Abstract

Why do developing countries fail to specialize in products that they (at least potentially) have a comparative advantage in? For example, farmers in land poor developing countries overwhelmingly produce staples rather than say exotic fruits that command high prices. We propose a simple model of trade and intermediation that models how holdup resulting from poor contracting environments can produce such an outcome. We use the model to examine which polices can help ameliorate the problem, even when its cause cannot be eliminated.

Wheat or Strawberries? Intermediated Trade with Limited Contracting

Kala Krishna
The Pennsylvania State University, NBER and CES-IFO

Yelena Sheveleva
The Pennsylvania State University

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1 Introduction

Why do small farmers in developing countries produce staples (like wheat, corn, maize) rather than crops (like exotic tropical fruits or vegetables) that are highly valued, but often not suitable for production in, rich countries which tend have cooler climates. Staples are efficiently produced using highly capital intensive techniques applied to large farms. With population growth, loss of arable land to desertification and falling water tables, arable land is becoming scarcer in much of the developing world. On the other hand, vast swathes of land suitable for growing such staples are available in the US, Canada and parts of the former Soviet Union where low population density makes land relatively cheap, and mechanization offers a way to both combat higher labor costs and increase productivity. High income countries have a cereal yield per acre of about 4,800 kg per hectare, compared to about 3,100 kg per hectare for middle income countries and 1,900 kg per hectare for poor countries.[2]

Why then, do farmers in developing countries persist in producing staples rather than such products? One reason has to do with "food security" and the national interest.[3] India often invoked this mantra in its drive to raise agricultural productivity during the green revolution.[4] Another reason given is the phyto-sanitary requirements imposed by countries that make it hard for developing countries to export fresh produce to them. For example, Indian mangoes could not be exported to the US without being irradiated. However, irradiation was impossible prior to the nuclear deal struck during the Bush Administration. In the same vein, Australia and New Zealand, with their strict phyto-sanitary requirements, are in essence impossible to export to for most developing countries. Even relatively developed countries are adversely affected at times by such rules and regulations. In the Chilean poisoned grape incident, see Engel (1999), Chilean exports of grapes were banned for four days in March of 1989, at the cost of $330 million, when two grapes

[2] data source: http://data.worldbank.org/topic/agriculture-and-rural-development

[3] Japanese rice subsidies may be due more to political pressures by a well organized group, as the futility of Japan's attempting to be self sufficient in rice is obvious: imports in 2008 were 596,627,664 kg (Comtrade) and local production was 11,028,800 tonnes (FAO)).

[4] Governments, both of developed and developing countries, give huge farm subsidies whether as price supports and/or as fertilizer, water and energy subsides. In 2008, a typical cow in the EU received a subsidy of $2.20 a day, more than the extreme poverty level of $1.25 defined by the World Bank.

poisoned with cyanide were found after an anonymous phone tip-off led to heightened inspection of these imports.

In this paper we focus on an alternative explanation for this choice: farmers grow a staple, say wheat, because they can survive on their wheat if the need arises, while they cannot survive on exotic fruits and vegetables, say strawberries, both because they are perishable and because they are nutritionally inadequate. A farmer thus faces disaster if he chooses to grow strawberries and ends up having a problem selling them. In this paper, we argue that in the environment prevalent in most LDCs with contracts poorly enforced and direct access to world markets being difficult, market thinness creates severe problems. Once a product is produced by many agents, its market functions reasonably well. But if it is produced by only a few agents, then its production will be unprofitable due to endogenous trading frictions that are particularly severe for perishable products, like milk and strawberries.

The contracting environment is very different in a developing country compared to that in developed one. Even if the price in the city (or the world) is high for strawberries, the farmer has no way to get his strawberries there to reap these returns. He must rely on intermediaries (traders), as roads are poor and trucks are expensive. However, traders are scarce, irregular in their arrivals, and unreliable as contracts are poorly enforced. Small wonder that the poor farmer sticks to the modest profit he can make with staples for subsistance.

The polices pursued by governments can ameliorate or aggravate these difficulties. In Mali and Ethiopia for example, governments intefered in the output market with marketing boards, price cotrols and quota systems. Such policies left farmers and traders there with little of the potential rents, thereby reducing incentives of the latter to produce anything but staples for subsistance.

On the positive side, dairy cooperatives in India, as part of "Operation Flood" were key in linking milk producers with urban consumers. Prior to this, farmers were reluctant to produce milk because of the risk of spoilage and the lack of distribution channels for their milk. Urban consumers would buy milk from small scale "milkmen" who transported their milk door to door without refrigeration or quality control. The addition of (not very clean) water to the milk was a common practice. Milk had to be boiled before being safe for consumption and was not homogenized and processed as in developed countries.

Cooperatives shared rents with the farmers by giving them a "fair" price for their milk. They also provided refrigeration, quality control and marketing services needed to serve urban consumers as well as extension services to improve productivity. Their success produced a flood of milk was a key part of the "white revolution" in India. India went from being a milk deficient nation in the 1970s to being the worlds largest milk producer in 2011. While we will talk of farmers in the model below to illustrate what is going on, our arguments are more generally applicable.

Our purpose in this paper is to develop a simple model that captures essential features of such an environment in a manner that allows us to model and evaluate the effects of the various policy options that might be open to a government or an NGO. In our model farmers can produce two goods that differ along three dimensions: the farmer's ability to consume them, the farmer's efficiency in producing them, and the kind of market in which they are traded. The first good is what we have been calling a staple that has a local market and/or the farmer can subsist on it alone though he is relatively inefficient at making it, and with perfect markets, would not choose to do so. The other good is not directly consumed by the farmer, though he is better off producing it if he could access the retail market at no cost. We also assume that this non staple good is perishable so the farmer cannot just store it and wait for a trader to show up. Its perishability is accentuated by poor storage conditions farmers in the developing world face as well as the lack of access to credit. Even goods that are potentially storable can deteriorate rapidly in the presence of vermin and absence of refrigeration. Moreover, as agents in developing countries live close to the edge, they do not have the luxury of waiting for a better offer, even if it is likely. Interest rates from informal sources are very high, rates of 20% a month are not uncommon, and formal credit is very hard to come by. All of this heightens the "perishability" of the non staple good.

In our model traders meet farmers randomly. When a farmer and a trader meet, the trader offers the farmer a price and the farmer accepts or rejects it. When the trader makes the offer he doesn't know the number of rival traders who have visited a given farmer or the prices they have offered. The trader who offers the highest price to the farmer gets the good. Of course, there may be no traders at a farmer's doorstep, in which case the farmer exercises his outside option, which may be zero. Traders have access to a Walrasian market and for their efforts, can sell the good at the given world price.

Central to the model is the inability of farmers and traders to contract ex ante on a price. The absence of enforceable contracts sets the stage for the classic hold up problem and precludes negotiating the terms of trade prior to production. If long term contracts were enforceable, traders and farmers could search for matches in the beginning of the period and then make production decisions *after* bargaining over the surplus from the match. The price of the good would be determined by the farmers outside option: producing the simple good. This sort of interaction has been modeled by Antras and Costinot (2011). Here we consider an environment where such contracts cannot be made as the trader has an incentive to defect from such arrangements ex post.

Factors that affect specialization are the price of the export good in the local market and the sunk cost the trader needs to pay to intermediate the export good. When the price the farmer can get in the local market for the export good (his outside option) is low, beliefs about the level of intermediation are important in determining the equilibrium output of each commodity. Economies with low cost of entry for traders can successfully overcome the matching friction and specialize in the export good regardless of the farmer's outside option. The outside option becomes more important when entry costs for traders are high.

Some support for the make in the model comes from Fafchamps, Gabre-Madhin and Minten (2005), who document that market liberalization in poor countries has resulted in multiple layers of intermediaries. There are a large number of small market participants and a few large ones. Large traders specialize in wholesaling and rarely sell retail. They rarely buy directly from producers, buying instead from many small intermediaries who specialize in buying from producers and selling to wholesale traders or organized markets. These are like what we call intermediaries in our model and we focus on the behavior of such small itinerant traders who mediate between the organized market and small producers. They are large in total number, but small in terms of their presence in any particular neighborhood.

We assume that traders who specialize in purchasing output from producers face fixed costs. For example, they may have to pay for a truck. They face a time constraint so they can either go to place A or B but not both. We incorporate this by allowing for a sunk/fixed cost that trader's incur which allows a trader to go to a single place. If they are not sucessful there, they cannot try elsewhere.

Although this is cast as a model of agricultural trade it relates to a number of other areas in development. The idea that producing some goods is more growth enhancing than producing others is an old one in the development literature. Hirschman (1958) suggests that sectors with greater linkages (both backward and forward) are likely to be more growth enhancing. More recently, Hidalgo, Klinger, Barabasi and Hausmann (2007) associated growth with being active in certain sectors that are linked to key sectors. The "big push" type stories a la Nurkse (1953) and Rosenstein-Rodan (1943) and more recently Murphy, Vishny and Shleifer (1989) argue that there are multiple equilibria and the lack of investment in industry in LDCs is the manifestation of an underdevelopment trap which can be broken once enough investment occurs. In contrast to this literature we focus on the contracting imperfections that potentially explain why the agricultural community may specialize in staples.

Hausmann and Rodrik (2003) and Hausmann, Hwang and Rodrik (2006) portray development as a process of self discovery. In their framework entrepreneurs don't know which products a country is good at producing until someone tries it. Trials involve uncertainty and are costly. Moreover, successful products can be replicated so whoever makes a successful discovery will soon face tight competition so that the cost is private while the benefit is public. As a result, too little discovery occurs. Our model does not rely on such informational problems to explain the lack of investment in new products but on contractual frictions: our agents know about their options but are limited in their ability to avail of these.

We construct a stylized model of agricultural trade with intermediation that is consistent with the facts available in the development and agricultural economics literature and use it to analyze the patterns of specialization in the presence of coordination problems and lack of enforceable contracts which are prevalent in developing countries. Fafchamps and Vargas Hill (2004) document that farmers face a decision whether to sell at the farm gate or to travel to the nearest centralized market to sell the good. Farmers are less likely to travel to the local market and more likely to sell to the local trader when the nearest market is far or the cost of transportation is high. Similarly Osborne (2005) finds that in poorer and more remote areas, traders have more market power than in markets that are close to big trading centers. In our model we allow the presence of a local market (or proximity of the organized market) for the export good in the form of an "outside option" for the farmer in his interactions with the trader. In other words, the farmer will find it worthwhile to sell at his door only if the trader offers a price at least as good as the price he can obtain in the local market, which may be zero if such a market does not exist.

Our work is related to Antras and Costinot (2011) which introduces intermediation into a two-good two-country Ricardian framework. Their focus is on the implications of globalization in the presence of intermediation. They find that integration of the commodity markets produces gains for both countries while integration of matching markets (markets where intermediaries and producers/farmers meet) does not if intermediaries in one country are more efficient and have greater bargaining power. Moreover, as we have already alluded in their model contracts are enforceable. Producers and intermediaries first form matches, and then make production decisions. Unlike them, we are not interested in the effects of globalization but rather wish to explore the implications of search frictions and *lack* of enforceable contracts on specialization patterns with a view to policy.

This paper is also related to a small literature focusing on the price transmission mechanism in agricultural trade from retail market to the producer price and more broadly on the gap between producer and consumer prices. Fafchamps, Vargas-Hills (2007) analyze transmission of the export coffee price to the Uganda farmer who sells at the farm gate. Their analysis is based on original data collected by the authors on all coffee exporters as well as on random samples of coffee traders and producers in Uganda. They find that when the international price rises, domestic prices follow suit, except for the price paid to producers, which rises by far less than the international price. They argue that the cause of this incomplete pass through is the lack of information about world price movements on the part of the farmer. World price increases attract more traders into the market which dissipates the rents but due to the farmer's ignorance of the world price, there is little or no benefit to him. In our model slow increase in the producer price is explained by low entry. Indeed for policy reasons it is important to understand why farmer prices are low: if they are low because of trade frictions, then providing information to farmers, say by posting the world price in a public place, would not help raise the price they obtain or affect the extent of pass through.[5] However, greater cell phone usage, if it reduced the cost to a trader of visiting a farmer, and so led to a flood of trader entry, would raise the price offered to farmers.

Section 2 lays out the model. Section 3 constructs the equilibrium when

[5] See Mookherjee, Dilip et. al. (2011) for evidence suggesting this may be the case in practice.

farmers are risk neutral. Section 4 looks at the efficacy of various policy options. Three kinds of policies are considered: decreasing the cost of entry for traders, a production subsidy to farmers, and moving the outside option for the farmers closer to the world price. There is reason to think that decreasing the entry cost is the most effective policy, followed by a production subsidy and then by changing the farmer's outside option. Section 5 looks at extensions of the model including risk aversion on the part of the farmer. Section 6 concludes.

2 The Baseline Model

The modelling framework builds on Burdett and Mortensen (1998) and Galenianos and Kircher (2008). The economy consists of a continuum of farmers of measure one and a continuum of traders whose measure is determined endogenously in equilibrium. Farmers can produce the staple or the perishable good. It takes a unit of labor to produce a unit of the staple while each unit of labor produces α units of the perishable good. Each farmer is endowed with one unit of labor. All farmers are ex-ante identical and of measure zero so that their actions do not affect the equilibrium outcome. We begin by assuming that farmers and traders are risk neutral. This causes farmers to (generically) completely specialize in either the export or the staple good. Adding risk aversion on the side of the farmers, as we do later, moves us away from this bang bang solution as farmers diversify their output which makes the supply of the export and staple good a continuous function of the model's parameters.

Farmers can consume the staple themselves or sell it at a fixed price which is normalized to unity. The perishable good has to be exchanged for the staple in a Walrasian market to which farmers have no direct access. To exchange the perishable good farmers have to meet with a trader. The role of the trader in this model is to deliver the good from the farmer to the Walrasian market (i.e. the world market which has a single market clearing price). The objective of the trader is to maximize his expected profit. There is an infinite number of potential traders who can become actual traders by paying a sunk entry cost κ. Each trader who paid the sunk cost randomly meets a single farmer. It is possible that the farmer is approached by more than one trader. However, the trader at the time he makes his offer does not know how many traders he is competing with, though he knows the ratio of traders to farmers and so can infer the probabilities of having each of the different possible numbers of competitors. This assumption simplifies things a lot as it ensures that the trader offers the same price to any farmer while keeping the feature we desire, namely that the possibility of competition frames the prices the trader offers.[6] The good is then allocated to a trader through the first price auction mechanism: in other words, the trader with the highest bid gets the product.

The model is a static one. Farmers and traders simultaneously choose their strategies. The strategies are played and the outcomes are revealed. A strategy on the part of a farmer is labor, $l \in [0, 1]$, that he allocates to the production of the export good. The strategy of a potential trader consists of a binary decision to enter or not, and the price (or distribution of prices to draw from) to offer upon conditional on entry. All agents take the strategies of all other traders and farmers as given.

Traders meet farmers in a random manner. A trader can approach a single farmer. Traders approach farmers who make the export good and offer a price for the output. Each trader neither observes the bid of any of the other trader nor observes the number of competing traders present. Hence every trader makes the decision about the price based on the expected number of rivals and their bidding strategies. In all stable equilibria, farmers choose to do the same thing. If some farmers made the perishable good and some did not and this was an equilibrium, then an additional farmer making the perishable would raise the profits of the traders, more would enter, and this would tip the choice of farmers towards making the perishable good.

2.1 The Meeting Process:

We assume that farmers and traders meet randomly according to a Poisson Process. This process arises naturally when traders arbitrarily meet one out of N farmers producing for export and is convenient in modelling coordination frictions that result when there are many small market participants.

Let P_k be the probability that a trader who randomly arrives to one of the farmers in the continuum meets k rivals. Denote the probability that a trader meets a particular farmer i by λ.With N identical farmers in the market the probability of meeting a particular farmer i is given by $\lambda = \frac{1}{N}$.

[6] We believe the essential results of the model would go through even if the trader knew the number of competitors he faces before making his bid, though the analysis would be more complex.

With a finite number of traders (denoted by T) in the market the probability that the trader meets k rivals is the probability that he meets exactly k out of $T-1$ agents which is given by

$$P_k = \binom{T-1}{k} \lambda^k (1-\lambda)^{T-1-k}.$$

Denote the ratio of traders to farmers by $\theta = \frac{T}{N}$. Rewriting P_k in terms of θ and λ yields

$$\begin{aligned} P_k &= \binom{T-1}{k} (\frac{1}{N})^k (1-\frac{1}{N})^{T-1-k} \\ &= \frac{(T-1)!}{(T-1-k)!k!} (\frac{\theta}{T})^k (1-\frac{\theta}{T})^{T-1-k} \\ &= \frac{(T-1)!}{(T-1-k)!T^k} \frac{(\theta)}{k!}^k (1-\frac{\theta}{T})^T (1-\frac{\theta}{T})^{-(1+k)} \end{aligned}$$

Now let T and N go to infinity keeping θ constant. Then $\lambda = \frac{1}{N}$ goes to zero while θ is a finite number.

Thus

$$\begin{aligned} \lim_{T,N\to\infty} P_k &= \lim_{T,N\to\infty} \frac{\theta^k}{k!} \left[\frac{(T-1)!}{(T-1-k)!T^k} \right] \left[(1-\frac{\theta}{T})^T \right] \left[(1-\frac{\theta}{T}) \right]^{-(1+k)} \\ &= \frac{\theta^k}{k!} e^{-\theta} \end{aligned}$$

This follows from

$$\lim_{T\to\infty} \frac{(T-1)!}{(T-1-k)!T^k} = \lim_{T\to\infty} \frac{(T-1)(T-2).....(T-k)}{T^k} = \lim_{T\to\infty} (1-\frac{1}{T})...(1-\frac{k}{T}) = 1$$

and

$$\lim_{T\to\infty} \left[(1-\frac{\theta}{T}) \right]^{-(1+k)} = 1.$$

Also, by definition,$e = \lim_{T\to\infty} \left[(1-\frac{1}{T})^T \right]$ so that

$$\lim_{T\to\infty} \left[(1-\frac{\theta}{T})^T \right] = e^{-\theta}.$$

Thus, for a sufficiently large number of market participants the probability that a trader meets k rivals, or P_k,is given by $\frac{\theta^k}{k!} e^{-\theta}$.

2.2 The Trader's problem

The trader's problem consists of two parts. For a given level of market intermediation, that is, for a given number of traders and producers, a potential trader needs to decide whether to enter the intermediation market or not. Second, given that he has entered, he has to decide what price to post. As usual, we need to solve this backwards. First, consider the problem of optimally choosing the price to post, given the number of traders in the market.

As all traders are ex-ante identical, we limit ourselves to considering only symmetric equilibria. The trader knows that the probability that a given p is the highest posted price in a meeting with k rivals is given by $[F(p)]^k$. Thus, if he meets k rivals and offers p, he will be the highest bidder with probability $[F(p)]^k$. As discussed earlier, for large T and N, the number of rivals in a meeting is given by the Poisson process. Hence the probability that a trader offering price p is the highest bidder involves summing over the number of rivals the trader could potentially meet

$$\begin{aligned}\sum_{k=0}^{\infty} P_k[F(p)]^k &= \sum_{k=0}^{\infty} e^{-\theta}\frac{\theta^k}{k!}[F(p)]^k \\ &= \sum_{k=0}^{\infty} e^{-\theta}\frac{[\theta F(p)]^k}{k!}. \\ &= e^{-\theta}e^{\theta F(p)} \\ &= e^{-\theta(1-F(p))}\end{aligned}$$

If a trader offering p has the lowest price and wins, he makes $(p^w - p)\,\alpha l^*$ where l^* is the labor devoted to making the export good by a farmer. Thus, the expected profits of a trader offering price p, conditional on the farmer making the export good, is $(P^w - p)\alpha l^*$ times the probability of being the highest bidder there.[7]

$$\pi(p) = (P^w - p)\,\alpha l^* e^{-\theta(1-F(p))}.$$

For traders to choose to mix over prices in equilibrium, it must be that profits for any price in the support of $F(p)$ must be the same. Thus, $\pi(p) = \overline{\pi}$, for each p in the support.

Let R be the price which a farmer can obtain if he does not meet a trader. This may be the price offered by the local canning factory. It may even be

[7] Note that if there is a per unit cost of transport, c, that has to be paid in addition to any sunk costs of visiting the market, we can replace P^w by $P^w - c$ in what follows.

zero. This defines the farmer's outside option regardless of how many traders he meets. It can also be interpreted as the price net of costs obtained by a farmer travelling to the local market. The value of R puts a lower bound on the price that the farmer will accept for his output from a trader.

Proposition 1 *In the symmetric mixed strategy equilibrium, traders mix over the interval* (R, p^{max}) *according to* $F(p)$ *where*

$$\begin{aligned} F(p) &= 0 \ for \ p < R \\ &= \frac{1}{\theta}\ln\left(\frac{P^w - R}{P^w - p}\right) \ for \ R \le p \le p^{max}, \end{aligned}$$

and expected equilibrium profits equal $(P^w - R)\alpha l^* e^{-\theta}$.

Proof. First, we show that the support starts at R, has no gaps and the distribution function is continuous, i.e., the density function has no mass points. Since no farmer will accept a price below R, the support of $F(\cdot)$ cannot include any such points. Suppose the support of $F(\cdot)$ starts at $\underline{p} > R$. Then a trader who bids a price in the interval $\left[R, \underline{p}\right)$ will only win if there are no other traders, i.e., with probability $P_0 = e^{-\theta}$. His expected profit if he wins is

$$\pi(p) = (P^w - p)\alpha l^* e^{-\theta}$$

which is decreasing in p. Thus, the trader would be better off charging R, or any price in $\left[R, \underline{p}\right)$ than offering $\underline{p}$ which contradicts the assumption that $\underline{p}$ is in the support of the mixed strategy equilibrium.

Next, we establish that there are no gaps in the support of the distribution. Nor are there any atoms anywhere in the interior or at the lower bound of the support of the distribution. There may be a mass point at the top of the support.

Let's first rule out gaps in the support of the distribution. Suppose there is a gap in the support of $F(\cdot)$: no one bids in the interval (p', p''). If there is no mass point at p'', then a trader who posts a price $p^* \in (p', p'')$ will be better off than bidding $p^{''}$as the probability of winning does not decrease but the margin rises. Hence there are no gaps in the support *unless* there is a mass point at p''. Such a mass point would cause a jump down in profits at prices just below p'', and validate the hole in the price distribution posited . Can we rule out such atoms at p''? Yes, we can. If there is an atom at p'', then bidding $p'' + \varepsilon$ causes a discrete jump in the trader's profits as he increases the offer price only marginally but this increases his probability of winning discretely.

The same argument rules out atoms at any $\widehat{p}$ in the interior of the support of the distribution or at R: bidding $p = \widehat{p}+\varepsilon$ causes a discrete jump in trader's profits as he increases the offer price only marginally but this increases his probability of winning discretely. In equilibrium all prices in the support must yield the same profits, hence such mass points cannot occur. They cannot even occur at the upper end of the support. As will be confirmed later, the upper end of the distribution support is given by $p^{\max} < P^w$. If there were a mass point at $p^{\max}$, raising p slightly above $p^{\max}$ must raise profits which rules out a mass point at $p^{\max}$.

Next we can use the property of the equality of payoffs at every point of the support to obtain the explicit expression for the cumulative distribution of bids, $F(p)$. Equating the expected profits at an arbitrary price p and expected profits at the lower end of the support R , i.e., setting $\pi(p) = \pi(R)$, we can solve for the bidding function of the trader as a function of world price (P^w), market thickness (θ), and R, the farmer's outside option.

$$\begin{aligned}
(P^w - p)e^{-\theta(1-F(p))} &= (P^w - R)e^{-\theta} \\
e^{\ \theta F(p)} &= \frac{(P^w - R)}{(P^w - p)} \\
F(p) &= \frac{1}{\theta}\ln(\frac{P^w - R}{P^w - p})
\end{aligned}$$

Setting the obtained expression for the probability distribution to equal unity at $p = p^{\max}$ gives

$$F(p^{\max}) = 1 = \frac{1}{\theta}\ln(\frac{P^w - R}{P^w - p^{\max}}). \tag{1}$$

Solving for $p^{\max}$ from equation (1) we obtain

$$\begin{aligned}
e^{\theta} &= (\frac{P^w - R}{P^w - p^{\max}}) \\
p^{\max} &= P^w(1 - e^{-\theta}) + e^{-\theta}R.
\end{aligned}$$

■

Note that $e^{\theta} = 1 + \theta + \frac{\theta^2}{2!} + \frac{\theta^3}{3!}... > 1$ for any $\theta > 0$. Thus, $0 < e^{-\theta} < 1$. The upper bound of the support is thus a convex combination of the world price and the outside option of the farmer which is his reservation price. The higher is θ, the level of intermediation, the closer $p^{\max}$ is to P^w. The lower bound of the support is fixed by the farmer's reservation price, while the upper bound is increasing in the world price of the specialized good, but lies strictly below it. $p^{\max}$ is increasing in the prevalent level of intermediation (θ), and the farmers's outside option. Expected profits of the trader (which are equal to profits at $p = R$) in equilibrium are,

$$\pi(p) = (P^w - R)\alpha l^* e^{-\theta}$$

These expected profits are clearly increasing in P^w, and decreasing in R and θ.

Now that we can evaluate traders' expected profits prior to entry (given P^w, R and θ) we can consider the decision regarding whether to enter or not.

Proposition 2 *The free entry level of intermediation is*

$$\begin{aligned} \theta &= 0 \textit{ if } l^* < l_{\min} \\ \theta &= \ln(\frac{(P^w - R)\alpha l^*}{\kappa}) \textit{ if } l^* \geq l_{\min} \end{aligned}$$

Proof. *There are an infinite number of potential traders who can enter if the expected traders profits from entry exceed the sunk cost of entry. Entry of traders will continue until the benefits from entry exactly equal the costs.*

$$\pi(p) = \kappa$$

Since profits are the same at every point in the support, without loss of generality we can solve for the level of intermediation by equating profits at the lower end of the support to the cost of entry.

$$(P^w - R)\alpha l^* e^{-\theta} = \kappa \tag{2}$$

Solving for θ gives

$$\theta = \ln(\frac{(P^w - R)\alpha l^*}{\kappa}).$$

Thus, the equilibrium level of intermediation is increasing in the world price and the output of the export good. It is decreasing in the sunk cost and the farmer's outside option. Note that $\theta > 0$ if and only if

$$\ln(\frac{(P^w - R)\alpha l^*}{\kappa}) > 0,$$

or

$$l^* > l_{\min} = \frac{\kappa}{\alpha(P^w - R)}.$$

■

Proposition 2 says that positive levels of intermediation prevail when the output of the export good αl^* is higher than a minimum level denoted by $\alpha l_{\min} = \frac{\kappa}{(P^w - R)}$ which ensures that the profits made from trading the good exceed the fixed cost of doing so. Equilibrium intensity of intermediation is higher when the world price is higher, the farmers' reservation price is lower, or the fixed cost of entry into intermediation is lower.

2.3 The Farmer's Problem

Having characterized the traders' problem, we now describe the problem of a risk neutral farmer and consider the implications of the model for policy in this setting. With risk neutrality, farmers choose to produce the crop that gives them higher expected profits. Only when the two crops give the same level of expected profits are they willing to diversify. However, this case is inherently unstable: should farmers make more of the non staple, more traders would enter and farmers would be stictly better off making the non staple. Thus, looking forward, when we consider the market equilibrium, taking into consideration the behavior of both traders and farmers we will only consider the stable equilibrium. Hence, there will only be two possible levels of output of the export good α or 0. This implies that the level of intermediation can take on only two values as well, which makes the problem with the risk neutral farmer very tractable.

$$\begin{aligned} \theta &= \ln\left(\frac{(P^w - R)\alpha}{\kappa}\right) \text{ if } (P^w - R)\alpha \geq \kappa \text{ with } l^* = 1 \\ \theta &= 0 \text{ if } (P^w - R)\alpha < \kappa \text{ with } l^* = 0 \end{aligned}$$

Farmer's risk neutrality is relaxed in Section 4.3.

Let $G_k(p) = [F(p)]^k$ be the cumulative density function of the highest price offered by the k ex-ante identical traders that a farmer faces when he meets k traders. Each farmer has a linear utility function defined over the units of the numeraire (staple good). If the farmer puts l units of labor into the non staple good and gets price p, with $1 - l$ units going to produce the staple good, he makes

$$\begin{aligned}\pi(l,p) &= \alpha lp + (1-l) \\ &= (\alpha p - 1)\, l + 1.\end{aligned}$$

The farmer maximizes the expected value of his profits if he is risk neutral. As the farmer consumes only the numeraire good, his indirect utility is the same as his income.

Let $E(p)$ be the price farmers expect to fetch for the export good. It will be derived later. If $\alpha E(p) - 1 > 0$, the farmer will produce only the non staple.

Lemma 3 *As the number of traders and farmers goes to* ∞, *the probability that a farmer meets* k *traders, or* Q_k, *is also given by* $\frac{\theta^k}{k!}e^{-\theta}$.

Proof. With a finite number of traders (denoted by T) in the market the probability of the farmer having k traders arrive at his door is the probability that exactly k out of T agents arrive at his door which is given by

$$Q_k = \binom{T}{k}\lambda^k(1-\lambda)^{T-k}.$$

Denote the ratio of traders to farmers by $\theta = \frac{T}{N}$. Rewriting Q_k in terms of θ and λ yields

$$\begin{aligned}Q_k &= \binom{T}{k}(\frac{1}{N})^k(1-\frac{1}{N})^{T-k} \\ &= \frac{(T)!}{(T-k)!k!}(\frac{\theta}{T})^k(1-\frac{\theta}{T})^{T-k} \\ &= \frac{(T)!}{(T-k)!T^k}\frac{(\theta)^k}{k!}(1-\frac{\theta}{T})^T(1-\frac{\theta}{T})^{-(k)}\end{aligned}$$

Thus

$$\begin{aligned}\lim_{T,N\to\infty} Q_k &= \lim_{T,N\to\infty}\frac{\theta^k}{k!}\left[\frac{(T)!}{(T-k)!T^k}\right]\left[(1-\frac{\theta}{T})^T\right]\left[(1-\frac{\theta}{T})\right]^{-(k)} \\ &= \frac{\theta^k}{k!}e^{-\theta}.\end{aligned}$$

Farmers take the level of intermediation (θ), the pricing strategy of the traders $F(\cdot)$, and the meeting process $\{Q_k\}_{k=0}^{\infty}$ as given. ■

Lemma 4 *Given the level of intermediation, θ, the expected price is given by*

$$\begin{aligned} E(p) &= \sum_{k=0}^{\infty} Q_k \int_{R}^{p_{\max}} p dG_k(p) \\ &= P^w - e^{-\theta}(P^w - R)(1+\theta) \\ &= P^w \left(1 - e^{-\theta}(1+\theta)\right) + Re^{-\theta}(1+\theta) \end{aligned} \tag{3}$$

As $0 < e^{-\theta}(1+\theta) < 1$,[8] *the expected price is also a convex combination of the world price and R.*

Proof. As this proof involves some tedious calculations, it is in the Appendix. ■

The expected producer price is increasing in world price (P^w), level of intermediation θ, and the producer reservation price (R) which makes intuitive sense.

To show this note that

$$\frac{\partial E(p)}{\partial P^w} = 1 - e^{-\theta}(1+\theta) > 0 \text{ for } \theta > 0$$

This follows from $e^{-\theta}(1+\theta) < 1$, which is the same as $e^{\theta} > 1+\theta$. This holds as by definition, $e^{\theta} = 1 + \frac{\theta}{1!} + \frac{\theta^2}{2!} + ... > 1 + \theta$ for any $\theta > 0$.

$$\begin{aligned} \frac{\partial E(p)}{\partial \theta} &= (P^w - R)e^{-\theta}\theta > 0 \\ \frac{\partial E(p)}{\partial R} &= e^{-\theta}(1+\theta) > 0 \end{aligned}$$

2.4 Equilibrium

In the Nash equilibrium, each farmer chooses what to produce so as to maximize his profits, each *active* trader chooses the price (or distribution of prices) to offer, all *potential* traders are indifferent between becoming *active* and not, and finally the decisions of these agents are mutually consistent.

An equilibrium is defined by the following equilibrium objects $(\theta, F(p), l(\theta))$, where θ is the equilibrium ratio of traders to farmers which can be interpreted

[8] $e^{\theta} > 1+\theta$ so $\frac{1}{1+\theta} > e^{-\theta}$ or $1 > e^{-\theta}(1+\theta)$.

as the level of intermediation; $F(p)$, is the distribution of prices for the non staple good the profit maximizing trader offers in equilibrium; and $l(\theta)$ is the profit maximizing output of the export good for the farmer. We have shown so far that the following holds:

1.

$$\begin{aligned} \theta &= \ln(\frac{(P^w - R)\alpha l(.)}{\kappa}) > 0 \text{ if } l(.) > l_{\min} = \frac{\kappa}{\alpha(P^w - R)} \\ \theta &= 0 \text{ if } l(.) \leq l_{\min} \end{aligned} \tag{4}$$

We can think of $\theta(l)$ as coming from above. It is zero for low l : unless farmers produce a minimum output of the non staple, i.e., $l_{\min}$, traders do not find it worthwhile to enter so that $\theta = 0$. Above $l_{\min}$, $\theta(.)$ rises with l.[9]

2.

$$F(p) = \frac{1}{\theta} \ln(\frac{P^w - R}{P^w - p}) \text{ for } p \in [R, p^{\max}]$$

where $p^{\max} = P^w(1 - e^{-\theta}) + e^{-\theta} R$. Note that as θ rises, i.e., we have more traders relative to farmers, the upper end of the distribution rises. The price distribution with higher values of θ first order stochastically dominates distributions with the lower ones. This makes intuitive sense as greater competition among traders to buy from the farmers will raise prices.

3.

$$\begin{aligned} l(E(p)) &= 1 \text{ if } \alpha E(p) \geq 1 \\ &= 0 \text{ if } \alpha E(p) \leq 1 \end{aligned}$$

where

$$E(p) = P^w(1 - e^{-\theta}(1 + \theta)) + Re^{-\theta}(1 + \theta). \tag{5}$$

As expected, an increase in θ raises the expected price as it reduces the weight on R. Hence, once θ exceeds a cutoff level, lets call this $\theta_{\min}$, then the $E(p)$ will exceed $\frac{1}{\alpha}$, and $l(.)$ will equal unity. Let $l(E(p|\theta)) \equiv l(\theta)$. Then, we can write the above as

$$\begin{aligned} l(\theta) &= 0 \ for \ \theta \leq \theta_{\min} \\ l(\theta) &= 1 \ for \ \theta \geq \theta_{\min}. \end{aligned} \tag{6}$$

[9] We already know that $l(.)$ is going to be either zero or unity. If no farmer makes the specialized good, then no traders will enter and $\theta = 0$. Given no traders will enter, no farmers will make the specialized good. Thus, this is always an equilibrium.

where $\theta_{\min}$ is the solution to $E(p|\theta) = \frac{1}{\alpha}$. It is easy to see that $\theta_{\min}$ decreases as α rises. When farmers become more productive in non staples, they are willing to make it even at a lower intermediation level.

Equations (6) and (4) above give us the equilibrium. Possible configurations of equilibria are depicted in Figures 1-4. In these figures, $\theta(.)$ is zero for $l < l_{\min}$, and then is increasing in l. Given risk neutrality on the part of the farmer $l(\theta)$ is either zero (when $\theta \leq \theta_{\min}$) or unity (when $\theta \geq \theta_{\min}$). There are three possible cases as depicted in Figures 1, 2 and 3.

In Figure 1, $\theta_{\min} < \theta(1)$. As a result, $l(.)$ and $\theta(.)$ have only one intersection at the origin. In this case, even if all farmers produced only the specialized good the number of intermediaries who would enter is not enough for the farmers to choose to produce any of the specialized good. Since no specialized good can be produced for any level of intermediation no equilibrium with intermediation can exist. This outcome occurs when either $\theta_{\min}$ is high (a lot of intermediation is needed to get farmers to produce), and/or $l_{\min}$ is high (i.e. a lot of output is needed to get intermediaries to come in). This in turn happens when α is low (agriculture is inefficient), P^w is low, R is high (so that traders capture little of the rent) or κ, the cost of entry for traders, is high. In these situations, the profits from intermediation are too low for an equilibrium with intermediation to exist.

When profits from intermediation are large enough as depicted in Figure 2, there are three equilibria, two of which are stable. If no farmer makes the specialized good, then no traders will enter and $\theta = 0$. Given no traders will enter, no farmers will make the specialized good. This is always a stable equilibrium. The other stable equilibrium is where farmers produce only the specialized good, $l(.) = 1$, and given this, the number of intermediaries who enter is enough for the farmers to choose to produce only the specialized good.

There is also an unstable equilibrium where farmers produce both the specialized good and the staple. They do not care how much of each good to produce as they yield same expected profits. Just enough traders enter to make farmers indifferent, and given indifference, farmers produce just enough to keep entry at this indifference level. But this is a very fragile equilibrium: small perturbations will move the equilibrium to one of the two stable equilibria.

In Figure 3, $R > \frac{1}{\alpha}$ and as a result, even if there are no intermediaries, farmers will make the non staple. Thus, $l(\theta) = 1$ for all θ. The unique equilibrium is thus at $\theta(l = 1)$. It may be the case that if R is too high, i.e.,

$$\frac{(P^w - R)\alpha}{\kappa} < 1 \text{ or } R > P^w - \frac{\kappa}{\alpha}$$

then $\theta(l = 1) = 0$ as $l_{\min} > 1$. For $R > \frac{1}{\alpha}$ there is a unique equilibrium where only the specialized good is made by all farmers as dipicted in Figure 4.

Figure 5 depicts the possible outcomes for different values taken by the parameters R (the outside option) and κ (cost of entry), given values for the world price (P^w) and productivity in the specialized good (α). The key to the figure is the value of R.

When R is low, as in the region M (for multiple), multiplicity of equilibria is endemic (multiplicity in the sense of Figure 1). The exception is when κ is so high that traders are dissuaded from entering no matter what and as a result, in the unique equilibrium none of specialized good will be made. This is the semicircular region in Figure 4 labelled N for no production. This situation corresponds to Figure 1. The boundary between region M and N is defined by $\theta(1) = \theta_{\min}$. Recall that $\theta_{\min}$ is defined implicitly by $E(p/\theta_{\min}) = \frac{1}{\alpha}$ and that $\theta(1) = \ln\left(\frac{(P^w-R)\alpha}{\kappa}\right)$. Using the expression for $E(P)$ from equation (5) gives this boundary as the R and κ such that[10]:

$$P^w(1-\left(\frac{\kappa}{(P^w - R)\alpha}\right))(1+\ln\left(\frac{(P^w - R)\alpha}{\kappa}\right))+R\left(\frac{\kappa}{(P^w - R)\alpha}\right)(1+\ln\left(\frac{(P^w - R)\alpha}{\kappa}\right)) = \frac{1}{\alpha}.$$

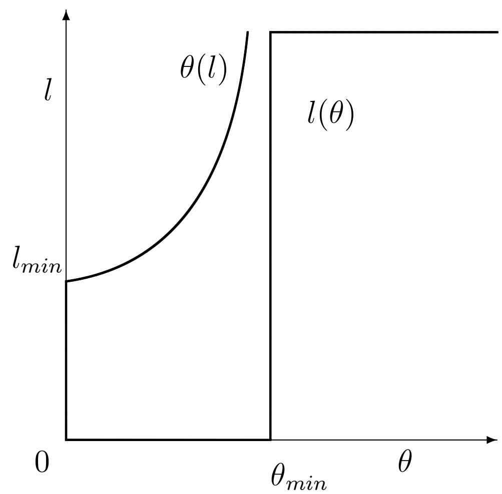
When R is above a cutoff level (of $1/\alpha$), the farmer's outside option for selling the specialized good is high enough that the no production of the specialized good outcome is eliminated. Thus, taking the free entry condition, equation (2), and setting $l^* = 1$ in it, gives

$$\frac{(P^w - R)\alpha}{\kappa} = e^{\theta}.$$

For θ to be positive in the above, it must be that $\frac{(P^w-R)\alpha}{\kappa} > 1$. Thus, $(P^w - R)\alpha = \kappa$ defines the boundary between the regions with and without intermediation, though the export good is produced. If R is high, then while the specialized good is made, it is sold only at R (i.e. to the canning factory) and there is no intermediation. This corresponds to scenario depicted in Figure 4 which corresponds to the region where $R > P^w - \frac{\kappa}{\alpha}$ in Figure

[10]In Figure 5, $P^w > R$ and $\alpha > 1$ are taken as fixed.

Figure 1: Unique Equilibrium (N)



5 (labelled P-NI for Production and No Intermediation). Traders will not enter as the profits they would make are too low to cover their entry costs. Only in the trianglular area (labelled P-I for production and intermediation) is there a unique equilibrium where the specialized good is produced and Intermediation occurs so that farmers are connected to the world market. (Figure 3)

The moral of this story is that too much of a good thing may be bad. Raising R, up to a point, helps as it removes the bad equilibrium where none of the specialized good is made. But raising it beyond a point destroys intermediation. Having some idea now of when intermediation can connect farmers to the world market, we now focus on the effect of various parameter changes on the outcomes.

Figure 2: Multiple Equilibria (M)

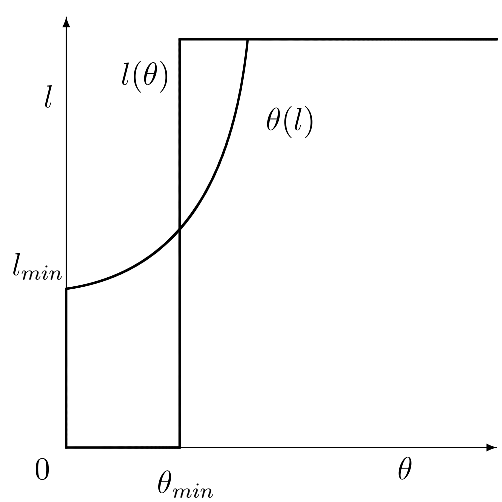


Figure 3: Unique Equilibrium (R-I)

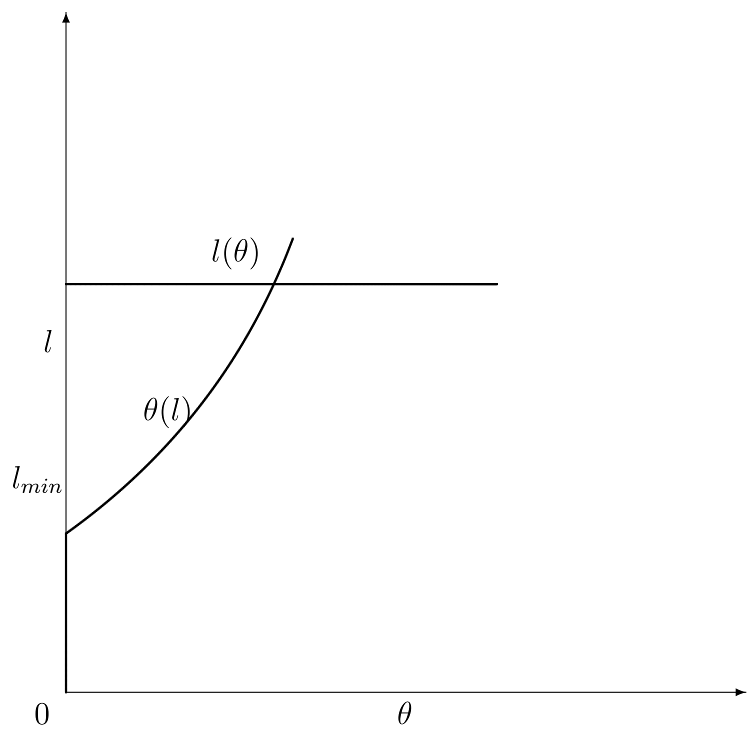


Figure 4: Unique Equilibrium (P-NI)

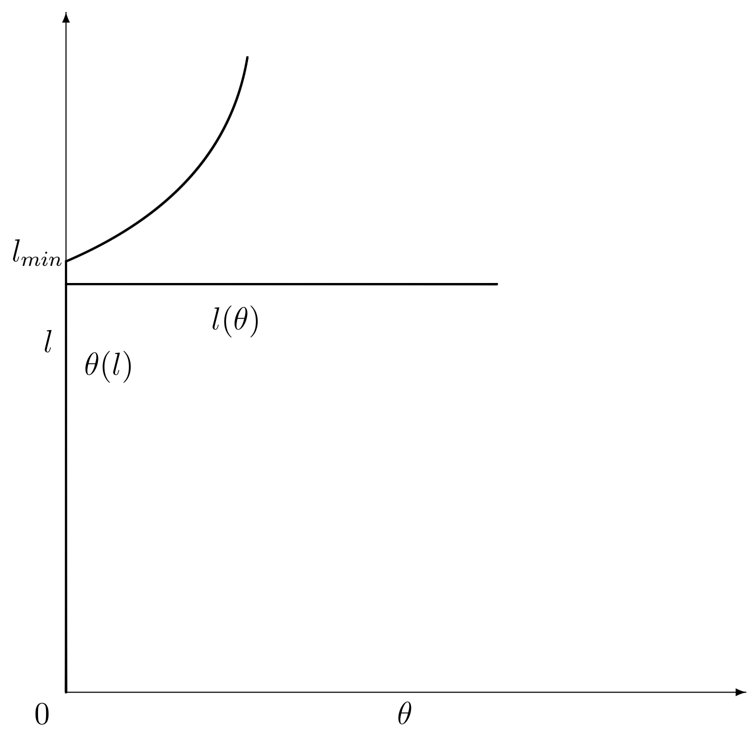
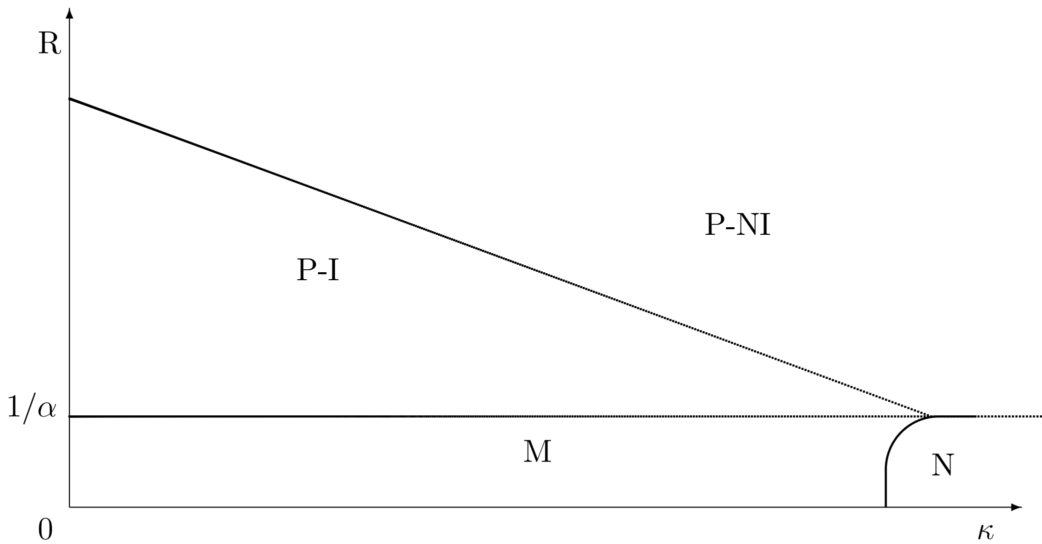


Figure 5: Equilibrium Types and the Parameter Space



3 Comparative Statics

We have shown that there are a number of regions: in some, the equilibrium is unique and in others it is not. What happens as parameters change depends on what region and what equilibrium we are in.

What happens when we change parameters in Region M where multiple equilibria exist? Consider the equilibrium with specialization in the export good. With risk neutral farmers the aggregate output of the economy is fixed. What we focus on first is the effect of changes in the exogenous parameters on the equilibrium level of intermediation and the expected producer price in equilibrium. As the expected producer price rises, farmers gain. If the total surplus is unchanged, this gain comes at the expense of intermediaries.

3.1 Price and Intermediation as κ, R, α, P^w Change

As might be expected, an increase in the world price (P^w), productivity (α), farmer reservation price (R) and decrease in the entry cost (κ) lead to an increase in the expected producer price in equilibrium whenever farmers specialize in the export good.

3.1.1 E(p) and κ

Consider, for example, the effect of a decrease in κ. For a given mass of traders, expected profits will turn positive, which will induce entry. This in turn will raise the competition at the farmers gate and raise the expected price paid by intermediaries. Entry will occur untill the rise in this expected price just compensates for the lower κ. Thus, a fall in the entry costs raises the the level of intermediation in equilibrium as well as the equilibrium expected producer price.

This can be seen in Figure 2 where a lower κ will shift the $\theta(l)$ function to the right so that the equilibrium θ (when $l = 1$) moves to the right as well. Then using the expression for expected price from equation (3)

$$E(p) = P^w(1 - e^{-\theta}(1 + \theta)) + Re^{-\theta}(1 + \theta),$$

the higher θ will reduce $e^{-\theta}(1 + \theta)$, the weight on R, thereby raising the expected price which is a convex combination of R and P^w.

More formally,

$$\begin{aligned}
\frac{d\theta(l=1)}{d\kappa} &= \frac{d\ln(\frac{(P^w-R)\alpha}{\kappa})}{d\kappa} = -\frac{1}{\kappa} < 0 \\
\frac{dE(p|\theta(l=1))}{d\kappa} &= \frac{dE(p)}{d\theta}\frac{d\theta}{d\kappa} \\
&= (P^w - R)e^{-\theta}\theta\left(-\frac{1}{\kappa}\right) & (7) \\
&= -\frac{\theta}{\alpha} < 0 & (8)
\end{aligned}$$

as $\theta(1) = \ln(\frac{(P^w-R)\alpha l(.)}{\kappa})$ so that $e^{-\theta} = \frac{\kappa}{(P^w-R)\alpha}$ in the intermediation equilibrium.

3.1.2 $E(p)$ and α

What about the effect of an increase in the productivity in the export good. At the existing level of intermediation, each trader will make positive expected profits, entry into intermediation will occur and increased level of intermediation will raise the expected price and bring profits back in line with entry costs.[11] In Figure 5, the $l(\theta)$ curve will shift to the left as farmers

[11] It will also affect the definitions of the regions in Figure 3.

will be willing to make the export good at a lower level of intermediation, and $\theta(l)$ will move to the right. Only the latter affects the equilbrium where $l = 1$, and thus the equilibrium θ rises, raising $E(p)$. Thus, α and $E(p)$ move in the same direction. This is the opposite of the effect of a productivity increase in competitive markets. Farmers will gain both because they are more productive and because they get more for what they make when their productivity rises! Thus, extension programs that aim to improve agricultural productivity will have have a double positive whammy.

Doing the comparative statics more formally

$$\frac{dE(p|\theta(l=1))}{d\alpha} = \frac{\kappa \ln\left(\frac{\alpha(P^w-R)}{\kappa}\right)}{\alpha^2} > 0 \text{ for } \theta > 0 \tag{9}$$

3.1.3 $E(p)$ and R

In Figure 2, an increase in R will shift the $l(\theta)$ curve to the left as farmers will be willing to make the export good at a lower level of intermediation. However, $\theta(l)$ will also move to the left. Only the latter affects the equilbrium where $l = 1$, and thus the equilibrium θ falls. While the rise in R raises $E(p)$ directly, the fall in θ results in more weight being put on R and this reduces $E(p)$, but this is not large enough to outweigh the direct effect.

Expressing the producer price in terms of the model primitives (using $\theta(1) = \ln(\frac{(P^w-R)\alpha l(.)}{\kappa})$, $l(.) = 1$, and equation (3)) and differentiating with respect to R :

$$\begin{aligned} E(p) &= P^w - (P^w - R)\, e^{-\theta}(1+\theta) \\ &= P^w - \frac{\kappa}{\alpha}\left(1 + \ln\left(\frac{(P^w-R)\alpha}{\kappa}\right)\right) \\ \frac{dE(p)}{dR} &= \frac{\kappa}{\alpha}\frac{1}{(P^w-R)} = e^{-\theta} > 0 \end{aligned} \tag{10}$$

There are two channels through which an increase in R affects $E(P)$: directly via R and indirectly via the effect of θ on R. The direct effect raises $E(p)$ as expected[12] while the indirect one reduces it[13], though the former dominates.

[12] More money when no trader is met raises the expected price, given θ.

[13] A higher R reduces θ, which raises the chance of not being matched, and lowers expected price.

Also note that $\frac{d^2 E(p)}{dR d\kappa}$ is positive. This is noteworthy. Raising R and reducing κ both raise $E(p)$. However, the marginal effect of an increase in R is larger when κ is large. This suggests that reducing κ and raising R are substitutes: using one policy instrument makes the other weaker. Also noteworthy is the fact that changes in the outside option have little effect on the expected price when entry cost for traders is relatively low. This suggests that the lack of a local market for the good is important in economies with high entry costs for traders, i.e. communities with poor road conditions or landlocked economies. In the economies with easy access to farmers, the value of the outside option or the local market for the export good plays a small role as competition among traders is sufficient to sustain a high expected producer price.

3.1.4 $E(p)$ and P^w

In Figure 2, an increase in P^w will shift the $\theta(l)$ to the right, raising the equilibrium θ. While the rise in P^w raises $E(p)$ directly, a higher θ further reinforces the direct effect. Doing the comparative statics more formally,

$$\begin{aligned}
\frac{dE(p|\theta(l=1))}{dP^w} &= \frac{d\left[P_w - \frac{\kappa}{\alpha}\left(1 + \ln\left(\frac{(P^w - R)\alpha}{\kappa}\right)\right)\right]}{dP^w} \\
&= 1 - \frac{\kappa}{\alpha}\frac{1}{\left(\frac{(P^w-R)\alpha}{\kappa}\right)}\frac{\alpha}{\kappa} \\
&= 1 - \frac{\kappa}{(P^w - R)\alpha} \\
&= 1 - e^{-\theta} \qquad (11) \\
&> 0 \text{ for } \theta > 0
\end{aligned}$$

as $(P^w - R)\alpha = \kappa e^{\theta}$ from the free entry condition.

The effect of changes in the world price deserves special attention as it connects the model to the observable outcomes. Empirical studies (i.e.Fafchamps and Hill) find that the pass through of the changes in world commodity price to the producer prices is only partial. Our model predicts that the elasticity of the expected producer price with respect to the world price is less than unity in the short run, and may be greater or smaller than unity in the long run depending on the values of the parameters. The distinction between the long run and the short run elasticities comes from the definition of the short run as being such that the level of intermediation does not adjust in response to changes in the world price, while it does in the long run.

Proposition 5 *In the short run the elasticity of the expected farmer price in response to a change in the world price is less than unity for $R > 0$, and equals unity for $R = 0$.*

Proof. Differentiating with respect to the world price taking the level of intermediation as given and rearranging the terms we can see that the elasticity is smaller than one.[14]

$$\frac{\partial E(p)}{\partial P^w}\frac{P^w}{E(p)}_{Short\ Run} = \frac{1}{1+\frac{Re^{-\theta}(1+\theta)}{P^w\left(1-e^{-\theta}(1+\theta)\right)}} \leq 1$$

Details of the calculations are in the Appendix. This elasticity is equal to exactly one when R is zero but is strictly less than one whenever R is positive. ■

Intuitively this result makes sense as the expected price is a convex combination of the world price and R. An increase in the world price, given θ, changes only a part of the expected price which results in the percentage increase in the expected price being less than that of the world price, unless R is zero.

Proposition 6 *In the long run, the elasticity of the expected price farmers obtain with respect to the world price is more than that in the short run. It is more than unity when R is low, and less than unity when R is high.*

Proof. That the long run elasticity is more than the short run can be seen from the following expression where $\frac{\partial E(p)}{\partial \theta} > 0$

$$\begin{aligned}\frac{dE(p)}{dP^w}\frac{P^w}{E(p)} &= \left[\frac{\partial E(p)}{\partial P^w} + \frac{\partial E(p)}{\partial \theta}\frac{\partial \theta}{\partial P^w}\right]\frac{P^w}{E(p)} \\ &= \frac{\left(1-e^{-\theta}\right)P^w}{P^w(1-e^{-\theta}(1+\theta)) + Re^{-\theta}(1+\theta)}\end{aligned}$$

[14]The requirement for the elasticity to be less than $1-e^{-\theta}(1+\theta) > 0$ is equivalent to $e^{\theta} > 1+\theta$. The cut off value of $\overline{\theta}$ such that for $\theta > \overline{\theta}$ the inequaliiy holds is given by the solution to $e^{\overline{\theta}} = 1+\overline{\theta}$ which is the lambert function $W(k, \exp(-1)) - 1$, with $k \in Z$. It has multiple branches and analyzing where this condition holds using analytical methods is hard. However, drawing the inequality in the two dimensions shows that it holds for almost all positive values of θ independently of the model parameters.

The range of θ here is from 0 to .5. Clearly e^{θ} increases faster than $1+\theta$.

It is clear from the expression that for R close to zero, the long run elasticity is close to $\frac{\left(1-e^{-\theta}\right)}{\left(1-e^{-\theta}(1+\theta)\right)} > 1$, while if R is close to $\overline{R} = P^w - \frac{\kappa}{\alpha}$,the value of R that implies no intermediation ($\theta(\overline{R}) = 0$), farmers sell their output at R and hence the elasticity of substitution is 0. A more formal proof is in the appendix. ■

4 Policy Implications:

In our model the interaction of several market frictions can prevent the efficient allocation of resources; the economy may even end up specializing in the commodity in which it has a comparative disadvantage. In what follows, we take the existence of these frictions as given and look at the efficacy of alternative policies in our model. We consider a production subsidy, lump sum taxes and transfers, and the creation of a cooperative that affects R, the the reservation price of the farmer.

The economy presented in the model can be in one of the four regimes in Figure 2. The economy may have a unique equilibrium where only the staple is produced (N), it may have multiple equilibria (M). It may have a unique equilibrium where only the export good is produced, with intermediation (P-I) or no intermediation (P-NI) occuring. Here we will ignore the unstable equilibrium, for obvious reasons, and focus on moving the economy to the good equilbrium, where the non staple is produced.

We will consider these regimes separately. If the parameters are such that the economy is in N, there is no scope for policy. In this case, the export good should not be produced as it would earn less for the farmer in the *world* market than the staple.

If the parameters place the economy in M, the export good should be produced as it earns more for the economy than the staple. Both a production subsidy and a marketing board can ensure this by making the export good more attractive than the staple under all conditions. If the parameters are such that we are in P-I or P-NI, production does not need to be encouraged, though intermediation does and raising the level of intermediation will raise welfare. Thus, subsidies to entry into intermediation are desirable.

4.1 Production Subsidy

Consider a production subsidy per unit of output of the export good. As domestic agents consume only the staple, welfare is the income of farmers (from production and the production subsidy) plus that of traders and net government revenue, NGR.

$$W = \alpha E(p)l^* + \alpha s l^* + (1 - l^*) + (\pi(p) - \kappa) + NGR$$

Traders make zero expected profits so that their contribution to welfare, $(\pi(p) - \kappa)$, is zero. NGR equals expenditure on the subsidy or $-\alpha s l^*$. The subsidy is a transfer between farmers and the government so that it washes out in welfare in terms of its direct effect. Thus, welfare boils down to the earnings of farmers, net of the production subsidy.

$$W = \alpha E(p)l^* + (1 - l^*)$$

where p denotes the price obtained by the farmer.

Suppose the government offers a per unit subsidy slightly above $s = \frac{1}{\alpha}$, say $\frac{1}{\alpha} + \epsilon$. Then farmers will specialize in the export good as even with no traders, farmers' expected income from making the export good exceeds that from making the staple: $\alpha(\frac{1}{\alpha} + \epsilon) > 1$. Knowing that farmers will produce the export good, traders will enter. Farmers who are approached by traders transact, though farmers who meet no traders sell their output at $R \geq 0$.

It is easy to see that as long as the parameters of the economy put it in case M or N to begin with, such a subsidy will create a unique equilibrium with all farmers producing the export good and traders providing intermediation. This will be welfare enhancing if $\alpha E(p) > 1$, i.e., we are in case M not N. In the N case, even if $l = 1$, the level of intermediation is so low that $E(p) < 1$. Thus, while the production subsidy can make farmers produce the good, this reduces welfare as intermediation remains inadequate.

If the economy is in P-I or P-NI the policy will just create a transfer between the government and farmers with no real effects as the production subsidy has no effect on intermediation in our model due to inelastic supply and risk neutrality.

Proposition 7 *A per unit production subsidy greater than or equal to* $1/\alpha$ *will raise welfare if the economy is in region M. It will lower it if it is in region N and have no effect otherwise.*

4.1.1 The Government Budget Balance

At this point we take a small digression. We ask, is such a subsidy feasible for the government? In the presence of multiple equilibria such a subsidy scheme can be implemented with a balanced budget. There are two ways in which government can raise revenues to cover the costs of the subsidy. First -a lump sum tax, second -an excise tax levied on the farmer when he transacts with the trader. With a lump sum tax, the farmers get a dollar and are taxed a dollar so their income is non-negative even if they meet no traders so that such a tax is always feasible..

With an excise tax, the subsidy can pay for itself whenever the farmer is better off making the export good, given the budget is balanced. The farmer is better off making the export good with an ad valorem tax of t and the production subsidy of $\frac{1}{\alpha}$ per unit when what he gets post tax, plus his subsidy earnings of $\frac{1}{\alpha}$ per unit of output, exceeds his income making the staple good. This is the farmer's incentive constraint:

$$\alpha(1-t)E(p) + \underbrace{1}_{\alpha\frac{1}{\alpha}} \geq 1. \tag{12}$$

Budget balance requires that government revenue exceeds expenditure and with the excise tax in place is given by

$$\alpha t E(p) - 1 \geq 0 \tag{13}$$

From the balance budget condition, a feasible tax rate must satisfy: $t > \frac{1}{\alpha E(p)}$, and from the farmer's incentive constraint $t < 1$.

The range of tax rates that satisfy both conditions in the presence of multiple equilibria is given by:

$$t \in [\frac{1}{\alpha E(p)}, 1]$$

In the case of a unique non-production equilibrium, a sufficiently high production subsidy will eliminate the non-production equilibrium. However, such a production subsidy is infeasible using an excise tax as the Government Budget Constraint is violated: $\alpha E(p) < 1$ so that the region $[\frac{1}{\alpha E(p)}, 1]$ does not exist. It is always feasible with lump sum taxes. However in region N, it is welfare decreasing.

4.2 An Export Board

What would be the effect of an export board that commits to purchase the output of the export good from the farmer at a fixed price? If the board offers a price less than $\frac{1}{\alpha}$, multiplicity will remain. Thus, the board will have no effect when the export good is not produced, and will not affect production, only intermediation, when the good is produced. Intermediation is affected because increasing the farmer's outside option affects the incentives of traders to enter the intermediation market. This needs to be taken into account.[15] An export board that pays a price $R \geq \frac{1}{\alpha}$ per unit of the output of the export good eliminates multiplicity of equilibria.

Consider what happens when the government sets $R = \frac{1}{\alpha}$ and where the government can sell the strawberries it buys for jam, but jam is less lucrative than fresh strawberries. Thus, we assume that instead of the world price P^w the government receives $P^g < P^w$ while it pays R.

Such an export board has two effects. First, it can move the economy to the equilibrium where the export good is produced from one where it is not, just like a subsidy does. This is clearly a good thing in the M case and a bad thing in the N case for the same reasons as above. Second, changing the farmers' outside option has real effects on the economy even if the export good is produced by all farmers. An increase in R reduces intermediation and although total output is unaffected, total income in the economy changes. Recall that farmers who do not meet a trader, which happens with probability $e^{-\theta}$ where θ is the prevailing level of intermediation, sell their output to the export board which sells in the world market for $P^g < P^w$. A fall in intermediation raises $e^{-\theta}$ and this is a real cost to the economy.

In the case of export board the welfare function becomes

$$W = \alpha E(p) + \alpha(P^g - R)e^{-\theta}$$

This can be interpreted as the expected earnings of a farmer through meeting a trader or selling to the board $(\alpha E(p))$, plus the board's profits when the farmer sells to it $\left(\alpha(P^g - R)e^{-\theta}\right)$.[16] Welfare increases in R as long as the intermediation level remains positive. This can be seen by differentiating the

[15] In contrast, recall that a production subsidy had no effect on intermediation.

[16] Recall that a farmer only sells to the board if there is no match with a trader which occurs with probability $e^{-\theta}$.

welfare function with respect to R.

$$\frac{dW}{dR} = \alpha \left[\frac{dE(p)}{dR} - e^{-\theta} - (P^g - R)e^{-\theta} \frac{d\theta}{dR} \right].$$

Substituting for

$$\frac{dE(p)}{dR} = e^{-\theta}$$

in the above gives

$$\begin{aligned} \frac{dW}{dR} &= \alpha \left[-(P^g - R)e^{-\theta} \frac{d\theta}{dR} \right] \\ &= \alpha \left[\frac{(P^g - R)}{(P^w - R)} e^{-\theta} \right] \\ &= \frac{\kappa(P^g - R)}{(P^w - R)^2} > 0 \text{ if } P^g - R > 0 \end{aligned}$$

using the fact that $e^{-\theta} = \frac{\kappa}{\alpha(P^w - R)}$. An increase in R raises the earnings of the farmer but reduces the marketing board's expected earnings from the farmer. The former effect dominates.

Proposition 8 *Increasing the payment offered by an export board that offers $R > 1/\alpha$ per unit will have no effect on welfare in regions P-NI, will have a positive effect in region M and N. In the region P-I, an increase in R will have positive effect as long as R does not exceed $\overline{R}$, the level of R that implies no intermediation.*

4.3 Entry Cost Subsidies

What are the effects of and entry cost subsidy? Decreasing the entry cost for traders will shift the $\theta(l)$ curve to the right and reduce $l_{\min}$. However, it will not affect $l(\theta)$. Thus, subsidizing entry costs will not remove the bad equilibrium, though it will raise the level of intermediation in the equilibrium where all farmers make the export good. In the presence of an export board, the welfare is given by:

$$W = \alpha E(p) + \alpha(P^g - R)e^{-\theta}.$$

Recall that intermediation, and hence expected price, rises as κ falls as shown in equation (7). Moreover that the chance of not matching with a trader, $e^{-\theta} = \frac{\kappa}{\alpha(P^w - R)}$, falls as κ falls. Thus

$$\begin{aligned} \frac{dW}{d\kappa} &= \alpha \frac{dE(p)}{d\kappa} + \alpha(P^g - R)\frac{de^{-\theta}}{d\kappa} \\ & \alpha\left[-\frac{\theta}{\alpha} + \frac{(P^g - R)}{\alpha(P^w - R)}\right] \\ &= \left[\frac{-\theta(P^w - R) + (P^g - R)}{(P^w - R)}\right] \end{aligned}$$

where we substitute from equation (7). If $P^g - R \leq 0$ then welfare falls as κ rises. This makes sense as $E(p)$ falls as κ rises and the government makes losses from the marketing board and these losses rise with κ as the board is used more when intermediation falls.[17]

4.4 Homogeneous Farmers, Risk Aversion

When farmers are risk neutral, they choose to produce the crop with the higher expected payoff. When they are risk averse, they could choose to produce both goods to help insure themselves. This is consistent with annecdotal evidence on small agricultural households.

Risk aversion affects the farmers' side of the model. A risk averse farmer with a concave utility function $U(\cdot)$, defined over the units of the numeraire good, maximizes his expected utility by allocating his labor endowment between the production of the two goods for a given distribution of expected prices :

$$\max_{l\in[0,1]} \left\{ e^{-\theta}U(l,R) + \sum_{k=1}^{\infty} \frac{e^{-\theta}\theta^k}{k!} \int_{p_{\min}}^{p_{\max}} U(l,\tilde{p})dG_k(p) \right\}$$

where $G_k = [F(p)]^k$, as before, denotes the CDF of the distribution of the maximum price when a farmer meets k traders. If l^* is the equilibrium output of the export good by each farmer, then the level of intermediation is given by $\theta(l^*) = \max\left\{\ln(\frac{(P^w - R)\alpha l^*}{\kappa}), 0\right\}$.

[17] Of course one could also use combinations of policies. Consider an entry subsidy combined with a production subsidy. The production subsidy could ensure that $l = 1$ and the entry subsidy would raise the level of intermediation in equilibrium.

Multiplicity of equilibria persists in this set up. When farmers believe that no intermediaries will enter and the local price of the export good is low, they chose not to produce the export good at all so that no intermediation occurs. Two features of the results when farmers are risk averse stand out. First, farmer does not specialize in the production of the export good as soon as the expected price exceeds the opportunity cost. He requires a premium for taking the risk of receiving a low price for the export good. Second, $l^*(\theta)$ is no longer a step function as farmers choose to diversify their output. As a consequence, policies can affect the allocation of labor across crops so that they have real effects on output. Unfortunately, anlytical solutions with risk aversion are impossible so that we have to rely on simulation results.

Production subsidy: With risk aversion a production subsidy increases both the output of the export good and the level of intermediation in the good equilibrium. The production subsidy gives farmers a direct incentive to increase output. The increase in output, in turn, has a positive effect on the level of intermediation which again increases the expected producer price.

We simulate the equilibrium for different values of the parameters. The results are similar across different sets of parameters so here we report the simulation for the CRRA utility function with relative risk aversion of 1.5 for the following parameter values $P^w = 3, \alpha = 2, R = 0, \kappa = 1$. In this simulation we solve for the equilibrium level of intermediation and output by each farmer for a set of subsidy values from 0 to $\frac{1}{\alpha}$[18]. Figures 5 and 6 below show that the output of the export good and the level of intermediation (on the y-axis) rise with the amount of the subsidy (on the x-axis). Until the farmer completely specializes in the export good, increases in the subsidy increase both the level of intermediation and the output of the specialized good. It is worth pointing out that the subsidy has no direct effect on the level of intermediation as it does not directly enter the expression for the level of intermediation 4. Increases in intermediation occur entirely via the equilibrium effect of increased output. Figure 7 depicts the Farmer's utility as the subsidy rises. Note that utility rises faster before there is specialization than after. Farmers choose to make both goods because poor intermediation increases the risk of not being matched. A subsidy increases the production

[18] Although we compute allocations for subsidies $\leq \frac{1}{\alpha} = .5$, the figure only contains values untill .2. The rst of the outcomes were omitted because the specialization has occured long before .5 is reached.

of the export good, which in turn induces more intermediation, which reduces the risk of making the export good and raises utility. There is also a direct effect of the subsidy on utility. Once specialization occurs, only the latter operates.

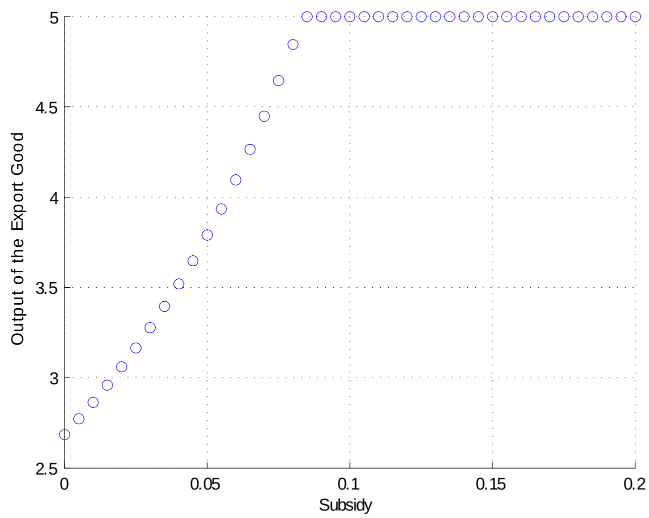


Figure 5: Output response to a subsidy

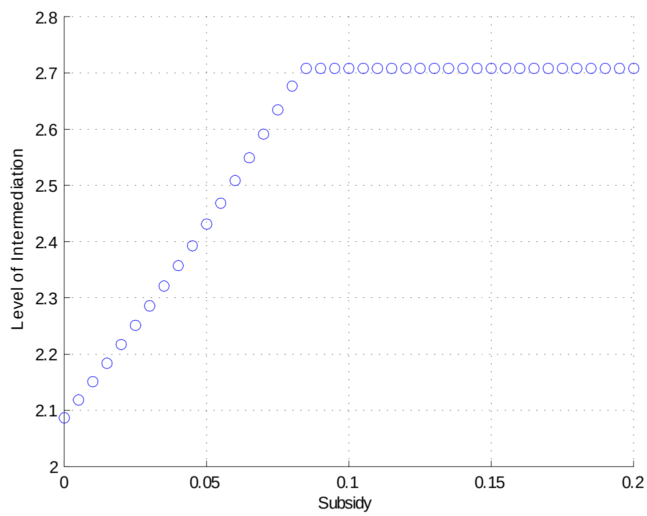


Figure 6: Intermediation and the subsidy

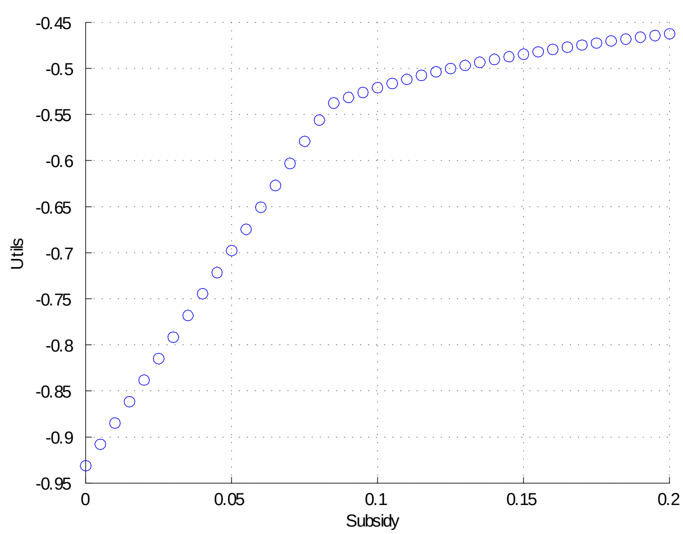


Figure 7: Utility as a function of the subsidy.

Export Board: An increase in the farmer's reservation price has a direct effect on the expected producer price of the export good just as in the risk neutral case. Unless the farmer has already specialized in the export good, an increase in the expected price leads to a reallocation of labor from the production of the staple good to the production of the export good. Increases in the output of the export good that each farmer produces increase the profit margin of traders and induces more trader entry. On the other hand, increases in the farmer outside option reduce the price the trader obtains and this decreases the level of intermediation. The equilibrium level of intermediation depends on whether this former effect outweighs the latter.

The simulation shows that until farmers specialize, labor allocated to the export good and intermediation levels both *increase* with R. Thus, at least in our simulations, the first effect above dominates. This is depicted in Figures 8 and 9 respectively. Once farmers have specialized in the export good, only the effect via the outside option operates and the level of intermediation starts falling. The farmer's utility continues to increase in R even after specialization has occurred, although at a slower rate than before specialization. Finally, the expected producer price increases with R.[19]

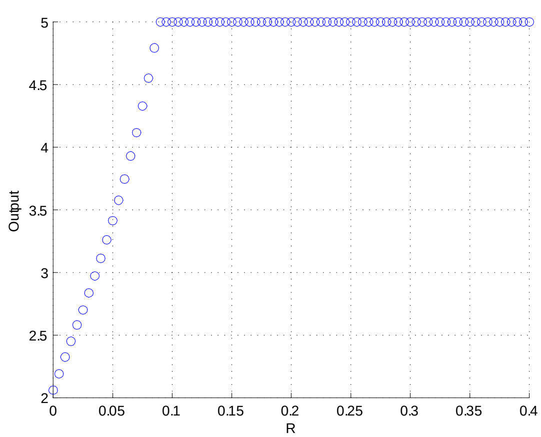


Figure 8: Response of output to R

[19] The simulation reported here is done for the same parameters as in the exercise with the subsidy.

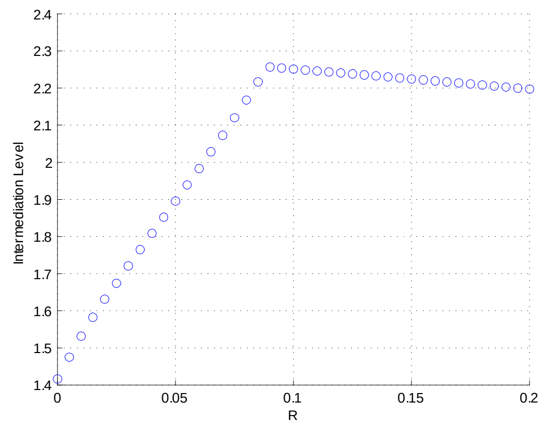


Figure 9: Response of intermediation to R

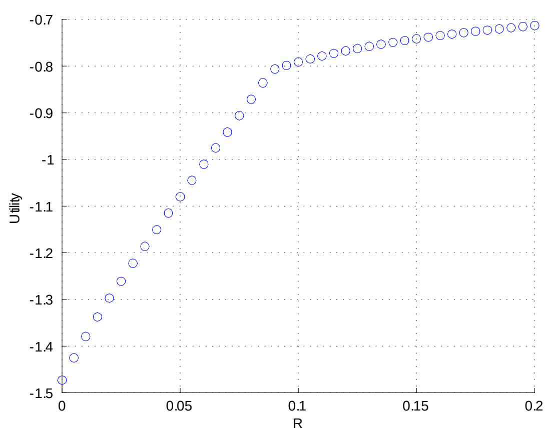


Figure 10: Response of farmer's utility to R

5 Conclusion

Our model is related to the literature that relates the low incomes of the developing countries to specializing in the wrong goods (i.e. Hausmann, Hwang, Rodrik). However it is different from this strand of literature in that the root cause of the problem is not that producers are ignorant about the profitability of the goods they have no experience in. Rather, the root cause is the lack of enforceable contracts that hamper intermediation. Our model provides an alternative rationale as to why developing countries specialize in the traditional goods despite the presence of more lucrative options.

In the model we present, even though farmers are more efficient in producing the export good, they may not specialize in it. The lack of enforceable contracts between intermediaries and producers gives rise to multiple equilibria. When a lot of people produce the intermediated good, markets function reasonably well. Otherwise the economy ends up specializing in the staple good instead of the export good.

Our paper suggests that there may be some simple solutions to these problems even if the government is not able to resolve the core issue (the lack of enforcable contracts) reponsible for the problem. A temporary production subsidy, or a marketing board that ensures a minimum price to the farmer can help an economy remove the bad equilibrium without intermediation. In the presence of risk aversion these policies are shown to have an extra bang as there are additional production effects that amplify the effects of such policies.

5.1 Appendix

Lemma 4 : Given the level of intermediation, θ, the expected price is given by

$$\begin{aligned} E(p) &= \sum_{k=0}^{\infty} Q_k \int_{R}^{p_{\max}} p dG_k(p) \\ &= P^w - e^{-\theta}(P^w - R)(1+\theta) \\ &= P^w \left(1 - e^{-\theta}(1+\theta)\right) + Re^{-\theta}(1+\theta) \end{aligned} \tag{14}$$

As $0 < e^{-\theta}(1+\theta) < 1,$[20] the expected price is also a convex combination of the world price and R.

[20] $e^{\theta} > 1+\theta$ so $\frac{1}{1+\theta} > e^{-\theta}$ or $1 > e^{-\theta}(1+\theta)$.

Proof. By definition, the expected value of price the farmer gets is

$$\begin{aligned} E(p) &= \sum_{k=0}^{\infty} Q_k E_k(p) \\ &= Q_0 R + \sum_{k=1}^{\infty} Q_k [\int_R^{p_{\max}} p g_k(p) dp] \\ &= Q_0 R + \sum_{k=1}^{\infty} Q_k [\int_R^{p_{\max}} pk[F(p)]^{k-1} f(p) dp]. \end{aligned}$$

Recall that

$$\begin{aligned} Q_k &= \frac{\theta^k}{k!} e^{-\theta} \\ G_k(p) &= [F(p)]^k \\ g_k(p) &= k[F(p)]^{k-1} f(p) \end{aligned}$$

$$\begin{aligned} p^{\max} &= P^w(1 - e^{-\theta}) + e^{-\theta} R \\ \frac{P^w - R}{P^w - p^{\max}} &= \frac{P^w - R}{P^w - [P^w(1 - e^{-\theta}) + e^{-\theta} R]} \\ &= e^{\theta} \end{aligned}$$

$$\begin{aligned} F(p) &= \frac{1}{\theta} \ln(\frac{P^w - R}{P^w - p}) \; for \; R \leq p \leq p^{max} \\ f(p) &= \frac{1}{\theta}(\frac{P^w - p}{P^w - R}) \left(\frac{P^w - R}{(P^w - p)^2} \right) \; for \; R \leq p \leq p^{max} \\ &= \frac{1}{\theta} \left(\frac{1}{(P^w - p)} \right) \; for \; R \leq p \leq p^{max} \\ f(R) &= \frac{1}{\theta} \\ f(p^{\max}) &= \frac{1}{\theta}(\frac{P^w - (P^w(1 - e^{-\theta}) + e^{-\theta} R)}{P^w - R}) \\ &= \frac{e^{-\theta}}{\theta}. \end{aligned}$$

Now we are ready to do show that

$$Q_0 R + \sum_{k=1}^{\infty} Q_k [\int_R^{p_{\max}} pk[F(p)]^{k-1} f(p)dp] = P^w \left(1 - e^{-\theta}(1+\theta)\right) + Re^{-\theta}(1+\theta).$$

First we obtain the expected price when k traders show up:

$$\begin{aligned} E_k(p) &= \int_R^{p_{\max}} p g_k(p) dp \\ &= k \int_R^{p_{\max}} p f(p) \left[F(p)\right]^{k-1} dp \\ &= \frac{k}{\theta^k} \int_R^{p_{\max}} [\ln(\frac{P^w - R}{P^w - p})]^{k-1} \frac{p}{P^w - p} dp \text{ for } k \geq 1 \end{aligned} \tag{15}$$

Then we take the expectation over all possible k.

But first, we explain how $E_k(p)$ is obtained in detail. To that end, we start by solving for the indefinite integral, a key part of $E_k(p)$.

$$\int [\ln(\frac{P^w - R}{P^w - p})]^{k-1} \frac{p}{P^w - p} dp. \tag{16}$$

To do so we change variables. Let $x = \ln(\frac{P^w - R}{P^w - p})$.

$$\begin{aligned} e^x &= \frac{P^w - R}{P^w - p} \\ &\implies P^w - p = e^{-x}(P^w - R) \\ &\implies p = P^w - e^{-x}(P^w - R). \end{aligned} \tag{17}$$

This gives p in terms of x.To change variables we note

$$dp = e^{-x}(P^w - R)dx. \tag{18}$$

Substituting for p from (17) we get

$$\begin{aligned} \frac{p}{P^w - p} &= \frac{P^w - e^{-x}(P^w - R)}{e^{-x}(P^w - R)} \\ &= \frac{P^w}{e^{-x}(P^w - R)} - 1. \end{aligned} \tag{19}$$

Using equations (17),(18), and (19) we can rewrite the integral in eq (16) as

$\int x^{k-1}[e^{x}\frac{P^w}{(P^w-R)}-1]e^{-x}(P^w-R)dx = P^w\int x^{k-1}dx-(P^w-R)\int e^{-x}x^{k-1}dx$
$= P^w\frac{x^k}{k}-(P^w-R)\left[x^{k-1}e^{-x}(-1)-(k-1)\int(-1)e^{-x}x^{k-2}dx\right]$
$= P^w\frac{x^k}{k}+(P^w-R)e^{-x}(k-1)!\left[\frac{x^{k-1}}{(k-1)!}+\frac{x^{k-2}}{(k-2)!}+..+1\right]$
$= P^w\frac{x^k}{k}+(P^w-R)(k-1)!e^{-x}[\sum_{j=0}^{k-1}\frac{x^j}{j!}]$

Now backsubstitute x in terms of p to obtain (1) $P^w\frac{x^k}{k}$ and (2) $(P^w-R)(k-1)!e^{-x}[\sum_{j=0}^{k-1}\frac{x^j}{j!}]$ in terms of p to obtain the 16:

$$\int_R^{p_{\max}}[\ln(\frac{P^w-R}{P^w-p})]^{k-1}\frac{p}{P^w-p}dp = (1)+(2)$$

$$\begin{aligned}
(1) &= \frac{P^w}{k}[\ln(\frac{P^w-R}{P^w-p})]^k|_R^{p^{\max}} \\
&= \frac{P^w}{k}[\ln(\frac{P^w-R}{P^w-p^{\max}})]^k-\frac{P^w}{k}[\ln(\frac{P^w-R}{P^w-R})]^k \\
&= \frac{P^w}{k}[\ln(e^\theta)]^k-0 \\
&= \frac{P^w}{k}\theta^k
\end{aligned}$$

$$\begin{aligned}
(2) &= (P^w-R)(k-1)!\frac{P^w-p}{P^w-R}[\sum_{j=0}^{k-1}\frac{[\ln(\frac{P^w-R}{P^w-p})]^j}{j!}]|_R^{p_{\max}} \\
&= (k-1)!\{(P^w-R)e^{-\theta}[\sum_{j=0}^{k-1}\frac{[\ln(e^\theta)]^j}{j!}]-\underbrace{(P^w-R)[1-\sum_{j=0}^{k-1}\frac{[\ln(\frac{P^w-R}{P^w-R})]^j}{j!}]}_{(P^w-R)}\} \\
&= (k-1)!(P^w-R)\{e^{-\theta}[\sum_{j=0}^{k-1}\frac{\theta^j}{j!}]-1\} \\
&= (P^w-R)(k-1)!\{e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!}-1)\}
\end{aligned}$$

where we use the fact that $P^w-p^{\max}=e^{-\theta}(P^w-R)$.

Next we find $E_k(p)$ for $k > 1$ for a given θ.

$$\begin{aligned}
E_{k\geq 1}(p|\theta) &= \frac{k}{\theta^k}\int_R^{p_{\max}} \frac{p}{P^w - p}[\ln(\frac{P^w - R}{P^w - p})]^{k-1}dp \\
&= \frac{k}{\theta^k}\left[(1) + (2)\right] \\
&= \frac{k}{\theta^k}(P^w \frac{\theta^k}{k} + (P^w - R)(k-1)!\{e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!}) - 1\}) \\
&= P^w + (P^w - R)\frac{(k)!}{\theta^k}\{e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!} - 1\}
\end{aligned}$$

Hence the expected price conditional on at least one trader showing up is as follows:

$$\begin{aligned}
\sum_{k=1}^{\infty} Q_k E_k(p) &= \sum_{k=1}^{\infty}\frac{\theta^k}{k!}e^{-\theta}\left[P^w + (P^w - R)\frac{k!}{\theta^k}(e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!} - 1)\right] \\
&= \sum_{k=1}^{\infty}\frac{\theta^k}{k!}e^{-\theta}P^w + (P^w - R)e^{-\theta}\sum_{k=1}^{\infty}(e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!} - 1) \\
&= e^{-\theta}P^w(e^{\theta} - 1) + (P^w - R)e^{-\theta}\left[\sum_{k=1}^{\infty}(e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!} - 1)\right] \\
&= e^{-\theta}P^w(e^{\theta} - 1) + (P^w - R)e^{-\theta}\left[-\theta\right]
\end{aligned}$$

where we use the fact that [21]Finally, the first moment of price is

$$\begin{aligned}
E(p) &= Q_0 R + \sum_{k=1}^{\infty} Q_k E_k(p) \\
&= e^{-\theta} R + P^w e^{-\theta}(e^{\theta} - 1) + e^{-\theta}(P^w - R)(-\theta) \\
&= e^{-\theta} R + P^w - P^w e^{-\theta} - \theta e^{-\theta}(P^w - R) \\
&= -e^{-\theta}(P^w - R) + P^w - \theta e^{-\theta}(P^w - R) \\
&= P^w - e^{-\theta}(P^w - R)(1 + \theta).
\end{aligned}$$

■

[21] $\sum_{k=1}^{\infty}(e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!} - 1) = -\theta$. To see this consider the following:

$$\begin{aligned}
\sum_{k=1}^{\infty}(e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!} - 1) &= \sum_{k=1}^{\infty}(e^{-\theta}(\sum_{j=0}^{\infty}\frac{\theta^j}{j!} - \sum_{j=k}^{\infty}\frac{\theta^j}{j!}) - 1) \\
&= \sum_{k=1}^{\infty}(e^{-\theta}(e^{\theta} - \sum_{j=k}^{\infty}\frac{\theta^j}{j!}) - 1) \\
&= \sum_{k=1}^{\infty}((1 - e^{-\theta}\sum_{j=k}^{\infty}\frac{\theta^j}{j!}) - 1) \\
&= -e^{-\theta}\sum_{k=1}^{\infty}\sum_{j=k}^{\infty}\frac{\theta^j}{j!} \\
&= -e^{-\theta}\sum_{j=1}^{\infty}\sum_{k=1}^{j}\frac{\theta^j}{j!}
\end{aligned}$$

The above change in summations can be verified by writing out terms in each one and noting that the first term in the former corresponds to the last term in the latter. Thus

$$\begin{aligned}
\sum_{k=1}^{\infty}(e^{-\theta}\sum_{j=0}^{k-1}\frac{\theta^j}{j!} - 1) &= -e^{-\theta}\sum_{j=1}^{\infty}\frac{\theta^j}{j!}(\sum_{k=1}^{j} 1) \\
&= -e^{-\theta}\sum_{j=1}^{\infty}\frac{\theta^j}{(j-1)!} \\
&= -e^{-\theta}\theta\sum_{j=1}^{\infty}\frac{\theta^{j-1}}{(j-1)!} \\
&= -\theta
\end{aligned}$$

Proposition 5: In the short run t*he elasticity of the expected farmer proce in response to a change in the world price is less than unity for* $R > 0$, and equals unity when $R = 0$.
Proof.

$$\begin{aligned}
\left.\frac{\partial E(p)}{\partial P^w}\frac{P^w}{E(p)}\right|_{Short\ Run} &= \frac{P^w}{P^w - e^{-\theta}(P^w - R)(1+\theta)}\left[\left(1 - e^{-\theta}(1+\theta)\right)\right] \\
&= \frac{P^w\left(1 - e^{-\theta}(1+\theta)\right)}{P^w - (P^w e^{-\theta}(1+\theta) - Re^{-\theta}(1+\theta))} \\
&= \frac{P^w\left(1 - e^{-\theta}(1+\theta)\right)}{P^w(1 - e^{-\theta}(1+\theta)) + Re^{-\theta}(1+\theta)} \\
&= \frac{1}{1 + \frac{Re^{-\theta}(1+\theta)}{P^w\left(1 - e^{-\theta}(1+\theta)\right)}} < 1
\end{aligned}$$

■

Proposition 6 In the long run t*he elasticity of the expected price farmers obtain in response to a change in the world price is more than unity when* R is low, and less than unity when R is high. More precisely, given κ and α, there exists a unique value of R, R^*, such that:

$$\begin{aligned}
\text{for } R &\in [0, R^*),\ \varepsilon_{PW} > 1 \\
\text{for } R &= R^*\ \varepsilon_{PW} = 1 \\
\text{for } R &\in (R^*, \overline{R}]\ \varepsilon_{PW} < 1
\end{aligned}$$

This cutoff R^* is increasing in both $\frac{\alpha}{\kappa}$ and P^w.
Proof. First , the long run price elasticity s given by:

$$\begin{aligned}
\left.\frac{dE(p)}{dP^w}\frac{P^w}{E(p)}\right|_{Long\ Run} &= (1 - e^{-\theta})\frac{P^w}{E(p)} \\
&= \frac{P^w(1 - e^{-\theta})}{P^w(1 - e^{-\theta}(1+\theta)) + Re^{-\theta}(1+\theta).}
\end{aligned}$$

[22]After some algebraic manipulations one can see that the price elasticity is

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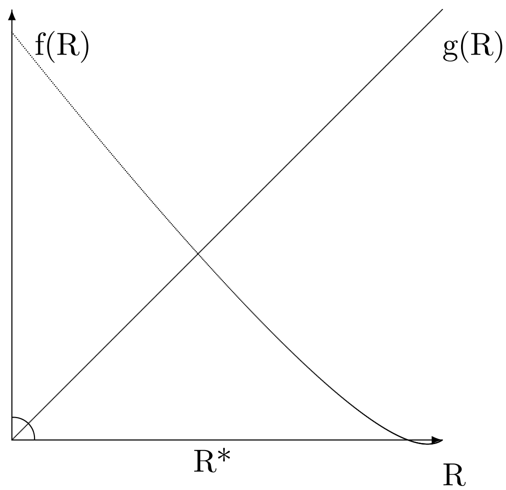
[22]

$$\begin{aligned}
\frac{\partial E(p)}{\partial P^w} + \frac{\partial E(p)}{\partial \theta}\frac{\partial \theta}{\partial P^w} &= 1 - e^{-\theta}(1+\theta) - (P^w - R)\left(-e^{-\theta}(1+\theta) + e^{-\theta}\right)\frac{\partial \theta}{\partial P^w} \\
&= 1 - e^{-\theta}(1+\theta) - (P^w - R)\left(-e^{-\theta}(1+\theta) + e^{-\theta}\right)\frac{1}{(P^w - R)} \\
&= 1 - e^{-\theta}
\end{aligned}$$

Figure 6: Picture for the intutition of the proof



equal to greater than/equal to/less than unity when

$$(P^w - R)e^{-\theta}\theta \gtreqless Re^{-\theta}.$$

Rewritten in terms of the model primitives this gives

$$(P^w - R)\ln(\frac{\alpha}{\kappa}(P^w - R)) \gtreqless R$$

Denote the RHS of the inequality by $f(R)$ and the LHS $g(R)$. It is easy to see that

$$f'(R) = -\ln(\frac{\alpha}{\kappa}(P^w - R)) + \frac{-1}{(P^w - R)}(P^w - R) = -\ln(\frac{\alpha}{\kappa}(P^w - R)) - 1 < 0$$

Thus, $f(R)$ is a decreasing function of R and $g(R)$ is an increasing function of R. Elasticity is unity at their intersection, i.e., for $R = R^*$, above unity for $R < R^*$, and below unity for $R > R^*$.

As $\frac{\alpha}{\kappa}$ and P^w rise, the curve $f(R)$ shifts up raising R^*. ■

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