perfect competition prices equal costs, $p = p_w m$, and the full world price (net of trade costs) is transmitted to the farmers. When intermediaries are oligopsonistic (i.e.N and k are finite), farmers receive a smaller share of the world price:

$$\text{Farmer Share} \equiv \frac{p}{p_w m} = \frac{N(k-1)}{N(k-1)+1} < 1$$

In the extreme cases of infinite entry ($N \to \infty$) or a perfectly equal land distribution ($k \to \infty$), prices do not change the extent to which farmers alter their supply to intermediaries, so the full world price is transmitted to farmers.

Ignoring the integer constraint, free entry of intermediaries ensures profits are driven down to the entry cost. The free entry condition determines the equilibrium number of intermediaries as:

$$\pi_i = \frac{k}{k-1}\frac{1}{N}\frac{a_{\min}^k p^k}{N(k-1)}\left[(p_h s)^{-k+1} - (\theta r/(\delta-1))^{-k+1}\right] = rf. \tag{3.2}$$

where the price paid by the intermediaries is given by Equation 3.1. The number of intermediaries rises with export receipts $p_w m$ and falls with alternative cropping receipts and entry costs. We summarize these observations for farm incomes in Proposition 1 below.

Proposition 1. *(1) Intermediaries behave oligopsonistically when there are few intermediaries and an unequal land distribution (N and k are finite).*
(2) The share of the export price transmitted by intermediaries to farmers rises with more intermediaries and greater land equality (Farmer Share rises with N and k).
(3) The elasticity of the farmer share with respect to world prices is proportional to the elasticity of the number of intermediaries:
$d\ln \textit{Farmer Share}/d\ln p_w = (d\ln N/d\ln p_w)/(N(k-1)+1)$.

3.2.3. *Agribusiness Payments.* The total supply of export crops to agribusinesses is $X_B = \int_{a_l}^{\infty} adG(a) = \frac{k}{k-1}a_{\min}^k a_l^{-k+1}$. Assuming each farmer matches with different agribusinesses with equal probability, the total purchases of agribusiness b from small farmers is

$$x_b \equiv \int 1_{a \text{ meets } b} adG(a) = X_B/M.$$

The matching assumption captures the observation that small farmers typically have access to monopsonistic buyers due to government policies such as monopsony licenses, zoning regulations and minimum distance rules. Macchiavello and Morjaria (2015) explain the rationale for these policies by showing that competition among coffee mills in Rwanda undermined relational contracts between mills and farmers, leading to lower farmer welfare and reduced quality of the delivered produce.

As discussed earlier, farmers receive their reservation income $T(a,b) = \delta pa - \theta r$ from agribusinesses. Substituting for this in the profit function of the agribusiness, the optimal capital investment in quality is $q = [\beta p_w m_b B/Mr]^{1/(1-\beta)}$, which increases with the size of the agribusiness. These quality investments directly benefit small farmers who through δ. But the quality investments indirectly lower the farmer's

income as they drive up the cost of capital which is needed for selling the export crops.

3.2.4. *Market Equilibrium.* Having explained the income decisions, we determine the number of intermediaries and the rental rate in the economy. The number of intermediaries N is determined by the free entry condition (Equation 3.2). The rental rate is determined by capital market clearing which implies $Mq + Nf = \bar{K}$. Substituting for the optimal quality investment, the rental rate is determined by:

$$M\left[\beta p_w m_b B/Mr\right]^{1/(1-\beta)} + Nf = \bar{K}. \tag{3.3}$$

Given N, entry costs rf increase with the number of agribusinesses M and their sales B/M. The entry decision of intermediaries and the investment decision of agribusinesses are interrelated through the capital market, and this is reflected in the reservation income of small farmers. The size of the agribusiness has detrimental effects on the earnings of small farmers. An increase in the agribusiness' own farm size lowers entry of intermediaries and increases the rental rate, leading to a fall in the earnings of small farmers.

3.3. **The Impact of World Price Changes.** Having determined the market equilibrium, we examine how a change in the world price of the export crop affects the earnings of small farmers. We start with a discussion of changes in entry and rents, and then discuss the impact on earnings of each type of farmers.

From the free-entry condition of Equation 3.2,

$$\left(2 - \frac{k}{N(k-1)+1}\right)\frac{d\ln N}{d\ln p_w} = k - \left(1 - \frac{(k-1)\left(\theta r/\left(\delta-1\right)\right)^{-k+1}}{\left(p_h s\right)^{-k+1} - \left(\theta r/\left(\delta-1\right)\right)^{-k+1}}\right)\frac{d\ln r}{d\ln p_w}. \tag{3.4}$$

The direct effect of a rise in p_w is to increase entry through higher export earnings. The indirect effect is to decrease entry through a rise in the entry cost which depends on the change in the rental rate of capital.

From capital market clearing, the change in the rental rate of capital is $\frac{Mq}{1-\beta}\frac{d\ln r}{d\ln p_w} = \frac{Mq}{1-\beta} + Nf\frac{d\ln N}{d\ln p_w}$. Substituting for the change in entry from Equation 3.4 and letting $\kappa \equiv \frac{Mq}{1-\beta} + \frac{Nf}{2-\frac{k}{N(k-1)+1}}\frac{(p_h s)^{-k+1} - k(\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1} - (\theta r/(\delta-1))^{-k+1}}$, the rental rate rises with an increase in

the world price because

$$\frac{d\ln r}{d\ln p_w} = \left(\frac{Mq}{1-\beta} + \frac{kNf}{2-\frac{k}{N(k-1)+1}}\right)/\kappa \tag{3.5}$$

As world prices rise, agribusinesses make greater investments in quality. Entry also rises with world prices because the direct effect of higher earnings dominates the indirect effect of an increase in the competition for capital. More intermediaries enter when world prices are higher, because they expect to earn higher profits. This increases competition for scarce capital, and rental rates increase further. Solving for Equations 3.4 and 3.5, entry rises with world prices because

$$\frac{d\ln N}{d\ln p_w} = \frac{k-1}{2-\frac{k}{N(k-1)+1}} \frac{(p_h s)^{-k+1}}{(p_h s)^{-k+1} - (\theta r/(\delta-1))^{-k+1}} \frac{Mq}{1-\beta}/\kappa. \tag{3.6}$$

The rise in the rental rate reduces the trickle down of world price increases to farmer incomes due to lower entry of intermediaries. The net effect of higher world prices is to increase the number of intermediaries. As a result, farmers selling to intermediaries experience a rise in the share of the export incomes they receive from intermediaries. The elasticity of the share of the export price transmitted by intermediaries to farmers is

$$\frac{d\ln p/p_w m}{d\ln p_w} = \frac{1}{N(k-1)+1}\left(\frac{d\ln N}{d\ln p_w}\right) \geq 0$$

We summarize this in Proposition 2 below.

Proposition 2. *A rise in the world price of the export crop increases competition for capital ($d\ln r/d\ln p_w > 0$), which dampens the entry of intermediaries. The net effect is a rise in the number of intermediaries ($d\ln N/d\ln p_w > 0$), which increases the share of the export price transmitted by the intermediaries to farmers ($d\ln$ Farmer Share$/d\ln p_w > 0$).*

Subsistence farmers are unaffected by the rise in world prices. But farmers selling through agribusinesses are affected through the change in the price paid by the intermediaries and the rise in the rental rate of capital. A farmer transacting with an agribusiness earns her reservation income of $T(a,b) = \delta\frac{N(k-1)}{N(k-1)+1}p_w ma - \theta r$.Differentiating $T(a,b)$ with respect to world prices, the trickle-down effect of world

price changes into farmer incomes is as follows:

$$\frac{d\ln T(a,b)}{d\ln p_w} = \underbrace{\frac{\delta\frac{N(k-1)}{N(k-1)+1}p_w ma}{T(a,b)}}_{\text{Direct Effect on Intermediary Prices}}\left[1+\underbrace{\frac{1}{N(k-1)+1}\frac{d\ln N}{d\ln p_w}}_{\text{Indirect Effect on \#Intermediaries}}\right. \left.\underbrace{-\frac{\theta r}{T(a,b)}\frac{d\ln r}{d\ln p_w}}_{\text{Indirect Effect on Non-Export Profits from Capital Market}}\right].$$

The world price directly affects how much intermediaries receive from sales of the export crop, which in turn is reflected in the price that is paid to farmers. This is the first term in the expression above. The second and third terms are the indirect effects of world price changes. An increase in the world price alters the profitability of intermediation and this is captured in the second term which contains the elasticity of the number of intermediaries with respect to world price. The third term reflects the competition for limited capital resources. An increase in the world price alters the number of intermediaries and the investments of agribusinesses, which change the rental rate of capital. We summarize these channels in Proposition 3 below.

Proposition 3. *When a farmer sells through an agribusiness, the elasticity of the farmer's income wrt world prices consists of: (1) a positive direct effect of a change in world price of the export crop on the export revenue earned by intermediaries, (2) a positive indirect effect on the number of intermediaries, and (3) a negative indirect effect on the cost of farming the non-tradable crop.*

For θ close to zero, farmers selling through agribusinesses and farmers selling through intermediaries experience the same trickle down of world prices into their incomes. When $\theta > 0$, farmers selling through agribusinesses cannot immediately divert their harvest to intermediaries. They need to incur some capital costs to take their harvest to the market in the event of a disagreement with their agribusiness. The rise in the rental rate of capital inputs therefore worsens the outside option of the farmers.

To understand the underlying economic channels determining the extent of trickle-down, we discuss the earnings under $\theta = 0$ and $\theta > 0$. When $\theta = 0$, earnings of farmers selling through agribusinesses is affected by rental rates only through the number of intermediaries and not directly. The entry response of intermediaries is decreasing in Nf because:

$$\frac{d\ln N}{d\ln p_w} = \frac{k-1}{2-\frac{k}{N(k-1)+1}}\frac{Mq}{1-\beta}\Big/\left(\frac{Mq}{1-\beta}+\frac{Nf}{2-\frac{k}{N(k-1)+1}}\right).$$

The returns to quality decline as agribusinesses invest more and more capital. So more intermediaries can enter when the share of capital use by agribusinesses is high relative to the capital use by intermediaries. This occurs when entry cost f is relatively low and the size of agribusinesses b is relatively high which ensure Nf is low. The pass-through of world prices into prices received by farmers who sell through intermediaries ranges from 1 to $\frac{2N(k-1)+1}{2N(k-1)-(k-2)}$. This is the effect from oligopsonistic intermediaries which shows that the change in the share of export earnings passed through to consumers is $d\ln \text{Farmer Share}/d\ln p_w \in \left(0,\ \frac{k-1}{2N(k-1)-(k-2)}\right)$.

Once we build in the interconnections through competition for scarce capital, the trickle down effects for farmers selling through agribusinesses depend crucially on the capital costs incurred to divert the harvest to the market through θ. A rise in the world price disproportionately increases the rental rate of capital inputs, and this implies that essential inputs required for diverting the export crop become more scarce. Farmers lose from a rise in the world price as their ability to earn profits from the export crop declines. The trickle down effect would be negative for high levels of capital requirement θ and greater than one for low levels of θ. Agribusinesses gain at the expense of the small farmers as θ rises. The negative trickle down rises with the size of the agribusiness. This is because a bigger agribusiness makes larger capital investments which intensifies competition for scarce capital. Higher entry costs also increase competition for capital and the losses are bigger. We summarize this result in Remark 4.

Remark 4. The trickle-down effect of world price changes to incomes of farmers selling through agribusinesses falls with the capital required to divert the export crop to intermediaries in the event of a disagreement with the agribusiness. For

$\theta = 0$, the elasticity of farmer incomes to world prices is greater than one. For $\theta > 0$, increases in world prices can have a negative trickle down effect, and the loses to farmers rise with the size of agribusiness and with the entry costs of intermediaries.

The trickle down effect of agribusinesses is lower than the trickle down effect of intermediaries when farmers need capital inputs to divert their export crops away from the agribusiness. The capital requirement θ is crucial in determining the extent to which farmers share with agribusinesses in the gains from trade. The next Section examines this empirically by estimating the difference in the trickle down rates of intermediaries and agribusinesses. For $\theta > 0$, farmers selling through intermediaries see a higher trickle down rate of world prices changes into their incomes, compared to farmers selling through agribusinesses. We will test this in the next Section, but before proceeding to the empirics, we extend the model to allow for capital inputs in subsistence farming and quality investments that vary with the size of farmers selling through agribusinesses.

3.4. **Extension: Capital Inputs for the Non-tradable Crop.** We have assumed unit now that the capital input is needed to sell export crops but not the non-tradable crop. This is likely to capture capital inputs such as port facilities that are specific to the export crop. There might be other capital inputs, such as credit collateral, that are needed for selling both the export crop and the non-tradable crop. We now extend the model to include capital requirements for the non-tradable crops. Let α denote the units of capital needed to grow or sell the non-tradable crop. Then farmers earn $p_h s - \alpha r$ from the non-tradable crop.

The key difference from the equilibrium earlier is that capital market clearing changes to $Mq + Nf + \alpha G(a_s) = \bar{K}$. The rest of the analysis is similar, and the qualitative results are similar to Propositions 1, 2 and 3. We now get a new result that subsistence farmers see an absolute reduction in their incomes when the world price of the export crop rises ($d\left(p_h s - \alpha r\right)/dp_w < 0$). This is because the rise in the world price bids up the rental rate of capital. As capital is needed for non-tradable crops, farmers growing the non-tradable crop are worse-off. We summarize this result in Proposition 5 below, and details are provided in the Appendix.

Proposition 5. *Earnings of small farmers growing the non-tradable crop fall with a rise in the world price of the export crop.*

This result is consistent with Brambilla and Porto (2011) which finds that failure of outgrower schemes between Zambian cotton farmers and monopsonistic agribusinesses caused farmers to move back to subsistence farming, and led to reductions in cotton yields of over 40%.

4. Testing for Differences in the Trickle Down Effects

This Section compares the trickle down rate of world prices into farmer earnings across the types of buyers that the farmers sell to. We use data from a household panel collected during three surveys in Kenya during 2000, 2004, and 2007. We start with an explanation of why Kenya is a suitable application for our analysis. Then we discuss the stylized facts of smallholder farming in the context of Kenyan agriculture. Finally, we estimate the trickle down effects from small traders and large agribusinesses to farmers.

4.1. **Kenyan farming.**

The application to Kenyan agriculture captures the institutional context of small farmers selling through intermediating exporters and agribusinesses in an economy that is highly dependent on agriculture. Kenya is a lower middle-income country in sub-Saharan Africa, where agriculture makes up 25% of GDP and 75% of the labor force.[2] Exports from the agricultural sector make up about two-thirds of the total exports of Kenya. About 80% of Kenya's population lives in rural areas and depends on agriculture directly or indirectly. A majority of the rural labor force is in smallholder farming, and our dataset consists of households that own less than 50 acres of land. The median household owns less than 5 acres of land, and earns Ksh 1,430 per month which is roughly USD 19.3.[3]

While a vast majority of people continue to be employed in agriculture, productivity growth has been slow and yields per acre of land are low. Kenyan agriculture typifies the broad debate on how to cope with declining agricultural productivity in

[2]http://www.fao.org/fileadmin/user_upload/fsn/docs/Ag_policy_Kenya.pdf

[3]For comparison, the average household expenditure per adult equivalent per month is Ksh2,270 in rural areas of Kenya. Source: http://inequalities.sidint.net/kenya/abridged/consumption-expenditure/

TABLE 2. The number of households surveyed

Year of survey	Number of households surveyed
2000	1,512
2004	1,397
2007	1,342

TABLE 3. The number of times each household was surveyed

#of times	% of households
1	10.1
2	5.4
3	84.5

a predominantly smallholder agricultural economy. A principal solution proposed to address this problem is to encourage large scale agribusinesses to improve the inputs and technologies used in farming and to expand revenues through access to markets (Collier and Dercon 2014). We inform this debate by examining the extent to which agribusinesses differ from small traders in sharing the gains from access to world markets with farmers. The Kenyan survey records the type of buyer that each farmer sells to, which allows us to disentangle the trickle down rates across different types of buyers.

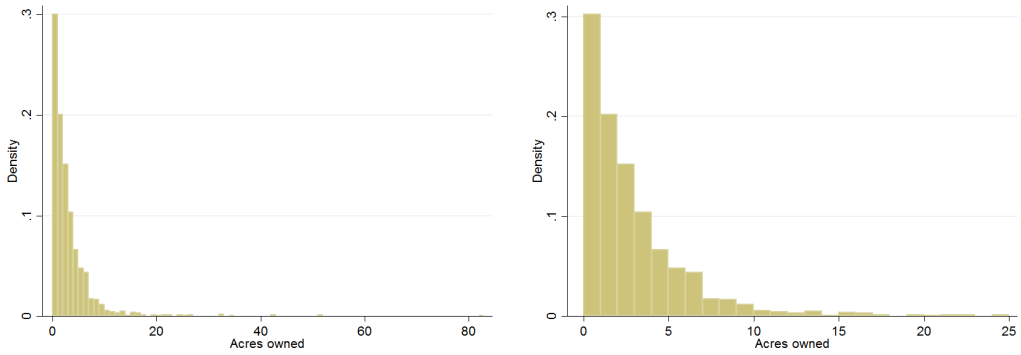
4.2. **Data.** The survey was implemented by the Tegemeo Institute of Egerton University in Nairobi. The sampling frame was designed in consultation with the Kenya National Bureau of Statistics. The surveys randomly sample over 1,300 rural households that represent eight different agricultural-ecological zones in Kenya (see Chamberlin and Jayne 2013 for details of the stratified random sampling). The frequency of households surveyed across different rounds is summarized in Tables 2 and 3. The attrition rates of the original sample are low (less than 10 percent) compared to similar surveys in developing countries, which can have attrition rates as high as 20% (Suri et al. 2009) or even 50% in the World Bank's LSMS datasets.

4.3. **Summary statistics for Kenyan farming.** Section 2 documented that developing country agriculture is dominated by a large number of farmers with small land holdings. This is a characteristic of farming in Kenya, as shown in Table 4 which

TABLE 4. Summary statistics for income from farming and acres owned by households

	Mean	Median	S.D.	Min	Max	#obs
Acres owned	3.3	2.1	6.6	0.0	250.1	4,251
Farm income (current USD)	734.2	231.4	2,165.6	0.0	94,943.9	4,251

FIGURE 4.1. Distribution of acres owned by farmers in 2000



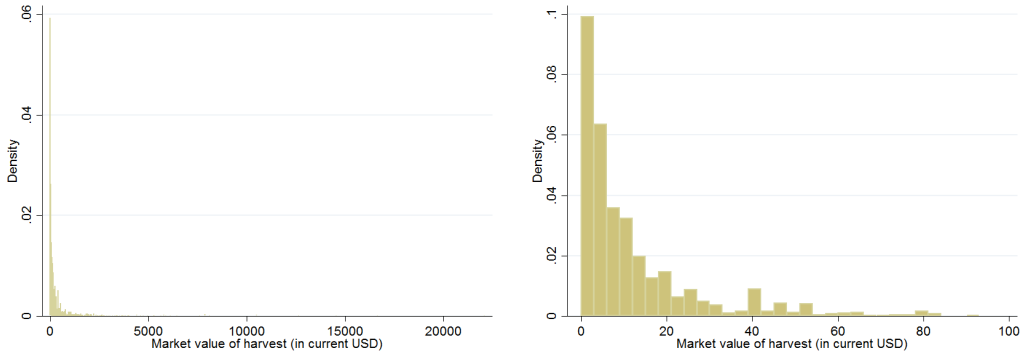
(A) All farmers (B) Farmers with <25 acres

contains summary statistics for the acres owned by the household and their yearly income from farming. Most households own small farms, with a median ownership of 2.1 acres. Figure 4.1 shows the distribution of farm size which is highly skewed. This is also reflected in the distribution of farm incomes. Figure 4.2 shows that the vast majority of farmers earn less than USD 100 per year.

The main crops for farmers in Kenya are maize, tea, sugarcane, coffee cherries, bananas, wheat and tomatoes. We define the main crop as the crop that provides the highest income share for the household. Maize is the most important main crop every year and the ranking of the other main crops changes slightly across years. Table 5 contains the percentage of households that grow each crop as their main crop in 2000, and Table 6 provides the ranking of each crop by average share of household income in each year.

Farmers can sell their produce to a number of different types of buyers. We categorize the buyers into four types - consumers, cooperatives, small traders and

FIGURE 4.2. Distribution of market value of harvest for all farmers in 2000



(A) All farmers (B) Farmers earning <$100

TABLE 5. Ranking of main crops by percentage of households getting their highest income from the crop in 2000

Main crop	% of households
Maize dry	15.0
Tea	12.1
Sugarcane	10.1
Coffee cherries	9.7
Bananas	8.5
Wheat	4.3
Tomatoes	2.9

TABLE 6. Share of income from main crop as an average across households in 2000

Main crop	% Income from crop
Maize dry	23.1
Tea	14.5
Sugarcane	11.8
Coffee cherries	5.5
Bananas	4.6
Wheat	7.1
Tomatoes	4.9

TABLE 7. Frequency and percentage of households across buyer types in each year

Buyer types	year							
	2000		2004		2007		Total	
	No.	Col %	No.	Col %	No.	Col %	No.	Col %
Consumer	194	14.6	173	13.3	194	15.5	561	14.5
Cooperative	162	12.2	60	4.6	84	6.7	306	7.9
Small trader	631	47.4	766	59.0	541	43.2	1,938	49.9
Large firm	344	25.8	299	23.0	432	34.5	1,075	27.7
Total	1,331	100.0	1,298	100.0	1,251	100.0	3,880	100.0

large firms. A large firm refers to any one of the following: large company, miller, Kenya Tea Development Agency Holding Ltd (which is one of the largest private tea management agencies in Kenya) or the National Cereals and Produce Board of Kenya (which is one of the largest commodity trade and grain management corporations in Kenya). Table 7 shows the share of the sample selling through different buyers. About 15 per cent of the farmers sell directly to consumers and a small share sell mainly to cooperatives. The bulk of the sales are to firms - small traders and large firms. Within the category of large firms, most farmers sell to large companies as shown in Table 8. Table 9 shows that the bigger farmers in terms of acreage and incomes tend to select into selling through large firms, so there is positive assortative matching of farmers and firms.

Finally, we supplement the household survey with international price data for the crops. Our baseline specifications use COMTRADE international trade data for the crops reported as produced by the households in Kenyan data. For each year, we have the following information about the world exports of the different products (6-digit level HS96 classification): country that exports, quantity traded and value traded. With this information, we compute the average international price p^w of a given crop, using the value of the transactions as weights. Table 10 summarizes the international prices of the main crops in each year. Having computed the international price p^w, we match these to the crops reported by the households.

While the COMTRADE data provides unit values, we can also get annual prices in US dollars for many primary products from the World Bank's Pink Sheet (World

TABLE 8. Frequency of households across large buyers in each year

Large buyers	year 2000 No.	2004 No.	2007 No.	Total No.
Large company	169	91	118	378
Kenya Tea Development Agency Holdings Ltd	153	173	182	508
National Cereals and Produce Board	11	11	15	37
Miller	3	24	34	61
Exporter	0	0	14	14
Processor	0	0	60	60
Pyrethrum board	0	0	1	1
National Irrigation Board	7	0	8	15
Other institutions	1	0	0	1
Total	344	299	432	1,075

TABLE 9. Average acres owned and average household income received across buyer types in each year

Buyer types	year 2000	2004	2007	Total
Acres owned				
Consumer	2.1	2.6	3.1	2.6
Cooperative	2.3	2.0	1.5	2.0
Small trader	3.4	3.5	3.2	3.4
Large firm	4.1	4.7	4.6	4.5
Farm income (current USD)				
Consumer	172.4	187.8	285.7	216.3
Cooperative	807.2	421.1	493.6	645.4
Small trader	670.0	483.6	437.5	531.4
Large firm	1,527.3	1,458.9	1,855.9	1,640.3

Bank Commodity Price Data). The crops for which these data are available include maize, banana, coffee, rice, sorghum, soybeans, sugar, tea, tobacco, wheat and barley. The Pink Sheet price data are compiled from a variety of sources. The prices of maize, rice, sorghum, soybeans, tobacco, wheat and barley are based primarily on the data from the US Department of Agriculture. The prices of banana are based on the information provided by the Food and Agriculture Organization, the US

TABLE 10. Summary statistics for the international prices of the main crops produced in Kenya

Main crop	International prices (in current USD)					
		2000		2004		2007
	$p^w_{Comtrade}$	p^w_{WB}	$p^w_{Comtrade}$	p^w_{WB}	$p^w_{Comtrade}$	p^w_{WB}
Maize dry	10.79	88.53	1.30	111.80	1.58	163.66
Tea	2.86	1.81	3.56	1.72	5.21	1.92
Sugarcane	0.65	0.56	0.99	0.67	0.61	0.68
Coffee cherries	2.17	1.92	2.30	1.77	3.85	2.72
Bananas	0.42	0.71	0.61	0.89	0.59	1.04
Wheat	23.18	98.91	0.16	144.44	0.24	238.59
Tomatoes	0.95	NA	0.97	NA	1.37	NA

Bureau of Labor Statistics, among others. The prices of coffee are obtained from the International Coffee Organization, the prices of sugar are from the International Sugar Organization, and the prices of tea are from the Sri Lanka Tea Board, the Tea Board of India, and the International Tea Committee etc. Although the information is not as complete as that from COMTRADE (which has about 100 crop prices per year), these prices cover the most important crops in terms of value and ubiquity of production. The correlation between the two prices is positive but low (0.152).

4.4. **Empirical Strategy.** Having described the main features of Kenyan framing, we examine whether farmers selling through agribusinesses see a higher trickle down effect of world price changes to their incomes. For each household i, the trickle down of world prices to farmer incomes is estimated as:

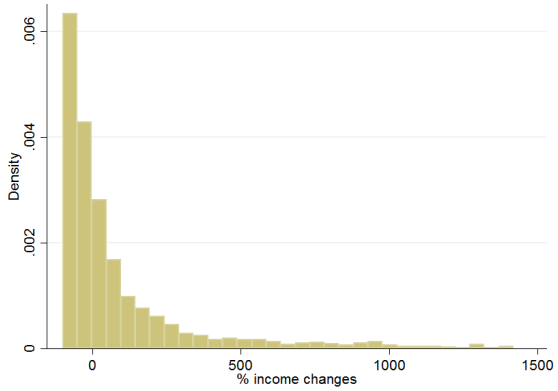
$$\ln(income_{it}) = \alpha_i + \alpha_t + \beta \ln p_{it} + \sum_k BuyerType_k + \sum_k \ln p_{it} \cdot BuyerType_k + \varepsilon_{it} \quad (4.1)$$

where $income_{it}$ is the income from farming received by household i in year t, and p_{it} is the world price faced by the household in that year. Since the surveys report the sales revenues for each crop, we first aggregate the revenues to obtain the household incomes. We then compute the world price p_{it} as a weighted average of the international prices of all crops grown by the household. Our baseline specifications use the concurrent income shares of the crops as the weights. More specifically, the world

TABLE 11. Summary statistics for variables in the baseline regressions

	Mean	Median	S.D.	Min	Max	#obs
Log household income	9.74	9.94	1.81	3.04	15.67	3,879
Log price (Comtrade, concurrent weight)	0.37	0.18	0.98	-3.59	5.14	3,830
Log price (WB, concurrent weight)	2.10	2.34	2.24	-5.66	8.00	3,196

FIGURE 4.3. Distribution of percentage changes of household incomes

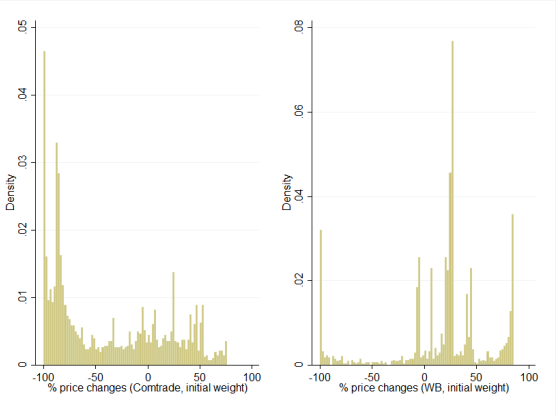


price faced by household i in year t is constructed as $p_{it} = \sum_a \omega_{ait} p^w_{at,Comtrade}$, where ω_{ait} is the concurrent income share of crop a in household i, and $p^w_{at,Comtrade}$ is the COMTRADE international price of the same crop. We also constructed the world prices from the international prices reported by the World Bank's Pink Sheet, $p^w_{at,WB}$, and use these price variables as a robustness check of our baseline regressions. The variables are described below, and then we proceed to the baseline estimates and the robustness checks.

4.4.1. *Variable Summary.* Table 11 contains the summary statistics for household incomes and prices used in estimating Equation 4.1 and Figures 4.3 and 4.4 graph the variation in incomes and prices in our sample. The household level price changes shown in Figure 4.4 hold the weight of each crop constant to illustrated the variation in world prices of the crops.

4.4.2. *Baseline Estimates.* Having described the variables, we proceed to the baseline results examining how the trickle down effects vary across intermediaries and large

FIGURE 4.4. Distribution of percentage changes of prices



agribusinesses. The results of the baseline specifications are reported in Table 13. Column (1) contains the cross-sectional results to show the correlations between income changes and price changes for the households. Column (2) adds household fixed effects and year fixed effects to focus on changes within a household and to net out economy-wide changes. The average trickle down rate is 4% but it is imprecisely estimated. Columns (3) and (4) show that the trickle down rates vary by the type of buyer that the farmer sells to, as expected from the theory. Column (4) contains our preferred specification with household fixed effects and year fixed effects. We find that on average, a 1 percentage point increase in world prices faced by a household change the household's income by 0.239% when the farmer sells directly to consumers. Farmers that sell indirectly have higher incomes as reflected in the premia estimated on selling through small traders, large firms and cooperatives. But the farmers selling through small traders barely see any further trickle down of world price changes into their incomes, as shown in the statistically insignificant and small coefficient on the interaction between $\ln p_{it}$ and the indicator variable for selling mainly through small traders $Small_{it}$. Large firms pay an even bigger premium to farmers as seen in the positive coefficient on $Large_{it}$. This could be due to cherry-picking of bigger farmers by agribusinesses or due to productivity spillovers from agribusinesses. The trickle down effect from large agribusinesses to farmers is however much smaller than that from small traders or consumers, as seen in the negative coefficient on the interaction between $\ln p_{it}$ and the indicator variable for selling mainly through large

TABLE 12. Baseline results: Average COMTRADE prices weighted by concurrent income shares

Dependent variable: $\ln(income_{it})$				
	(1)	(2)	(3)	(4)
$\ln p_{it}$	0.468***	0.0380	0.482***	0.239***
	(0.0325)	(0.0321)	(0.0695)	(0.0771)
$Small_{it}$			1.073***	0.639***
			(0.0859)	(0.0849)
$Large_{it}$			2.765***	1.784***
			(0.0902)	(0.109)
$Coop_{it}$			1.074***	0.502***
			(0.196)	(0.181)
$\ln p_{it} \cdot Small_{it}$			-0.154*	-0.131
			(0.0792)	(0.0814)
$\ln p_{it} \cdot Large_{it}$			-0.401***	-0.477***
			(0.0813)	(0.0907)
$\ln p_{it} \cdot Coop_{it}$			0.0949	0.173
			(0.201)	(0.147)
Constant	9.615***		8.291***	
	(0.0401)		(0.0772)	
Household FE α_i	No	Yes	No	Yes
Year FE α_t	No	Yes	No	Yes
N	3830	3646	3830	3646
R^2	0.068	0.724	0.302	0.768

Prices used: $p^w_{Comtrade}$. Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

firms $Large_{it}$. This shows that the extent to which farmers can divert their incomes away from large firms to small traders is limited. In terms of the theory, we can reject the null hypothesis that $\theta = 0$ which implies that farmers cannot fully divert their produce for sales to world markets outside of their relationship with agribusinesses.

4.4.3. *Robustness.* We look at two robustness checks. First, we change the price variables from unit values in COMTRADE to price data collected by the World Bank. Second, we examine a different weighting scheme for the different crops grown by the household.

TABLE 13. Robustness: Average World Bank prices weighted by concurrent income shares

Dependent variable: $\ln(income_{it})$				
	(1)	(2)	(3)	(4)
$\ln p_{it}$	0.0738***	0.00608	0.130***	0.0428
	(0.0151)	(0.0207)	(0.0324)	(0.0351)
$Small_{it}$			0.951***	0.530***
			(0.125)	(0.125)
$Large_{it}$			2.520***	1.767***
			(0.121)	(0.154)
$Coop_{it}$			1.071***	0.521***
			(0.167)	(0.173)
$\ln p_{it} \cdot Small_{it}$			-0.00552	0.00625
			(0.0367)	(0.0369)
$\ln p_{it} \cdot Large_{it}$			-0.0774**	-0.136***
			(0.0388)	(0.0431)
$\ln p_{it} \cdot Coop_{it}$			0.0931	0.0883
			(0.0714)	(0.0650)
Constant	9.997***		8.549***	
	(0.0528)		(0.108)	
Household FE α_i	No	Yes	No	Yes
Year FE α_t	No	Yes	No	Yes
N	3196	2933	3196	2933
R^2	0.011	0.727	0.273	0.766

Prices used: p^w_{WB}. Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

World Bank Prices. Table 13 contains the results using World Bank prices of crops to construct the price variable on the RHS of the estimating equation. The main results are similar - farmers selling through agribusinesses earn a premium but get lower trickle down effects of world price changes into their incomes. The coefficients on the premia and the trickle down rates are smaller, but this might have to do with higher average price levels recorded in the World Bank data.

Weighting of Crop Prices. While our interest is in estimating the trickle down of world prices changes to farmer incomes, households are likely to adjust production in response to price changes so that concurrent income shares as weights may overstate

price movements by placing more weights on those crops with rising prices. To test the robustness of our baseline results, we use the initial income shares in 2000 to construct the world price changes of Equation 4.1. With constant shares across time, all the within household variation in $\ln p_{it}$ comes from the changes in world prices of individual crops. Table 14 confirms the baseline result that large firms are associated with higher income premia for farmers, but lower trickle-down effects of world price changes into farmer incomes. This is reassuring but unsurprising because the correlation between initial crop weights and concurrent crop weights (used in Table 13) is high (0.755).

An additional finding of Table 15 is that the coefficient on the interaction between world price changes and the indicator for farmers selling mainly through cooperatives is more precise and positive. Farmers selling through cooperatives have much higher trickle down effects. In the baseline results of Table 12, farmers selling through cooperatives earn a premium over direct sales. But the higher trickle down effect from cooperatives is not precisely estimated.

We also re-examine the main results using World Bank prices and initial crop shares as weights to construct the price variable for households. Table 15 shows that large agribusinesses are associated with higher income premia but lower trickle down rates.

Based on Tables 12, 13, 14 and 15, we find that farmers selling through large agribusinesses earn higher incomes, but they do not share as much in the gains from trade arising from higher prices in world markets. The income premia of farmers selling through agribusinesses might reflect positive assortative matching or productivity spillovers from large agribusinesses. Compared to farmers selling through small traders, farmers who sell through large agribusinesses have trickle down rates that are 13 to 48 percent lower. Therefore, the extent to which farmers are locked into their relationships with large farmers matters and constrains their ability to fully benefit from changes in the prices of agricultural products in the world market.

4.4.4. *Variance of Income of Farmers by Buyer Types.* We find that the trickle down rate is lower for agribusinesses, and interpret it as farmers getting lower than the full potential gains from trade. But one reason for lower trickle down from agribusinesses

TABLE 14. Robustness: Average COMTRADE prices weighted by initial income shares

Dependent variable: $\ln(income_{it})$				
	(1)	(2)	(3)	(4)
$\ln p_{it}$	0.360***	0.115***	0.271***	0.190***
	(0.0286)	(0.0290)	(0.0617)	(0.0607)
$Small_{it}$			1.109***	0.633***
			(0.0937)	(0.0901)
$Large_{it}$			2.669***	1.694***
			(0.0991)	(0.115)
$Coop_{it}$			1.054***	0.484***
			(0.144)	(0.149)
$\ln p_{it} \cdot Small_{it}$			-0.0102	-0.0321
			(0.0695)	(0.0649)
$\ln p_{it} \cdot Large_{it}$			-0.132*	-0.291***
			(0.0731)	(0.0735)
$\ln p_{it} \cdot Coop_{it}$			0.306**	0.385***
			(0.124)	(0.103)
Constant	9.773***		8.380***	
	(0.0408)		(0.0869)	
Household FE α_i	No	Yes	No	Yes
Year FE α_t	No	Yes	No	Yes
N	3492	3336	3492	3336
R^2	0.060	0.729	0.296	0.772

Prices used: $p^w_{Comtrade}$. Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

could be that they provide a lower variance in incomes for farmers. Farmers would choose to trade off their income changes for lower variance in incomes if they are risk averse. In this case, an insurance motive would be driving the lower trickle down effects from Large Firms. To examine this, we look at the variance in income of each farmer over the three time periods in our sample.

Table 16 shows that the variance in income for the average household that sells to Large Firms is an order of magnitude higher than the average farmer who sells to Small Traders. This is true whether we look at the household income from all crops or the household income from a given crop. Table 17 regresses the variances on

TABLE 15. Robustness: Average World Bank prices weighted by initial income shares

Dependent variable: $\ln(income_{it})$				
	(1)	(2)	(3)	(4)
$\ln p_{it}$	0.0832***	0.395***	0.0557	0.288***
	(0.0183)	(0.0647)	(0.0392)	(0.0627)
$Small_{it}$			0.958***	0.490***
			(0.123)	(0.110)
$Large_{it}$			2.552***	1.810***
			(0.123)	(0.146)
$Coop_{it}$			1.102***	0.545***
			(0.168)	(0.185)
$\ln p_{it} \cdot Small_{it}$			0.0722*	0.0335
			(0.0423)	(0.0374)
$\ln p_{it} \cdot Large_{it}$			-0.00202	-0.130***
			(0.0439)	(0.0460)
$\ln p_{it} \cdot Coop_{it}$			0.158*	0.0196
			(0.0911)	(0.0814)
Constant	9.972***		8.539***	
	(0.0536)		(0.110)	
Household FE α_i	No	Yes	No	Yes
Year FE α_t	No	Yes	No	Yes
N	2913	2791	2913	2791
R^2	0.013	0.729	0.278	0.771

Prices used: p^w_{WB}. Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

indicators for each buyer type to examine if Large Firms provide systematically lower variance in incomes. The omitted category is direct sales to Consumers. Columns (1) and (2) refer to total household income from all crops and Columns (3) and (4) refer to household income from a given crop. Columns (2) and (4) are our preferred specifications, as they contain district fixed effects and crop-district fixed effects. Comparing farmers within a district, farmers selling to Large Firms do not have a systematically lower variance in income from all their crops. Comparing farmers that grow the same crop in the same district but to different buyers, we find that farmers selling through Large Firms do not have a lower variance in income relative to farmers

TABLE 16. Summary Statistics for the Variance in Income of Households Over Time by Buyer Type

	Variance in Income per Household			Variance in Income per Hh-Crop		
Buyer Type	#Obs	Mean	Std. Dev.	#Obs	Mean	Std. Dev.
Consumer	173	289,594.3	1,443,490.3	560	28,733.1	319,525.1
Cooperative	156	678,850.8	3,350,227.3	818	62,267.0	392,498.0
Small trader	581	720,489.4	3,785,516.5	2,569	83,416.7	1,176,473.9
Large firm	328	6,132,241.7	68,053,554.5	1,462	768,650.8	13,810,829.3
Total	1,238	2,088,837.0	35,193,893.6	5,409	259,768.9	7,233,009.9

selling through Small Traders. Therefore, the lower trickle down rate of large firms is unlikely to be a reflection of higher welfare for farmers through greater insurance. This conforms with the anecdotal evidence mentioned earlier that small farmers in developing economies have limited recourse to getting their contracts reinforced after the harvest.[4]

5. Conclusion

Agricultural markets in developing economies typically consist of a large number of small farmers who sell their produce through intermediaries and big agribusinesses with market power. We develop a flexible approach to embed the complexity of the industrial organization of agricultural markets.

Incorporating a richer market structure shows that a small farmer receives a greater share of the world price when there is greater equality in land ownership and more competition among intermediaries. Farming by large agribusinesses increases farm incomes through productivity transfers. But agribusinesses also increase competition for scarce capital, which is necessary for marketing farm produce. These conflicting forces imply that the trickle down effect of increases in world commodity prices ranges from negative to greater than one, depending on the degree to which small farmers are locked into their relationship with big agribusinesses.

Testing for the degree of lock-in of small farmers to agribusinesses in Kenyan farming, we find that farmers selling through large firms have higher incomes but

[4]When we use the coefficient of variation (CV) in income as a dependent variable, farmers selling through large firms tend to have CVs that are statistically indistinguishable from CVs of farmers selling through small traders.

TABLE 17. Robustness: Variance in Income by Buyer Type

	$\ln(Variance\,in\,income_{it})$			
	(1)	(2)	(3)	(4)
Cooperative	389256.5	3311681.7	33533.9*	188402.0
	(289366.3)	(2385106.1)	(19244.8)	(135065.1)
Small trader	430895.2**	-962489.5	54683.6**	-188400.5
	(191612.8)	(1098332.2)	(26852.9)	(154476.5)
Large firm	5842647.4	7689823.3	739917.6**	823882.4
	(3759570.5)	(5801964.3)	(361460.7)	(551124.6)
Constant	289594.3***		28733.1**	
	(109606.1)		(13495.3)	
District FE	No	Yes	No	No
Crop-District FE	No	No	No	Yes
Unit of Observation	Household		Household-Crop	
Observations	1238	1238	5409	5256
R^2	0.005	0.022	0.002	0.021

Omitted category is Consumer. Standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

lower trickle down of world price increases to their own household incomes. Compared to farmers selling directly to consumers and farmers selling through small traders, farmers that sell through agribusinesses share less in the gains from trade. When the world price faced by farmers rises by 1%, the rise in the incomes of farmers selling through large agribusinesses is 13% to 48% less than that of farmers who sell to small traders.

Our findings suggest that although farmers might experience higher productivity by selling through large agribusinesses, they do not share much in the gains from trade that agribusinesses obtain from favorable movements in the prices of crops in world markets. We show a sizable lock-in of farmers to agribusinesses which prevents them from sharing in the gains from trade. Future work can identify the sources of the lock-in of farmers to agribusinesses and the role of policy in ensuring that small farmers realize the gains from integration of agricultural markets.

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Appendix A. Results

A.1. **Equilibrium Existence.** This Section sketches the conditions needed to ensure the existence of an equilibrium that has well-defined prices and more than one intermediary. Let $r_{low} \equiv k^{1/(k-1)} p_h s \left(\delta - 1\right) / \theta$ which will be the lower bound on

rental rates to guarantee that the value of export crops with intermediaries rises with world prices. Let $r_{K1} \equiv \beta p_w m_b B/M^{\beta}\left(\bar{K}-f\right)^{1-\beta}$ denote the rental rate implied by the capital-market condition when there is only one intermediary in the economy. Similarly, $r_{FE1} \equiv (k-1)^{k-1}\left(a_{\min} p_w m/k\right)^k / \left(p_h s\right)^{k-1} f$ denote the rental rate implied by the free entry condition when there is only one intermediary in the economy. To ensure the existence of a unique equilibrium, we assume the following parameter conditions on B and f.

Assumption. $r_{low} \leq r_{K1} \leq r_{FE1}$**.**

The assumptions ensure that the market equilibrium is in the region where rental rates are such that there is at least one intermediary in the market and the value of exports with intermediaries rises with world prices. We explain this in greater detail below.

The market equilibrium can be summarized by the following two equations - free entry and capital market clearing. The equilibrium values for the number of intermediaries N and the rental rate r are determined by the free entry condition and the capital-market clearing condition as follows:

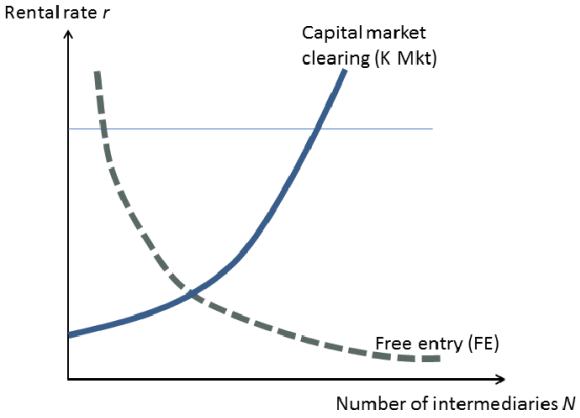
$$\frac{k}{k-1}\frac{1}{N}\frac{1}{N(k-1)+1}a_{\min}^{k}\left(\frac{N(k-1)p_w m}{N(k-1)+1}\right)^{k}\left[\left(p_h s\right)^{-k+1}-\left(\theta r/\left(\delta-1\right)\right)^{-k+1}\right]=rf \qquad \text{FE}$$

$$M\left(\beta p_w m_b B/Mr\right)^{1/(1-\beta)}+Nf+\alpha-\alpha\left(\frac{N(k-1)}{N(k-1)+1}\frac{a_{\min}p_w m}{p_h s-\alpha r}\right)^{k}=\bar{K} \quad \text{K Mkt}$$

The equilibrium existence conditions are explained through Figure A.1. The equilibrium values of N and r are given by the intersection of the FE and K Mkt curves. The FE curve is downward-sloping in (N,r) space. Higher entry lowers profits of intermediaries through greater competition, so rental rates must fall to maintain profits net of entry costs. FE implies $d\ln r/d\ln N = -\frac{\left(p_h s\right)^{-k+1}-\left(\theta r/(\delta-1)\right)^{-k+1}}{\left(p_h s\right)^{-k+1}-k\left(\theta r/(\delta-1)\right)^{-k+1}}\left(2-\frac{k}{N(k-1)+1}\right) < 0$ and FE asymptotes as r and N get close to zero. The K Mkt curve is upward-sloping because higher entry drives up capital market competition and increases rental rates, $d\ln r/d\ln N = Nf\left(1-\beta\right)/Mq > 0$.

For $N \geq 1$, K Mkt gives $r \geq \beta p_w m_b B/M^{\beta}\left(\bar{K}\right)^{1-\beta} \equiv r_{K1}$ and the first inequality in our Assumption ensures that the curve lies above r_{low} which ensures that the value of exports of intermediaries rise with world prices. The first inequality in our

FIGURE A.1. Market Equilibrium



Assumption also guarantees that there are some farmers that would choose to sell to agribusinesses because $r \geq k^{1/(k-1)} (\delta - 1) p_h s/\theta > (\delta - 1) p_h s/\theta$. We also need to ensure that there is in fact an intersection for values of $N \geq 1$. The second inequality guarantees that at $N = 1$, the rental rate implied by free entry is higher than the rental rate implied by capital market clearing so that equilibrium is restored at a point where at least one intermediary operates in the market.

A.2. **Impact of World Price Changes.** From free entry of intermediaries, $d\ln r/d\ln p_w = \frac{(p_h s)^{-k+1} - (\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1} - k(\theta r/(\delta-1))^{-k+1}} \left[k - \frac{2N(k-1)-k+2}{N(k-1)+1} d\ln N/d\ln p_w\right]$. From optimal quality choice, $d\ln q/d\ln p_w = [1 - d\ln r/d\ln p_w]/(1-\beta)$. From capital market clearing, the change in entry from $Mqd\ln q/d\ln p_w + Nfd\ln N/d\ln p_w = 0$. Substituting for the changes in quality and rental rates, the change in entry is

$$\left[Nf + \frac{(p_h s)^{-k+1} - (\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1} - k(\theta r/(\delta-1))^{-k+1}} \frac{2N(k-1)-k+2}{N(k-1)+1} \frac{Mq}{1-\beta}\right] \frac{d\ln N}{d\ln p_w}$$
$$= \frac{(k-1)(p_h s)^{-k+1}}{(p_h s)^{-k+1} - k(\theta r/(\delta-1))^{-k+1}} \frac{Mq}{1-\beta}$$

The RHS is positive and the square bracket term on the LHS is also positive under the Assumption of Section A.1, so that entry rises with world prices. This directly implies that $d\ln p/d\ln p_w \geq 1$. Substituting for the change in entry, we see that the

rental rate also rises with world prices because

$$\begin{aligned}\frac{d\ln r}{d\ln p_w} =& \frac{(p_h s)^{-k+1}-(\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1}-k\,(\theta r/(\delta-1))^{-k+1}}\left[k-\frac{2N(k-1)-k+2}{N(k-1)+1}d\ln N/d\ln p_w\right]\\ =& \frac{(p_h s)^{-k+1}-(\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1}-k\,(\theta r/(\delta-1))^{-k+1}}\left[k-\frac{\frac{(k-1)(p_h s)^{-k+1}}{(p_h s)^{-k+1}-k(\theta r/(\delta-1))^{-k+1}}\frac{2N(k-1)-k+2}{N(k-1)+1}\frac{Mq}{1-\beta}}{Nf+\frac{(p_h s)^{-k+1}-(\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1}-k(\theta r/(\delta-1))^{-k+1}}\frac{2N(k-1)-k+2}{N(k-1)+1}\frac{Mq}{1-\beta}}\right]\\ \geq& \frac{2N(k-1)-k+2}{N(k-1)+1}\frac{Mq}{1-\beta}>0\end{aligned}$$

The change in the income from agribusinesses is $d\ln T/d\ln p_w=(\delta pa/T)\,d\ln p/d\ln p_w-(\theta r/T)\,d\ln r/d\ln p_w$. Clearly, if θ is close to zero, the trickle down effect is the same as from intermediaries which is greater than one. As the ratio of capital demanded by agribusinesses relative to intermediaries becomes arbitrarily small, the change in entry becomes arbitrarily small and the trickle down from intermediaries gets close to one. The rental rate change becomes $\frac{d\ln r}{d\ln p_w}=k\frac{(p_h s)^{-k+1}-(\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1}-k(\theta r/(\delta-1))^{-k+1}}$ so that the change in income from agribusinesses is $\frac{d\ln T}{d\ln p_w}=\frac{\delta pa}{T}-\frac{\theta r}{T}k\frac{(p_h s)^{-k+1}-(\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1}-k(\theta r/(\delta-1))^{-k+1}}$. At the cutoff point, the change in income is $\frac{T}{\theta r}\frac{d\ln T}{d\ln p_w}=\frac{\delta}{\delta-1}-k\frac{(p_h s)^{-k+1}-(\theta r/(\delta-1))^{-k+1}}{(p_h s)^{-k+1}-k(\theta r/(\delta-1))^{-k+1}}$ which is negative for all $\delta\geq k/(k-1)$.

A.3. **Capital in Subsistence Farming.** Let $\alpha\in[0,1/k]$ denote the units of capital needed to grow or sell the non-tradable crop. Then the cutoff between subsistence and intermediaries is $a_s\equiv(p_h s-\alpha r)/p$ and the cutoff between intermediaries and agribusinesses is $a_l\equiv\theta r/(\delta-1)\,p$. The equilibrium price paid by intermediaries continues to be $p=N(k-1)p_w m/(N(k-1)+1)$. The free entry condition and the capital market clearing condition change as follows:

$$\frac{k}{k-1}\frac{1}{N}\frac{1}{N(k-1)+1}\left(\frac{N(k-1)}{N(k-1)+1}a_{\min}p_w m\right)^k\left[(p_h s)^{-k+1}-(\theta r/(\delta-1))^{-k+1}\right]=rf \qquad \text{FE}$$

$$M\left(\beta p_w m_b B/Mr\right)^{1/(1-\beta)}+Nf+\alpha-\alpha\left(\frac{N(k-1)}{N(k-1)+1}\frac{a_{\min}p_w m}{p_h s-\alpha r}\right)^k=\bar{K} \quad \text{K Mkt}$$

From the equilibrium price and quality, the changes in price and quality with respect to world price are the same as before - $\frac{d\ln p}{d\ln p_w}=1+\frac{1}{N(k-1)+1}\frac{d\ln N}{d\ln p_w}$ and $\frac{d\ln q}{d\ln p_w}=\frac{1}{1-\beta}\left(1-\frac{d\ln r}{d\ln p_w}\right)$. The changes in the cutoffs are $\frac{d\ln a_s}{d\ln p_w}=-\frac{d\ln p}{d\ln p_w}-\frac{\alpha r}{p_h s-\alpha r}\frac{d\ln r}{d\ln p_w}$ and

$\frac{d\ln a_l}{d\ln p_w} = -\frac{d\ln p}{d\ln p_w} + \frac{d\ln r}{d\ln p_w}$. From the free entry condition (FE),

$$\frac{d\ln r}{d\ln p_w}\left[1-(k-1)\frac{a_s^{-k+1}\frac{\alpha r}{p_h s-\alpha r}+a_l^{-k+1}}{a_s^{-k+1}+a_l^{-k+1}}\right] = k - \frac{2N(k-1)-(k-2)}{N(k-1)+1}\frac{d\ln N}{d\ln p_w}$$

and from capital market clearing,

$$\left[Nf - \frac{k\alpha a_{\min}^k/a_s^k}{N(k-1)+1}\right]\frac{d\ln N}{d\ln p_w} = \left[\frac{Mq}{1-\beta}+\frac{\alpha r}{p_h s-\alpha r}k\alpha\left(\frac{a_{\min}}{a_s}\right)^k\right]\frac{d\ln r}{d\ln p_w} - \left[\frac{Mq}{1-\beta}-k\alpha\left(\frac{a_{\min}}{a_s}\right)^k\right].$$

Solving for the changes in entry and rental rates, we find that both increase with a rise in the world price for $N \geq 1$. This is because free entry implies

$$\left[1-(k-1)\frac{a_s^{-k+1}\frac{\alpha r}{p_h s-\alpha r}+a_l^{-k+1}}{a_s^{-k+1}-a_l^{-k+1}}\right]\frac{d\ln r}{d\ln p_w} = k - \frac{2N(k-1)-k+2}{N(k-1)+1}\frac{d\ln N}{d\ln p_w}$$

and capital market clearing gives

$$\left[Nf - \frac{k\alpha a_{\min}^k/a_s^k}{N(k-1)+1}\right]\frac{d\ln N}{d\ln p_w} = \left[\frac{Mq}{1-\beta}+\frac{\alpha r}{p_h s-\alpha r}k\alpha\left(\frac{a_{\min}}{a_s}\right)^k\right]\frac{d\ln r}{d\ln p_w} - \left[\frac{Mq}{1-\beta}-k\alpha\left(\frac{a_{\min}}{a_s}\right)^k\right]$$

Let $\mathrm{Dr} \equiv 1-(k-1)\frac{a_s^{-k+1}\frac{\alpha r}{p_h s-\alpha r}+a_l^{-k+1}}{a_s^{-k+1}+a_l^{-k+1}}$, then the change in entry is

$$\begin{aligned}&\left[Nf - \frac{k\alpha a_{\min}^k/a_s^k}{N(k-1)+1} + \frac{1}{\mathrm{Dr}}\frac{2N(k-1)-(k-2)}{N(k-1)+1}\right]\frac{d\ln N}{d\ln p_w}\\ =&\left[\frac{Mq}{1-\beta}+\frac{\alpha r}{p_h s-\alpha r}k\alpha\left(\frac{a_{\min}}{a_s}\right)^k\right]\frac{k}{\mathrm{Dr}} - \left[\frac{Mq}{1-\beta}-k\alpha\left(\frac{a_{\min}}{a_s}\right)^k\right].\end{aligned}$$

The RHS is positive because the denominator Dr is less than one. The LHS is positive for all $k\alpha \leq 1$. Therefore, entry rises with world prices and the trickle down from intermediaries is greater than one.

From the equation above,

$$\frac{2N(k-1)-(k-2)}{N(k-1)+1}\frac{d\ln N}{d\ln p_w} = \frac{\frac{Mq}{1-\beta}\left(\frac{k}{\mathrm{Dr}}-1\right)+\left(\frac{\alpha r}{p_h s-\alpha r}\frac{k}{\mathrm{Dr}}+1\right)k\alpha\left(\frac{a_{\min}}{a_s}\right)^k}{\frac{N(k-1)+1}{2N(k-1)-(k-2)}\left(Nf-\frac{k\alpha a_{\min}^k/a_s^k}{N(k-1)+1}\right)+\frac{1}{\mathrm{Dr}}}$$

so that the change in the rental rate is

$$\left[\frac{Mq}{1-\beta}+\frac{\alpha r}{p_h s-\alpha r}k\alpha\left(\frac{a_{\min}}{a_s}\right)^k\right]\frac{d\ln r}{d\ln p_w}=\frac{Mq}{1-\beta}-k\alpha\left(\frac{a_{\min}}{a_s}\right)^k+\left[Nf-\frac{k\alpha a_{\min}^k/a_s^k}{N(k-1)+1}\right]\frac{d\ln N}{d\ln p_w}$$

which is positive because M and q are greater than one and $k\alpha \leq 1$. Therefore, the rental rate rises and subsistence farmers are worse off after an increase in the world price of the export crop.