



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# **Challenges to Farm Produce Marketing: A Model of Bargaining between Farmers and Middlemen under Risk**

**Ram Ranjan**

We present a model of bargaining between farmers and middlemen in which long-term risk considerations by farmers constrain their ability to engage in hard bargaining. In order to avoid the risk of middlemen exiting their region in the future due to hard bargaining, farmers settle for lower prices for their produce. The risks of prolonged drought-induced decline in produce quality and future oversupply of the perishable agricultural commodity also result in lower price outcomes under bargaining. If farmers join a collective that enhances their bargaining power, they tend to be better off when the group is homogeneous.

*Key words:* agricultural produce marketing, asymmetric bargaining power, drought risks, farm gate price, horticultural price bargaining, market information systems, middlemen in agriculture

## **Introduction**

Horticultural production and marketing hold promise for augmenting the livelihoods of farmers, particularly those in developing regions. For instance, horticulture contributes up to 30% of agricultural GDP in India, despite using less than 10% of cropped area (Government of India, Ministry of Finance, Department of Economic Affairs, Economic Division, 2017). In Senegal, an increase in horticultural exports has enhanced the bargaining power of women in the household, given their role in the crop production process. This has further positively impacted the human capital of females within the household by improving school enrollment rates (Maertens and Verhofstadt, 2012).

Despite its potential as an option for enhancing livelihoods, horticultural farmers tend to lose out to middlemen, who extract the most profits from this trade. Farmers often negotiate prices for their produce from a weaker bargaining position, which stems from a lack of outside options (in terms of buyers), risk aversion, lack of patience, high transportation costs, and the perishable nature of the crops (Oczkowski, 2004). Some examples of risks that weaken farmers' bargaining power include the risk of middlemen abandoning the region in favor of more profitable areas, the risk of not being able to sell their produce due to its perishable nature, the risk of future prolonged droughts, and the risk of oversupply of farm produce. Devising mechanisms that help farmers overcome the challenge of farm produce marketing in the presence of such risks is a significant policy concern. A better understanding of decision-making constraints under risk is crucial for designing policy mechanisms and effectively targeting intervention programs.

In addition to these risks, farmers face significant institutional and infrastructure-related hurdles in their pursuit of attractive prices for perishable farm produce. Transportation and storage infrastructures are often lacking or costly in poorer regions, preventing farmers from taking their

---

Ram Ranjan is a senior lecturer in the Department of Environmental Sciences, Faculty of Science and Engineering, at Macquarie University, Australia.

The author would like to thank two anonymous reviewers for their helpful comments.

Review coordinated by Tian Xia.

produce to distant markets that may offer better prices. Even if a farmer does manage to get produce directly to the central markets (locally known as “*mandi*” in India), there is no guarantee of receiving a better price because these markets are dominated by large traders and auction-based sales of agricultural commodities, which could be difficult for individual farmers to compete in. *Mandi* markets also have a substantial middleman presence. Middlemen’s profits depend on procuring farm produce at the lowest possible prices. In India, middlemen “*cuts*” comprise up to 75% of the agricultural prices, which also contributes to inflation (Bhardwaj and Singh, 2014). In the absence of infrastructural development, this middleman-based crop-marketing system has become highly resilient to policy reform. The state of Bihar, India, recently revoked the Agricultural Produce Marketing Act, which used to favor the middlemen, but most middlemen continue to do business, as farmers have no other options.

While in some cases it may be desirable to eliminate middlemen to reduce costs and enhance farmers’ welfare, farmers still tend to rely heavily on middlemen in remote regions where the infrastructure necessary for direct trade between farmers and consumers is missing. In fact, this reliance on middlemen—which is partly orchestrated by traders involved in the supply chain to make it difficult for individual farmers to sell directly—further aggravates the weak bargaining position of smaller and remote farmers.

A number of measures—including contract farming and collective farming (or marketing)—have been introduced in various parts of the world to alleviate the uncertainties faced by small farmers in finding the right buyers and prices (da Silva and Rankin, 2013). In the recent past, direct interventions, albeit confined to experimental scales, have been made to improve the bargaining power of farmers by making them better aware of current trading prices in the central markets. These intervention programs are popularly referred to as information and communication technology services (ICTs) and marketing information systems (MIS). ICT-based services can be provided in various ways, including through call centers, Google’s *Farmer’s Friend*, distance learning (e.g., Moodle), community radios, financial services, market information (e.g., Reuters Market Light), marketing links (e.g., E-choupals), community agents, etc. (Buxton et al., 2014). ICT services have been tried outside of agriculture as well: fishermen have benefited from access to ICTs, which allow them to find timely buyers for their catch, reducing fish perishability (Jensen, 2007).

A number of studies have reported positive benefits from ICT interventions. In northern Ghana, farmers were provided with market information services, and prices received for their maize and groundnut crops increased by 10% and 7%, respectively (Courtois and Subervie, 2015). Haile and Kalkuhl (2016) noted that access to ICT information also helped Ethiopian farmers avoid price expectation errors and hence helped them efficiently allocate their crop production decisions. In another study, farmers obtained 15% higher farm gate prices when they took advantage of crop-price information (from main marketing centers) made available through radios in various districts of Uganda (Svensson and Yanagizawa, 2009). A randomized control trial based study in the central highlands of Peru reported an increase in the price of perishable crops received by farmers who had access to price information through a mobile SMS service (Nakasone, 2013).

Empirical evidence seems to suggest that ICT-based services and MIS have helped mitigate the bargaining power of middlemen vis-à-vis farmers. Svensson and Yanagizawa (2009) found that farmers with better access to commodity price information (through use of radios) were able to bargain for better prices for their produce in Uganda. ICT services and MIS have also been found to lead to bargaining spillover effects on control groups (groups of farmers who did not receive ICT information) in Ghana by altering traders’ behaviors (Hildebrandt et al., 2015). Aker and Fafchamps (2015) found that the prevalence of mobile phones in rural areas in Niger led to a 6% reduction in spatial producer price dispersion for semi-perishable commodities. These effects were stronger in remote areas.

Despite the emergence of encouraging evidence from the farmers’ perspective, the long-term implications of better access to market information are not fully clear. Mitra et al. (2017) used an asymmetric bargaining model to analyze a market-price-information-based intervention among

potato farmers in West Bengal, India, and concluded that access to better price information does not necessarily benefit farmers in their negotiations with middlemen because they have few outside options. However, Courtois and Subervie (2015) found that Ghanaian farmers received about 10% higher prices for maize and groundnuts when they had access to MIS. They used a two-period bargaining model (where both periods occur on the same day) and accounted for discounting of utility in the second period by the buyer (seller) due to the risk of not being able to find another seller (buyer).

Several challenges to exploiting the full potential of market information systems remain. When farmers are not provided with relevant direct market prices, it may become costly for them to search for the same information. Under such circumstances, farmers may not be able to use market information to their advantage. In one such study conducted in rural Ethiopia, Tadesse and Bahiigwa (2015) found that despite having mobile phones, farmers did not search for market prices, given the substantial costs involved in searching for that information and then finding buyers who would agree to such prices. Another study conducted in Uganda found that farmers who were not wealthy, lived far from district centers and trading capitals, and were not members of any farmer associations were less likely to access ICT-based information (Kiiza and Pederson, 2012). However, the same study also reported that those farmers who accessed ICT-based information were also more likely to adopt improved seed varieties. In a randomized controlled trial of 1,000 farmers in about 100 villages in Maharashtra, Fafchamps (2012) tested for the effect of ICT information provided by Reuters Market Light. Subscribers were sent monthly SMSs for a nominal price of USD 1.50/month. However, the authors did not find that receiving this information had any significant benefit on the treated group of farmers, leading them to conclude that only a small number of clients benefited and the uptake rate was largely sluggish.

Svensson and Yanagizawa (2009, 2010) explicitly modeled how much output a farmer offered for sale to traders as a result of access to MIS and showed that having such access reduced the risk of market failure. Mitchell (2017) conducted a framed experiment on Gujarat farmers, assuming that middlemen differed in terms of the level of guilt they felt while driving down prices for farmers' produce, and concluded that middlemen who did not feel morally wrong while offering lower prices to farmers were less likely to offer low prices when farmers were informed about market prices and had the option to switch to another middlemen.

Given that the rate of introduction of such ICT- and MIS-based programs has increased substantially in the past few years, it is still too early to come to a conclusion about their effectiveness and success rates. However, other important factors come into play. One crucial factor that has been overlooked thus far is farmers' heavy dependence on middlemen in remote areas due to a lack of outside alternatives. This makes them risk averse to the fact that traders could leave in the future, abandoning a particular farmer or a village, forcing farmers to cut production or sell their produce at a lower price at local village markets. The risk of middlemen exiting could accumulate over time. Moreover, this risk could be endogenous. That is, farmers who bargain hard (when armed with ICT-based price knowledge), run the risk of losing the middlemen with whom they have traded in the past.

Another risk is that of a future loss in produce quality and quantity due to a prolonged drought event. Climate change is expected to significantly impact horticultural crop productivity and profitability through reduced rainfall and increased temperature and pest incidences, etc. Heat waves, in particular, can be devastating for fruit crops. For example, the 2009 Australian heat wave led to a 50% decline in table grape exports (State Government of Victoria, Department of Primary Industries, 2011). When farmers expect future water shortages, they may anticipate a reduced bargaining position vis-à-vis traders given reduced crop quality. Further, in developing economies, where technology-induced growth in crop productivity is still far from plateauing, higher prices received by farmers can lead to a significant long-term oversupply (Ash and Lin, 1987). For instance, interventions in the state of Madhya Pradesh, India, to improve access to wholesale price information for soybeans led to a significant increase in area under cultivation (Goyal, 2010). It is possible that

such future oversupply risk considerations could influence how farmers bargain today. We take up this crucial issue of farmers' dynamic and long-term risk considerations in influencing bargaining strategy and profitability.

While the literature related to bargaining between farmers and middlemen thus far has dealt only with static risks, the crucial question of how access to market-price information may influence bargaining strategies of farmers who also face long-term risks of middlemen exiting the region or of price decline has not yet been analyzed. This question is especially relevant in remote regions that are frequented by fewer middlemen and where farmers are more vulnerable due to lack of outside options. In order to address this question, we develop a dynamic model of long-term optimal bargaining strategy for farmers where the risk of middleman exit is endogenous. While our model builds on the existing literature (particularly Courtois and Subervie, 2015), it differs in a number of ways. First, we specifically model how long-term considerations of managing middleman-exit-related risks influence farmers' current and future bargaining strategies. Second, we derive bargaining outcomes in the presence of asymmetric bargaining power and multiple risks faced by the farmers. Finally, we extend the model to consider the implications of farmers joining a collective on their bargaining outcomes.

### Model

Consider that farmers produce a perishable crop, which they can sell either to a middleman at price  $p_x$  or in the local market at a lower price,  $p_l$ .<sup>1</sup> They can also take their produce to the mandi, where they receive a much higher price,  $p_m$  ( $p_m > p_x > p_l$ ), but must also consider the costs of transportation and time. The time cost materializes through a continuous depreciation in produce quality, until it is sold. There is also the risk of being unable to find a buyer at the mandi and having to bring it back and sell it at the local market. We assume that there is no uncertainty involved in selling produce in the local market, but the price received will be much lower due to quality depreciation. Let  $p_d$  represent the expected price resulting from the decision to take produce to the mandi.

Farmers become aware of the mandi price through freely available ICT- and MIS-based services, but they do not know how many traders are involved further down the supply chain in marketing the produce from the farm gate to the mandi. Therefore, there is a range of prices that a farmer can consider the middleman receiving when the middleman sells the produce to someone further down the supply chain. That is, while dealing with the middlemen, the farmers are negotiating over the price range  $[p_l, p_m]$ . ICTs and MIS make the farmer aware of the mandi price,  $p_m$ , but knowing this price is just one aspect of the bargaining process. Given that numerous middlemen could be involved further down the supply chain, knowing the mandi price may not help the farmer greatly in their bargaining outcome. When the farmer is bargaining with the middleman, they have in mind a certain price  $p_y (< p_m)$ , which they assume to be the actual price received by the middleman for selling the produce further down the supply chain. If the actual price at which trade eventually occurs between the middleman and the farmer is  $p_x$ , then the surplus for the middleman is given by

$$(1) \quad (p_y - p_x)$$

and the surplus of the farmer is given by

$$(2) \quad (p_x - p_l).$$

Maximizing the product of their surpluses yields:

$$(3) \quad p_x = \frac{p_l + p_y}{2}.$$

<sup>1</sup> In this paper, we use "mandi" to represent a distant central market that attracts agricultural produce for marketing from a large number of farming regions, while "local market" refers to a nearby market, which in most cases would be the village market.

In reality, the middleman would hold unequal bargaining power, especially in a remote area. In order to incorporate asymmetry in bargaining power, we follow the Nash bargaining model under asymmetry (Binmore, Rubinstein, and Wolinsky, 1986). Assuming that the bargaining power of the farmer is given by the parameter  $\theta_i$ , the product of their surpluses is<sup>2</sup>

$$(4) \quad (p_x - p_l)^\theta \cdot (p_y - p_x)^{1-\theta},$$

where  $0 < \theta < 1$  (Binmore, Rubinstein, and Wolinsky, 1986). Maximizing equation (4) yields the actual traded price,  $p_x$ , as a weighted function of  $p_y$  and  $p_l$ :

$$(5) \quad p_x = p_l(1 - \theta) + p_y\theta.$$

While the farmer could, in principle, take the produce to the market in the case of a negotiation breakdown, we assume here that the middleman takes the local market price,  $p_l$ , as the farmer's reservation price and not the expected price,  $p_d$ , that the farmer would receive if they took their produce to the mandi. The farmer's reservation price could also be the price received from another middleman, but we ignore this complication here, assuming that they are dealing with a representative middleman and they are in a remote region that has only a few middlemen.

Negotiation over sharing the surplus is not costless, as it could have future implications. Here we incorporate the risk of the middleman leaving the particular village (or the farmer) and going to other regions where they could make higher profits if the farmer engages in hard bargaining. This risk could be determined by a number of factors, including the proximity of the village to the mandi, the quality of the farmer's produce, other options available to the middlemen, etc. The farther the village is from the mandi, the costlier and more logistically difficult it would become for the farmer to take produce there. In that case, the risk of middlemen leaving a particular village (or the farmer) due to hard bargaining could be real and could influence the farmer's bargaining power and the negotiation strategy.

Next, let us derive the expected price received by the farmer in the scenario where the middleman exits the village for good, and the farmer is thereafter forced to consider whether to take produce to the mandi or sell it in the local market. Assume that the quality of the produce declines as a function of the time it sits with the farmer. The price,  $p(t)$ , received for the produce (as a function of the mandi price,  $p_m$ ), when accounting for depreciation, is given by

$$(6) \quad p(t) = p_m \cdot \left[ 1 - \frac{t^{\beta_0}}{t^{\beta_0} + \beta_1} \right],$$

where  $t$  is the duration for which the produce remains unsold with the farmer and  $\beta_0$  and  $\beta_1$  are parameters that cause the quality of produce to decline steeply beyond a certain point. Most horticultural produce, such as tomatoes, has a short shelf life, which is further reduced the longer it takes to put it in cold storage (Arah et al., 2015). Parameter  $\beta_1$  in equation (6) can also be interpreted as the time by which the price of the produce would be reduced to half of the mandi price,  $p_m$ , when  $\beta_0 = 1$ .

Assume that the time required for the farmer to take produce to the mandi is given by  $t_0$ . There is a possibility that the farmer may not find a suitable buyer (or price) at the mandi. If the farmer is unable to sell their produce in the mandi, the quality of their produce by the time they sell it back to the local market would have declined further and would result in price

$$(7) \quad p(t) = p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right].$$

<sup>2</sup> While we are not aware of any estimates of bargaining power for farmers vis-à-vis middlemen, Draganska, Klapper, and Villas-Boas (2010) estimated bargaining power for coffee retailers in the German market. The lowest value of bargaining power,  $\theta$ , among retailers while bargaining with manufactures was 0.3.

Apart from depreciation cost associated with taking the produce to the mandi, the farmer could also face transportation costs, but we do not explicitly add transportation cost into the model. While the mandi price is higher (even when accounting for transportation costs), we assume that the expected price,  $p_d$ , from taking produce to the mandi could be lower than the price,  $p_x$ , that they could get from the middleman.

The utility,  $U(t)$ , of the farmer is a logarithmic function of price received:

$$(8) \quad U(t) = \log(p(t)),$$

where  $p(t)$  is the price received for their produce in any given year. The expected price received from taking produce to the mandi is derived as

$$(9) \quad E[p_d(t)] = \left[ (1-z) \cdot p_m \cdot \left[ 1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1} \right] + z \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right] \right],$$

where  $z$  is the exogenous probability of not finding a buyer in the mandi and  $E$  is the expectation operator. This probability could also be endogenous depending upon a farmer's networks, marketing abilities, and product quality (which is partly affected by the time it takes to arrive at the market). A farmer will take produce to the mandi if the expected price from doing so is higher than the price in the local market:

$$(10) \quad \left[ (1-z) \cdot p_m \cdot \left[ 1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1} \right] + z \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right] \right] > p_l.$$

Solving equation (10) would yield the maximum distance (in terms of time taken to travel) beyond which the farmer will find it optimal to sell the produce at a lower price,  $p_l$ , in the local market instead of taking it to the mandi. This maximum time can be solved as

$$(11) \quad t_0 = \frac{1}{p_l} \cdot \left( 2^{-1-\beta_0} \left( \frac{-\beta_1 \cdot p_l - 2^{\beta_0} \beta_1 \cdot p_l + 2^{\beta_0} \cdot \beta_1 \cdot p_m + \sqrt{\beta_1^2 \cdot \left( (p_l \cdot (1 + 2^{\beta_0} - z) + 2^{\beta_0} \cdot p_m \cdot (-1 + z))^2 + 2^{2+\beta_0} p_l \cdot (p_l - p_m) \cdot (-1 + z) \right)}}{+ \beta_1 \cdot p_l \cdot z - 2^{\beta_0} \cdot \beta_1 \cdot p_m \cdot z} \right) \right)^{\frac{1}{\beta_0}}.$$

The utility from deciding to take the produce to the mandi will be given as

$$(12) \quad \begin{aligned} U(t) &= \log(E[p_d(t)]) \\ &= \log \left[ (1-z) \cdot p_m \cdot \left[ 1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1} \right] + z \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right] \right]. \end{aligned}$$

Likewise, the utility from selling the produce in the local market will be given as

$$(13) \quad U(t) = \log(p_l).$$

A farmer's decision problem in the post-middleman-exit scenario would be to pick the option (between equations 12 and 13) that yields the higher utility. The post-exit optimization problem for the farmer would be to maximize the post-exit value function,  $V_{post\_exit}$ :

$$(14) \quad V_{post\_exit} = \int_0^{\infty} \max \left( \log(p_l), \log \left[ (1-z) \cdot p_m \cdot \left[ 1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1} \right] + z \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right] \right] \right) dt.$$

In equation (14), the maximum of the local price,  $p_l$ , and the expected price,  $p_d$ , determines the utility received in each time period. A farmer's decision problem in the pre-middleman exit scenario would be to optimize the post-exit value function as well as the pre-exit value function ( $V_{pre\_exit}$ ). That is, when the middleman is present, the farmer bargains with them to maximize expected long-term profits.

As discussed earlier, hard bargaining could drive away the middleman to areas that do not access mandi prices through ICTs or MSI or are willing to negotiate lower prices. The hazard rate of the middleman exiting the village is a function of the difference between the mandi price,  $p_m$ , and the price,  $p_y$ , that the farmer takes as actual price received by the middleman from selling the produce further down the supply chain. It would be reasonable to assume that the higher this difference, the lower the risk of the middleman exiting. That is, if the farmer believes (based upon ICT data) there to be no more middlemen involved further down the chain and the middleman actually receives the mandi price from selling it, then they would choose  $p_y = p_m$ . This would reduce the bargaining surplus of the middleman, resulting in a higher price  $p_x$  extracted by the farmer (as derived through equation 4) and would greatly increase the chances of the middleman leaving.

The risk of the middleman exiting evolves over time and is cumulative, with an uncertain exit time, in the sense that the middleman is more likely to exit if there has been a long history of the farmer bargaining hard. Specifically, the hazard rate,  $\dot{\lambda}(t)$ , of exit is modeled as

$$(15) \quad \dot{\lambda}(t) = \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))},$$

where  $\lambda_0$  is the maximum per period hazard rate of exit possible and will occur when  $p_y = p_m$ . The hazard function declines exponentially with an increase in the difference between  $p_y$  and  $p_m$ . The higher this difference, the lower the price,  $p_x$ , that the middleman pays to the farmer (equation 4) and hence the lower the chance of exit. Parameter  $\lambda_1$  adjusts the effect of the difference between  $p_y$  and  $p_m$  on the exogenous component of the hazard rate.

The pre-exit optimization problem for the farmer is to maximize the below function with respect to  $p_y$ :

$$(16) \quad \int_0^{\infty} \left[ \left( \log(p_l(1 - \theta) + p_y(t) \cdot \theta) \cdot \exp\left(-\int_0^t \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} dt\right) \cdot \exp(-r \cdot t) + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot \exp(-r \cdot t) \right) \cdot \int_t^{\infty} \max \left( \log(p_l), \log \left[ (1 - z) \cdot p_m \cdot \left[ 1 - \frac{t_0 \beta_0}{t_0 \beta_0 + \beta_1} \right] + z \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0) \beta_0}{(2 \cdot t_0) \beta_0 + \beta_1} \right] \right] \right) dt \right) dt,$$

where  $r$  is the discount rate. Equation (16) maximizes the expected value of outcomes in the pre- and post-exit scenarios (see Reed and Heras, 1992, for a formulation of optimization problems using exponential hazard functions). The term

$$\log(p_l(1 - \theta) + p_y(t) \cdot \theta) \cdot \exp\left(-\int_0^t \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} dt\right) \cdot \exp(-r \cdot t)$$

is the utility derived by the farmer in each time period until the middleman has exited. The second term,

$$\lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot \exp(-r \cdot t) \cdot \int_t^{\infty} \max \left( \log(p_l), \log \left[ (1 - z) \cdot p_m \cdot \left[ 1 - \frac{t_0 \beta_0}{t_0 \beta_0 + \beta_1} \right] + z \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0) \beta_0}{(2 \cdot t_0) \beta_0 + \beta_1} \right] \right] \right) dt,$$



is the sum of future expected utility derived if the middleman were to exit at time  $t$ . The current value Hamiltonian ( $CVH$ ) of the above problem is given as

$$\begin{aligned}
 (17) \quad & \log(p_l(1 - \theta) + p_y(t) \cdot \theta) \cdot \exp\left(-\int_0^t \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} dt\right) \\
 & + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \int_t^\infty \max\left(\log(p_l), \log\left[(1 - z) \cdot p_m \cdot \left[1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1}\right]\right.\right. \\
 & \left.\left.+ z \cdot p_l \cdot \left[1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1}\right]\right]\right) \cdot \exp\left(\int_0^t -\lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} dt\right) \\
 & + \mu_1 \cdot \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))},
 \end{aligned}$$

where  $\mu_1$  is the shadow price of the cumulative risk of the middleman exiting, and  $\lambda(t)$  is the cumulative hazard. Using notations  $p_x(t)$  for  $p_l(1 - \theta) + p_y(t) \cdot \theta$ ,  $V_{post\_exit}$  for the post-exit value function, and  $\lambda(t)$  for the cumulative hazard of exit, the  $CVH$  can be rewritten as

$$\begin{aligned}
 (18) \quad & \log(p_x(t)) \cdot \exp(-\lambda(t)) \\
 & + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot V_{post\_exit}(z, t_0, p_m) \\
 & + \mu_1 \cdot \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))}.
 \end{aligned}$$

The first-order condition with respect to  $p_y(t)$  gives

$$\begin{aligned}
 (19) \quad & \frac{\theta}{p_l(1 - \theta) + p_y(t) \cdot \theta} \cdot \exp(-\lambda(t)) \\
 & + \lambda_0 \cdot \lambda_1 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot V_{post\_exit}(z, t_0, p_m) \\
 & + \mu_1 \cdot \lambda_1 \cdot \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} = 0,
 \end{aligned}$$

which can be rewritten to find the produce-selling price:

$$(20) \quad p_x(t) = - \frac{\theta \cdot \exp(-\lambda(t))}{\left( \frac{\mu_1 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \lambda_0 \cdot \lambda_1}{+ \lambda_0 \cdot \lambda_1 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot V_{post\_exit}(z, t_0, p_m)} \right)}.$$

Note that the shadow price of the cumulative risk of exit would be negative, as an increase in exit risk would lead to lower profits for the farmer. From equation (20) we can see that the higher the bargaining power of the farmer (given by  $\theta$ ), the higher the price they receive. A higher mandi price would lower the hazard rate of exit,  $e^{-\lambda_1 \cdot (p_m - p_y(t))}$ , which through its effect on the denominator in equation (20) would result in a higher price received by the farmer. However, a high shadow price of stock of cumulative hazard in the denominator would have the opposite effect on the price received by the farmer.

The arbitrage condition with respect to the shadow price of the cumulative risk gives

$$\begin{aligned}
 (21) \quad \dot{\mu}_1 &= - \frac{\partial CVH}{\partial \lambda(t)} + r \cdot \mu_1 \\
 &= \log(p_x(t)) \cdot \exp(-\lambda(t)) \\
 &\quad + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot V_{post\_exit}(z, t_0, p_m) + r \cdot \mu_1.
 \end{aligned}$$

When  $\lambda_1$  is sufficiently high and  $p_y$  sufficiently low, the hazard rate could theoretically be reduced to 0, which would result in the shadow price of cumulative risk stabilizing. When  $\dot{\mu}_1 = 0$  in a steady

state, we can write

$$(22) \quad -\frac{\left(\log(p_x(t)) \cdot \exp(-\lambda(t)) + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot V_{post\_exit}(z, t_0, p_m)\right)}{r} = \mu_1,$$

which suggests that the shadow price of the cumulative hazard is the sum of forgone utilities in the pre- and post-exit scenarios when the risk of the middleman exiting is marginally increased. Substituting from the first-order condition, we can further derive a relation between bargaining price outcome and the bargaining power:

$$(23) \quad p_x(t) = -\frac{\theta \cdot \exp(-\lambda(t))}{\left( \left( -\frac{(\log(p_x(t)) \cdot \exp(-\lambda(t)) + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot V_{post\_exit}(z, t_0, p_m))}{r} \right) \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \lambda_0 \cdot \lambda_1 \right) + \lambda_0 \cdot \lambda_1 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda(t)) \cdot V_{post\_exit}(z, t_0, p_m) \right)}.$$

An analytical solution to the above is not possible; however, later on we will perform a numerical exercise to derive further intuition. Next we consider the possibility of the risk of a prolonged drought event as well as the risk of a decline in the future price of the commodity affecting the farmer's bargaining outcome.

### Bargaining under Multiple Risks and within a Collective

In this section we consider bargaining outcomes when the farmer faces multiple risks. Apart from the middleman exit risk, additional threats could exist either in the form of a future weather event, resulting in prolonged water scarcity, or a long-term price decline resulting from oversupply of the commodity. Let us first consider the risk of a weather event.

#### Prolonged Drought Event

Once the drought arrives, the farmer suffers a permanent reduction in the quality of their agricultural produce due to persistent water scarcity. While the quantity could also be reduced with prolonged water scarcity, it is not relevant to our model except that a lower quantity produced could increase the risk of middleman exit. Owing to a reduction in the quality, the local price for produce goes down by some fraction, say  $\gamma$ . The mandi price they would receive for the produce also gets marked down by the same proportion. Given this risk, the farmer needs to decide the price at which to sell the produce to the middleman when there are two risks present. The optimization problem can be written as

$$(24) \quad \int_0^{\infty} \left( \begin{aligned} &\log(p_x(t)) \cdot \exp(-\lambda_{exit}) \cdot \exp(-\lambda_{drought}) \\ &+ \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda_{exit}) \cdot V_{post\_exit\_pre\_drought} \\ &+ \lambda_{drought} \cdot \exp(-\lambda_{drought}) \cdot V_{post\_drought\_pre\_exit} \end{aligned} \right) \cdot \exp(-r \cdot t) dt,$$

where  $\lambda_{exit}(t)$  refers to the cumulative hazard of exit and  $\lambda_{drought}(t)$  refers to the cumulative hazard of a future drought event. The post-drought-pre-exit value function  $V_{post\_drought\_pre\_exit}$  is defined as

$$(25) \quad \int_t^{\infty} \left( \log(p_x(t)) \cdot \exp(-\lambda_{exit}(t)) + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda_{exit}(t)) \cdot V_{post\_exit}(z, t_0, p_m) \right) \cdot \exp(-r \cdot t) dt,$$

with the bargaining price outcome  $p_x(t)$  given as

$$(26) \quad \gamma \cdot p_l \cdot (1 - \theta) + p_y \cdot \theta,$$

and the hazard rate of drought  $\dot{\lambda}_{drought}$  is defined as

$$(27) \quad \dot{\lambda}_{drought} = \lambda_d,$$

where  $\lambda_d$  is some constant. The post-exit-pre-drought value function  $V_{post\_exit\_pre\_drought}$  is defined as

$$(28) \quad V_{post\_exit\_pre\_drought} = \int_t^{\infty} \left( \max \left( \log(\gamma \cdot p_l), \log \left[ (1-z) \cdot \gamma \cdot p_m \cdot \left[ 1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1} \right] \right] + z \cdot \gamma \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right] \right) \right) \cdot \exp(-r \cdot t) dt.$$

### Long-Term Price Decline Due to Oversupply

Farmers face another potential risk: price decline due to oversupply. If farmers get a better price from middlemen, it would induce long-term changes in cropping patterns and lead to an increase in the quantity produced with time. Such changes to cropping patterns are costly to alter due to optimal crop rotation plans. Here we briefly consider the implication of a future risk of long-term price decline due to oversupply. Let us assume that the risk of oversupply-related price decline is given as a hazard function,  $\dot{\lambda}_p$ , which is defined as

$$(29) \quad \dot{\lambda}_p = \lambda_{p0} \cdot e^{(p_x(t) - p_l)}.$$

The risk of arrival of this oversupply scenario accumulates over time and is endogenous. The higher the difference between the price received by the farmer from the middleman and the local market price for the same commodity, the higher the hazard of changes to cropping patterns in the future, leading to an oversupply. In order to keep the analysis tractable, assume that the price decline (in the oversupply scenario) is the same as that modeled in the drought-risk scenario presented in the previous section. The farmer faces effectively the same optimization problem as before but now with an endogenous risk of the price event compared to the exogenous risk of drought as modeled previously.

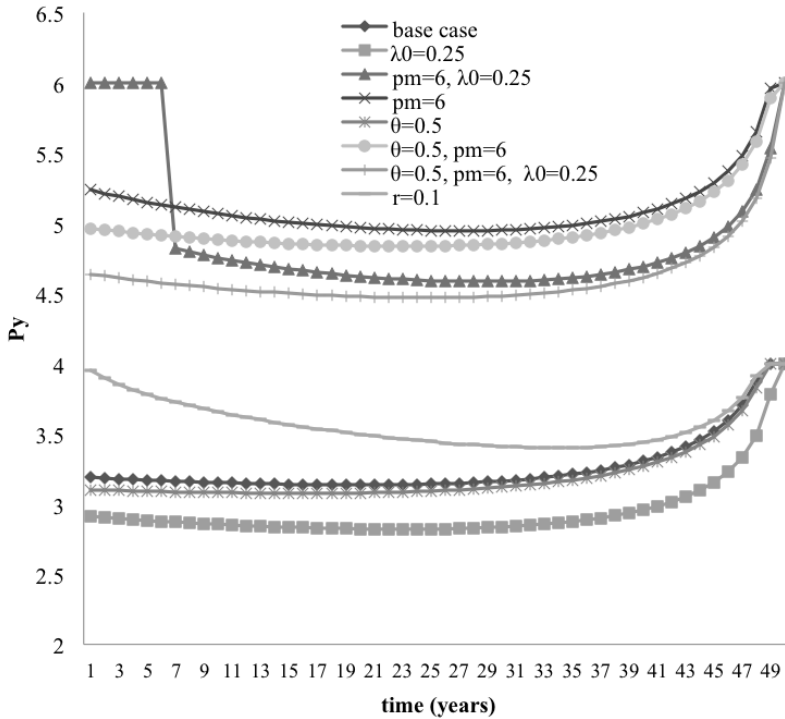
Finally, let us also briefly consider the possibility that farmers could come together in a collective to negotiate better price outcomes, while the exit risk remains as previously modeled.

### Bargaining within a Collective

Consider the case of farmers coming together to form a collective that offers the benefit of giving them equal bargaining power vis-à-vis the middleman. In reality, a collective comprises heterogeneous members, therefore, the bargaining outcome may not be conducive to every member of the collective, especially when they differ in their capabilities to take produce to the market. Consider a collective with only two farmers with different  $z$  values, where  $z$  is the probability of a farmer not being able to sell their produce in the mandi. The collective manager maximizes the joint utility of the two farmers as

$$(30) \quad \int_0^{\infty} \left[ 2 \cdot \log(p_l(1-\theta) + p_y\theta) \cdot \exp\left(\int_0^t -\lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} dt\right) \cdot \exp(-r \cdot t) + \exp(-r \cdot t) \cdot \left( \frac{\lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda_{exit}(t)) \cdot V(z_1)_{post\_exit\_farmer\_1}}{\lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda_{exit}(t)) \cdot V(z_2)_{post\_exit\_farmer\_2}} \right) \right] dt.$$

Note that the realized price from the collective bargaining will be the same for both the farmers. The two farmers face the same local market price. The collective manager, while optimizing their joint welfare, merely considers how the combined sum of their post-exit value functions,



**Figure 1. Optimal  $p_y$  Values for Various Scenarios Involving the Risk of Middleman Exit**

$$\left( \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda_{exit}(t)) \cdot V(z_1)_{post\_exit\_farmer\_1} + \lambda_0 \cdot e^{-\lambda_1 \cdot (p_m - p_y(t))} \cdot \exp(-\lambda_{exit}(t)) \cdot V(z_2)_{post\_exit\_farmer\_2} \right),$$

is differentially impacted in the post-exit scenario. A farmer would find it profitable to join the collective only if the higher bargaining strength of the collective made it possible to achieve a higher price and still keep the risk of the middleman exiting lower than if they were to operate outside of the collective. A number of factors (along with the ability to market produce on their own)—such as social norms, social pressure, etc.—can influence their decision to join the collective.

In order to derive some insights from the above models, we take recourse to a numerical example. We first start by optimizing the individual farmer's expected utility in the presence of middleman exit risk. We derive insights by varying several key parameters, such as the mandi price, price in the local market, rate of depreciation of farm produce, and the risk of not finding a buyer in the mandi. Next, we consider the presence of multiple risks and compare results with the single risk scenarios. Finally, we solve the collective model.

### Numerical Example

Parameter values selected for the numerical exercise are provided in Appendix A. The optimization model is run using the general algebraic modeling systems (GAMS) software using a discount rate of 5% and a time horizon of fifty years. In the base case, the initial level of optimal  $p_y$  is 3.2 units (see figure 1), which gradually increases to the mandi price level of 4 units toward the end of the time horizon. When the maximum possible hazard rate of exit ( $\lambda_0$ ) is 0.25, optimal  $p_y$  is lower at 2.9 and even declines in the early years to keep the risk of middleman exit minimal (see figure 2). An equal bargaining power ( $\theta = 0.5$  compared to the base case value of 0.35) also has a similar

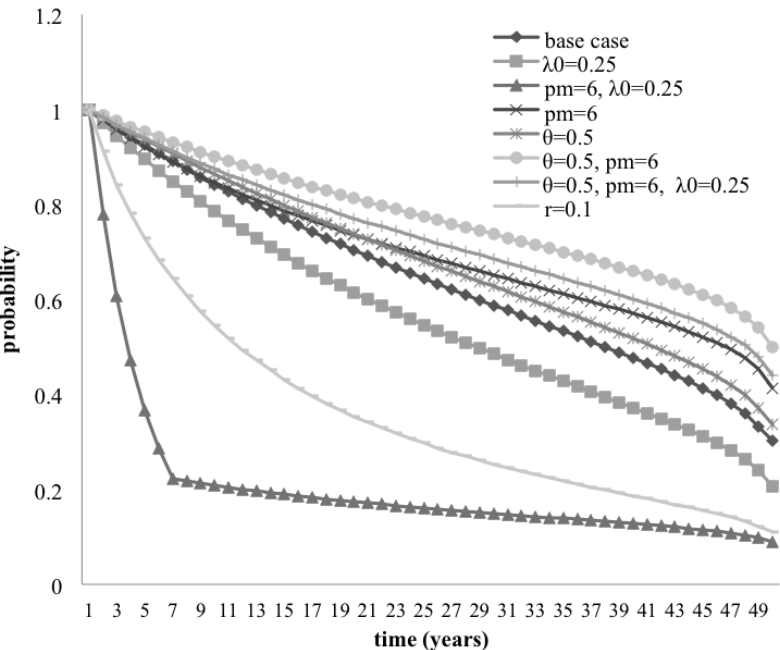


Figure 2. Probability of the Middleman Not Exiting until Time  $t$  for Various Scenarios

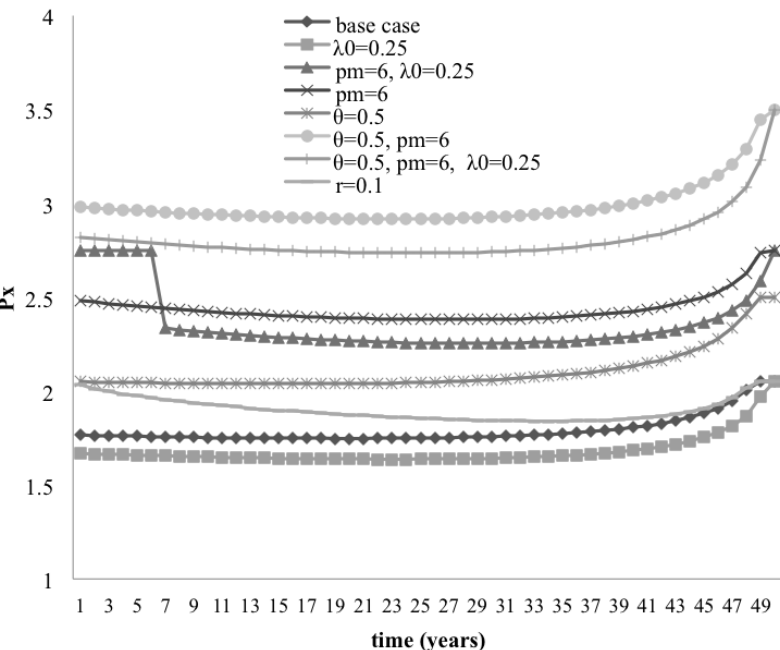
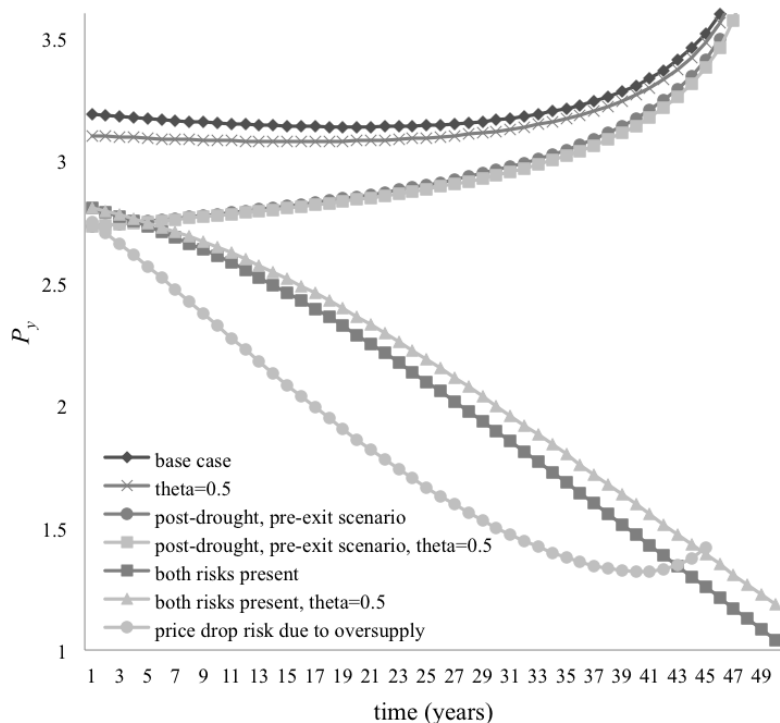


Figure 3. Realized Bargaining Price  $p_x$  for Various Scenarios Involving the Risk of Middleman Exiting

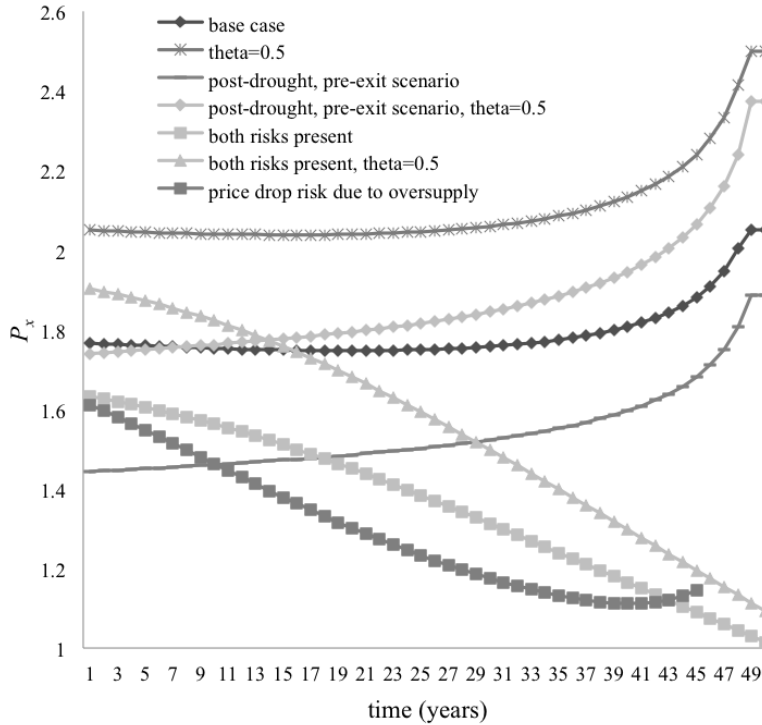


**Figure 4. Optimal  $p_y$  When Both Risks Are Present**

effect on lowering  $p_y$ , as the farmer can derive a higher  $p_x$  (which is the realized price through bargaining, as depicted in figure 3) even while picking a lower  $p_y$ , which helps keep the risk of exit low. Therefore, when we consider the effect of equal bargaining power combined with a higher maximum possible hazard rate of 0.25, the value for  $p_y$  reduces further down to its lowest levels of all scenarios considered here.

Next, we consider the effect of a higher mandi price,  $p_m$ , on  $p_x$ ,  $p_y$ , and the risk of exit. When the mandi price is higher at 6, the farmer is able to pick a higher  $p_y$  of 5.2, which declines marginally below 5 in the short run but increases to the mandi price of 6 in the long run (figure 1). The farmer is also able to keep the risk of middleman exiting lower (see figure 2) than in the base case (where the mandi price is 4). Equal bargaining power at a higher mandi price (scenario “ $\theta = 0.5$ ,  $p_m = 6$ ”) leads to an even better outcome, where a lower  $p_y$  (compared to the previous case, where  $p_m = 6$ ) is picked and yet the risk of middleman exiting is kept lower. Another scenario, where  $\lambda_0 = 0.25$  and  $p_m = 6$ , leads to a discounting effect. In this scenario, the farmer is better off bargaining hard in the first few years and letting the risk of exit increase significantly rather than trying to manage the high risks by settling for a lower price. This is an interesting outcome that may not be observed through static models that do not incorporate long-run risk considerations.

Further consider adding an equal bargaining power to this scenario. That is,  $p_m = 6$ ,  $\lambda_0 = 0.25$ , and  $\theta = 0.5$ . Now the farmer picks one of the lowest  $p_y$  of all the scenarios in which  $p_m = 6$ , therefore keeping the risk of exit very low, despite the fact that  $\lambda_0 = 0.25$ , which implies a high risk of exit. When the farmer can bargain equally, they can get a higher realized price without increasing the risk of middlemen exit. This mitigates the tendency to maximize profits in the short term. Finally, in a scenario (“ $r = 0.1$ ”) in which the discount rate is higher at 10% (signifying impatience), the farmer’s ask price,  $p_y$ , is higher, resulting in higher  $p_x$  than in the base case. However, the probability of the middleman exiting under this scenario is one of the highest (see figure 2).



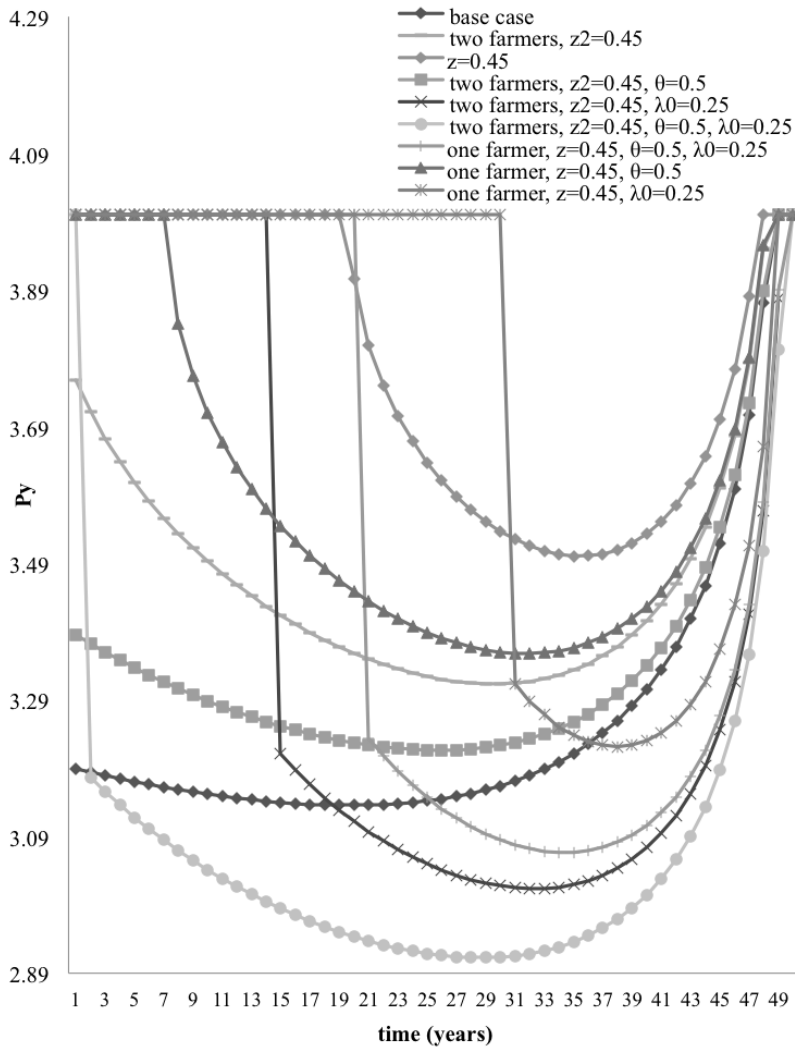
**Figure 5. Realized  $p_x$  for the Case When Both Types of Risks Are Present**

The presence of two risks makes the farmer more circumspect in their bargaining strategy. They settle for a lower  $p_y$  (figure 4), and the price received for their produce,  $p_x$ , declines over time (figure 5). When the farmer has equal bargaining power,  $p_y$  is higher, though it still falls over time. However, when one of the risks (that of prolonged droughts occurring) has already materialized, the farmer picks a higher  $p_y$  than when both risks are present (figure 4). The presence of equal bargaining power does not reduce  $p_y$  by much, yet the realized price,  $p_x$ , is much higher (see figure 5). Also compare these cases to the base case, where the farmer faces only the risk of middleman exit. In the base case, the bargaining outcome is much higher than in the cases where both risks are present or when drought has already occurred but the risk of middleman exit is still present. Finally, when there is a risk of long-term price decline due to oversupply, the farmer has an incentive to reduce  $p_y$ , and the resulting  $p_x$  is one of the lowest of all scenarios.

Next, consider the possibility that farmers come together to form a collective. We also introduce heterogeneity amongst farmers to see how their bargaining outcomes are determined when the risk of middleman exiting is present and farmers differ in their ability to market produce in the mandi. We assume that there are two (or two types of) farmers, with the second farmer having a better probability of selling their produce in the mandi, in the event that the middleman leaves. Specifically, farmer 2 has a post-exit expected price function of

$$(31) \quad E[p_d] = \left[ (1 - z_2) \cdot p_m \cdot \left[ 1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1} \right] + z_2 \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right] \right],$$

where  $z_2 = 0.45$ . For farmer 1,  $z_1 = 0.65$  unless otherwise specified. This means that farmer 2 would be willing to take more risks (of middleman exit) by bargaining harder, as they have a better chance of selling their produce in the mandi, thereby giving them higher expected returns. However, in a collective, they may have to sacrifice this extra profit if other members face a lower chance due to lower selling abilities.

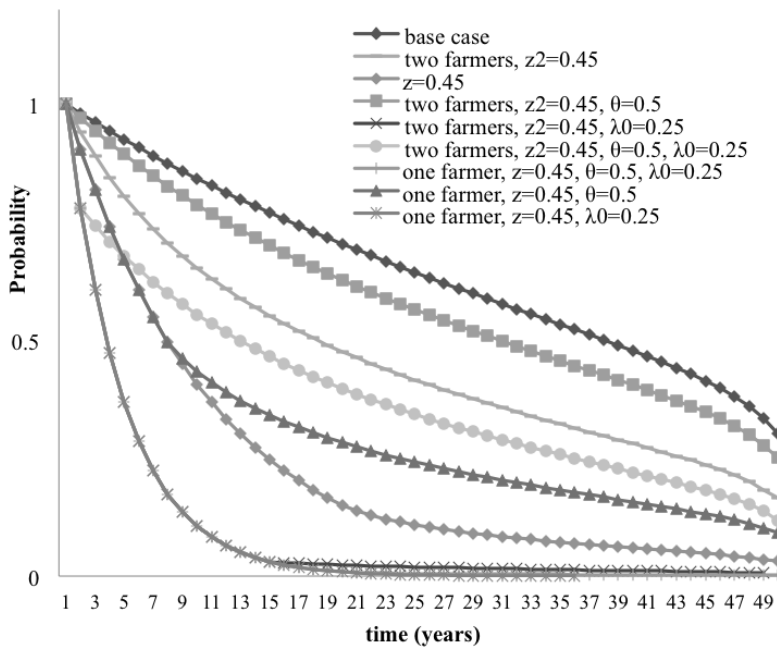


**Figure 6. Optimal  $p_y$  for Various Scenarios Involving the Collective Bargaining Problem**

In figure 6, consider first a scenario where the risk of the middleman exiting is higher than in the base case (“two farmers,  $z_2 = 0.45$ ,  $\lambda_0 = 0.25$ ”) and compare this to the case where there is only one farmer facing the same higher risk (“one farmer,  $z = 0.45$ ,  $\lambda_0 = 0.25$ ”). In the case of one farmer, the farmer goes for the maximum  $p_y$  of 4 until year 34; only after that do they lower it to roughly 3.35. This is consistent with our intuition that when faced with a high risk of exit but a better chance of being able to sell produce in the mandi, the farmer would bargain harder. However, when there is a collective, with one farmer facing a lower chance of selling produce in the mandi (“two farmers,  $z_2 = 0.45$ ,  $\lambda_0 = 0.25$ ”), the collective returns to the lower price much earlier, in year 15. How does this impact the risk of middleman exit? Figure 7 compares the survival probabilities for the two scenarios. In the case of the collective, the probability of the middleman exiting is much lower due to less intensive bargaining.

Consider another scenario in which the collective has an equal bargaining power (“two farmers,  $z_2 = 0.45$ ,  $\theta = 0.5$ ”). Compare this to the case of a single farmer outside the collective facing equal bargaining power (“single farmer,  $z = 0.45$ ,  $\theta = 0.5$ ”). Again, we see a similar pattern: the collective settles for a much lower  $p_y$  of 3.35 right from the beginning, whereas the single farmer goes for the





**Figure 7. Probability of the Middleman Not Exiting until Time  $t$  for Various Scenarios**

maximum  $p_y$  of 4 and drops it to lower levels only after year 8. Also, when considering another scenario in which the collective has equal bargaining power and faces higher risks of the middleman exiting (“two farmers,  $\theta = 0.5$ ,  $\lambda_0 = 0.25$ ,  $z_2 = 0.45$ ”), they settle for the lowest  $p_y$  of all scenarios. However, a single farmer facing higher risks but equal bargaining power goes for the maximum  $p_y$  value of 4 and drops it after year 20. The implications for probability of exit are in equally striking contrast for these scenarios. In the case of the collective, the risk of middleman exit is much lower than in the single farmer case (which leads to the highest exit risks).

### Conclusion

This paper addresses the crucial question of how farmers’ bargaining strategies are influenced when considering the long-term implications of their bargaining on the risk of the middleman exiting their region. We derive bargaining outcomes in the presence of multiple risks faced by farmers. These include the risk of prolonged droughts and the risk of a long-term decline in commodity prices due to oversupply of the farm produce. Finally, we compare individual bargaining outcomes to those achieved by a collective. A few key insights emerge from the modeling exercise.

First, when farmers face the risk of middlemen leaving their regions due to hard bargaining, long-term management of such risks requires a more circumspect bargaining approach on their part. Specifically, when farmers have lower bargaining power (for instance, due to their remote location), the optimal bargaining strategy involves settling for a lower price in order to mitigate future exit risks. Where the risk of the middleman exiting is higher, a higher reduction in price is warranted. However, when farmers have equal bargaining power, they are able to extract a higher price for their produce and still keep the risk of exit lower. When the risk of exit is high and a farmer has equal bargaining power, it leads to a discounting effect, and the farmer extracts maximum profits through hard bargaining. Even though this strategy exacerbates the risk of the middleman exiting in the future, the higher expected profits until the exit are enough to compensate for future losses.

When we introduce the additional risk of a prolonged drought, which adversely affects produce quality and price, such considerations further force farmers to lower their ask price. When farmers

expect to make much less from their produce in the wake of a drought event, it becomes optimal to reduce the risk of middlemen exiting, as the expected profits from the alternative option of taking the produce to the mandi or to the local markets also decline. Therefore, the optimal strategy is to settle for a much lower price in the presence of the two risks. However, when prolonged droughts have already set in (and the risk of exit has yet to materialize), the bargaining outcome is much better than in the case when none of the risks have materialized yet. When better bargaining outcomes in the current period could lead to changes in future production patterns that could cause an oversupply of the commodity and create a risk of prolonged decline in future prices, farmers are forced to lower their ask price in order to mitigate these risks.

Finally, when farmers have an option of joining a collective and improving their bargaining power, group homogeneity turns out to be crucial for achieving better profits. Even when participating within a heterogeneous collective, farmers may be better off remaining in the collective compared to undertaking individual negotiations outside of the collective, as long as the collective offers them better bargaining power. Through the numerical example, we find that price outcomes are weighed down by the presence of members who tend to be worse off in the case of the middleman exiting. A manager optimizing the joint welfare of the collective members would lower the bargaining price to reduce the risk of the middleman exiting. This adversely affects the profits of those who can do better than the rest in the case of the middlemen exiting.

A number of policy implications can be derived from the model insights. First, the bargaining power of the middleman increases as they travel farther away from the mandi. Therefore, the farther the area from the main market, the higher the risk of middlemen exploiting farmers. Introducing infrastructure that makes it cheaper to keep goods in cold storage would increase the shelf life of their produce and indirectly improve their bargaining outcome by improving their reservation price. It is important to keep in mind that farmers may not actually need to take produce to the market. Just the possibility of exercising that option should mitigate the higher bargaining power effect enjoyed by middlemen in remote areas.

Second, when the risk of prolonged drought threatens to lower the quality of the produce, government intervention would be needed to help farmers use water more efficiently and minimize quality losses. That is, intervention would be required at multiple levels. The first set of interventions should help farmers maintain the quality of their produce and the second set should facilitate farmers taking produce to better-paying markets. In the absence of such interventions, remote farmers would suffer most when facing multiple farming risks.

Third, the introduction of ICTs and MIS, which have generated cheap and timely market price information for the farmers, should increase their incentive to bargain hard. However, whether or not such information can improve the bargaining power of farmers is a question of significant policy concern. As the findings in this paper indicate, several risks could lower farmers' bargaining outcomes, even when they may have full information. In this context, encouraging the formation of collectives may be a good idea, as they help increase farmers' bargaining power. However, for such collectives to work, farmers who can do well both in and outside of the collective must be encouraged to participate because their participation would enhance the bargaining power of the collective. Collective members could be charged a small user fee to compensate these better-off farmers, which would help sustain the collectives for longer.

*[Received March 2017; final revision received September 2017.]*

## References

- Aker, J. C., and M. Fafchamps. "Mobile Phone Coverage and Producer Markets: Evidence from West Africa." *World Bank Economic Review* 29(2015):262–292. doi: 10.1093/wber/lhu006.
- Arah, I. K., H. Amaglo, E. K. Kumah, and H. Ofori. "Preharvest and Postharvest Factors Affecting the Quality and Shelf Life of Harvested Tomatoes: A Mini Review." *International Journal of Agronomy* 2015(2015):1–6. doi: 10.1155/2015/478041.
- Ash, M., and W. Lin. "Regional Crop Yield Response for U.S. Grains." Agricultural Economic Report AER-577, U.S. Department of Agriculture, Economic Research Service, Washington, DC, 1987. Available online at <https://naldc.nal.usda.gov/download/CAT10853172/>.
- Bhardwaj, M., and R. K. Singh. "India Targets Middlemen in Food Chain as Inflation Bites." *Reuters* (2014). Available online at <https://in.reuters.com/article/india-inflation-farming/india-targets-middlemen-in-food-chain-as-inflation-bites-idINKBN0FG0H020140711>.
- Binmore, K., A. Rubinstein, and A. Wolinsky. "The Nash Bargaining Solution in Economic Modelling." *RAND Journal of Economics* 17(1986):176–188. doi: 10.2307/2555382.
- Buxton, A., D. Seville, J. Shriver, P. Robbins, R. Best, and S. Ferris. "Linking Smallholder Farmers to Markets and the Implications for Extension and Advisory Services | Agrilinks." MEAS Discussion Paper Series 4, USAID Modernizing Extension and Advisory Services (MEAS), Washington, DC, 2014. Available online at <https://agrilinks.org/library/linking-smallholder-farmers-markets-and-implications-extension-and-advisory-services>.
- Courtois, P., and J. Subervie. "Farmer Bargaining Power and Market Information Services." *American Journal of Agricultural Economics* 97(2015):953–977. doi: 10.1093/ajae/aau051.
- da Silva, C. A., and M. Rankin, eds. *Contract Farming for Inclusive Market Access*. Rome: Food and Agriculture Organization of the United Nations, 2013. Available online at <http://www.fao.org/3/a-i3526e.pdf>.
- Draganska, M., D. Klapper, and S. B. Villas-Boas. "A Larger Slice or a Larger Pie? An Empirical Investigation of Bargaining Power in the Distribution Channel." *Marketing Science* 29(2010):57–74. doi: 10.1287/mksc.1080.0472.
- Fafchamps, M. M. "Impact of SMS-Based Agricultural Information on Indian Farmers." *World Bank Economic Review* 26(2012):383–414. doi: 10.1093/wber/lhr056.
- Government of India, Ministry of Finance, Department of Economic Affairs, Economic Division. *Economic Survey 2016–2017*. New Delhi, India: Department of Economic Affairs, Economic Division, 2017. Available online at <http://indiabudget.nic.in/es2016-17/echapter.pdf>.
- Goyal, A. "Information, Direct Access to Farmers, and Rural Market Performance in Central India." *American Economic Journal: Applied Economics* 2(2010):22–45. doi: 10.1257/app.2.3.22.
- Haile, M. G., and M. Kalkuhl. "Access to Information and Price Expectation Errors of Smallholder Farmers: Theory and Empirics." In M. Kalkuhl, J. von Braun, and M. Torero, eds., *Food Price Volatility and Its Implications for Food Security and Policy*, Switzerland: SpringerOpen, 2016, 513–541.
- Hildebrandt, N., Y. Nyarko, G. Romagnoli, and E. Soldani. "Price Information, Inter-Village Networks, and Bargaining Spillovers: Experimental Evidence from Ghana." 2015. Available online at [http://www.disei.unifi.it/upload/sub/pubblicazioni/seminari/pdf-seminari/emilia\\_soldani.pdf](http://www.disei.unifi.it/upload/sub/pubblicazioni/seminari/pdf-seminari/emilia_soldani.pdf).
- Jensen, R. "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics* 122(2007):879–924. doi: 10.1162/qjec.122.3.879.
- Kiiza, B., and G. Pederson. "ICT-Based Market Information and Adoption of Agricultural Seed Technologies: Insights from Uganda." *Telecommunications Policy* 36(2012):253–259.

- Maertens, M., and E. Verhofstadt. "Horticultural Exports, Female Wage Employment and Primary School Enrolment: Theory and Evidence from a Natural Quasi-Experiment in Senegal." Paper presented at the conference of the International Association of Agricultural Economists, August 18–24, Foz do Iguaçu, Brazil, 2012. Available online at <http://purl.umn.edu/126856>.
- Mitchell, T. "Is Knowledge Power? Information and Switching Costs in Agricultural Markets." *American Journal of Agricultural Economics* forthcoming(2017). doi: 10.1093/ajae/aax035.
- Mitra, S., D. Mookherjee, M. Torero, and S. Visaria. "Asymmetric Information and Middleman Margins: An Experiment with Indian Potato Farmers." *Review of Economics and Statistics* forthcoming(2017). doi: 10.1162/REST\_a\_00699.
- Nakasone, E. "The Role of Price Information in Agricultural Markets: Experimental Evidence from Rural Peru." Paper presented at the joint annual meeting of the AAEA and CAES, August 4–6, Washington, DC, 2013. Available online at <http://www.ifpri.org/publication/role-price-information-agricultural-markets>.
- Oczkowski, E. "Agricultural Bargaining Co-operatives and Associations: Australian Issues and Prospects." *Third Sector Review* 10(2004):67–84.
- Reed, W. J., and H. E. Heras. "The Conservation and Exploitation of Vulnerable Resources." *Bulletin of Mathematical Biology* 54(1992):185–207. doi: 10.1016/S0092-8240(05)80022-9.
- State Government of Victoria, Department of Primary Industries. *Economic Impact of Climate Change on the Victorian Horticulture Industry*. Victoria, Australia: Department of Primary Industries, 2011. Available online at <http://www.piccc.org.au/sites/piccc/files/fileattachments/pamstrange-economics-horticulture.pdf>.
- Svensson, J., and D. Yanagizawa. "Getting Prices Right: The Impact of the Market Information Service in Uganda." *Journal of the European Economic Association* 7(2009):435–445. doi: 10.1162/JEEA.2009.7.2-3.435.
- . "Tuning in the Market Signal: The Impact of Market Price Information on Agricultural Outcomes." Working Paper, 2010. Available online at <https://pdfs.semanticscholar.org/3686/5acf217cd62aa95f5a261c9703826222d188.pdf>.
- Tadesse, G., and G. Bahigwa. "Mobile Phones and Farmers' Marketing Decisions in Ethiopia." *World Development* 68(2015):296–307. doi: 10.1016/j.worlddev.2014.12.010.

### Appendix A: Selection of Parameter Values

The quality of produce depreciation (equation 6) is parameterized as

$$(A1) \quad p(t) = p_m \cdot \left[ 1 - \frac{t^{\beta_0}}{t^{\beta_0} + \beta_1} \right], \{\beta_1 = 1, \beta_0 = 2\}.$$

The expected price from taking the produce to the market (equation 9) is parameterized as

$$(A2) \quad E[p_d] = \left[ (1 - z) \cdot p_m \cdot \left[ 1 - \frac{t_0^{\beta_0}}{t_0^{\beta_0} + \beta_1} \right] + z \cdot p_l \cdot \left[ 1 - \frac{(2 \cdot t_0)^{\beta_0}}{(2 \cdot t_0)^{\beta_0} + \beta_1} \right] \right],$$

$$\{z = 0.65, p_m = 4, p_l = 1\}.$$

The base case bargaining power is given by

$$(A3) \quad \theta = 0.35.$$

The hazard rate of middleman exiting is parameterized as

$$(A4) \quad \dot{\lambda}(t) = 0.1 \cdot e^{-2 \cdot (p_m - p_y(t))}.$$

The hazard rate of a prolonged drought scenario is given by

$$(A5) \quad \dot{\lambda}_{drought} = \lambda_d = 0.1.$$

The reduction in prices in the drought scenario is assumed at 25%, given by parameter

$$(A6) \quad \gamma = 0.75.$$

The hazard rate of farm produce oversupply is given as

$$(A7) \quad \dot{\lambda}_p = 0.1 \cdot e^{(p_x - p_l)}.$$