THE RISE OF AGRIBUSINESSES AND ITS DISTRIBUTIONAL CONSEQUENCES

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Abstract. Crops are often modelled as homogeneous products that are exchanged in perfectly competitive markets. Yet smallholder farmers face high trade barriers in selling their crops at home and abroad. Selling to agribusinesses with better intermediation technologies can enable smallholder farmers to overcome these barriers. We document income premia and trickle down of world prices for farmers selling through agribusinesses. We then incorporate these empirical regularities in a theoretical model of intermediation to quantify the aggregate and distributional gains from policies that facilitate the operation of agribusinesses and to study the impacts of changes in world prices. Farmers selling through agribusinesses have higher elasticities of incomes to world prices, but policies encouraging farmers to sell through agribusinesses can shift surplus away from small farmers in economies with high land inequality and rents from barriers to entry of intermediaries.

JEL Codes: F1, F6, Q1, O1.
Keywords: Agribusiness, market power, intermediated trade, middlemen, oligopsony.

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1. Introduction

Agriculture continues to support a vast majority of people, particularly in low-income countries, where it is the main source of livelihood, employment and exports. Much of the literature in international trade treats crops as homogeneous products that are exchanged in perfectly competitive markets. While this may be a reasonable assumption to characterise world commodity markets, a vast literature finds that farmers face high trade barriers in selling their crops to markets at home and abroad. The bulk of the world's farmers - about 80 per cent- are smallholders who lack the productive assets, access to technologies, and infrastructure needed to directly access world markets for their produce (Lowder et al. 2014). They face large behind-the-border barriers to trade and sell through intermediaries such as traders, state parastatals and agribusinesses, who often make up thin crop markets for farmers.

Following a string of national reforms in the 1980s and 1990s, governments have moved away from controlling crop markets to encouraging participation by agribusinesses. There has been an accompanying increase in the production of export crops and a rise in new intermediaries including supermarket chains, agro-industrial firms, and export oriented companies offering outgrower schemes (UNCTAD 2009). The rise of agribusinesses has provided a way of reducing the barriers that farmers face when accessing markets for their crops. This has motivated policies to encourage agribusiness-led development of crop markets. For example, under the New Alliance with high-income countries, ten countries in Africa have taken on commitments to reform legislations for seeds, land, contract enforcement, and taxes to ease consolidation and operation of large commercial farms. Many of these investments are for non-food crops, including cotton, biofuels and rubber, or for projects explicitly targeting export markets.

These reforms and agribusiness policies offer the potential to stimulate growth in smallholder agriculture through better technology and market development, and therefore to lift millions of low-income households out of poverty. However, after decades of such policies being tried, there is growing concern that much of agriculture, especially in the poorest parts of the world, has shown few signs of the radical transformation that was hoped for. Market reforms may in fact have contributed to creating a dual structure in farming activities, with few large agribusinesses that have the scale and capital to access world markets and many small farmers who continue to face low yields, low prices for their produce or high barriers to market access.[1] More recently, the introduction and rollback of contract farming laws in India present a stark example of these arguments.

[1]See excellent surveys by Barrett and Mutambatsere (2008), Collier and Dercon (2014), Dillon and Dambro (2017), and the most recent by Barrett et al. (forthcoming).

The laws were aimed at developing a national market for commodities and boosting the country's agricultural exports. But widespread protests followed their introduction as some farming communities were concerned that livelihood losses would result from the entry of big agribusinesses and from the loss of state protection in crop markets.

This paper embeds both these channels of increased productivity from agribusinesses and the potential for losses in farm incomes to examine the welfare consequences of crop markets faced by farmers. This enables the paper to make three key contributions. It firstly provides empirical facts on intermediation in crop markets, including the relation between farmers' incomes and access to agribusinesses. It then develops a theoretical model of the microstructure of intermediation that features buyer power and rents from entry barriers to embed these empirical regularities. Finally, it combines the model with microdata to quantify the aggregate and distributional gains from policies that facilitate the operation of agribusinesses and to infer entry barriers from changes in world prices.

Building on panel data on farm sales for various countries, we first document that farmers selling to agribusinesses differ systematically from others. In particular, farmers who sell to agribusinesses are larger in terms of income and often acreage. They also receive a greater trickle down from world prices into farmgate prices and incomes. The theoretical model embeds these facts in a model with heterogeneous farmers, who in equilibrium, sort into selling through different intermediaries. Smaller farmers sell to traders while larger farmers undertake the investments needed to sell through agribusinesses to achieve gains in marketable surplus.

What is less obvious is that this heterogeneity among farmers is critical in determining the direction and the extent to which world prices and entry costs of intermediaries impact farm incomes. The reasoning is that farmer sorting determines the farm supply elasticity to different intermediaries and hence the resulting market power of intermediaries. Farmgate prices paid by intermediaries are higher when farm productivity is more equally distributed. In this case, the usual intuition for welfare gains from trade goes through. As world prices rise or entry costs for intermediaries fall, intermediaries compete more fiercely and farmers experience income gains.

But the opposite can happen for small farmers who sell through traders when farm productivity is highly unequal. As relatively larger farmers switch to agribusinesses, farm supply to traders takes a big hit because the remaining farmers are much smaller than the farmers who switch. Traders experience reduced profitability and exit, making the crop market less competitive for the smallest farmers who are left behind. Consequently, these small farmers who rely on the surviving traders are worse-off after a rise in world prices or a reduction in agribusiness entry costs.

To sum up, inequality and intermediary market power introduce a wedge between the aggregate gains from trade and the gains from trade that accrue to small farmers. We highlight these consequences of productivity differences across farmers in a benchmark version of the model. Then we generalise the model to real-world features, including state presence in crop markets and rents from barriers to entry of agribusinesses. The generalised model activates the channels of government subsidisation and rent shifting across agents in the economy. Importantly, it yields a set of national income accounting identities which we combine with microdata on household-crop-buyer incomes to infer the trickle down from world prices to farmer incomes and the distribution of the gains from trade arising from removal of agribusiness entry barriers.

Our empirical strategy exploits variation in licencing and investment requirements for agribusinesses across different crops to gauge the aggregate and individual gains from the removal of entry barriers. These policy changes were implemented in a majority of crop markets in an economy (Kenya) that is largely reliant on agriculture. Despite the importance of intermediation policies in alleviating poverty, severe measurement challenges have led to limited work on agribusinesses and behind-the-border barriers to trade for farmers. The national policy we examine lends itself well to codification because it directly repealed sections of legislation related to licencing and investment requirements for agribusinesses, and provides a count measure of the number of sections repealed. The sections are comprehensively documented in legal texts which were changed quickly within a couple of years to introduce new parliamentary acts. This enables us to use trade data, farmer-buyer-crop income data and company accounts to quantify the aggregate and distributional gains from legislative changes under assumptions on farmer sorting, profit maximisation and resource clearing. It also provides insights into the modelling of barriers to entry in crop markets

The main finding is that the policy raised exports of policy-affected crops. But it shifted surplus away from farmers to agribusinesses and the state. Smallholder farmers were left worse-off, consistent with the channel highlighted in the benchmark model when inequality in farm productivity is high, as was the case in Kenya. Interestingly, our empirical findings point to an additional effect from the new policy: a shift in surplus away from all farmers (not just smallholders) to both agribusinesses and the state. This can be accounted for by our generalised model, which realistically incorporates state purchases and rents from entry barriers. The reduction in government purchases hurt all farmers because of the effective subsidy provided by the state. Large farmers who sold to agribusinesses before the policy was implemented suffered further income losses from rent erosion. The findings help shed light on why agribusiness policies can often be unpopular with farmers even when they sell more through agribusinesses. It also helps conceptualise

the various channels through which export revenues are distributed across smallholder farmers in the presence of large barriers to entry of intermediaries.

Related Literature. The paper is related to a large literature in industrial organisation and international trade which shows classic welfare results are altered in the presence of market power and rents, typically examined on the seller side (e.g. Dixit and Norman 1980, Helpman and Krugman 1985, Vives 1999). Early work on monopsony shows that real incomes can move in opposite directions to those arising in the absence of market power, leading even to ambiguous welfare effects from trade liberalization (Bishop 1966, Feenstra 1980; Markusen and Robson 1980; McCulloch and Yellen 1980; Bhagwati et al. 1998, Devadoss and Song 2006). Following this traditional line of inquiry, we model the aggregate and individual welfare gains from trade under monopsony power.

A growing body of work is examining recent trends in value added and labour share arising from monopsony in factor markets (e.g. Manning 2011, Syverson 2019). The focus here is on agricultural markets faced by smallholder farmers because there are few examples where the role of monopsony takes on greater significance for economic welfare and equity (Antras and Costinot 2011). Recent contributions in this context have modelled the microfoundations of buyer market power, such as search and matching frictions, reputational rents and the contractual environment in developing economies (e.g. Bardhan et al. 2013, Chau et al. 2009, Sheveleva and Krishna 2016).[2] We abstract away from the microfoundations, which are difficult to apply to large-scale data (such as national surveys of households and firms) that are typically available for analysis in international trade. Instead, we draw on advances in monopolistic competition models of international trade (Melitz and Redding 2015), generalise them to intermediation and oligopsonistic market power, and provide a mapping from observable sufficient statistics to welfare impacts.

Following the literature on misallocation and rents (Baqaee and Farhi 2021, Restuccia and Rogerson 2017), we model entry barriers in a reduced form way as wedges and focus on the welfare consequences of removal of entry barriers that generate rents and distortions. We therefore contribute to a growing line of work quantifying misallocations from microdata and examining welfare gains in the presence of distortions (e.g. Bau and Matray 2020, Grant and Startz 2019, Kroft et al. 2020, Peters 2020). Unlike these papers, our focus is on highlighting the dual structure of markets faced by farmers, which is also related to a new body of work on co-existence of small and large firms (e.g. Parenti 2018, Helpman and Niswonger 2022).

[2]Also see recent work by Tomar 2018 and Chatterjee 2019 on behind the border barriers, and by Zavala 2021 on agri-exporters in Ecuador.

On the measurement side, we contribute to a nascent strand of the literature in international trade that seeks to model and quantify behind-the-border barriers to trade (BTBs for brevity). Despite their increasing importance, research on non-tariff barriers - including BTBs - remains highly underdeveloped (Bown and Crowley 2016). Unlike tariffs and customs barriers (e.g. Conconi et al 2018), comprehensive data on non-tariff barriers to trade is severely lacking even in settings where data constraints are less binding, such as trade in industrial goods among developed countries. Our empirical setting is unique in terms of the coverage and depth of non-tariff barriers, and the findings contribute to theory and empirics on the welfare consequences of behind the border policies.

On the empirical side, our findings are related to work on the gains from trade in the presence of intermediaries. For example, Atkin and Donaldson (2012) and Startz (2018) examine the gains from trade to consumers of products sold by imperfectly competitive intermediaries. As imported products make up relatively small shares of consumption baskets of many low-income households, our theoretical and empirical analysis apply to much larger margins for welfare in contexts where farming forms the bulk of income-generating activities.

The paper is also related to a large body of work in development and agricultural economics examining farmer-buyer interactions. Much of this analysis has focused on specific crops and experimental evidence which usually precludes analysis of large firms and national policy changes. Recent work has examined the role of trade in farming (for example, Bustos et al. 2020, Dippel et al. 2016, Dragusanu and Nunn 2020, Fajgelbaum and Redding 2021, Macchiavello and Morjaria 2020; see Atkin and Khandelwal 2019 for a survey) and we contribute to this literature by examining agribusinesses and policies to encourage their participation.

The remainder of the paper is organised as follows. Section 2 documents empirical regularities in intermediation. Section 3 embeds the facts in a theoretical framework which determines cropping, intermediation and comparative statics for welfare. Section 4 goes from the theory to an empirical model, which is applied to BTBs and world price trickle down. Section 5 concludes.

2. Agribusiness Facts

In this section, we highlight four facts about intermediation in crop markets for smallholder farmers. They are drawn from the World Bank's Living Standard and Measurement Surveys which provide consistent panels of households from Ethiopia (2004, 2006) and Malawi (2010, 2013, 2016) and from the Rural Household Survey of Kenya (2000, 2004), which is explained in more detail later.

2.1. **Empirical Regularities.**

1. Small farmers often piggy-back on agribusinesses and other intermediaries to sell their produce in crop markets at home and abroad. Since the rise of supermarket chains, agro-industrialization, and export-oriented reforms, there has been a substantial increase in contract farming and outgrower schemes between agro-industrial firms and farmers in low-income countries. Table 1a shows the share of different buyer types for the pooled sample of 6,695 households growing 87 distinct crops with 19,203 distinct household-crop observations in Ethiopia (2,459 households), Malawi (2,770 households) and Kenya (1,466 households) over the last two decades.

Over four-fifths of farm sales are made to intermediaries, including cooperatives, traders and agribusinesses. Agribusinesses now constitute about a sixth of crop sales by farmers. Table 1b focuses on Kenya for which we have a panel spanning over a decade. Agribusinesses doubled in importance from about a fifth in terms of market share in crop sales of small farmers (with less than fifty acres of land).

Table 1. Facts 1 and 2: Intermediation and Agribusinesses in Crop Markets

(a)

Buyer types	Market share of Buyer Type %
Consumer	19.8
Cooperative	21.9
Trader	43.7
Agribusiness	14.6

(b)

Year	Market share of Agribusiness in Kenya %
2000	19.8
2004	21.5
2007	21.5
2010	37.8

(c)

Buyer types	Farm Income (Constant USD)	Farm Area (Acres)
Sell to Agribusiness	1,708	7.6
Sell to Other Buyers	569	4.2

The broad facts are supported by case study evidence which documents a trend towards globalisation in agriculture over the years. Examples of the rise of agribusinesses in smallholder farming include potato farming for Pepsi Co in Punjab, tobacco production for the British American Tobacco company, contract farming in Senegalese groundnut production, vegetable farming for European supermarkets by farmers in Madagascar, production for supermarket supply chains in Latin America, Asia and Africa, commercial farming of export crops in Kenya and commercial farming of cash crops like sugar, cotton and tea in Europe and Central Asia, contract farming of high-value crops (such as strawberries,

melons and frozen vegetables) between Mexican farmers and agribusinesses that export to the United States and pineapple and banana farming in Central America for exports to the United States and Europe.[3]

2. Farmers selling to agribusinesses have higher incomes and larger farms. A less well-documented fact is that farmers who sell to agribusinesses have higher incomes and larger farms. Table 1c shows that the 894 households that sell to agribusinesses in the pooled sample have an average farm income of USD 1,708 per year (in 2010 values), compared to USD 569 for the 8,695 households that do not sell to agribusinesses at all. Farmers selling to agribusinesses have, on average, 7.6 acres of land, compared to 4.2 for households that sell to other buyers.

Following the vast literature on exporter premia, these patterns can be examined more systematically by regressing income (or acreage or farmgate prices) on buyer type. Table 2 documents the premia for households who sell to agribusinesses. Columns 1 and 2 of Table 2 regress household incomes and acreage respectively on an indicator for whether the household sells crops to agribusinesses. Farmers who sell to agribusinesses have farm incomes that are 109 per cent higher and acreage that is 43 per cent larger, than those for farmers who do not engage with agribusinesses. Columns 3 and 4 regress household-crop income and household-crop prices on an indicator for whether the farmer sold that crop to an agribusiness. Even at the household-crop level, we find that farmers who sold to agribusinesses have substantially higher incomes. They receive higher farmgate prices but these are not statistically significant. (Acreage is not always available at the household-crop level).

The vast majority of crops grown by farmers also show up in the world trade database as an export of the country. Almost all sales to agribusinesses are of crops that are exported by the country. Including an indicator for export crops and its interaction with the indicator for selling to agribusinesses, the income premia is estimated to be 96 per cent at the household level and 87 per cent at the household-crop level.

3. Farmers selling to agribusinesses differ in the trickle down of world prices into farm incomes. While the elasticity of factor prices to world prices is an important line of research in international economics, systematic evidence on the transmission of world prices into agricultural incomes and farmgate prices is sparse. Table 3 estimates a first difference regression of changes in crop farmgate prices and crop incomes of households with respect to changes in world prices. There are two time periods per

[3]For case studies, see Runsten 1994, Goodman and Watts 1997, Warning and Key 2002, Robbins and Ferris 2003, Reardon and Timmer 2007, Minten et al. 2009, Minot 2011.

TABLE 2. Fact 2: Premia for Farmers Piggy-backing on Agribusinesses

	$\ln Income_{ht}$	$\ln Acreage_{ht}$	$\ln Income_{cht}$	$\ln Price_{cht}$
	(1)	(2)	(3)	(4)
Sold to Agribusiness	1.0932	0.4294	0.6891	0.0570
	(0.0603)	(0.0434)	(0.1446)	(0.0953)
Crop-Country-Year FE	No	No	Yes	Yes
Country-Year FE	Yes	Yes	No	No
N	9507	9482	23399	23399
R^2	0.183	0.0153	0.338	0.563

The dependent variable in Column 1 is the income from all crops of household h in year t, acreage of fields of household h in Column 2, income from crop c in Column 3 and price received for crop c in Column 4. The RHS is an indicator for selling to agribusinesses which is A_{cht} for crop c in Columns 3 and 4 and $A_{ht} = \max_c A_{cht}$ for the household in Columns 1 and 2. Agribusiness is defined as private company/business in the World Bank LSMS for Ethiopia and Malawi (distinct from local merchant/trader/parastatal/market), and as large company/miller/processor/exporter in the Rural Household Surveys of Kenya. Country-year fixed effects are included in Columns 1 and 2, while crop-country-year fixed effects are included in Columns 3 and 4. Standard errors are clustered by households in parentheses in Columns 1 and 2 and by crop in Columns 3 and 4.

household-crop observation and country fixed effects are included to account for country-year differences such as through exchange rates. The first row shows that on average, the passthrough of a 1 percent higher world price into farmgate prices of the crop is 0.122 percent and the trickle down to crop incomes is smaller at 0.037 percent, albeit imprecisely estimated.

To understand differences across sales to agribusinesses and other intermediaries, we report the interactions of world price changes with the initial share of agribusinesses in the crop income of the household and the change in the agribusiness shares across the survey years. Farmers selling to agribusinesses show higher passthrough of world prices into farmgate prices and crop incomes. Farmers that previously sold to agribusinesses show a 0.078 and 0.221 percent higher trickle down into prices and incomes from a 1 percent higher world price. (This category includes farmers who sold all of their crop to agribusinesses and who continue to do so in the following period.) Farmers who increased their share of agribusiness sales during the period experience a 0.168 and 0.205 percent higher trickle down in prices and incomes respectively. They also have higher prices and incomes (0.221 and 0.267 percent respectively), consistent with the agribusiness premia reported before.

By the metric of world price transmission, agribusinesses make farmers more connected to world markets for crops. It is worth noting though that this also implies agribusinesses

TABLE 3. Fact 3: Trickle Down from World Price Changes for Farmers Piggy-backing on Agribusinesses

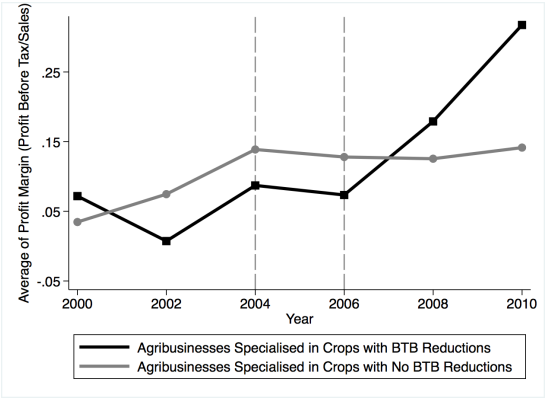
	$\Delta \ln Price_{ch}$	$\Delta \ln Income_{ch}$
	(1)	(2)
Δ ln World Crop Price$_c$	0.1224	0.0372
	(0.0582)	(0.0514)
Agribusiness Share$_{ch}$·Δ ln World Crop Price$_c$	0.0783	0.2205
	(0.1027)	(0.0849)
ΔAgribusiness Share$_{ch}$·Δ ln World Crop Price$_c$	0.1681	0.2054
	(0.0618)	(0.0745)
ΔAgribusiness Share$_{ch}$	0.2211	0.2673
	(0.1570)	(0.1584)
Country FE	Yes	Yes
N	4330	4330
R^2	0.027	0.024

The dependent variable in Column 1 is the change in sales-weighted mean log price received for crop c by household h during survey year 1 relative to the previous survey year 0 and in Column 2, it is the change in log income of the household-crop. ΔX denotes the first difference $X_1 - X_0$. The RHS is the change in the log of the world price for the crop between survey years. The agribusiness share is the share of the crop income received from agribusinesses in survey year 0 and the change in agribusiness share is relative to the previous survey year. Agribusiness is defined as private company/business in the World Bank LSMS for Ethiopia and Malawi (distinct from local merchant/trader/parastatal/market), and as large company/miller/processor/exporter in the Rural Household Surveys of Kenya. The regression is estimated in first differences, with crop income shares of the households as weights to ensure each household gets a weight of 1. Standard errors are clustered by household and by crop-country.

pass on more of any reductions in world prices to farmers. The Appendix shows heterogeneity in trickle down rates by increases or decreases in world prices, which suggest that farmers selling to agribusinesses are not shielded from world price reductions. In fact, trickle down rates are systematically lower during world price increases and even more so for farmers who sell through agribusinesses (Table 16).

4. Agribusiness profits need not co-move with farmer incomes. New trade models generate welfare gains that can be summarised by aggregate changes in trade values and the trade elasticity (with respect to trade costs). Figures 2.1 and 2.2 show agribusiness profits need not co-move with farmer incomes and two sufficient statistics are unlikely to summarise the distribution of the gains from trade. The Figures summarise the evolution of profit margins and the distribution of farm incomes before and after Kenya's national policy to remove investment and licencing barriers for agribusinesses (BTB policy, which we discuss in more detail later).

FIGURE 2.1. Fact 4a: Agribusiness Profit Margins by Crop Specialisation, Before and After the BTB Policy



Mean Profit Margins %	(1) Pre	(2) Post
Companies Specialised in Crops with BTB Reductions	5.54	18.90
Companies Specialised in Crops with No BTB Reductions	8.27	13.16

Average Profit Margin is the average of profit margins (defined as Profit Before Tax/Turnover) across firms in each group. The black line refers to the group of agribusiness firms who, between 1999-2004, had specialised in crops that had more than one section of legislation repealed by the policy change between 2005-2006 after the announcement in 2004. The grey line refers to agribusinesses who specialised in crops that had no BTB policy change. Profit margins are averaged across two-year periods to match the corresponding household survey years.

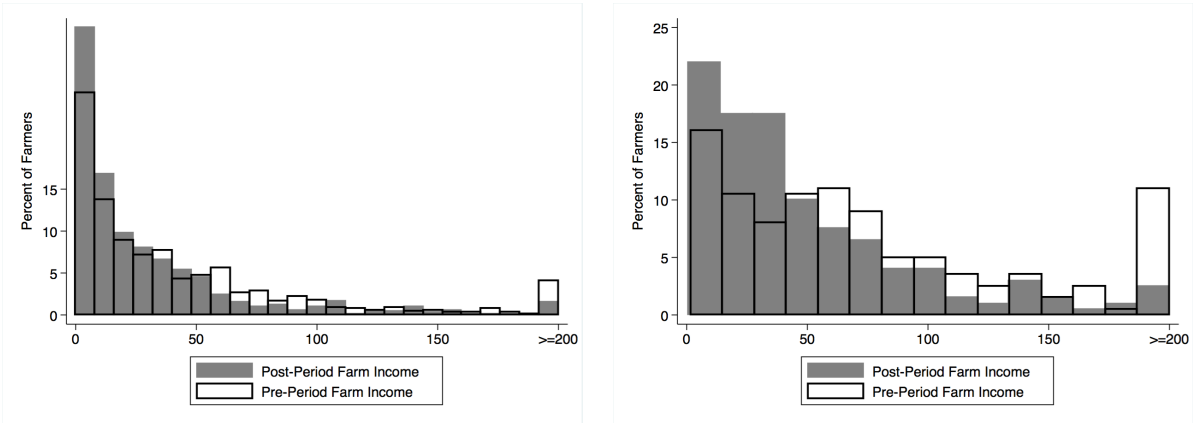
Mean profit margins tripled for agribusinesses specialising in policy-affected crops but the increase was much more muted for agribusinesses that specialised in other crops. Although agribusiness market shares increased after the policy, Figure 2.2 shows that farmers who sold policy-affected crops experienced a leftward shift of their income distribution. This was also the case for farmers who sold the policy-affected crops to agribusinesses in Panel B, even though they had higher incomes to begin with.

3. From Facts to Theory

This sub-section develops a theoretical framework to embed the empirical facts above into the microstructure of intermediation in crop markets. The benchmark model of this section elucidates the intermediary choices of farmers and the general equilibrium interlinkages between traders and agribusinesses.

3.1. **Theoretical Framework.** We consider a small open economy that takes the world price p of its export crop as given. Farmers in the economy do not have direct access to the world crop market and rely on intermediaries to sell their produce. Intermediation is provided by Traders and Agribusinesses who compete oligopsonistically. In what follows,

FIGURE 2.2. Fact 4b: Farm Income Distribution of Households Selling Policy-Affected Crops, Before and After the BTB Policy



(A) Farmers Specialised in Crops with BTB Reductions

(B) Farmers Specialised in Crops with BTB Reductions Sold through Agribusinesses

Farm Income is the total income from sales of crops of the household. The grey bars refer to the post-policy period (2007 and 2010), while the black-outline bars refer to the pre-policy period farm incomes of these households (2000 and 2004). Panel A consists of the sample of farmers who specialised in crops (before the policy change) that experienced an above-median number of BTB reductions. Panel B consists of farmers who sold crops with above-median BTB reductions to agribusinesses before the policy change.

we characterise the pricing decisions and welfare comparative statics with respect to world prices and entry costs.

3.1.1. *Farmers.* There is a continuum of farmers each endowed with a unit of land. They have linear utility for a consumption good and therefore maximise farm earnings. Farmers draw their productivity φ from a Pareto productivity distribution $G(\varphi) = 1 - (\varphi_{\min}/\varphi)^k$ where $\varphi \geq \varphi_{\min} > 0$ and $k \geq 1$. Higher values of $\varphi_{\min}$ reflect higher average farm productivity, while lower values of the Pareto shape parameter k summarise higher inequality in the productivity of land (as measured by the Gini index for land quality).

Farmers choose whether to just trade their produce in the crop market or to engage with agribusinesses. Agribusinesses improve the quality of farmers' marketable produce. Obtaining these quality gains requires investments by farmers, denoted by $f > 0$ in terms of the numeraire consumption good. As is standard in the international trade literature, this will generate the stylised fact of income premia for households selling to agribusinesses. Let p_t denote the price that farmers receive from selling to traders and let p_a denote the price received from agribusinesses. Then a farmer with productivity draw

φ chooses to sell to agribusinesses if

$$\varphi \geq f/\left(p_a - p_t\right) \equiv \varphi_a \tag{3.1}$$

where φ_a summarises the threshold productivity for choosing agribusinesses over traders. The rest of the farmers with productivity between $\varphi_a > \varphi \geq \varphi_{\min}$ sell to traders. As long as agribusinesses pay more per efficiency unit $p_a > p_t$ (which will be determined in equilibrium later), fixed investment costs imply more productive farmers sell to agribusinesses who provide quality gains that cannot be realised otherwise. Remark 1 below summarises the farmer sorting pattern.

Remark 1. *As long as $p_a > p_t$, crop markets have a dual structure where higher productivity farmers sell to agribusinesses and lower productivity farmers sell to traders.*

For simplicity, we only consider the choice of selling through traders or agribusinesses here. The Appendix and earlier working papers contain generalisations to subsistence crops, multiple crops, comparative advantage (differences in $\varphi_{\min}$ across crops) and different formulations of fixed investments, showing that the main qualitative results of this section carry through.[4]

3.1.2. *Intermediaries.* There are N traders who compete in a Cournot oligopsonistic fashion. Each trader pays an entry cost of f_t units of the consumption good to commence trading services. The profit of a trader is

$$\pi_t = (pm_t - p_t)q_t$$

where $0 \leq m_t \leq 1$ is the intermediation productivity which acts like the inverse of an iceberg trade cost, p_t is the Cournot price paid to farmers by trading firms and q_t is the quantity sold to trader t by all farmers.

There are M agribusinesses who incur entry costs f_a to compete in a Cournot oligopsonistic way in agribusiness activities, such as marketing, processing and exporting. Agribusinesses provide farmers with technical services to transform their produce into more marketable surplus through, for example, quality control, knowhow or processing facilities. Realising quality or productivity gains in marketable farm surplus is often a key motivation for agribusiness-friendly policies across the world. Let m_a denote the productivity gain from engaging with an agribusiness, and we assume $0 \leq m_a \leq m_t$ to summarise the quality gains in marketable surplus from agribusiness activities. Profit from providing agribusiness services to farmers is

$$\pi_a = (pm_a - p_a)q_a$$

[4]See Dhingra and Tenreyro (2017, 2020)

where q_a is the quantity sold to agribusiness a by all farmers.

3.1.3. *Prices.* Optimal prices paid by intermediaries can be determined by solving for a symmetric Cournot equilibrium. Agribusinesses choose prices p_a that they pay to farmers to maximise their profits π_a, taking the decisions of all other firms as given. From the first-order condition for profit maximisation, the optimal farmgate price equates the markdown on intermediated world prices to the inverse of the agribusiness's perceived elasticity of supply from farmers:

$$(pm_a - p_a)/p_a = 1/(\partial \ln q_a/\partial \ln p_a).$$

The total quantity supplied by farmers to agribusiness a and all other agribusinesses $-a$ is

$$q_a + q_{-a} = \int_{\varphi_a}^{\infty} \varphi dG(\varphi) = \frac{k}{k-1}\varphi_{\min}^{k} f^{-k+1}(p_a - p_t)^{k-1}.$$

Taking q_{-a} as given, agribusiness a's perceived elasticity of supply is

$$\partial q_a/\partial p_a = k\varphi_{\min}^{k} f^{-k+1}(p_a - p_t)^{k-2} = (k-1)(q_a + q_{-a})/(p_a - p_t)$$

In a symmetric Cournot equilibrium, $q_a + q_{-a} = Mq_a$ and the price paid by agribusinesses to farmers is:

$$p_a = \frac{M(k-1)pm_a + p_t}{M(k-1)+1} \tag{3.2}$$

The optimal price shows that the price paid by agribusinesses is a weighted average of the world price (net of intermediation costs) and the price paid by traders. The weights depend on the entry of agribusinesses and the farm supply inequality. As might be expected, perfect competition among agribusinesses ($M \to \infty$) results in complete passthrough of world prices into farmgate prices, net of intermediation costs ($p_a = pm_a$). A less apparent result is that a perfectly equal land distribution ($k \to \infty$) also results in complete passthrough because prices no longer determine the extent to which farmers alter their supply to intermediaries. When intermediaries are oligopsonistic (finite M and k), farmers receive a smaller share of the price net of trade costs, $p_a < pm_a$ because $M(k-1)/(M(k-1)+1) \in (0,1)$ for finite values of entry and heterogeneity.

The price paid by traders provides a floor for what agribusinesses must pay to induce farmers to undertake the investments needed to sell to agribusinesses. Proceeding similarly, trader t chooses price p_t that it pays to farmers to maximise profits π_t, taking the decisions of all other firms as given. The total quantity supplied by farmers to trader t and all other traders $-t$ is

$$q_t + q_{-t} = \int_{\varphi_{\min}}^{\varphi_a} \varphi dG(\varphi) = \frac{k}{k-1}\varphi_{\min}^{k}\left(\varphi_{\min}^{-k+1} - f^{-k+1}(p_a - p_t)^{k-1}\right)$$

From the first-order condition for profit maximisation, the optimal farmgate price equates the markdown on intermediated world prices paid by traders to the inverse of their perceived elasticity of supply:

$$(pm_t - p_t)/p_t = 1/(\partial \ln q_t / \partial \ln p_t).$$

Taking q_{-t} and the decisions of agribusinesses as given, the perceived elasticity of supply of trader t is

$$\partial q_t / \partial p_t = k\varphi_{\min}^k f^{-k+1}(p_a - p_t)^{k-2} \equiv \mu(k-1)(q_t + q_{-t})/p_t$$

where $\mu \equiv \frac{f^{-k+1}(p_a-p_t)^{k-2}p_t}{\varphi_{\min}^{-k+1} - f^{-k+1}(p_a-p_t)^{k-1}} = \frac{Mq_a}{Nq_t}\frac{p_t}{p_a-p_t}$ summarises the direct competition that traders face from agribusinesses through shared farm supply, which they take into account when setting prices.

Substituting for the perceived supply elasticity in the first-order condition for profit maximisation, the optimal price paid by traders to farmers is

$$p_t = \frac{\mu N(k-1)}{\mu N(k-1)+1} pm_t. \tag{3.3}$$

As earlier, perfect competition among traders or a perfectly equal land distribution leads to full passthrough from traders to farmers. Under finite entry and land inequality, the markdown paid by traders depends on the entry of traders, land inequality and the relative quantities and prices of agribusinesses. We summarise the pricing results in Remark 2 below, and then proceed to determining entry of intermediaries.[5]

Remark 2. *Prices received by farmers rise with the number of of traders and agribusinesses in the crop market and with equality in the land productivity distribution among farmers. In the benchmark case of perfect competition among intermediaries or a perfectly equal land distribution, farmers receive the full world price (net of intermediation costs).*

3.1.4. *Entry.* Free entry of intermediaries ensures average profits are driven down to entry costs. Ignoring the integer constraint, free entry gives

$$(pm_a - p_a)q_a - f_a = 0, \tag{3.4}$$

$$(pm_t - p_t)q_t - f_t = 0. \tag{3.5}$$

3.1.5. *General Equilibrium.* The equilibrium of the economy can be specified in terms of the optimal cutoff, optimal prices and optimal entry. These are given jointly by the cutoff equation 3.1, the pricing equations 3.2 and 3.3, and the free entry equations 3.4 and 3.5.

[5]The second-order conditions for profit maximisation are $(k-2)(pm_a - p_a) - \frac{M+1}{M}(p_a - p_t) < 0$ and $(k-2)(pm_t - p_t) + \frac{N+1}{N}(p_a - p_t) > 0$.

Together, these conditions define the general equilibrium for the economy given a set of world crop prices.

Substituting for quantities and entry in terms of prices, the two unknown prices p_a and p_t are determined by the two equilibrium equations below:

$$(pm_a - p_a)^2 (p_a - p_t)^{k-2} = f_a f^{k-1}/k\varphi_{\min}^k \tag{3.6}$$

$$(pm_t - p_t)^2 (p_a - p_t)^{k-2} = f_t f^{k-1}/k\varphi_{\min}^k \tag{3.7}$$

Solving for the unknowns, the price paid by agribusinesses is $p_a = pm_a - (f_a/f_t)^{1/2} (pm_t - p_t)$, which rises with world prices, reductions in agribusiness entry barriers and the price paid by traders (because of interlinked markets).

Substituting for the price of traders, the main equilibrium condition is:

$$(pm_a - p_a)^2 \left((f_t/f_a)^{1/2} pm_a - pm_t + p_a \left(1 - (f_t/f_a)^{1/2} \right) \right)^{k-2} = f^{k-1} f_a/k\varphi_{\min}^k \tag{3.8}$$

and a solution exists and is unique as long as the SOCs hold, which occurs for sufficiently productive agribusinesses.[6] We summarise the equilibrium result in Remark 3 below, and then proceed to determining comparative statics.

Remark 3. *For sufficiently productive agribusinesses, an equilibrium exists and is unique.*

3.2. **Theoretical Results.** We discuss the comparative statics of farmer incomes with respect to world prices and agribusiness entry costs to show the importance of heterogeneity and the dual structure of crop markets for farmer income impacts.

3.2.1. *Comparative Statics with World Prices and Agribusiness Entry Costs.*

Proposition 4. The value of trade and the prices paid by agribusinesses to farmers rise with world prices p and with reductions in agribusiness entry costs f_a. Prices paid by traders to farmers rise with world prices and reductions in agribusiness entry costs when farm productivity is more equal ($k > 2$) and fall otherwise ($k < 2$). Prices paid by agribusinesses respond more than prices paid by traders to changes in world prices and agribusiness entry costs.

We first discuss results for farmers selling to agribusinesses in Proposition 4 and then proceed to farmers selling through traders. Totally differentiating equation 3.8, it may be

[6]A unique solution is guaranteed for $k < 2$ and for $k > 2$, a sufficient condition in terms of primitives is $m_a/m_t > \left((k/2 - 1) \left(1 - (f_t/f_a)^{1/2} \right) - 1 \right) (f_t/f_a)^{1/2}$. This condition ensures a monotonically decreasing LHS of the equilibrium condition that ranges over high enough values to guarantee sales to agribusinesses. It applies to any possible set of parameter values because it holds when traders are perfectly competitive, though the condition can be weakened outside of a competitive fringe of traders.

shown that agribusinesses pay higher prices and hence higher incomes to farmers when world prices rise and entry costs of agribusinesses fall (proofs in the Appendix).

The economic reasoning behind this result arises in many settings where factor prices rise with output prices and entry. In general terms, the optimal price paid by agribusinesses is $p_a = \frac{\mu_a \theta_a}{\mu_a \theta_a + 1} pm_a$ where $\mu_a \equiv \partial \ln (q_a + q_{-a}) / \partial \ln p_a$ is the aggregate crop supply elasticity to agribusinesses and $\theta_a \equiv 1/ (\partial \ln (q_a + q_{-a}) / \partial \ln q_a)$ is the inverse of the perceived elasticity of aggregate supply to own purchases of the agribusiness. The pass-through into farmgate prices is therefore $d \ln p_a = 1 + \frac{1}{1+\mu_a \theta_a} d \ln \mu_a \theta_a$ where the direct impact comes from the rise in farm surplus and the indirect impact from increased competition among intermediaries. Under Pareto productivity and Cournot oligopsony, the aggregate supply elasticity to prices is $\mu_a = k - 1$ and to own purchases is $\theta_a = ((q_a + q_{-a}) / q_a) \cdot (\partial (q_a + q_{-a}) / \partial q_a) = M \cdot 1$.

The change in markdowns can be seen from the free entry of agribusinesses. From the envelope theorem, free entry ensures $d \ln q_a (p_a, p, f_a) = -\frac{pm_a}{pm_a - p_a} d \ln p + d \ln f_a$. A rise in world prices and a reduction in entry costs encourage entry and lower the purchases made by an individual agribusiness, which is an inverse measure of the degree of competition among agribusinesses. Then the commonly-made assumption of markdowns $\mu\theta$ decreasing with agribusiness size, gives the main result of income gains for farmers selling through agribusinesses.

This usual intuition however is more subtle in our setting because there can be countervailing forces arising from farmers switching from traders and reducing farm competition among agribusinesses. This does not dominate the positive forces because the direct impacts of world prices and reduced entry costs are larger for agribusiness firms due to their better intermediation technology. In particular, when profits are supermodular in world prices and intermediation productivity, farm surplus and hence the prices paid by agribusinesses are more positively affected by world price increases than those for traders. Consequently, more farmers also start selling to agribusinesses but the farm price impact remains positive. This also implies that the value of trade rises from the direct impact of increased prices and the indirect impact of better intermediation productivity for farmers who switch from traders to agribusinesses.

The business stealing from traders to agribusinesses matters for the comparative statics of incomes of small farmers selling through traders. Depending on the degree of heterogeneity (or inequality) in farm productivity, farmers who continue to sell to traders may have higher or lower incomes after an increase in world prices or a reduction in agribusiness entry costs. The loss of aggregate supply to agribusinesses leaves only the smallest farmers reliant on traders and pushes against the positive forces of world price increases to induce exit of traders.

The farmgate price received by farmers who sell to traders rises for $k > 2$ and falls for $k < 2$. This is because inequality in farm productivity determines the elasticity of the quantity supplied by farmers to traders and agribusinesses, and hence the market power in intermediation. As agribusiness entry barriers fall (or world prices rise), agribusiness profits rise linearly from the direct impact. This induces entry and greater competition among agribusinesses who must now offer higher farmgate prices. More farmers switch from selling through traders to selling through agribusinesses. For relatively equal distributions of farm productivity (larger values of k), the usual intuition goes through for the spillovers to prices offered by traders. The reduced supply of crops to traders puts competitive pressure on them to pay more to farmers. Intermediary markets therefore become more competitive and farmgate prices rise for all farmers.

The opposite occurs for small farmers who sell through traders when inequality is high ($k < 2$). As before, the direct impacts are larger for agribusinesses and more farmers switch to selling to agribusinesses to get the higher farmgate prices paid by them. But the indirect impacts are different because now the volumes are heavily skewed towards farms with relatively higher productivity. Even for small shares of farmers switching to agribusinesses, the shift in volume is large because the switching farmers have much higher volumes than the small farmers who are left behind with traders. The disproportionate drop in scale from this indirect business stealing by agribusinesses lowers the profitability of traders. This induces exit of traders and the smallest farmers who continue to rely on the surviving traders are left worse-off.

The critical point occurs at $k = 2$ because then the supply curves faced by agribusinesses and traders become linear. Therefore the direct impact of a linear increase in agribusiness profitability is exactly matched by the rate at which switching patterns of farmers induce changes in the relative supply to different intermediaries. More generally, the scale of traders takes a hit when productivity is highly unequal and they must increase their profit margins if they are to stay in the market.

3.2.2. *Welfare Gains from Trade.* To close the model, it is noteworthy that resource clearing is subsumed in the equilibrium conditions. Consequently, the model results in national income identities, which we discuss next because they will later enable inference of rent shifting in the economy.

Aggregate revenue of the economy from crop exports is $R = Mpm_a q_a + Npm_t q_t$. In equilibrium, aggregate revenues equal aggregate incomes of factors $I_a + I_t + \Pi_a + \Pi_t$ where $I_a + I_t = p_a \int_{\varphi_a}^{\infty} \varphi dG + p_t \int_{\varphi_{\min}}^{\varphi_a} \varphi dG$ are farm incomes from agribusinesses and traders and total profits are $\Pi_a + \Pi_t = 0$ from free entry of intermediaries. Farmer incomes in turn equal their aggregate consumption and investments, $C + f(1 - G(\varphi_a))$.

Writing the identities in terms of first differences of equilibrium outcomes ($\Delta X(p_a, f_a) = X(p', f_a') - X(p, f_a)$), the aggregate comparative statics with respect to world prices and entry costs can be determined as follows:

$$\begin{aligned}\Delta R/R &= (\Delta\Pi_a + \Delta\Pi_t + \Delta I_a + \Delta I_t)/R \\ &= \sum_{i\in a,t} \Delta\mathscr{M}_i R_i/R + \sum_{i\in a,t} \Delta(1-\mathscr{M}_i) R_i/R\end{aligned}$$

where R_a and R_t are the export revenues of agribusinesses and traders respectively. $\mathscr{M}$ denotes firm markdowns of world prices to farmgate prices: $\mathscr{M}_a \equiv 1 - p_a/pm_a$ and $\mathscr{M}_t \equiv 1 - p_t/pm_t$. $\Delta\mathscr{M}_i R_i/R$ can be further decomposed into the change in markups $\Delta\mathscr{M}_i$ and the change in market share of each intermediary $\Delta(R_i/R)$ which arises because farmers switch between traders and agribusinesses, resulting in changes in real aggregate revenue from differences in intermediation technologies.

The national income identities above show that trade values can be exactly decomposed into incomes of various factors in the economy. In many trade models, commonly made assumptions guarantee that changes in trade values co-move with factor incomes, and information on trade value changes, the trade elasticity and factor shares delivers the same direction of changes in the aggregate and individual gains from trade. For example, this arises when aggregate profits are a constant fraction of revenues or when firm profit margins arise from choke prices (see Costinot and Rodriguez-Clare 2014). In our setting, aggregate gains from trade need not co-move with farm incomes. This arises because markdowns vary among the cross-section of intermediaries and they vary with model primitives (like world prices or entry costs).

4. Applications to The Distribution of the Welfare Gains from Trade

This section generalises the model to incorporate real world features - barriers to entry of agribusinesses and state parastatals. As mentioned in the introduction, encouraging agribusiness-led development of crop markets is high on the agenda of policymakers. We therefore introduce a government sector and entry barriers into the model to conceptualise rent shifting from agribusiness policies. We obtain a set of sufficient statistics for the aggregate and distributional gains from removal of agribusiness entry barriers. Having estimated moments from the data, we revisit income changes from asymmetric trickle down of world prices to infer entry barriers.

4.1. **Behind-the-Border Barriers for Agribusinesses.**

Crop markets in many developing economies feature high barriers to entry of agribusinesses and purchases by state

parastatals. On the first, we follow the classic reasoning on import quota rents in international economics and the recent advances in macroeconomic modelling of distortions as wedges to provide a flexible and tractable way of modelling entry barriers. As is well-known from the import quota literature, the assignment of property rights to the proceeds of entry barriers determines the distribution of the gains from trade. In standard textbook analysis, when governments auction off quotas to firms, they earn the rents but when they distribute them lumpsum, they show up with the agents who receive them. Similarly, in our setting, removal of entry barriers shifts rents across agents and we can exploit the general equilibrium relationships to quantify unobserved welfare changes through rent shifting (in addition to the channel of interlinked intermediary markets specified before). To account for the second feature of state parastatals, we introduce the channel of direct participation in crop markets by the government.

4.1.1. *Theoretical framework.* Entry barriers can be introduced in the benchmark model through the free entry condition for agribusinesses. The condition is generalised to $\Pi_a = MB - MB_g - Mbn$ where B is the cost of barriers per entrant, MB is the total cost of entry barriers, MB_g is the rent accruing to the government from agribusiness entry barriers and Mbn is the rent accruing to each of n farmers who engage with agribusinesses (where $n = (\varphi_{\min}/\varphi_a)^k$ for brevity). This is a reduced form way of introducing entry barriers and associated rent shifting across agents, as we explain further.

Reductions in B operate in a way similar to the usual entry costs for firms (like f_a before), and they therefore reduce the rents accruing to agribusinesses. Reductions in B_g instead reflect a lowering of entry fees paid to the government by agribusinesses and are a shift in surplus from the government to agribusinesses. Reductions in b reflect rent erosion for farmers who sell to agribusinesses. It directly shifts surplus away from farmers to agribusinesses but can also affect the surplus of governments through resource clearing.

Resource clearing gives national income identities which now feature the government surplus and the rents from barriers to entry. Letting I_g denote the income earned by farmers from sales to the government and C_g denote own consumption of the government, the budget constraint of the government is $\Pi_g = C_g - MB_g = R_g - I_g$ when it receives R_g as export revenues.[7]

The operations of the government in the crop market is specified as the government offering a price p_g for the crop and targeting a share κ of farmgate output to purchase.

[7]To see that B and B_g can lead to opposing comparative statics, consider a simple example where $b = R_g = I_g = 0$. Reductions in entry fees B_g from the government directly produce the opposite effects as entry cost reductions on farmgate prices. Additionally, when the government uses the rents to purchase crops at higher prices, there will be a direct positive impact on farmer incomes. The government however will need to be relatively more productive in selling to export markets to result in overall gains from subsidisation.

Most farmers engage in some form of sales to governmental agencies, so we assume there is a subsidisation element to crop purchases by the government: $p_g > p_t, p_a$ (which is verified in our empirical application). This formulation flexibly accounts for the role of state parastatals and cooperatives that often pay higher prices to farmers and co-exist with private sector intermediaries. We assume farmers are randomly matched to government agencies and expect to sell κ share of their produce to them. Then the cutoff for farmers who sell to agribusinesses is $\varphi_a = (f-b)/(\bar{p}_a - \bar{p}_t)$ where $b \leq f$. The expected price of farmers who sell to traders is $\bar{p}_t = (1-\kappa)\, p_t + \kappa p_g$ and $\bar{p}_a = (1-\kappa)\, p_a + \kappa p_g$ is the expected price of those who sell to agribusinesses. The term κp_g summarises the higher prices (or farm subsidies) paid by government agencies and the size of the government sector in the crop market, $I_g = \kappa p_g \frac{k}{k-1} \varphi_{\min}$.

The presence of a higher-paying government sector affects the optimal prices paid by traders and agribusinesses: $p_t = \frac{\mu N(k-1) pm_t - \kappa p_g/(1-\kappa)}{\mu N(k-1)+1}$ and $p_a = \frac{M(k-1) pm_a + \bar{p}_t/(1-\kappa) - \kappa p_g/(1-\kappa)}{\mu_a M(k-1)+1}$ where $\mu/\bar{p}_t \equiv \frac{(f-b)^{-k+1}(\bar{p}_a - \bar{p}_t)^{k-2}}{\varphi_{\min}^{k-1} - (f-b)^{-k+1}(\bar{p}_a - \bar{p}_t)^{k-1}}$. The main insight is that the government makes the crop market for intermediaries smaller and lowers the farmgate prices that private intermediaries pay to farmers. However, expected farmgate prices are higher on account of the subsidisation element of government purchases.

The system of equilibrium equations is now given by:

$$(pm_t - p_t)^2 (f-b)^{-k+1} (\bar{p}_a - \bar{p}_t)^{k-2} (1-\kappa)^2 k \varphi_{\min}^k = f_t$$
$$(pm_a - p_a)^2 (f-b)^{-k+1} (\bar{p}_a - \bar{p}_t)^{k-2} (1-\kappa)^2 k \varphi_{\min}^k = f_a + B - B_g - bn$$

and the national income identity by: $R = R_t + R_a + R_g = \Pi_t + \Pi_a + \Pi_g + I_t + I_a + I_g$. The identity can be exploited to express the aggregate gains from trade in terms of observable outcomes and elasticities, which we turn to next.

To account for multiple crops, we first assume that a farmer has L parcels of land. Each farmer has a vector of productivity draws $\varphi_c \sim G_c(\varphi)$ where c is the crop with the highest productivity for that parcel. Then the aggregate equilibrium outcomes are a sum of the outcomes across all crops: $X \equiv \sum_c X_c$. Let $\hat{X} \equiv \Delta X / X$ denote the usual percentage change in outcomes.[8] The aggregate comparative static is

(4.1)
$$\hat{R} = \left(1 - S_a^R - S_t^R - S_g^R\right) \left(S_a^I \hat{I}_a + S_t^I \hat{I}_t + \left(1 - S_a^I - S_t^I\right) \hat{I}_g\right) + \left(S_a^R \hat{\Pi}_a + S_t^R \hat{\Pi}_t + S_g^R \hat{\Pi}_g\right)$$

where S_a^R, S_t^R and S_g^R are the profits received by agribusinesses, traders and the government respectively as a share of aggregate revenues while S_a^I and S_t^I are the shares of agribusinesses and traders in aggregate farm incomes respectively. Typically, aggregate

[8]Later we will also examine within-household across-crop spillovers.

comparative statics are exploited to infer welfare changes from observable moments and elasticities that can be estimated from trade data. For example, the import penetration ratio together with the trade elasticity are sufficient statistics for the aggregate welfare gains from trade across various models of international trade. While much of the focus of that literature is therefore on summarising welfare in terms of few sufficient statistics, the presence of rich microdata enables a quantification that requires less model structure because more moments and elasticities are available from the data. To sum up, changes in B, B_g and b are unconstrained and they have consequences for the division of the gains from trade that are estimated and inferred from microdata, as explained next.

4.1.2. *Theory to Quantification.* The aggregate gains from trade $\hat{R}$ are estimated through a standard gravity regression where the trade elasticity is estimated with respect to the policy measure. The change in farmer incomes and agribusiness profits is estimated from data on household-crop-buyer incomes and profit margins reported in company accounts of agribusinesses. The unobservables are changes in trader profits and changes in government rents, which are rarely available in standard data sources. The change in profit margins of traders are inferred using equilibrium conditions that rely on farmer sorting and profit maximisation, but are not constrained by the structure of the benchmark model. Finally, changes in government rents (or rent of other intermediaries such as state parastatals) are inferred from the national income identity after accounting for the estimated changes in trade, farm incomes, agribusiness profits and (inferred) trader profits.

The trader profit change is based on sorting of farmers across intermediaries and free entry of traders. The aggregate supply to traders is $Nq_t = (1-\kappa)\left(\int_{\varphi_{\min}}^{\varphi_a} q(\varphi)\, dG\right)$ where $q(\varphi)$ is the quantity of a farmer with productivity φ, φ_a is the cutoff productivity below which farmers sort into selling to traders and $1-\kappa$ is the share of farmers that sell to private intermediaries. From free entry of traders, $(pm_t - p_t)\, q_t = f_t$ and the envelope theorem gives the total (indirect) change in trader quantity as $\hat{q}_t(p_t, B - B_g - bn) = 0$ where the price effect from p_t drops out because of profit maximisation. Then the change in aggregate trader profits can be written as

$$\begin{aligned}\hat{\Pi}_t = &-\frac{\kappa}{1-\kappa}\hat{\kappa} + \frac{1-\kappa}{Nq_t} q(\varphi_a)\, g(\varphi_a)\, \varphi_a \hat{\varphi}_a (p_t, B - B_g - bn) \\ &+ \frac{1-\kappa}{Nq_t}\int_{\varphi_t}^{\varphi_a} q(\varphi)\, \hat{q}_t(p_t, B - B_g - bn)\, dG\end{aligned}$$

where $\hat{q}_t$ in the second line is zero when supply does not directly depend on entry barriers (although it is indirectly affected through free entry). The productivity cutoff condition for farmers selling to agribusinesses is $\varphi_a = (f - b) / (\bar{p}_a - \bar{p}_t)$. Therefore, the indirect change

in the cutoff is the observed change in the cutoff net of the change arising in it from the direct impact of changes in prices paid by traders: $\hat{\varphi}_a\left(p_t, B - B_g - bn\right) = \hat{\varphi}_a - \frac{\bar{p}_t}{\bar{p}_a - \bar{p}_t}\hat{\bar{p}}_t$. This gives the change in trader profits as

(4.2)
$$\hat{\Pi}_t = -\frac{\kappa\hat{\kappa}}{1-\kappa} + (1-\kappa)\frac{I\left(\varphi_a\right)}{I_t}\left(\hat{\varphi}_a\left(p_t, B - B_g - bn\right) - \frac{\bar{p}_t\varphi_a}{\left(\bar{p}_a - \bar{p}_t\right)\varphi_a}\hat{\bar{p}}_t\left(p_t, B - B_g - bn\right)\right)$$

In economic terms, the first term on the RHS is the change in market size of traders from changes in governmental purchases. The second term is the change in market size of traders from farmers switching to agribusinesses, net of the price changes from traders.

The LHS $\hat{\Pi}_t$ is unobserved and the RHS is observed or can be estimated from data on household-crop-buyer incomes over time. The share of government purchases κ is directly observed and the change in sales to government $\hat{\kappa}$ is estimated using data on household-crop-buyer incomes with respect to the policy measure. The incomes of marginal sellers to agribusinesses $I\left(\varphi_a\right)$, the income sold to traders I_t and the relative incomes from traders and agribusinesses for marginal sellers is $\frac{\bar{p}_t\varphi_a}{(\bar{p}_a - \bar{p}_t)\varphi_a}$, whose components are directly observed in the income data too. The change in the share of farmers selling to agribusinesses $\hat{\varphi}_a$ and the change in trader prices is estimated with respect to the policy measure.

4.2. **Context of Application to BTBs.** This section starts with a description of the data on households and agribusinesses and then discusses the context and policy application.

4.2.1. *Context and Policy.* The model is applied to Kenyan agriculture, which captures the institutional context of small farmers selling through traders and agribusinesses in an economy that is highly dependent on agriculture. Kenya is a lower middle-income economy with a mean consumption of USD 1,176 for rural households in 2005 (World Income Inequality Database/Kenya Integrated Household Budget Survey consumption data). A vast majority of people continue to be employed in agriculture which makes up 25 per cent of GDP and 75 per cent of the labor force.

Agricultural growth in Kenya had stagnated by the 1980s and state presence had expanded to state purchases and administered prices. For example, maize and wheat prices were set by a national board until 1996, after which the administered price regime was largely done away with (Winter-Nelson and Argwings-Kodhek 2007). Although price controls had been lifted and divestment in state companies had started, the big push to commercialize agriculture came in 2004 when policies were put in place to encourage agribusiness participation in crop markets. Two key developments prompted this policy shift. A new government headed by President Kibaki came to power in 2002 on the

platform to "do something about agriculture." The general view was that intermediation costs of traders and state companies were higher in Kenya than best practices elsewhere. Moreover, horticulture and floriculture, which had been relatively open to private sector operations, had experienced high growth rates (see Machhiavello and Morjaria 2015). They however made up a small share of farmer incomes, which led to the view that the success of the growing sectors could be scaled up by encouraging agribusinesses in crop markets.

In March 2004, the Strategy for Revitalising Agriculture (SRA) was launched, proposing a "radical reform" of the role of the state within Kenyan agriculture. Agribusinesses operated in Kenya before 2004, but their operations were constrained by government policy. After the launch of the new policy, within a couple of years, licencing and investment restrictions were relaxed for agribusiness activities across the majority of crops grown by smallholder farmers. For example, the Investment Promotion Act (31st December 2004) entitled any investment certificate holders the licence to mill maize, establish sisal factories and deal in coffee. These were enshrined as amendments in the Acts and they lend themselves well to codifying a count measure of the number of sections of legislation that were deleted/repealed/amended. We read every law (and its antecedents) to categorise and count the number of sections changed in the legal texts. A section largely corresponds to a specific requirement, typically a licence or permission or registration, that needs to be fulfilled for the crop(s) to which the Act applies.

The full list of legislations (and their antecedents) are available from the Kenya National Assembly, and cross-verified through FAOLEX and ECOLEX. This consists of 22 different pieces of legislation among the universe of Acts applicable between 2004 to 2006. The crops where Acts were repealed include different varieties of maize, coffee, wheat, cotton, sugarcane, sisal, pyrethrum, cashewnuts, rice and certain varieties of fruit, vegetables and flowers. A typical example, a full list of Crops and Acts for the BTB policy measure construction is provided in the Online Appendix in Table 17.

4.2.2. *Context and Farm Data.* Information on cropping patterns and incomes per buyer before and after the policy was implemented is obtained from surveys by 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 and follow them over time (see Chamberlin and Jayne 2013 for sampling details). The Kenyan household panel covers rural households with less than fifty acres of land. They are surveyed in 2000, 2004, 2007 and 2010 to gather information for June of the previous year to May of the survey year. Households report farming activities during the main and short cropping seasons of

each year. Attrition rates of the panel are low – over 90 per cent of the households are resampled. This is particularly important because standard datasets of rural households in low-income countries can have high attrition rates (for example, 50 per cent in many World Bank LSMS datasets).

Aggregating up across all fields, the income earned per household-crop-buyer is defined as the sum across all fields of the quantity times the price paid by the largest buyer for each field on which the crop is grown. As is well-known quality and productivity are isomorphic in many trade models and we focus on the income impacts to capture both. Buyers include consumers/traders, state companies/cooperatives and agribusinesses. Agribusinesses in the survey refer to large companies, exporters, miller, processors or supermarkets.[9] The overwhelming majority of households sell a particular crop to just one type of buyer. We therefore aggregate the data up to the household-crop level for each cropping season and year, and sales are characterised by an indicator for the buyer type for each household-crop-season-year observation. For analysis of household welfare, the household-crop information across all crops is aggregated up to the level of the household to arrive at total farm income. We also consider non-farm channels through which the BTB policy may have impacted households, such as wages and business enterprises, incomes for which are reported for the household annually.

The main crops for farmers in Kenya are maize, tea, sugarcane, coffee cherries, bananas, wheat and tomatoes. In each of these crops (except tea), Kenya is an exporter but made up less than 1 per cent of world exports. Maize is the most important crop every year and the ranking of the other main crops changes slightly across years. In each year, the survey asks households to report the quantity harvested of each crop on each field, the type of buyer to whom the largest sale is made and the price paid for the latter. The mean share of farmer incomes from crops by their changes in behind-the-border barriers to entry of agribusinesses is summarised in Table 4. While 26 of the 128 crops experience no change in BTBs, the bulk of crops experience policy changes, ranging from just one section of legislation being removed (74 such crops) to over dozens being removed for crops such as cotton. Crops with BTBs larger than one make up the majority of household farm incomes in the pre-policy period (2000 and 2004). A detailed analysis of the BTBs and their correlation with key variables is in the Appendix. Here we emphasize that the policy had its desired impact of raising farmer engagement with agribusinesses as reflected in

[9]As our focus is on profit-maximising firms, co-operatives, boards and worker controlled agencies like the National Cereals and Produce Board or the Kenya Tea Development Agency Holdings Limited are excluded from the agribusiness category. We combine consumers and traders for brevity and to capture market sales, though keeping them separate makes little difference to the main results.

the mean shares sold to agribusinesses for crops that were affected by the BTB policy in Table 4.

TABLE 4. Mean Share of Agribusinesses in Farmer Incomes by Crops %

	All crops		Grown crops		Balanced crops	
	Pre	Post	Pre	Post	Pre	Post
$\Delta B_c = 0$ crops (26)	6.62	8.03	9.57	9.08	4.81	3.45
$\Delta B_c = 1$ crops (74)	3.72	10.30	4.67	11.54	4.75	8.46
$\Delta B_c > 1$ crops (28)	5.01	14.37	7.02	16.09	4.76	14.27

All crops refer to the full set of crops, Grown crops refer to crops that have positive sales and Balanced crops refer to the crops that have positive sales in pre and post periods.

4.2.3. *Context and Agribusiness Data.* As is well-known, data on intermediaries is scarce, particularly in developing economies. We therefore put together a primary data source on profit margins of agribusinesses listed on the Nairobi stock exchange. We first looked up names of all publicly listed agricultural firms through the Capital Markets Authority of Kenya for each year from 1999 to 2010. Then we manually collected sales and profit data (and any restatements) from their audited financial reports for each year. Listed companies are mandated to declare their annual audited reports by law, and we therefore have all the listed agricultural companies in the country. Alternative sources of company records, such as Orbis, do not have the coverage that we get by manually compiling the dataset.[10]

There are 13 agribusiness companies which operate in almost all years since the start of the Nairobi Stock Exchange, with an average annual revenue of 6.2 billion Kenyan Shillings per firm. There is no entry and one company is de-listed for a couple of years. The companies include multinational firms like Limuru (Unilever) and British American Tobacco Company and domestic conglomerates like the Unga group and Uchumi supermarkets, which are well-recognized brands in Kenya. Although firms report their accounts in different ways, two key variables are available consistently over time and across firms. The first key variable is the profit margin of the firm (profit before tax reported by the company divided by its revenue). The median profit margin of companies is 5.7 per cent and the mean is 6.8 per cent (though the sales-weighted average is much higher).

[10]Datastream and Orbis are other sources of information with which we cross-check the firm names. Datastream gives a similar listing but Orbis does not contain all the information. A potential shortcoming of Orbis is that it does not typically keep track of firms that get de-listed so that historical company information is available just for firms that survive to recent years. Two firms that appear in Datastream during the period but seemingly do not appear in our database are Kenya National Mills and Unilever Tea Kenya. This is because the former files joint accounts with its parent company Unga Group, which is in our dataset. Unilever is also in our dataset but it is called Limuru Tea Plc, which is an outgrower company for Unilever in Kenya.

The second key variable is the cropping segment in which the company operates, which is available from company sales reports and sales descriptions. Segment refers to Beer and Beverages, Coffee, Horticulture, Sisal, Cotton spinning and services, Sugar made from cane, Tea, Maize milling, Wheat production, Poultry feeds and Animal health and nutrition, or All of these. The crop-level exposure of a company is defined as its sales shares in each crop segment in the pre period (1999-2004) and we use this to assign the crop-specific BTB policy value to each company. Table 18 in the Appendix contains the list of companies, their segments and BTB policy measure values.

4.3. **Results of Application to BTBs.** This sub-section contains estimation results for the elasticities of the gains from trade with respect to the policy and welfare inferences. Detailed regression tables are in the Online Appendix with different specifications and here we focus on the baseline results.

4.3.1. *Trade, Crop Incomes and Agribusiness Profits.* We start with estimating a gravity regression of log trade values on the BTB policy changes to obtain an estimate for the aggregate gains from trade $\hat{R}$. For source country s exporting crop c to world markets in year t, the log of the COMTRADE reported trade value is

$$\ln R_{cst} = \beta_R \cdot Post_t \cdot \Delta B_c \cdot Kenya_s + \alpha_{cs} + \alpha_{st} + \alpha_{ct} + \varepsilon_{cst}$$

where $Post_t = 1$ after 2004, ΔB_c is the number of sections of legislation that are repealed for crop c, $Kenya_s$ is an indicator for Kenya and ε is an error term. The coefficient of interest is β_R which is the trade elasticity of behind the border barriers to agribusiness operations. The fixed effects include crop-source country α_{cs}, source country-year α_{st} and crop-year α_{ct} terms, which respectively account for time-invariant crop-country characteristics, source country macroeconomic changes and world crop demand and supply shocks. There are 66 crops and 175 countries from 1997 to 2010. The estimated increase in Kenya's exports of crops with one section of legislation repealed is 1.91 percent on average in Column 1 of Table 5. Therefore, there is a substantive rise in Kenya's exports of policy-affected crops.

Column 2 estimates the household-crop elasticity of farm incomes to the BTB policy $\hat{I}_{hcm}$. For household h selling crop c in season m (main or short) of year t, the log of income in (1000 Kenyan shillings) is

$$\ln I_{hcmt} = \beta_I \cdot Post_t \cdot \Delta B_c + \alpha_t + \alpha_{hcm} + \alpha_{cmt'} + \varepsilon_{hcmt}$$

where β_I is the coefficient of interest and α_t are year fixed effects. Household-crop-season fixed effects α_{hcm} ensure that the variation is from within household-crop changes in incomes and $\alpha_{cmt'}$ are crop-season-pre 2004 fixed effects that allow for differences in crop

TABLE 5. BTB Reductions and Source Country-Crop Exports, Household-Crop Incomes and Profit Margins of Agribusinesses

	(1) Exports $\ln R_{sct}$		(2) Incomes $\ln I_{hcmt}$	(3) Profits $\mathscr{M}_{at}$
$Post_t \cdot \Delta B_c \cdot Kenya_s$	0.0191	$Post_t \cdot \Delta B_c$	-0.0177	0.0091
	(0.0053)		(0.0089)	(0.0045)
Fixed effects	Crop-Country	Fixed effects	Hh-Crop-Season	Company
	Crop-Year		Year	Year
	Country-Year		Crop-Season-Pre Years	
N	83759	N	17130	156

The dependent variable is Log of Crop Exports $\ln R_{sct}$ (in '000 USD) from selling agricultural commodity (crop group) c by source country s in year t for a panel of crop-source country-year observations for all crops and for all countries in years 1997 to 2010. $Post_t$ is an indicator for years 2005-2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. The dependent variable in Column 2 is the Log of Crop Income $\ln I_{hcmt}$ (in '000 KSh) from selling crop c for household h in season m of year t for a panel of household-crop-season-year observations for all crops and for all households. The dependent variable in Column 3 is the Profit Margin (Profit Before Tax/Sales) of the agribusiness firm a during year t. The sample consists of the universe of agricultural companies listed on the Nairobi Stock Exchange between 1999 to 2010. Regressions are weighted by the share of the crop in the initial farm income of Kenyan households in Column 1, unweighted in Column 2 (weighted versions are in the Appendix) and by the agribusiness sales share in Column 3. Standard errors are clustered by crop and source country in parentheses in Column 1, by crop and household in Column 2 and by company and crop segments, correcting for small clusters in Column 3.

pre-trends. There are 76 crops and 1,284 households during four survey years (1999/2000, 2003/2004, 2006/2007, 2009/2010). The estimated elasticity of household-crop incomes to repealing one section of the BTB policy is a reduction of 1.77 percent. Farmers received lower prices and rents after the policy change, and we discuss these income changes across different farmers in detail later.

Column 3 estimates the elasticity of agribusiness profit margins to the BTB policy. The profit margin of firm a specialising in crop segment c is specified as:

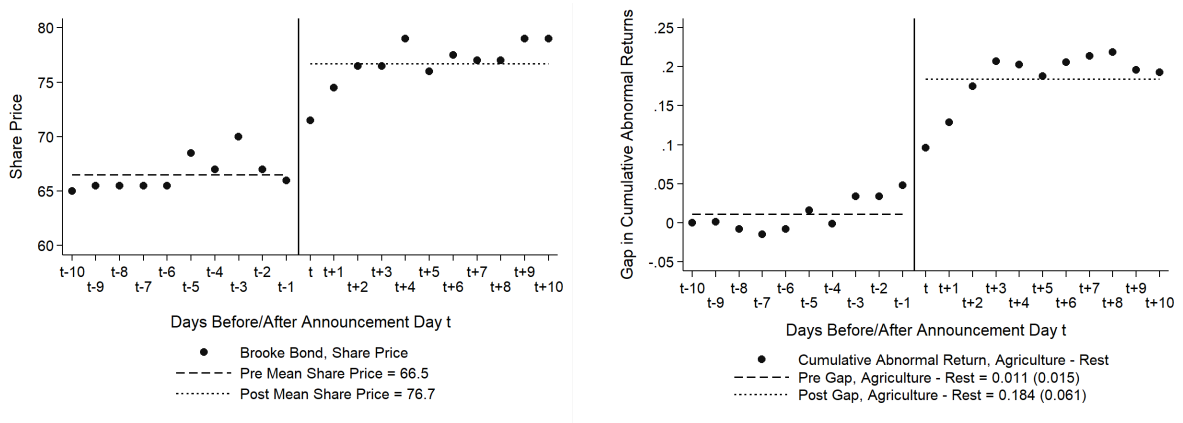
$$\mathscr{M}_{at} = \beta_a \cdot Post_t \cdot \Delta B_a + \alpha_a + \alpha_t + \varepsilon_{at}$$

where $\Delta B_a = \sum_c (S_{ca}/S_a)\, \Delta B_c$ for sales S_{ca} of crop c by agribusiness a between 1999 to 2004. Column 3 shows that on average the elasticity of agribusiness profits to repealing of one section of BTB is 9.1 percent. This confirms the evolution of profits depicted in Figure 2.1 of fact 4a.

As there is a small number of listed agribusinesses in Kenya, we also show an event study graph of stock returns as additional evidence for the rise in agribusiness profitability. On

March 4, 2004 after uncertainty surrounding the president's health and a political party meeting, the East African Standard reported imminent changes in agricultural policy which later became the national legislative reform (retrieved from LexisNexis). There were some slight but uncertain murmurings in the press a few days before the meeting too, but the meeting solidified support for the large policy reform in agriculture. We start in Figure 4.1 (a) with the evolution of the share price of the well-known agribusiness Brooke Bond (or PG Tips or Lipton) which is listed on the Nairobi Stock Exchange (NSE). Its share price jumped relative to the share price of all other listed companies within days of the leak of the policy announcement. Panel (b) compares the evolution of share prices for agricultural companies compared to the 39 other companies listed on the NSE. Cumulative abnormal returns (CAR) refer to the change in share prices of the agricultural companies over the previous day relative to the change in the NSE-20 share index over the previous day. CAR for the Rest refer to the change in share prices (relative to the previous day and relative to the change in the daily NSE-20 share index) for the 39 other companies. The horizontal lines indicate the mean CAR gap between agricultural companies and the rest in the ten days before and after the policy announcement. The stock returns of agribusinesses in Kenya shows substantial uptick just after the policy was announced.

FIGURE 4.1. Stock Returns Before and After the Announcement Day of the BTB Policy



(A) Brooke Bond (B) Agricultural Companies

The announcement date is March 4, 2004. The share price is the average daily price, available from the Nairobi Stock Exchange.

While the gravity specification is standard, robustness of agribusiness profits and crop-level incomes of households is explored in greater detail in the Appendix. Table 10 shows the profit margin results are robust to different variations of weighting and samples.

Tables 11 and 12 further show that the income results are not driven by world price changes, spoilage of harvest, initial crop-level distortions or elections to crop boards, different weighting for buying stage of agribusiness operations (also see theory appendix for stages), incomes from maize (which is the main food crop) and incomes from tea (which is the main export crop).

4.3.2. *Intensive and Extensive Margins of Crop Sales to Buyers.* Having estimated the key elasticities, we examine the heterogeneity in farm income impacts by buyer type suggested by the theory. The estimated elasticities of household-crop incomes from each buyer to the BTB policy is shown in Table 6. For farmers who continue to sell to agribusinesses, Column 1 shows an estimated elasticity of incomes from agribusinesses of -9.38 percent for a repeal of one section of legislation. The policy is therefore associated with a sharp reduction in rents (b in the theory) for farmers selling to agribusinesses before and after the policy change. The corresponding income elasticity for government purchases is estimated to be -2.41 percent in Column 2 (although imprecisely). This confirms the subsidisation feature of government purchases, $\hat{\kappa} < 0$ in the theory, which reduces farmer incomes as state purchases give way to higher agribusiness sales.

Importantly, the losses were not restricted to rent shifting and rollback of government purchases. There were knock-on effects on incomes earned by farmers from traders and village markets. The estimated income elasticity is -1.38 percent for sales to traders in crop markets in Column 3. Even though farm sales to traders are not directly affected by agribusiness policies, farmers selling to traders and village markets experience income losses. Theoretically, this would arise when inequality is high and we confirm this in our setting by estimating the Pareto shape parameter. The estimated Gini coefficient for crop income per acre, φ in the theory, in the pre-policy period is $G = 0.36$. As the Pareto shape parameter is $k = 1/2 + 1/2G = 1.88 < 2$, inequality is above its critical level and increases in agribusiness engagement have theoretically negative consequences for farmers selling through traders.[11]

Farmers switch across buyers and the estimated elasticities of the extensive margins are provided in Columns 4 and 5. The share of farmers switching to agribusinesses from traders/consumers is estimated to rise by 1.67 percent with a repeal of one BTB section. The policy therefore had the desired consequence of increased engagement with agribusinesses. Further, the share of farmers switching to governmental agencies from market sales is estimated to be -0.32 percent, showing the general decline in government purchases. This decline had corresponding negative changes in household-crop incomes of switchers. Farmers who switch to agribusinesses from other private sales are estimated to

[11]The Pareto shape parameter for income (instead of income per acre) is even lower, at 1.69.

see a reduction in household-crop incomes of -0.025 (0.016) for a single BTB repeal from 1815 household-crop-year observations. It also had negative consequences for incomes of the small number of 123 household-crops that switch out of governmental agencies to market sales. Their income elasticity is estimated as -0.048 (0.005), which shows an expected farm income contraction from the rollback of government purchases.

TABLE 6. BTB Policy and Household-Crop-Buyer Incomes: Intensive and Extensive Margins of Farm Sales to Buyers

	Log of Crop-Level Incomes from Buyer b: $\ln I_{bchmt}$			Sell Crop to Buyer b: $1_{I_{bhcmt}>0}$	
	(1) $\ln I_{ahcmt}$	(2) $\ln I_{ghcmt}$	(3) $\ln I_{ohcmt}$	(4) $I_{ahcmt} > 0$	(5) $I_{ghcmt} > 0$
$Post_t \cdot \Delta B_c$	-0.0938	-0.0241	-0.0138	0.0167	-0.0032
	(0.0339)	(0.0089)	(0.0084)	(0.0061)	(0.0016)
Hh-Crop-Season FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Crop-Season-Pre FE	Yes	Yes	Yes	Yes	Yes
N	473	1903	13629	14938	15371

The dependent variable is the Log of Crop Income $\ln I_{bhcmt}$ from selling crop c in Columns 1, 2 and 3 for household h in season m of year t to buyer $b \in \{a, g, o\}$, where a = Agribusiness, g = Board/Coop and o =Other (Trader or Consumer). The dependent variable is an Indicator for Positive Sales of crop c for household h in season m of year t to agribusinesses (among the group that makes a switch between agribusinesses and traders/consumers) in Column 4 and for positive sales to government agencies (among the group that makes a switch between government and agribusinesses/traders/consumers). $Post_t$ is an indicator for 2007 and 2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. Hh refers to households and Pre refers to survey years 2002-03 before the BTB policy.

4.3.3. *Other Income Margins.* Before we turn to quantifying the welfare changes with the agricultural income elasticity estimates in hand, we examine whether the policy had spillovers on to other income sources (see Table 15 in the Online Appendix). The first is across-crop spillovers within the household, for which we construct a share-weighted BTB policy variable for crops other than the one under consideration, $\sum_{c' \neq c} S_{hc'm0} \Delta B_c$ where $S_{hc'm0}$ is the income share of crop c' in the household's income. Entering in the initial share-weighted BTB policy change for other crops in the household-crop income specification shows that the across-crop policy spillovers into incomes are almost zero. There is also no systematic change in crops grown by the household and the BTB policy change for the crop, so the extensive margin of entry into crops is negligible.

Farming input expenditures also show almost zero changes with respect to the policy measure. If interlinked input transactions were driving the income losses of farmers, costs would be expected to respond to the policy change. As a number of the reported cash

costs are zeros, the estimation is done in levels rather than logs. Finally, the log of other income sources- wages, livestock and enterprise incomes – show a fall with respect to the initial share-weighted BTB measure for the household, $\sum_c S_{hcm0}\Delta B_c$. But the estimated elasticity is small (-0.32 of a percent) and an order of magnitude lower than the estimated household-crop income elasticity. We therefore focus on agricultural income elasticities, though changes in total incomes are also summarised later.

4.3.4. *Distribution of the Gains from Trade.* Having estimated the income elasticity and with data on initial household-crop-buyer incomes, the aggregate change in incomes of farmer who do not switch buyers can be predicted as $\sum_h \sum_b \sum_c \beta_b I_{bhcmt}$ from the estimated log income regressions for each household-crop-buyer and evaluated at the mean change in crop BTBs for the sample (Columns 1, 2, 3 of Table 6). For farmers who switch buyers, the income change is predicted as the estimated β_b in Columns 4 and 5 multiplied by the mean BTB policy change for the sample. This is further multiplied by the estimated elasticity of household-crop incomes for switchers mentioned earlier (-2.5% and -4.8%). Aggregating the income impacts for the farmers who continue with their buyers and those who switch gives the aggregate farm income loss of $\hat{I} = 6.84$ percent. When divided by total initial income (and not just farm income), the estimated total income loss is 3.25 percent. Dividing the households by quintiles of total initial income, the bottom to top quintiles lose on average 6.2, 6.2, 6.4, 8.2 and 7.1 percent of their farm income or 2.1, 3.5, 3.1, 4.7 and 2.9 percent of their total income.

The estimated revenue elasticity from the export gravity regression is $\hat{R} = 1.91$ percent (Column 1 of Table 5). Evaluated at the mean policy value of 5, the estimated trade impact is 9.6 percent of initial trade value. The estimated agribusiness profit margin increase (in levels) is $\Delta\mathscr{M}_a = 9.1$ percent, which is multiplied with the mean policy measure of 3.7 and divided by the mean sales-weighted markup of 0.156.

The initial aggregate revenue shares of agents in the economy are computed from various sources. From the ILO and the World Bank, 39 percent of the Kenyan population was in agricultural employment and the bottom two quintiles received 14.1 percent of national income in 2004-2005. Agribusiness profits were 15.6 percent of their total sales and they made up 21.5 percent of farm sales in 2004. Consequently, $\Pi_a/R_a = 0.156$. As $R_a = \Pi_a + I_a$, this gives $R_a = I_a/(1 - 0.156)$. For $I_a/I = .215$, we can therefore write aggregate revenues as $R = I_a/(1 - 0.156) + (0.785/0.215)\, I_a + \Pi_t + \Pi_g$. An upper bound on agribusinesses profit share in aggregate revenues is obtained by setting trader profits and government rents to their lowest values, $\Pi_t = 0$ and $\Pi_g = 0$.

To infer the changes in trader profits, we exploit the equilibrium condition of the model in Equation 4.2. The share of sales to governmental agencies κ is observed from household-crop-buyer income data for each crop. It is multiplied with the estimated elasticity of the extensive margin of sales to government agencies and evaluated at the mean policy measure for this sample to get $\hat{\kappa}$ (Column 5 of Table 6). The total income of farmers selling to traders I_t is observed from household-crop-buyer income data and the income of less productive farmers who sell to agribusinesses is proxied with the median farm sales to agribusinesses $I(\varphi_a)$. The elasticity of the extensive margin of sales to agribusinesses $\hat{\varphi}_a$ is from Column 4 of Table 6 and evaluated at the mean policy measure for the sample. The relative incomes from traders and agribusinesses is evaluated at the median farm sales to agribusinesses and traders $\frac{\bar{p}_t \varphi_a}{(\bar{p}_a - \bar{p}_t)\varphi_a}$. The change in trader prices $\hat{\bar{p}}_t$ is the estimated elasticity of crop incomes from traders to the policy measure, and evaluated at the mean of the policy measure for farmers who continue to sell to traders/consumers. The inferred impact on trader incomes $\hat{\Pi}_t$ turns out to be negligible at 0.0016 percent. This suggests that entry of traders barely responded to the policy, and it should be noted that free entry has not been imposed to arrive at this computation.

With each of the components in hand, we now infer the rents accruing to the government. These are given by

$$\begin{aligned} S_g^R \hat{\Pi}_g =& \hat{R} - S_a^R \hat{\Pi}_a - \left(1 - S_a^R - S_g^R - S_t^R\right) \hat{I} - S_t^R \hat{\Pi}_t \\ \leq& 9.6 - 0.245 \times 21.4 - 0.141 \times (-3.25) - 0 \\ =& 9.6 - 5.2 + 0.5 = 4.9 \end{aligned}$$

Agribusinesses saw large increases in profits but as they make up less than a quarter of all revenues, the residual government sector is inferred to have experienced gains in rents of a comparable but slightly lower magnitude. While it is plausible that many of these gains may be transferred back to farmers or intermediaries, they nonetheless had substantial impacts on earnings and rents (as opposed to transfers).

Summing up, household-crop incomes fell for farmers who were selling the BTB-affected crops, especially for farmers who were selling these crops to agribusinesses before. Evaluated at the mean BTB policy value, farmers experienced a 6.8 percent drop in farm incomes (or 3.25 percent drop in total income). It resulted in an aggregate gain of 9.6 percent in aggregate exports of affected crops and this surplus went largely to agribusinesses and government agencies. Traders saw negligible changes in profitability and the

smallholders who continued to sell to them were worse-off, as expected in an economy with high inequality.

4.4. **World Price Transmission.** In a second application of the theoretical framework, we revisit the trickle down of world prices into farmgate prices and incomes to inform the modelling of entry barriers.

A first observation is that Proposition 4 confirms fact 4 regarding higher world price transmission from agribusinesses to farmers, relative to other intermediaries. While the trickle down rates suggest that agribusinesses connect farmers better to world markets, the welfare implications are complicated by the reduced trade, profits and incomes that arise during world price decreases. The trickle down rates however are informative of the differences in profit margins across agribusinesses and other intermediaries, and their adjustment to world price movements. This provides insight into the modelling of entry barriers which are an important feature of crop markets faced by farmers.

Trader profits are unobservable in many settings, and the theory provides a way of inferring passthrough differences across intermediaries. The relative profit margins of agribusinesses compared to other intermediaries can be inferred from Equations 3.6 and 3.7 in the model. Dividing the equations by each other gives an intuitive result that the ratios of absolute margins reflect the entry cost differences across buyers: $(pm_a - p_a) / (pm_t - p_t) = (f_a + B - B_g - bn)^{1/2} / f_t^{1/2}$. Totally differentiating this relationship, the profit margins of agribusinesses compared to other intermediaries are reflected in the differences in their trickle down rates as follows:

$$\left(\frac{pm_a - p_a}{pm_a}\right) / \left(\frac{pm_t - p_t}{pm_t}\right) = \left(1 - \frac{p_a}{pm_a}\frac{d\ln p_a}{d\ln p}\right) / \left(1 - \frac{d\ln p_t}{d\ln p}\right) \tag{4.3}$$

The trickle down rates summarise the profit margin differences because given the direct increase in revenues from higher world prices, the trickle down rates contain the profit implications through farmgate price changes.

As productivity and quality are isomorphic in the model, we estimate the income trickle down from intermediaries and agribusinesses with respect to world prices to obtain the RHS of equation 4.3. Following Table 3, a first differences specification of change in household-crop incomes on change in world prices is estimated, but now with a full set of interactions for when world prices rise. Trickle down rates are compared for farmers who sold to agribusinesses in the first period and those who did not. We do not include farmers who start or stop selling to agribusinesses in that category so that the same group of farmers is being compared over time. The trickle down from world price changes to farmer income changes is 0.1796 (with a standard error of 0.0488) and there is an additional negative coefficient of -0.1995 (0.0535) for world prices when they rise (compared to

the previous survey year). The additional trickle down for farmers who sold to agribusinesses is 0.1841 (0.0681) and a further -0.1967 (0.1040) when world prices rise. (Other interactions turn out small and highly statistically insignificant and results are unaltered in their absence.)

At a mean profit margin of 0.068 for agribusinesses on the RHS of Equation 4.3 ($p_a/pm_a = 1 - 0.068$), the profit margins of agribusinesses relative to traders are about 60 percent of trader margins when world prices are falling but 103 percent of trader margins when they are rising.[12] Taking this observation to inform the model, entry barriers to agribusinesses relative to traders $(f_a + B - B_g - bn)/f_t$ are much more binding for agribusinesses when world prices are rising. This can be captured by modelling entry barriers as a function of domestic and international resources and by distinguishing between barriers to entry and exit (because agribusinesses are more price-responsive when world prices are lower). Relative entry costs can be modelled as $p^{\gamma}B$ (for $\gamma > 0$). Then barriers to agribusiness entry slow down the trickle down of world prices when they are rising. If international resources are not needed for the exit process, then the trickle down of world prices to farmer incomes still shows much greater responsiveness to world prices for farmers selling through agribusinesses.

5. Conclusion

Policies to encourage agribusiness-led development of crop markets have often been proposed as a way of raising agricultural productivity and reducing poverty. A number of proposals are on the table in several countries to adopt such policies. Yet there is limited systematic analysis of their impact on low-income farming households.

This paper starts from two observations: first, small farmers often sell their produce in crop markets, domestically or abroad, through agribusinesses or other intermediaries. And second, farmers selling to agribusinesses tend to have relatively larger farms, earn higher incomes and get higher transmission from world prices. We embed these stylised facts in a flexible theoretical model that features heterogeneous farmers who sort into different types of intermediation with buyer power. Agribusiness intermediation requires material fixed-investment outlays, while offering higher productivity. Thus, agribusiness intermediation tends to "select" higher income farmers.

The model allows us to analyse the general equilibrium welfare impacts of policies that reduce entry barriers for agribusinesses and the transmission of world prices to farmer incomes from intermediaries. In its general form, the model generates rich comparative statics for the distribution of gains from trade by allowing market power and rents to

[12]Note that variation in profit margins and lower profit margins of agribusinesses are consistent with the model (because higher profitability of agribusinesses arises from scale too).

respond to model primitives like entry barriers and world price movements. It provides national income identities that enable decomposition and inference of the gains from trade accruing to agents, including those whose incomes are rarely observable.

The model is applied to the study of a large national policy aimed at removing behind-the-border barriers to entry and expansion of agribusinesses. We codify the barriers from legal texts and find that the policy was systematically related to export revenue gains, farmer income losses and increases in agribusiness profit margins. We infer from the model that trader profits saw negligible changes and the residual government sector accounted for a substantial share of the gains from trade. Consequently, the policy shifted rents and subsidisation from farmers to agribusinesses and state agencies. More importantly, it also shifted surplus away from smallholder farmers who continued to lack access to agribusinesses and were dependent on surviving traders.

The results provide evidence for long-standing concerns that commercialisation of agriculture, via agribusinesses that wield oligopsony power and operate in economies with substantial barriers to entry, need not raise income-earning opportunities for small farmers.[13] As long panels start to evolve, further work can provide a better understanding of the barriers holding back widespread productivity gains for low-income farmers from agribusinesses. The model and applications highlight the importance of opening up the black box of behind-the-border barriers to trade for small farmers.

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[13]The results also confirm the lesson that seems to have been taken by policymakers, namely that, smallholder farmers could suffer when "liberalisation is carried out where there is no critical mass and enough capacity for the private sector to grow" (ASDS 2010).

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Appendix

5.1. **BTB Policy and Context.** A typical example of the codified legislation is produced here to fix ideas, and very few exceptions arise as most legal text have straightforward deletions of sections. The original National Cereals and Produce Board (NCPB) Act is our focus in this example as it covers some of the most important crops - maize and wheat. The NCPB Act 1985 contained, for instance, sections 19 to 23 which were amended under The Licensing Laws (Repeals and Amendment) Act 2006, reproduced in Figure 5.1 and further detailed in Figure 5.2 in the Online Appendix. In particular, these sections referred to (19) Registration and licensing of millers, (20) Licenses, (21) Expansion of Mills, (22) Allocation of produce to millers, and (23) Duration and renewal of registration, which were repealed in 2006 and affected all NCPB crops (maize, wheat, rice and cashews which are available as a schedule to the Act). Based on the legal texts in the Figure, Milling BTBs for NCPB crops are coded as 5 for the number of sections 19-23 that are removed from registration and licencing requirements. (Other changes in different BTBs for these crops are also added in from various legislations.)

Notably, the variation in BTBs is not systematically correlated with various crop characteristics in the pre-policy period. Table 7c reports the p-value for the F-statistic from a regression of crop-level BTB on the crop characteristic and year fixed effects in the pre-policy period. A full list of Crops and Acts for the BTB construction is provided in the Online Appendix in Table 17.

Table 7. Correlation of Crop BTBs with Crop Characteristics

Crop Characteristic in Pre-Period	p-value of F-stat
Farmers Selling to Agribusiness	0.98
Market Share of Agribusiness	0.46
Mean Price of Crop across Farmers	0.55
World Prices	0.75
World Price Changes (1, 2 years)	0.82, 0.28
Total Income Share of Crop for Farmers	0.24
Mean Acreage of Crop across Farmers	0.56

Crop-level BTB is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006. Crop characteristics refer to the pre-period values for the share of farmers selling to agribusinesses, the market share of agribusinesses in crop income, the mean frontage price of the crop before, the world price of the crop in the year and the year before, the total income share of the crop and the mean acreage of the area cultivated with the crop. The p-values refer to F-statistics from a crop-level regression of BTB on crop characteristic and year fixed effects in the pre-period.

5.2. **Theory Appendix.** The pricing solutions are

$$\begin{aligned}(pm_a - p_a)^2 (p_a - p_t)^{k-2} &= f_a f^{k-1}/k\varphi^k_{\min} \\ (pm_t - p_t)^2 (p_a - p_t)^{k-2} &= f_t f^{k-1}/k\varphi^k_{\min}\end{aligned}$$

FIGURE 5.1. Behind The Border Barriers: Example of National Cereals and Produce Board Act

National Cereals and Produce Board

(2) A person purchasing or otherwise obtaining maize, wheat or scheduled agricultural produce from a producer or his agent shall satisfy himself that the maize, wheat or scheduled agricultural produce has been dealt with in accordance with the provisions of this Act or regulations made thereunder and unless that person proves that he has taken all reasonable steps so to do, he shall be deemed to have had cause to suspect that the maize, wheat or scheduled agricultural produce has not been so dealt with.

(3) A person who contravenes subsection (1) shall be guilty of an offence and liable to a fine not exceeding five thousand shillings or to imprisonment for a term not exceeding two years or to both.

PART IV – IMPORTATION AND EXPORTATION OF MAIZE, WHEAT OR SCHEDULED AGRICULTURAL PRODUCE

18. Control of importation and exportation of maize, etc.

(1) *Deleted by Act No. 10 of 2006, s. 67.*

(2) The Board may with the authority of the Minister, export or authorize the exportation of maize, wheat or scheduled agricultural produce in such quantities as it deems to be surplus to the requirements of Kenya.

(3) No maize, wheat or scheduled agricultural produce shall be imported into or exported from Kenya otherwise than through a customs port of entry.

(4) A person who imports or exports maize, wheat or scheduled agricultural produce in contravention of subsection (3) shall be guilty of an offence and liable to a fine not exceeding twenty thousand shillings or to imprisonment for a term not exceeding two years or to both.

[Act No. 17 of 2006, s. 67.]

PART V – REGISTRATION AND LICENSING OF MILLERS

19. *Repealed by Act No. 17 of 2006, s. 68.*

20. *Repealed by Act No. 17 of 2006, s. 69.*

21. *Repealed by Act No. 17 of 2006, s. 70.*

22. *Repealed by Act No. 17 of 2006, s. 71.*

23. *Repealed by Act No. 17 of 2006, s. 72.*

Totally differentiating the equations with respect to world prices and agribusiness entry costs, changes in prices are

$$-\frac{(k-2)(pm_t-p_t)+2(p_a-p_t)}{(pm_t-p_t)(p_a-p_t)}p_t d\ln p_t = -\frac{2pm_t}{pm_t-p_t}d\ln p - \frac{k-2}{p_a-p_t}p_a d\ln p_a$$

$$\frac{(k-2)(pm_a-p_a)-2(p_a-p_t)}{(pm_a-p_a)(p_a-p_t)}p_a d\ln p_a = d\ln f_a - \frac{2pm_a}{pm_a-p_a}d\ln p + \frac{k-2}{p_a-p_t}p_t d\ln p_t$$

Substituting for the change in trader price, the change in agribusiness price is

$$p_a d\ln p_a = -\frac{(pm_a - p_a)\left((k-2)(pm_t - p_t) + 2(p_a - p_t)\right)/2}{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)} d\ln f_a$$
$$+ \frac{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)\, m_t/m_a}{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)} pm_a d\ln p$$

The RHS in the first line has a positive numerator and denominator from the second-order conditions (SOCs) for profit maximisation. For $k > 2$, the RHS in the second line also has a positive numerator and denominator from the SOCs and the existence condition. For $k < 2$, the numerator is always positive from the SOC and so is the denominator.

Substituting back into the trader price change, it can be solved as

$$p_t d\ln p_t = \frac{2pm_t(p_a - p_t)}{(k-2)(pm_t - p_t) + 2(p_a - p_t)} d\ln p + \frac{(k-2)(pm_t - p_t)}{(k-2)(pm_t - p_t) + 2(p_a - p_t)} p_a d\ln p_a$$
$$= -\frac{(k-2)(pm_t - p_t)}{(k-2)(pm_t - p_t) + 2(p_a - p_t)} \frac{(pm_a - p_a)\left((k-2)(pm_t - p_t) + 2(p_a - p_t)\right)/2}{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)} d\ln f_a$$
$$+ \frac{(k-2)(p_c m_t - p_t)\, pm_a}{(k-2)(pm_t - p_t) + 2(p_a - p_t)} \frac{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)(m_t/m_a)}{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)} d\ln p$$

Therefore, the trader prices take the same sign as the changes in agribusiness prices for $k \geq 2$ and vice-versa otherwise. Taking the difference in price changes, the comparative statics are

$$p_a d\ln p_a - p_t d\ln p_t$$
$$= \frac{2(p_a - p_t)\, pm_a}{(k-2)(pm_t - p_t) + 2(p_a - p_t)} \frac{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)(m_t/m_a)}{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)} d\ln p$$
$$- \frac{(p_a - p_t)(pm_a - p_a)}{(k-2)(pm_t - p_t) + 2(p_a - p_t) - (k-2)(pm_a - p_a)} d\ln f_a$$

and it follows that world price increases and entry cost reductions induce larger increases in the farmgate prices paid by agribusinesses relative to traders.

Subsistence. We now consider a general model with a government sector and a subsistence crop that gives s units of consumption when the unit of land can be sown with the subsistence crop or the market crop. The cutoff productivity for sales to traders (and hence growing the market crop) and for sales to agribusinesses are: $\varphi_t = \max\{s/\bar{p}_t, \varphi_{\min}\}$ and $\varphi_a \equiv f/(\bar{p}_a - \bar{p}_t)$. Defining $\mu/\bar{p}_t \equiv \frac{s^{-k+1}\bar{p}_t^{k-2} + f^{-k+1}(\bar{p}_a - \bar{p}_t)^{k-2}}{s^{-k+1}\bar{p}_t^{k-1} - f^{-k+1}(\bar{p}_a - \bar{p}_t)^{k-1}}$, the optimal prices are $p_t = \frac{\mu N(k-1)pm_t - \kappa p_g/(1-\kappa)}{\mu N(k-1)+1}$ and $p_a = \frac{M(k-1)pm_a + \bar{p}_t/(1-\kappa) - \kappa p_g/(1-\kappa)}{M(k-1)+1}$. The sufficient conditions for profit maximisation are $(k-2)(pm_t - p_t) + \frac{N+1}{N(1-\kappa)}(\bar{p}_a - \bar{p}_t) > 0$ and $(k-2)(pm_a - p_a) - \frac{M+1}{M(1-\kappa)}(\bar{p}_a - \bar{p}_t) < 0$ and an additional condition is needed when $\varphi_t = s/\bar{p}_t$ which is $(k-2)(pm_t - p_t) - \frac{N+1}{N(1-\kappa)}\bar{p}_t > 0$. From free entry, the equilibrium conditions are

$$(pm_t - p_t)^2 \left(s^{-k+1}\bar{p}_t^{k-2} + (f-b)^{-k+1}(\bar{p}_a - \bar{p}_t)^{k-2}\right)(1-\kappa)^2 k\varphi_{\min}^k = f_t$$
$$(pm_a - p_a)^2 (f-b)^{-k+1}(\bar{p}_a - \bar{p}_t)^{k-2}(1-\kappa)^2 k\varphi_{\min}^k = f_a + B - B_g - bn$$
$$C_g + \kappa p_g \frac{k}{k-1}\varphi_{\min}^k s^{-k+1}\bar{p}_t^{k-1} = R_g + MB_g$$

Stages of Agribusiness Activity. To enable a flexible formulation of agribusiness stages of operation (e.g. buying or marketing), let s index stages of agribusiness activity for a given crop. Without loss of generality, s rises with the distance to the world market. Then the closest stage, $s = 1$, refers to exporting to the world market. Stages further away from the world market, like processing of produce and buying of produce from the farmgate, imply that there will be more stages available for agribusinesses to provide their services as they come sequentially afterwards. For example, if an agribusiness buys from the farmgate then it can also provide the farmer with services such as processing, marketing and exporting which come after the procurement stage. This will be reflected in the sum paid to farmers for providing services at that stage and afterwards.

To formalize this, let $\delta_{s'c} \geq 0$ denote whether agribusinesses are allowed to operate at stage s' of the crop's journey from the farmgate to the world market. When $\delta_{s'c}$ is zero, agribusinesses are not allowed to operate at stage s'. More generally, when agribusinesses are allowed to operate up to stage s, the price premium paid to farmers by agribusinesses is

$$p_a = \frac{M(k-1)\, p \sum_{s'=1}^{s} \delta_{s'} m_{s'a} - \kappa p_g / (1-\kappa)}{M(k-1)+1}$$

The additive formulation across stages, starting with the closest to the world market, reflects the cumulative nature of services provided by agribusinesses and provides a simple way of summarising entry barriers across different stages of agribusiness activities. As the intermediation productivity is allowed to vary across stages, crops and villages, this formulation does not constrain responses to relaxing of different entry barriers and captures the sequential nature of the crop journey from the farmgate to world markets, as emphasized in the global value chain literature in other settings (such as Antras and Chor 2013). The free entry condition for agribusinesses in each crop market is now generalised to

$$(1-\kappa)\frac{k}{k-1}\varphi_{\min}^{k}\left(\sum_{s'=1}^{s}\delta_{s'} p m_{s'a} - p_a\right)\varphi_a^{-k+1}/M = f_a + \delta_s f_s$$

As explained earlier, $\delta_{s'}$ indicates the ability to operate in stage s' of agribusiness activities (with $1 \leq s' \leq s$) and δ_s refers to the ability to operate at stage s closest to the farmgate. Each stage entails investment costs f_s that must be incurred by agribusinesses to provide services up to stage s. If $f_s = \sum_{s'=1}^{s} f_{s'}$ it has the simple interpretation that agribusinesses must incur investment costs for each stage of the crop's journey. As agribusinesses are allowed to start operations at stage s, there are productivity gains and increased investments into new activities. When the productivity gains are higher than the increased investment costs, competition among agribusinesses raises the incomes received by farmers. The opposite holds when the investment costs are high relative to the productivity gains from the activity. Entry responses are then more muted than the rise in farm supply to agribusinesses due to productivity gains.

Empirical Results

Exports, Profits and Household-Crop Incomes. The full set of profit margins results are in Table 10. Column 2 winsorizes the profit margins (to lie between -0.4 to 0.4) to account

Table 8. BTB Policy and Crop Exports of Source Countries

	Log of Crop Exports $\ln R_{sct}$		
	(1)	(2)	(3)
$Post_t \cdot \Delta B_c \cdot Kenya_s$	0.0108***	0.0191***	0.0181***
	(0.0013)	(0.0053)	(0.0067)
Crop-Country FE	Yes	Yes	Crop-Country-Pre Years
Crop-Pre 2004 FE	Yes	Crop-Year	Crop-Year
Country-Year FE	Yes	Yes	Yes
N	83,759	83,759	82,469
Adjusted R^2	0.884	0.885	0.890

The dependent variable is Log of Crop Exports $\ln R_{sct}$ (in '000 USD) from selling agricultural commodity (crop group) c by source country s in year t for a panel of crop-source country-year observations for all crops and for all countries in years 1997 to 2010. $Post_t$ is an indicator for years 2005-2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. Pre refers to 2000-2004 before the BTB policy. Regressions are weighted by the share of the crop in the initial farm income of Kenyan households. Mean of $\ln R_{sct}$ is 12.89 and mean of ΔB_c is 5. Standard errors are clustered by crop and source country in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

for outlier values and results remain robust. Column 3 weights the regression by the initial sales shares of firms. Column 4 uses the stagewise policy measure. Column 5 drops Uchumi supermarkets from the sample to ensure that its assignment to the fruit and vegetable segments is not driving the result. Column 6 drops Kenya Orchards from the sample to ensure coding its profit margin as zero in the two years that it was not listed on the Nairobi stock exchange, does not alter the main results.

5.2.1. *Robustness of Household-Crop Income Elasticities.* Tables 11 and 12 contain a number of checks of robustness of household-crop income elasticities to other changes. The first robustness check in Column 1 puts world prices of the crop on the RHS to ensure that the results are not driven by a greater fall in *world prices* of BTB crops. World prices are obtained from trade-weighted unit values in COMTRADE data for all countries other than Kenya and an indicator for drop in world prices is constructed for crops that saw a drop in their world price between each survey period. The average changes are: log farm price -0.182, log income -0.109, log world price -0.868 and rise 0.508. About half of the farmers who sell to agribusinesses experience a fall in world prices. The latter accounts for the potential role of intermediaries in reducing negative world price shocks to farmers (Allen and Atkin 2016). Note that these results for world price trickle down are not directly comparable to the stylised facts earlier because they are relative to previous crop-year changes due to the presence of crop-season-pre 2004 fixed effects.

Negative *productivity shocks* to crops, for example, through bad weather, could lower income from policy-affected crops. Column 1 of Table 12 includes the share of harvest that got spoiled during the season-year for each crop interacted with the post-period indicator and this barely changes the coefficient on the policy variable, compared to the baseline.

Table 9. BTB Policy and Household-Crop Incomes of Farmers

	Log of Crop-Level Incomes of Households $\ln I_{hcmt}$						
	(1)	(2)	(3)	(4)	(5)	(6) Balanced	(7) Weighted
$Post_t \cdot \Delta B_c$	-0.0054	-0.0177**	-0.0178**	-0.0192***	-0.0172***	-0.0175*	-0.0173***
	(0.0085)	(0.0089)	(0.0089)	(0.0077)	(0.0092)	(0.0091)	(0.0026)
Hh FE, Crop-Season FE	Yes						
Hh-Crop-Season FE		Yes				Yes	Yes
Year FE	Yes	Yes	Yes	Hh-Year	Yes	Yes	Yes
Crop-Season-Pre FE		Yes	Yes	Yes		Yes	Yes
Hh-Crop-Season-Pre FE					Yes		
Hh-Pre FE			Yes	Yes			
N	27235	17130	16759	15899	10374	16114	17130
Adjusted R^2	0.552	0.672	0.632	0.658	0.670	0.669	0.802

The dependent variable is Log of Crop Income $\ln I_{hcmt}$ (in '000 KSh) from selling crop c for household h in season m of year t for a panel of household-crop-season-year observations for all crops and for all households. $Post_t$ is an indicator for 2007 and 2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. Hh refers to households and Pre refers to survey years 2002-03 before the BTB policy. Balanced refers to household-crop observations for households that are surveyed in each of the four years. Weighted refers to income share weighted regressions. Standard errors are clustered by crop and household in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Column 3 adds in an interaction of post with an index of *distortions* in the crop market in the pre-policy period. The latter is taken from a World Bank study by Winter-Nelson and Argwings-Kodhek (2007) which compiles information on the taxes and subsidies provided to different crops in Kenya. We use values from 1999 to 2004. (The index is reported for 1995-1999 and for 2000-2004 so a weighted average of the values is taken). As expected, higher distortions in the crop market reduce crop incomes for farmers, but this is not precisely estimated. The time period covered in this study includes changes in the power of *state parastatals*. We discuss this in detail, theoretically and empirically, in an earlier working paper (Dhingra and Tenreyro 2020). The policy variation in BTBs is much finer and not confounded by these other changes which included regulations and elections to crop boards, as shown in Column 3 which adds an indicator for 20 crops that received regulatory or election changes. Column 4 adds an indicator for households that were affected by the violence that followed a subsequent election in 2009.

To examine the *stages of agribusiness activity* affected by the policy, we examine an alternative policy variable where the buying stage is given a larger weight to account for the ability to do more downstream stages of agribusiness value addition (once procurement is done). Note that the magnitude of the coefficient changes as the policy variable has been scaled differently. Another concern is that our baseline results might reflect what happened in *maize* markets, which is the main food crop grown by households and also the chief source of income for the previous President Moi's home base. Column 6 restricts

TABLE 10. BTB Policy and Profit Margins of Listed Agricultural Firms

	Dependent Variable: Agribusiness Profit Margin $\mathscr{M}_{at}$					
	(1)	(2) Winsorize	(3) Initial	(4) Stages	(5) No Uchumi	(6) No KOrchards
$Post_t \cdot \Delta B_a$	0.0091*	0.0098**	0.0055*	0.0083**	0.0110***	0.0091*
	(0.0045)	(0.0045)	(0.0025)	(0.0036)	(0.0025)	(0.0045)
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	156	156	144	156	144	144
R^2	0.377	0.655	0.540	0.573	0.569	0.570

The dependent variable is the Profit Margin (Profit Before Tax/Sales) of the agribusiness firm during the year. The sample consists of the universe of agricultural companies listed on the Nairobi Stock Exchange between 1999 to 2010. $Post_t$ is an indicator for 2005 to 2010, Pre_t is an indicator for 2001 to 2004 and $Post_t = Pre_t = 0$ for 1999 to 2001. Firm-level BTB is $\sum_c S_{ca}\Delta B_c$ and Crop-level BTB_{sc} is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006. S_{ca} is the mean share of crop c in sales across all crops of firm a between 1999 to 2004. Winsorize refers to profit margins between -0.4 and 0.4. $BTB_c = \sum_s s \cdot BTB_{sc}$ in Column 4 is the Stagewise BTB where $s = 1$ for Marketing/Warehousing/Selling/Exporting/Milling/Processing and 2 for Buying. Regressions are weighted by firm sales shares in each period, except in Column 3 where the weight refers to firm sales shares in the initial period. No Uchumi and KOrchards in Columns 5 and 6 refer to regressions dropping Uchumi Supermarket (which sells all food and is given the modal value of all fruits and vegetables) and Kenya Orchards (which gets delisted during a couple of years). Standard errors in parentheses are clustered by company and crop segments and corrected for small clusters. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the sample to non-maize crop incomes and results remain qualitatively similar. Column 7 does the same for tea which is a major export crop of Kenya and Column 8 removes observations where there have been observed to be greater noise in the data in 2004 (Suri 2011).

Table 11. Robustness of BTB Policy and Household-Crop Incomes of Farmers to World Prices

	Log of Crop Income of Farmers	
	(1) All	(2) Post
$Post_t \cdot \Delta B_c$	-0.0211**	-0.0200**
	(0.0088)	(0.0088)
$\ln p^w_{ct}$	-0.0367	
	(0.1269)	
$Fall_{ct}$	-0.1034*	
	(0.0557)	
$\ln p^w_{ct} \cdot Fall_{ct}$	-0.0621	
	(0.0540)	
$Post_t \cdot \ln p^w_{ct}$		0.0622
		(0.0714)
$Post_t \cdot Fall_{ct}$		-0.1036
		(0.0930)
$Post_t \cdot \ln p^w_{ct} \cdot Fall_{ct}$		-0.0715
		(0.0585)
Hh-Crop-Season FE	Yes	Yes
Crop-Season-Pre FE	Yes	Yes
Year FE	Yes	Yes
N	17130	17130

The dependent variable is Log of Crop Income I_{hcmt} from selling crop c for household h in season m of year t for a balanced panel of household-crop-season-year observations for all crops and for all households. $Post_t$ is an indicator for 2007 and 2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. $\ln p^w_{ct}$ is the log of the lagged export unit value from COMTRADE for all countries except Kenya. $Fall_{ct}$ is an indicator for whether world prices fell compared to the previous survey year. Hh refers to households and Pre refers to survey years 2002-03 before the BTB policy. Standard errors are clustered by crop and household in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 18 contains the list of companies, their segments and BTB values. Uchumi operates in multiple segments because it is a supermarket, so we assign it the most common BTB for vegetables and fruits, and we examine robustness of key results to this assignment.

TABLE 12. Robustness of BTB Policy and Household-Crop Incomes to Other Channels

	Log of Crop Income of Farmers			
	(1)	(2)	(3)	(4)
Panel A. Controls				
$Post_t \cdot \Delta B_c$	-0.0196**	-0.0183**	-0.0240***	-0.0177**
	(0.0091)	(0.0089)	(0.0091)	(0.0089)
$Post_t \cdot Spoiled_{ct}$	-0.0290***			
	(0.0108)			
$Post_t \cdot Distortion_c$		-0.0048***		
		(0.0014)		
$Post_t \cdot Regulations_c$			0.0679***	
			(0.0141)	
$Post_t \cdot Violence_h$				0.0221
				(0.0670)
N	17130	17130	17130	17130
Panel B. Samples	Stages	No Maize	No Tea	No Coast
	(5)	(6)	(7)	(8)
$Post_t \cdot \Delta B_c$	-0.0145**	-0.0179**	-0.0171*	-0.0176**
	(0.0074)	(0.0091)	(0.0089)	(0.0089)
N	17130	15072	16373	16970
Hh-Crop-Season FE	Yes	Yes	Yes	Yes
Crop-Season-Pre FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

The dependent variable is Log of Crop Income $\ln I_{hcmt}$ from selling crop c for household h in season m of year t for a balanced panel of household-crop-season-year observations for all crops and for all households. $Post_t$ is an indicator for 2007 and 2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. $Spoiled_{cmt}$ is the log of the harvest that was spoiled for each crop and season-year. $Distortion_c$ is the distortion index for Kenyan crops from the World Bank for 1999-2004. $Regulations_c$ is an indicator for crops that saw changes in crop regulations or election requirements for boards of the crops, which applies to 20 crops. $Violence_h$ is an indicator for whether the household suffered directly or indirectly from the post-election violence in 2009. Column 5 recodes the BTB variables as $\Delta B_c \equiv \sum_s s \cdot BTB_{sc}$ where $s = 1$ for Marketing/Warehousing/Selling/Exporting/Milling/Processing stage and 2 for the Buying stage. Columns 6, 7 and 8 remove maize, tea and coastal provinces respectively transactions from the sample. Standard errors are clustered by crop and household in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 13. BTB Policy and Household-Crop Income Intensive Margins of Farmers by Buyer Types

	Log of Crop-Level Incomes of Households from Buyer b: $\ln I_{bhcmt}$					
	From Agribusiness $\ln I_{ahcmt}$		From State $\ln I_{ghcmt}$		From Traders $\ln I_{ohcmt}$	
	(1)	(2)	(3)	(4)	(5)	(6)
$Post_t \cdot \Delta B_c$	-0.0938**	-0.0966**	-0.0241	-0.0241	-0.0138**	-0.0187**
	(0.0339)	(0.0397)	(0.0089)	(0.0093)	(0.0084)	(0.0091)
Hh-Crop-Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Crop-Season-Pre FE	Yes	Yes	Yes	Yes	Yes	Yes
Hh-Pre FE		Yes		Yes		Yes
N	473	333	1903	1662	13629	13165

The dependent variable is Log of Crop Income $\ln I_{bhcmt}$ (in '000 KSh) from selling crop c for household h in season m of year t to buyer $b \in \{a, g, o\}$, where a = Agribusiness, g = Board/Coop and o =Other (Trader or Consumer). $Post_t$ is an indicator for 2007 and 2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. Hh refers to households and Pre refers to survey years 2002-03 before the BTB policy. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 14. BTB Policy and Household-Crop Income Extensive Margins of Farmers by Buyer Types

	Household Sells the Crop to Buyer b: $1_{I_{bhcmt}>0}$			
	To Agribusinesses		To State	
	(1)	(2)	(3)	(4)
$Post_t \cdot \Delta B_c$	0.0167***	0.0170***	-0.0032**	-0.0034**
	(0.0061)	(0.0061)	(0.0016)	(0.0017)
Hh-Crop-Season FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Crop-Season-Pre FE	Yes	Yes	Yes	Yes
Hh-Pre FE		Yes		Yes
N	14938	14504	15371	14952

The dependent variable is an Indicator for Positive Sales of crop c for household h in season m of year t to buyer $b \in \{a, g, o\}$, where a = Agribusiness, g = Board/Coop. $Post_t$ is an indicator for 2007 and 2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. Hh refers to households and Pre refers to survey years 2002-03 before the BTB policy. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 15. BTB Policy and Other Income/Expenditures of Farmers

	Log Crop Income$_{hcmt}$		Grow$_{hcmt}$	Log Other Income$_{ht}$	Cost$_{ht}$
	(1)	(2) Balanced	(3)	(4)	(5)
$Post_t \cdot \Delta B_c$	-0.0181*	-0.0179*	-0.0009		
	(0.0093)	(0.0095)	(0.0009)		
$Post_t \cdot \sum_{c' \neq c} S_{hc'm0} \Delta B_{c'}$	0.0033	0.0033			
	(0.0036)	(0.0037)			
$Post_t \cdot \sum_c S_{hcm0} \Delta B_c$				-0.0032*	-0.0001
				(0.0017)	(0.0019)
Hh-Crop-Season FE	Yes	Yes	Yes		
Crop-Season-Pre FE	Yes	Yes	Yes		
Hh-Pre FE				Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	17130	16114	107528	3238	3522

The dependent variable is the Log of Crop Income I_{hcmt} from selling crop c for household h in season m of year t in Columns 1 and 2. Balanced refers to household-crop observations for households that are surveyed in each of the four years. $Post_t$ is an indicator for 2007 and 2010. Crop-level BTB change is ΔB_c which is the number of sections of legislations regarding agribusiness requirements that are repealed/deleted/amended at each stage for the crop between 2005-2006 in all Columns. Grow$_{hcmt}$ in Column 3 is an indicator for growing crop c for sale where zeros are added for crops that are not sold. The dependent variables are Log of Other Income (Wages+Livestock+Enterprise incomes) of the household in Column 4 and Costs paid for fertilisers and land preparation in cash (in '000 KSh) in Column 5. Standard errors are clustered by crop and household in parentheses in 1-3, and are estimated according to Adao, Kolesar and Morales (2019) in Columns 4 and 5. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 16. Fact 3': Trickle Down from World Price Rise and Fall for Farmers Piggy-backing on Agribusinesses

	$\Delta \ln Price_{ch}$	$\Delta \ln Income_{ch}$
	(1)	(2)
Δ ln World Crop Price$_c$	0.2070***	0.1762***
	(0.0558)	(0.0641)
Agribusiness Share$_{ch}$·Δ ln World Crop Price$_c$	0.00003	0.1713**
	(0.0744)	(0.0843)
ΔAgribusiness Share$_{ch}$·Δ ln World Crop Price$_c$	0.2175**	0.2042**
	(0.0968)	(0.0974)
ΔAgribusiness Share$_{ch}$	0.3557	0.3916**
	(0.1570)	(0.1867)
Δ ln World Crop Price$_c$·Rise$_c$	-0.1423	-0.2325***
	(0.0986)	(0.0812)
Agribusiness Share$_{ch}$·Δ ln World Crop Price$_c$·Rise$_c$	-0.4352	-0.5446
	(0.2850)	(0.4273)
ΔAgribusiness Share$_{ch}$·Δ ln World Crop Price$_c$·Rise$_c$	-0.6734*	-0.7043
	(0.3513)	(0.4602)
Country FE	Yes	Yes
N	4330	4330

The dependent variable in Column 1 is the change in sales-weighted mean log price received for crop c by household h during survey year 1 relative to the previous survey year 0 and the change in sales-weighted mean log price received for the crop between the survey years. In Column 2, the dependent variable is the change in log income of the household-crop. ΔX denotes the first difference $X_1 - X_0$. The RHS is the change in the log of the lagged world price for the crop between the survey years. Rise is an indicator for an increase in the world price of the crop from survey year 0 to 1. The agribusiness share is the share of the crop income received from agribusinesses in survey year 0 and the change in agribusiness share is relative to the previous survey year. Agribusiness is defined as private company/business in the World Bank LSMS for Ethiopia and Malawi (distinct from local merchant/trader/parastatal/market), and as large company/miller/processor/exporter in the Rural Household Surveys of Kenya. The regression is estimated in first differences, with crop income shares of the households as weights to ensure each household gets a weight of 1. Country fixed effects are included and standard errors are clustered by household and by crop-country. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Online Appendix

Figure 5.2. Example of BTB Codification

(*c*) become invalid upon the mill to which it relates ceasing to be registered under this Act or ceasing to be under the effective control of the licensed miller;

(*d*) not be transferable.

PART V—REGISTRATION AND LICENSING OF MILLERS

Registration and licensing of millers.

19. (1) No person shall carry on the business of a miller unless he is the holder of a miller's licence.

(2) A person who wishes to commence the business of a miller shall, before he acquires a mill or commences to construct or equip any premises as a mill, apply to the Board for permission so to do.

(3) A person who wishes to carry on business as a miller of maize, wheat or any scheduled agricultural produce and who has received permission to construct or equip a mill as provided for in subsection (2) shall apply to the Board for registration, and the Board shall register that mill subject to such limitations and conditions as may be prescribed by regulations made under this Act, or as may be specifically imposed by the Board on any particular registration.

(4) An application for registration under this section shall be in writing and in such form as the Board may prescribe.

Licences.

20. A miller's licence shall—

(*a*) authorize the holder thereof to mill at any mill in respect of which he holds a registration certificate the quantity of maize, wheat or any scheduled agricultural produce allocated in respect of that mill or, at the discretion of that miller, the aggregate of the quantities allocated in respect of all or some of the mills for which mill registration certificates have been granted to him;

(*b*) be in the prescribed form;

Expansion of mills.

21. No person shall, except with prior consent in writing of the Board, make an addition to, replacement or substitution of, machinery in a registered mill which will have the effect of increasing the capacity for production of flour at that mill.

Allocation of maize, wheat or scheduled agricultural produce to millers.

22. The allocation of maize, wheat or scheduled agricultural produce by the Board to a licensed miller shall be determined by reference to the mill's rated capacity as stated at the time of registration of that mill, and the Board may allocate such quantities and any additional quantities, depending on the available supply of maize, wheat or scheduled agricultural produce.

Duration and renewal of registration.

23. (1) Every registration made under this Part shall, unless earlier revoked, remain in force for a period of twelve months and may be renewed.

(2) The Board shall renew the registration of a mill unless—

(*a*) the applicant has been convicted of an offence under this Act or under regulations made thereunder;

(*b*) the applicant has failed to observe any limitation or condition prescribed under this Act or regulations made thereunder, to which his registration has been made subject;

(*c*) the Board is satisfied that the business of the applicant is not being conducted in accordance with the provisions of this Act or the Public Health Act, or of any regulations or rules made thereunder; or

Cap. 242.

(*d*) the applicant has without reasonable cause failed to apply in writing for renewal before the expiration of the stipulated period of validity from the date of registration or from the date of last renewal.

(3) The Board may revoke the licence of a miller who has been convicted of an offence under this Act or regulations made thereunder.

(4) A person who is not a licensed miller who carries on business as a miller of maize, wheat or scheduled agricultural produce, or a licensed miller who contravenes the limitations or conditions to which that licence is subject, shall be guilty of an offence and liable to a fine not exceeding one thousand shillings.

Prices to be paid by millers for maize, etc.

24. (1) The sale of maize, wheat or scheduled agricultural produce by the Board to a miller shall be made at such prices as the Minister may from time to time specify by notice in the Gazette, and the grading of that maize, wheat or scheduled agricultural produce shall be determined by the Board in accordance with regulations made under this Act.

(2) In the event of a dispute over the grading of maize, wheat or scheduled agricultural produce, a miller may appeal to the Board for an amended grade and if dissatisfied may appeal to the Minister.

Source: NCPB Act, No. 7 of 1985

Table 17. BTBs from National Legislations by Crops

Act	**Crops**
National Cereals and Produce Board Act	Wheat Maize Rice Cashewnut
NCPB Exportation of Maize Act	Maize
Investment Promotion Act	Pyrethrum Sisal Maize
	Wheat Tea Sugarcane Coffee
Licensing Laws (Repeals and Amendment) Act	
Canning Crops Act	Pineapple Passionfruit
Coconut Industry Act	Coconut
Coffee License Fees Rules/Coffee Act	Coffee
Sugar Levy	Sugarcane
Cotton Act	Cotton
Pyrethrum Act	Pyrethrum
Sisal Industry Act	Sisal
Sale of Sisal and Collection of Cess	Sisal
Subsidiary Legislation	
Finance Act	Coffee
General Amendment Rules	Coffee
Agriculture Act	
Horticultural Crops Development Authority Act	Mangoes Onion
	Fruit Vegetable Flowers
Pyrethrum Act	Pyrethrum
Tea Elections Regulations Act	Tea
Seed and Ware Potato Regulations Act	Potato
Castor Seed Rules	Castor
Tea Forms Regulations	Tea
Wheat Rules	Wheat

TABLE 18. Policy Exposure of Agribusinesses: Sales Shares in Policy-Affected Segments

Agribusiness Name	Crop Segment	ΔB_a
British American Tobacco Company	Tobacco	0
East African Breweries Limited	Beer and beverages	0
Unga Group Plc	Animal Health and Nutrition	0
Kenya Orchards Plc	Horticulture	1
Uchumi Supermarkets Plc	All	1
Kapchorua Tea Kenya	Tea	1
Limuru Tea Company Limited	Tea	1
Williamson Tea Kenya Plc	Tea	1
Mumias Sugar Company Limited	Sugar	1
Rea Vipingo Plantations Limited	Sisal	2
Sasini Plc	Coffee and Tea	7.954
Kakuzi Plc	Coffee, Horticulture and Tea	8.356
Eaagads Limited	Coffee	41

TABLE 19. Summary Statistics: Household-Crops

Variable	Obs	Mean	S.D.	Min	Mdn	Max
Income ('000 KSh in 2000 values) I_{hcmt}	17130	11.75	57.62	0.00	1.49	3273.05
Change in BTBs ΔB_c	17130	5.23	10.69	0	1	48
$\ln p^w_{ct}$	17130	-0.85	0.84	-2.96	-0.98	1.26
$Fall_{ct}$	17130	0.56	0.50	0	1	1
$\ln p^w_{ct} \cdot Fall_{ct}$	17130	-0.53	0.82	-2.96	0	1.26
Spoiled$_{cmt}$	17130	1.96	2.49	-2.08	0	8.76
Distortion$_{c0}$	17130	1.71	8.57	-3.30	0	46.20
ΔRegulations$_c$	17130	0.70	1.33	0	0	4
$Violence_h$	17130	0.09	0.29	0	0	1
Change in Stagewise BTBs $\sum_s s\Delta B_{sc}$	17130	6.00	13.07	0	1	60
Change in Other BTBs $\sum_{c' \neq c} S_{c'm0}\Delta B_{c'}$	17130	5.96	7.67	0	3.04	41.00
Grow Indicator $Grow_{chmt}$	107528	0.25	0.43	0	0	1
Log Income from Agribusiness $\ln I_{ahcmt}$	473	3.41	1.41	-2.23	3.55	7.98
Log Income from Board/Coop $\ln I_{ghcmt}$	1903	1.93	2.12	-4.76	2.12	8.09
Log Income from Others (Trader/Consumer) $\ln I_{ohcmt}$	13629	0.21	1.58	-9.72	0.10	6.68
Sell to Agribusiness S_{ahcmt}	14938	0.07	0.26	0	0	1
Sell to Board/Coop S_{ghcmt}	15371	0.02	0.14	0	0	1

Table 20. Summary Statistics: Households and Exports

Variable	Obs	Mean	S.D.	Min	Mdn	Max
Log of Farm Income$_{it}$ ('000 KSh in 2000)	3522	2.60	1.78	-4.45	2.76	8.27
Log of Other Non-Farm Income ('000 KSh in 2000)	3238	3.47	1.80	-4.25	3.48	9.64
Cash Input Costs on Fertilisers/Land Preparation ('000 KSh in 2000)	3522	0.35	4.62	0	0	176.24
Log of Commodity Exports of Source Country	83759	11.72	3.95	0	11.83	23.65
Change in BTBs ΔB_c for All Source Exports	83759	2.68	7.00	0	1	48
Log of Commodity Exports of Kenya	882	11.39	3.83	1.39	11.20	20.87
Change in BTBs ΔB_c for Kenya Exports	882	2.41	6.19	0	1	48