Understanding Value Chain Structure and Functionality: The Domestic Onion Value Chain in Senegal

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Abstract

As food systems in developing countries transition from serving hyper-localized populations to serving consumers in urban centers nationally and abroad, both more and less complex value chain pathways often exist simultaneously. These pathways, which we define as unique sequences of actor types that transfer goods from producers to final consumers, may differ widely in their participants and functionalities. Hence policies aimed at upgrading "value chains" in general may miss important interactions and heterogeneity between pathways. In this paper, we suggest a framework for characterizing value chains as systems of unique pathways, which could be used for prioritization of value chain interventions. Specifically, we apply this framework to study the onion value chain in Senegal, characterizing the differences in inclusiveness, flexibility, quality recognition, and competitiveness between pathways.

1 Introduction

In recent years, researchers and policymakers have increasingly focused on the role that agricultural transformation strategies will likely play in sustaining economic growth in the developing world, and particularly in sub-Saharan Africa [Gollin et al., 2002, Jayne et al., 2019]. Part of these strategies is shifting from a paradigm where low-productivity producers mostly consume their own production and sell it in hyperlocal markets, to one where agricultural production sustains a growing population of domestic urban consumers, and is perhaps even exported to foreign markets. Naturally, the value chain, which De Brauw et al. [2021] define as, "the range of goods and services necessary for an agricultural product to move from the farm to the final customer or consumer" has become an object of interest. Yet, as opposed to a singular process describing how a given good moves from a producer to a consumer, value chains in modernizing economies can perhaps be best thought of ecosystem of various such processes, that vary in terms of their participants,

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practices, and overall efficiency. For example, in many countries, smallholder farmers and large producers grow the same commodity, but use different methods to transfer the produced goods to final consumers.

While policymakers may want to implement programs that support value chain development as part of their agricultural transformation strategies, the diversity of value chain activities may make this task less straightforward. For one, value chain "development" could be linked to multiple objectives that could suggest conflicting policy prescriptions. The value chain policy that causes the largest reduction in poverty among its actors, for instance, may not be the same as the policy that increases food supply the most or improves output quality the most. Second, even if the objective is explicitly to improve the welfare of a specific actor type (such as a smallholder producer), a more nuanced understanding of how that actor interacts within the value chain and what problems it may face will be needed to generate the optimal policy. Finally, the way that actors interact within the value chain may not be easily changed, in that a policy that seek to affect the interaction between two actors may lead these actors to look out other trading partners. For instance a quality certification system at local markets that makes it harder for traders to pay local aggregators/collectors a low price for a high quality product, could drive traders to instead buy directly from producers at farm-gate, rather than pay a high price to local collectors at the market.

In this paper, we propose a basic framework to categorize the diverse activities within a given value chain, which can help policymakers design well-informed value chain interventions that meet their policy objectives. Specifically, our framework describes a value chain as an ecosystem of pathways (sometimes also referred to as sub-chains). Each pathway is comprised of a unique sequence of actors. We define an "actor" as a type of value chain participant that serves a specific role in the process of transacting the good, starting at the producer and ending at the final consumer. Notably, this includes intermediaries such as traders and wholesalers, but not other stakeholders (like policymakers or financial institutions) who interact with the value chain indirectly. By looking at the characteristics of actors participating in different pathways, as well as differences in the sales volume transacted in each pathway, policymakers can get a sense of the pathways in which interventions might best align with policy objectives. By looking at differences in functionality between pathways, policymakers may get a sense of the types of interventions that could be most suitable within a given pathway. Finally, understanding the flexibility with which actors can move between pathways may help policymakers to anticipate how intervention within one pathway may affect activity in another pathway.

Additionally, we outline a simple empirical approach that allows us to answer these questions. The observation underlying this approach is that in many value chains, pathways can be uniquely identified by a 3-actor sequence. Hence simply identifying a value chain participant's actor type, as well the types of actors from which he sources and to which he sells, can place the participant within a specific pathway. When this is the case, stacked surveys of a representative sample of each type of actors allow us to estimate the flow of volume within each pathway. Notably, this does not require identifying or tracking the specific individuals with whom each respondent transacts, which is often difficult in practice. Empirically, our data collection framework consists of 1) key informant interviews to identify relevant actors and pathways, 2) stacked surveys of actors by type, and 3) observations of transactions among value chain actors. While only the stacked surveys (and key informant interviews) are needed to map out the structure and volume flows as described above, the transaction observations allow additional analysis of the functionality of different pathways. For instance, transaction data can be used to estimate whether there is a price premium paid for higher quality goods.

To demonstrate the use of this framework and empirical approach, we study the domestic onion value

chain in Senegal. Notably, in Senegal, domestic production and marketing of onions is fairly concentrated within 2 main regions (the Senegal River Valley and the Niayes) and a few key urban market centers (Dakar, Thiès, Touba, Kaolack, and Saint-Louis). This allows us to target our surveys to a few key geographical areas/markets, and capture behavior that we believe is representative of the overall value chain activity. Through our key informant interviews, we identified 5 actor types to survey: producers, rural coaxers (small aggregators/consignment agents that operate in local markets), banabanas (traders who buy onions in rural areas and then transport and sell them in urban markets), urban coaxers (aggregators/consignment agents that operate in urban market centers), and wholesalers (who buy onions either to sell to final consumers or retailers). Different pathways arise given that, for example, producers can either sell through a rural coaxer, sell directly to a banabana at farmgate or at a local market, or sell directly to an end-user/wholesaler at an urban market. Through a limited "proof-of-concept" data collection exercise in winter and spring of 2021, we surveyed 648 producers, 45 rural coaxers, 114 banabanas, 25 urban coaxers, and 27 wholesalers. We collected observations on over 250 transactions (though some of these are reported during the actor survey rather than observed directly in our data collection). We employ a weighting scheme based on the geographical distribution of onion producers and on national production statistics, to make the survey-collected data representative of domestic production.

Our analysis yields some key policy insights about the structure and functionality of the domestic onion value chain in Senegal. First, we find that policymakers likely face trade-offs when choosing between value chain interventions that would most decrease poverty among smallholders, and those that would have the largest food system impacts. Despite the common conception that value chains in developing countries are characterized by long pathways with many intermediaries, most of the domestic production is transacted through relatively short, simple pathways. However, smallholders are much less likely to participate in these simpler chains; a producer's choice of downstream link is closely related to his total production volume. Second, we note key similarities and differences in functionality between chains. We find that both producers and banabanas receive a price premium for higher quality onions, regardless of the pathway in which they participate. However, we see suggestive evidence that producers who participate in longer chains that include rural coaxers may be subject to anti-competitive behavior. 75% of producers and 58% of rural coaxers claim that some rural coaxers cheat farmers by reporting back a lower sale price than was actually received. However, we find little evidence of anti-competitive behavior between rural coaxers and banabanas; indeed rural coaxers report that prices go up when demand is high (as proxied by more banabanas being present in the market), as well as when supply is low (as proxied by less rural coaxers being present in the market). Finally, we see clear evidence of flexibility in the value chain structure, which should encourage careful consideration of how intervention in one pathway may cause actors to move between pathways. Aside from producers, most actors report activity in more than one pathway within the same season. Moreover, actors clearly choose to participate in different pathways based on heterogeneity in spatial and temporal factors. For instance, we see that producers in the Niayes are more likely than producers in the Senegal River Valley to sell directly to banabanas at farm-gate (rather than going through a rural coaxer). This is likely attributable to differences in proximity to urban markets and in market infrastructure. We also see banabanas in both regions shifting from buying straight from producers at farm-gate early in the season to transacting with rural coaxers later in the season, likely due to temporal supply fluctuations. This exercise helps validate our framework and empirical approach to describing value chain activity, and demonstrates how it could be useful for the purpose of policy prioritization.

The rest of the paper proceeds as follows. Section 2 provides background on relevant literature and

highlights our contribution. Section 3 provides additional information on the onion value chain in Senegal as well as the data collection process. Section 4 presents the results of our empirical exercise, and Section 5 concludes.

2 Literature and Contribution

2.1 Theory and Characterization of Value Chains

While much of the progress in understanding the role of agri-food value chains in developing countries has come from empirical work in recent decades [Bellemare et al., 2022], seminal theoretical frameworks from the industrial organization literature, though designed to describe market activity in developed countries, have played a guiding role in our conceptualization of value chains in emerging markets. For instance, many studies of value chains in developing countries, and especially in sub-Saharan Africa, have produced diagrams to describe value chain activity that are in part based on the models suggested in Porter [1985]. Such models attempt to characterize the position of value chain actors and flow of goods and materials between actors (See Nkuba et al. [2016], Kleih et al. [2019], Otekunrin and Sawicka [2019], Katjiuongua et al. [2018] for some recent examples). (NEED A BIT MORE TO EXPLAIN WHAT THESE MODELS/REPRESENTATIONS ARE) These models can be quite useful to understand basic value chain structure (and indeed we include one in this paper), yet given the complexity of value chains in developing countries, the presentation of such models can vary greatly by study, especially in terms of which stakeholders are included. Other classic industrial organization paradigms like the "Structure-Conduct-Performance" (SCP) [Bain, 1959] have also been used to characterize value chain functionality. (See for example Amentae et al. [2017], Ali et al. [2022], Figueiredo Junior et al. [2016].) The idea underlying the SCP framework is that the structure of a market determines firms' conduct, which in turn determines market performance. While we also adopt the general idea that market structure affects conduct and performance, the SCP framework does not necessarily provide ways to understand why market and firm structures can vary greatly within a given industry and over time.

The more recent theoretical literature describing value chain development in emerging markets has taken steps to characterize changes in value chain structure over time [Barrett et al., 2022]. Specifically, agri-food value chains are classified as belonging in one of three stages: traditional, transitional, and modern. Traditional value chains are generally short, and hyperlocal, with most intermediation (if any) going through local, rural brokers. Transitional value chains are more complex, feature more third-party logistics provision from small/medium enterprises, and cover a larger geographical span, as goods start to be transported from rural to urban areas. Modern value chains cover perhaps an even larger geographical span (sometimes extending to international export, and involve the participation of larger, technologically advanced firms who can simplify the value chain structure through vertical integration. These stages well-describe how value chains have generally evolved from highly localized to modern global value chains in various countries (such as in China and in Latin America). However, what is still missing in this framework is the inherent multiplicity in pathways that can exist throughout the transition. Within the same value chain, we often simultaneously observe transaction structures that are best characterized by traditional, transitional, and modern value chain characterizations. While in the long-run it's likely that more efficient value chains may drive out more traditional ones, given the inherent differences in heterogeneous transaction costs that producers and consumers in developing countries face, value chain pathways of various complexity levels can co-exist in the short term. While one could perhaps argue that this coexistence of pathways actually

makes them "different" value chains, perhaps serving different consumer demographics or selling slightly differentiated products, such distinctions in practice are often unclear. This is especially the case when the same individuals transact in multiple pathways.

Hence a key theoretical contribution of our approach is to argue for using a pathway-based lens to characterize heterogeneous activity within a given value chain, where pathways are defined as unique sequences of actor types through which a good is transacted on its path from producer to final consumer. Our approach highlights the contrasts in functionality in different pathways, while still treating the value chain as a singular object and acknowledging that the same actors may participate in multiple pathways. We believe characterizing value chain activity by exploring sequences of actors is a particularly useful way to study value chain activity, because the sequence of actors through which a good is passed often corresponds to differences in conduct, such as determining the location as to which the transaction takes place. (For instance in some cases the choice to sell to a local aggregator means that the good is sold to a trader at local market, whereas the choice to sell directly to a trader occurs at farmgate. The differences in competition, market infrastructure, etc. may vary as a result.) Yet beyond the construction of pathways, our approach also includes analysis at the decision node level (where nodes characterize how an individual actor of a given type chooses to participate in the value chain, including choices of seller type and choices of buyer type that one transacts with.) Not only is such node-level analysis practical from a data collection perspective (in that only one actor needs to be surveyed to understand their node level decisions), but it also acknowledges that understanding the entire pathway from producer to final consumer may be less relevant in decision-making by any individual actor. We believe the combination of pathway-level and node-level analysis allows us to develop a more complete characterization of heterogeneities in value chain functionality.

2.2 Empirical Analysis of Value Chains

Given the complexity of value chain objects, the empirical literature approaches their characterization and analysis from a variety of angles. The first angle is to conduct standard survey data collection but with a group of midstream (or downstream) actors, instead of simply surveying consumers. There are various examples of such data collection efforts, many of which are documented in Reardon et al. [2021] and Ambler et al. [2022b]. The second angle is to study behavior in a specific node or pathway, for instance asking what happens to trade between two specific actor types when a policy is changed or exploring what happens when producers choose a new downstream link through participation in contract farming [Bernard et al., 2017, Maertens and Velde, 2017]. The third angle, which is most similar to what we do here, is to take a more holistic approach to capturing value chain activity, but conducting stacked surveys of various actors [Minten et al., 2018, 2013, Kumar and Kapoor, 2010, Van Campenhout et al., 2021].

While our data collection process falls into this general stacked survey approach, our work is unique due to our focus on pathway-level analysis in addition to node-level analysis. In addition, we are very careful in our quantification of how sales volumes flow along different pathways. Specifically, when quantifying percentages of volume transferred between actors, we consider transaction history; we do not treat all volume received by a given actor as homogeneous. Much previous literature that does consider relative volumes passed through various configurations only considers the downstream linkage at each actor, much like a Markov process with independence between actor links (for examples, see [Habte et al., 2016, Mofya-Mukuka and Shipekesa, 2013, Tadesse and Fayera, 2018]). However this history-based distinction is important because goods received by different types of upstream actors may not be the same (in terms of quality or sourcing price for instance), and hence actors may choose to adopt different sale strategy to sell these products to downstream actors.

3 Context and Data

3.1 The Onion Value Chain in Senegal

Onion is the main horticultural crop in Senegal both in terms of production and consumption. Its production has increased from 245,000 tonnes in 2014 to an estimated 400,000 tons in 2017 [Beye and Komarek, 2020], and Senegal ranks 5th among all countries in per capita onion consumption [Arnoldus et al., 2021]. Production is concentrated in two regions: the Senegal River Valley (SRV) in the north of the country and the Niayes, a coastal area extending from Dakar to Saint-Louis and passing through the regions of Thiès and Louga. (See Figure 1.) Onion production in the SRV is limited to a single season, with harvest and marketing occurring from February to May/June. From May onwards temperatures are too high for onion production. Cooler temperatures in the Niayes allow producers to potentially bring 2 harvests to the market, and hence marketing activities last from February to August/September.

Since 2003, an import freeze on onions, spanning from February to September, has been put in place to support the development of the domestic onion market. This ensures less competition from the (often higher quality) imported onions during the peak of the domestic marketing period, while still fulfilling residual demand with imports during the other half of the year. Moreover, domestic onions are of lower quality and highly perishable, and adequate storage facilities are uncommon, such that producers have little control over when they sell their onions. This causes prices to decrease substantially at peak of the harvest periods (March-April in the SRV, and May-June in the Niayes), even without competition from imports [Arnoldus et al., 2021]. Perhaps because of this temporal sensitivity, the onion value chain in Senegal is mainly characterized by spot market transactions, rather than pre-arranged contracting between actors. Onions are generally sold either at farm-gate, in local markets (sometimes called collection points, which can be both formal nationally regulated markets or informally governed ones), and larger markets in major urban centers like Dakar, Thiès, Saint Louis, Touba, and Kaolack. The combination of the prevalence of spot market transactions and the geographical concentration of production and sales makes this value chain advantageous to study. Unlike in some value chains, it is fairly straight-forward to locate market actors in each of these locations, and the path of the geographical movement of goods is fairly easy to anticipate.

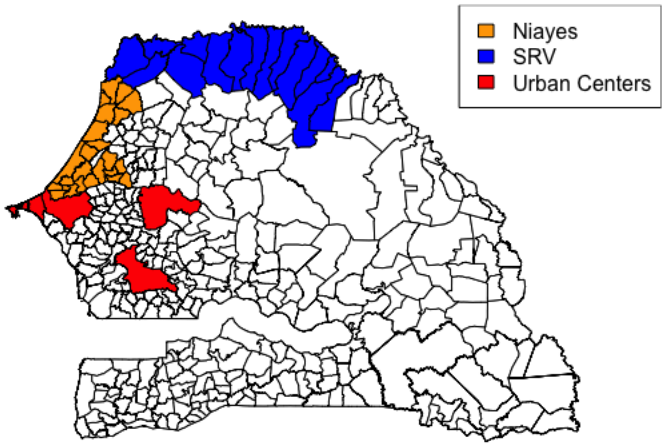
3.2 Value Chain Actors

Here we provide more information on the value chain actors of interest. In this "proof-of-concept" application, we predominantly define pathways based on the sequences of actors that participate midstream in the value chain. That is, we pause in our rigorous definition of pathways once the onions arrive at a wholesaler or any further downstream actor. We do this given that transitional value chains in developing countries notoriously can have complicated midstream operations and such midstream activity has greatly expanded over the last few decades [Reardon et al., 2021]. Hence the midstream of value chains is an area of keen research and policy interest. As we don't include stakeholders who do not directly handle/arrange for the transaction of goods as "actors" for the purposes of defining pathways, this leaves us with five key actor types.[1] They are described as follows:

- **Producers (P):** Producers are simply those who produce onions. They are often individuals producing

[1]While other stakeholders that do not directly transact goods, such as financial organizations, policy makers, producer organizations, and trade groups, are clearly important to understanding value chain functionality, we think of these as actors who can choose to intervene in various pathways, and whose differential intervention may help describe differences in functionality between pathways.

Figure 1: Main Onion Production Regions in Senegal



Notes: This map shows the main onion production areas and onion consumption areas in Senegal. The black lines delineate communes (the fourth level of administrative units in Senegal). Communes in orange belong to the coastal production area of the Niayes. Communes in blue are production areas in the middle and lower valleys of the Senegalese River. Areas in red represent the major urban centers.

onions at fields located near their residence, but also can include larger commercial growers. Many producers also belong to producer organizations, which are often organized in economic groups known as "Groupement d'Intérêt Economique (GIE)" for the financing and the acquisition of inputs.

- **Rural coaxers (RC):** Rural Coaxers rely on their networks and understanding of local market dynamics to facilitate negotiations between buyers and producers who are looking to sell their onions. Specifically, rural coaxers are generally consignment agents who sell producers' onions on their behalf. In most such arrangements, rural coaxers are to turn over the full sale price received the producer, and are then typically paid a fixed commission per unit sold. Some rural coaxers collect onions from farms/villages to then sell in rural markets, but most operate only at rural markets waiting for producers to bring in their production.

- **Banabanas (B):** Banabanas are itinerant traders that act as middlemen connecting upstream activity in rural areas and downstream activity predominantly in urban markets. They collect onions directly from producers at farmgate or directly from producers or rural coaxers at rural markets. Occasionally, these transactions are pre-arranged by phone. Banabanas leverage their market knowledge (of both rural and urban markets) and their network connection to perform spacial arbitrage, allowing them to capture part of the potential price surplus gained in moving onions between rural and urban markets. Banabanas also often combine onions sourced from multiple producers to sell in larger quantities.

- **Urban coaxers (UC):** Urban coaxers play a similar role to rural coaxers, rely on their networks understanding in urban markets to facilitate negotiations between buyers in urban markets and sellers

(usually producers or banabanas). Urban coaxers are also generally consignment agents, that sell on behalf of another actor and receive a fixed commission per unit sold.

- **Wholesalers (W), semi-wholesalers and retailers (O):** Wholesalers (and other related actors) buy onions in urban markets and engage in last-mile distribution to retailers and/or consumers. Wholesalers often both buy and sell in bulk. While we focus here on local onions, wholesalers also play a role in the distribution of imported onions, such that they operate year-round (and not just during domestic production seasons).

It is also perhaps worth noting that while in our empirical exercise we classify actors as one specific actor type, depending on how they were sampled, that in practice the same individual sometimes may fulfill the role of multiple actor types. For instance, it is not uncommon for rural coaxers to also engage in some production themselves. Additionally, as we will detail further below, our framework allows for the same individual to simultaneously participate in multiple pathways, which we will also show is not uncommon in this context. Moreover, we note that not all of these actors may participate in the domestic value chain per se, for instance some producers may simply consume their own production and/or give it to family and friends. As such pathways are generally not thought of as "value chain" activity, we focus only on the producers who sell at least some of their harvest. Any estimates of how much volume is transacted in various value chains only includes onions that were sold.

3.3 Data Collection and Preparation

3.3.1 Overview of Surveys

Before collecting any survey data, we first carried out a set of semi-structured key informant interviews to both identify key value chain actor types, and get a sense of the pathways we should expect to observe. Once this was done, we designed and implemented two surveys: a survey of actors and a survey of transactions. The actors survey consists of a stacked survey of the five actor types identified during the key-informant interviews, which are described in the previous section. This survey contains standardized questions regarding production and marketing activities in the last and in the current season, costs and revenues, marketing behavior, relationships with other actors, general perceptions. Data collection was carried out in winter and spring of 2021, to capture peak marketing behavior. A subset of rural coaxers and banabanas were re-surveyed via phone in fall 2022, given some data quality issues. This survey included more specific questions regarding each actors upstream and downstream links, asking whom they source onions from (and how much they did from each source) and to whom they sold onions coming from each source. This was done in order to make sure our characterization of the percentage of sales volume being transacted in each pathway was as accurate as possible.

The transactions surveys sought to record information regarding specific live transactions, in order to understand the relationships between price, quantity, quality, and negotiation dynamics. Such relationships are more challenging to tease out when looking at aggregate marketing activity, as opposed to specific transactions. Having an enumerator observe a transaction as it occurs, mitigates any issues of intentional misreporting or recall issues that might bias reports of past transactions. However, given this exercise is a proof of concept and we have relatively small sample sizes, we also consider past transactions reported during the actor survey in our node-level analysis of transactions.

3.4 Sampling

Our goal in this analytical exercise is to capture the activities that are the most representative of the overall action in the domestic onion value chain. Sampling is, as such, inherently challenging, as various types of actors are involved, and actors in different geographical areas may interact in different ways. Moreover, for actors other than producers, we did not have a clear census of the universe of actors. Hence we made various strategic decisions about where to locate and sample actors, such that we could capture the most value chain activity possible. Hence, while we cannot say that we have a properly randomized sample of the universe of actors for most of our actors (producers are the exception, disregarding implementation issues), we tried to sample widely enough spatially that we still get an accurate sense of the overall importance of different pathways.

To put some bounds on the problem, we first identified the two main regions where the overwhelming majority of onions is produced, the Niayes and the SRV, as our locations to study production and upstream value chain activity. For each region, through preliminary field work, we identified markets where onions are sold and the villages where onions are produced. We identified in total 64 markets (including both formal and informal collection points, as well as weekly markets) and 201 villages. We then formed "market clusters" to create a sampling frame. Markets were grouped together in a single cluster if they fit within a common 25km radius circle. Villages were there assigned to the cluster of the nearest market. This process resulted in the formation of 10 total clusters (4 clusters in the Senegal River Valley and 6 in the Niayes). Given logistical constraints, we limited investigation to 5 out of the 10 clusters, strategically choosing the clusters in which we would likely capture the most market activity, given the number of village and the activity level of the markets. To study further downstream market activity, we also survey actors and observe transactions in urban markets. For the selection of urban markets, we considered the 5 main regions with onion wholesale market activity, which are also the five biggest cities in the country: Dakar, Thiès, Touba, Kaolack and Saint-Louis. In each region, we chose the busiest urban market if there is more than one market. In Dakar and Touba, we chose two markets given the large volume of onion going to these two cities and the absence of one central market.

For each selected cluster, we randomly chose 15 villages to survey, with the only inclusion criteria being that they had least 10 onion producers reported in the village.[2]. In each village, the village chief helped identify onion producing households, and we randomly chose 10 of these to survey. We end up with a sample 648 producers. In any statistics calculated with this sample, we apply sampling weights to account for the fact that producers in villages of different sizes are not equally likely to be chosen. Additionally, given that we want our figures to be representative of overall value chain activity, estimates of how much volume transits in a given pathway are scaled such that the overall production amounts by region is that suggested by Senegal's national production statistics.

To sample rural coaxers, we strategically chose (up to) 5 markets in each cluster with high levels of market activity to maximize the number transactions we could observe. We chose, in each cluster, 2 formal collection points, 2 informal collection points and 1 rural/weekly market unless such markets were not present in the cluster. If a village has more than one type of market, then only one of its markets is chosen in the sample

[2]It proved difficult in the Niayes to identify an informant that could describe which villages contained sufficient numbers of onion producers to be included in our survey, and hence some villages that had less than 10 producers were sampled. Upon verification of the lack of sufficient onion producers, enumerators did not survey these villages. However, due to logistical constraints, we were unable to sample replacement villages, and hence some villages remain unsampled, and a few sampled less than 10 producers. Hence in practice, one of the clusters in the Niayes has only 11/15 villages surveyed, and the other two have only 14/15. villages surveyed

(unless there are less than 5 markets in the cluster in total). In each market visited, enumerators followed 2 rural coaxers over 5 days and recorded transactions made by these rural coaxers over that time. In markets with more than two rural coaxers, enumerators chose those they perceived to be engaged in the most market activity. At the end of these 5 days, they chose two additional rural coaxers among those present in the market, if possible. Otherwise, they kept following the same 2 coaxers. Given that less than five markets were present in some clusters, and less than 4 rural coaxers were able to be interviewed in most markets, we end up with a sample of 45 rural coaxers. In a follow-up phone survey in which we collected relevant data, 39 of these rural coaxers were reached.

To sample banabanas in rural markets, for each day of the survey, enumerators were mandated to interview one banabana among those who made a transaction with the rural coaxers that they follow. In urban markets, enumerators were mandated to interview: (i) one banabana or wholesaler among those who made a transaction with the urban coaxers that they follow, for the days in which they followed urban coaxers, and (ii) one banabana among those who made a transaction with the wholesalers that they follow, for the days in which they followed wholesalers. In total, we were able to survey 114 banabanas, and reach 79 of them in our follow-up phone survey. Finally, to sample urban coaxers and wholesalers, enumerators followed 2 urban coaxers or wholesalers in each urban market for 4 days. At the end of these 4 days, they again chose two urban coaxers or wholesalers among those present in the market. If there were more than two urban coaxers in the market, enumerators chose those that seemed to have the highest level of activity. This resulted in a sample of 25 urban coaxers, and 27 wholesalers. Additionally, to capture transactions in the transaction survey, the enumerator would record any transaction done by the actor they "followed" in a market.

3.5 Identification of Pathways

A key feature of our stacked survey approach is that we ask each actor to describe both from whom they buy and to whom they sell, and provide us with the associated quantities. This allows us (at least in this setting, given how we have defined the pathways), to use participation in a node (identification of actor type, as well as whom they buy from and sell to) to uniquely identify which pathway the actor is participating in.[3]

Using this information, we create a value chain diagram describing how volume flows through the value chain. This can be seen in Figure 2. Starting from the left, producers sell 37% of their production to banabanas, entrust 27% of their production to rural coaxers, and take 36% directly to downstream agents (urban coaxers, wholesalers, or others). Looking at banabanas, we distinguish to whom they sell their onions depending on the source of the product. From the onions that they sourced directly from producers, banabanas sell for example 5% to urban coaxers, while from onions sourced from rural coaxers, they sell 8% to urban coaxers.

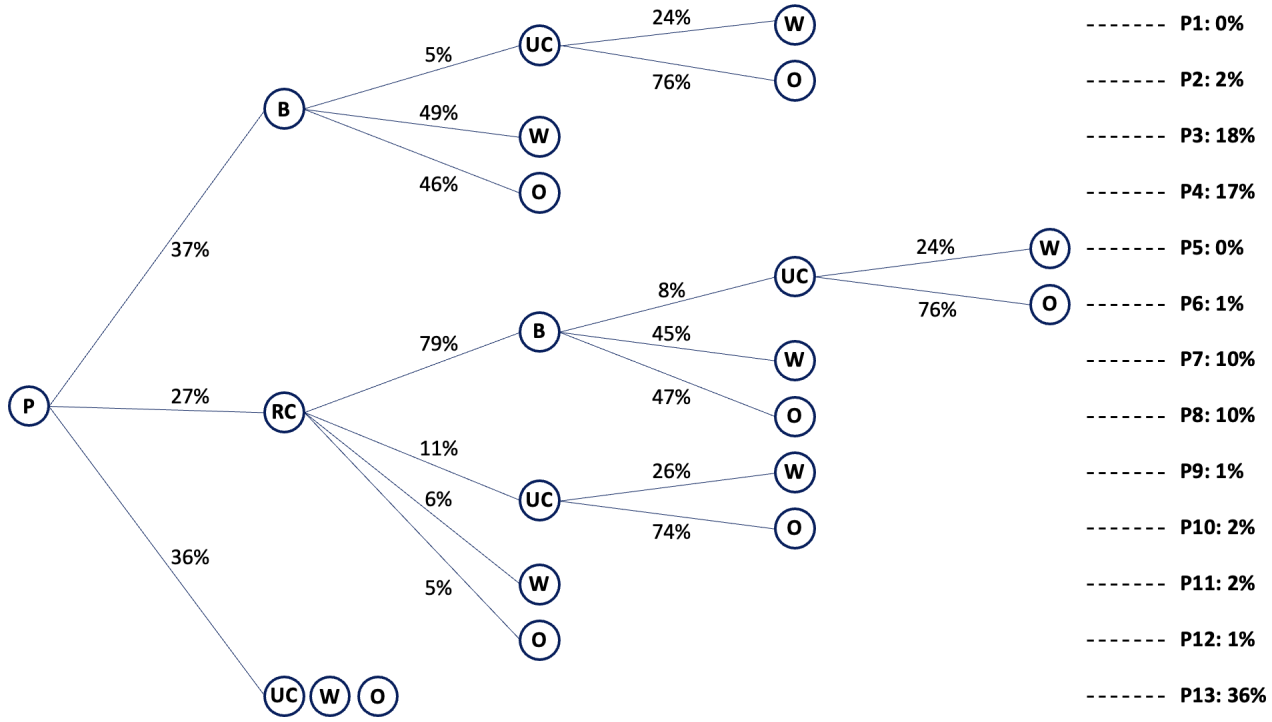
In order to construct this chart, at each node containing a producer, rural coaxer, or banabana, we assign their sales volume to either SRV or Niayes region depending on the production/transaction location or reported sourcing area. This allows us to scale production at each node both based on regional production statistics, as well as based on what percentage of overall production in that region would have "arrived" to a given actor type (e.g.; only part of production from producers goes to rural coaxers, so any estimates of who rural coaxers are then selling to needs to take this into account when re-scaling by region). As a reminder, volume sold by producers is also weighted according to sampling probabilities. For other actors, we assume that the activity we captured is representative of overall value chain activity, since we lack a clear sampling

[3]It is important to note that there may be some value chains in which a 3-actor linkage sub-sequence will *not* uniquely identify some pathways. In this trial application, we generally ignore far downstream behavior in which this issue, could arise.

frame.

We note in figure 2 the identification of 13 pathways (with the acknowledgement that we do not uniquely identify volume percentages for urban coaxers who source from banabanas and sell to wholesalers or other downstream actors). We note here that the pathways that transit the most volume are not the particularly complex ones; 36% of volume goes from a producer to an urban coaxer, wholesaler, or other further downstream actor.[4] Similarly, about 35% of overall volume goes from a producer to a banabana to a wholesaler/other downstream actor, avoiding the use of a coaxer of either type. Another 20% of volume goes through pathways that involve banabanas sourcing from rural coaxers but selling without using an urban coaxer. Notably, pathways containing all 5 actor types only account for around 1-2% of overall volume transacted. Hence simply calling the onion value chain in Senegal a "transitional" chain which is long and complex, categorized by the presence of these 5 actor types would not be a description of value chain activity as a whole. In reality, there are multiple pathways of differing complexity that operate simultaneously.

Figure 2: Percentage of overall volume transacted in different pathways



Notes: This figure displays the 13 different pathways through which onion goes from production to consumption areas. The number in black associated with each edge gives the share of the volume handled by the previous node that moved along this part of the pathway. Weighting adjusts for the probability of being selected in the sample. For each of the 13 pathways, the share of overall volume going through that pathway is shown next to P1-P13 on the right hand side of the figure. Producers are denoted with the letter "P". Rural Coaxers, which are collectors at rural markets, are denoted with "RC". Banabanas, which are traders that source from rural markets and sell at urban markets, are denoted with the letter "B". Urban Coaxers, which are collectors at urban markets, are denoted with "UC". Wholesalers at urban markets are denoted with the letter "W". Actors further downstream of the onion value chain (e.g. semi-wholesalers and retailers) are denoted with the letter "O".

[4]In practice, some producers had difficulties differentiating between these downstream actors in urban markets, so we pool them here.

4 Results

4.1 Inclusiveness: Prioritization of Intervention Pathways

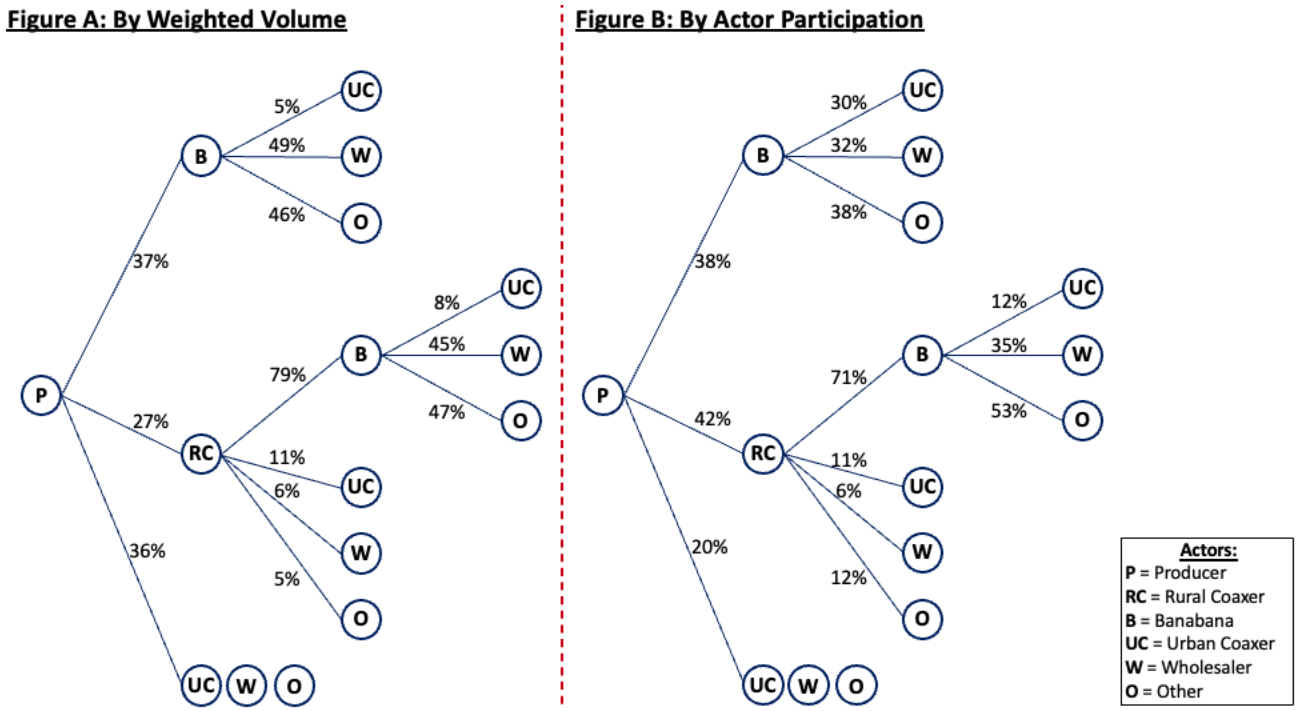
Policymakers may want to target interventions in the pathways that have highest impact potential. To perhaps have large effect on domestic food supply, one might intervene in pathways that move the largest amounts of overall sales volume. However, value chain development policy often has anti-poverty objectives for value chain participants, such as smallholder producers. The pathways that smallholders participate in may not be the same as these high volume pathways, perhaps because they do not have access to shorter, potentially more efficient pathways. Hence here as a proxy for poverty, we explore differences in the paths that smallholders do and do not participate in.

As a first indication of whether smallholders are disproportionately participating in certain chains is to look at the difference between volume transacted in each pathway vs. the number of actors participating in each pathway. (To calculate number of actors, we divide an individual that sell to (or buy from) different actor types evenly between all the edges in which he participates, again scaling for differences in region as well as incorporating sampling weights at the producer level.) This comparison can be made by comparing the links in Figure 3. When looking at producers, we see that 42% of the producers together only sell 27% of the total onion production to rural coaxers while only 20% of the producers selling to downstream agents acount for 36% of the volume. This shows that producers selling to rural coaxer on average sell much lower volumes than do producers that take their production straight to urban coaxers, wholesalers, and further downstream actors. We also see similar differences when looking at the trading volumes of banabanas that source directly from producers; our figures suggest that perhaps many banabanas trade relatively small quantities of onions to urban coaxers, and fewer banabanas sell larger amounts to wholesalers/other downstream actors.

This gives us some preliminary evidence that smallholders may not have equal access to shorter pathways. This hypothesis is explored further in Figure 4, which looks at the cumulative distribution of production, broken down by the type of buyer that the producer sells to. We note that most of those who sell through rural coaxers or directly to banabanas are predominantly small producers, while those that sell to a buyer at an urban market or to a mix of actor types tend to be larger producers on average. Indeed, a Kolomogorov-Smirnov test of distributional simularity rejects that distribution of production quantity for those only selling to rural coaxers is the same as those selling to a mix of buyer types. This also suggests that not only do larger producers sell to further downstream actors on average, but also that they have the option to sell to more than one actor type. We present similar results in regression form in Table 1, where we regress an indicator of a producer's choice to sell any volume to a given buyer type on their overall quantity sold (Columns 1-3 use total sales volume and Columns 4-6 use sales quartile bins, with the 4th quartile being the highest).

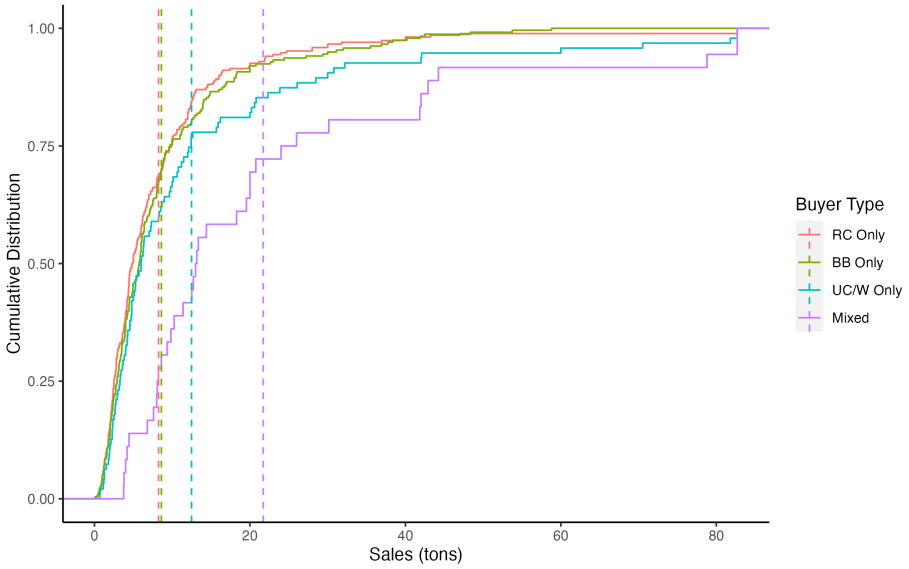
Moreover, we may want to understand if besides sheer quantity being transacted, that there might be other structural barriers that poor smallholder farmers and small-scale traders face in accessing less complex pathways. We explore these questions in Table 2 for producers, and Table 3 for other downstream actors. Notably, we see that in terms of demographic characteristics, producers that sell to different pathways and traders that sources from different actors look almost identical. This does indeed suggest that those actors transacting in less complex changes simply have larger operations, and hence do not need to go through various aggregating and transporting intermediaries in order to make sales. Indeed producers that sell farther downstream are more likely to own land and hire labor. Hence while not all value chain pathways are "inclusive" per se, there is not obvious evidence of structural barriers keeping them out, beyond any barriers

Figure 3: Percentage of volume transacted in each pathway vs. Percentage of actors transacting in each pathway



Notes: Figures A and B display the different pathways through which onion goes from production to consumption areas. The number in black associated with each edge of Figure A gives the share of the volume handled by the previous node that moved along this part of the pathway. Weighting adjusts for the probability of being selected in the sample. The number in black associated with each edge of Figure B gives the share of the actors in the previous node that transact along this part of the pathway. Producers are denoted with the letter "P". Rural Coaxers, which are collectors at rural markets, are denoted with "RC". Banabanas, which are traders that source from rural markets and sell at urban markets, are denoted with the letter "B". Urban Coaxers, which are collectors at urban markets, are denoted with "UC". Wholesalers at urban markets are denoted with the letter "W". Actors further downstream of the onion value chain (e.g. semi-wholesalers and retailers) are denoted with the letter "O".

Figure 4: Distribution of Sales by Buyer Type



Notes: This figure displays the cumulative distribution function (CDF) of the sales made by the 648 producers in our sample during the 2019/2020 season. The x-axis shows the value of sales in tons. The red solid curve corresponds to the CDF of sales made by producers that sold *only* to rural coaxers at rural markets during the 2019/2020 season, and the red dashed line corresponds to the mean value of their sales. The green solid curve corresponds to the CDF of sales made by producers that sold *only* to banabanas at farmgate during the 2019/2020 season, and the green dashed line corresponds to the mean value of their sales. The blue solid curve corresponds to the CDF of sales made by producers that sold *only* to urban coaxers and wholesalers at urban markets during the 2019/2020 season, and the blue dashed line corresponds to the mean value of their sales. The pink solid curve corresponds to the CDF of sales made by producers that sold to more than one actor type during the 2019/2020 season and the pink dashed line corresponds to the mean value of their sales. Rural Coaxers, denoted with "RC" in the legend, are collectors at rural markets. Banabanas, denoted with the letter "BB" in the legend, are traders that source from rural markets and sell at urban markets. Urban Coaxers, denoted with "UC" in the legend, are collectors at urban markets. Wholesalers are denoted with the letter "W" in the legend.

that limit the size of their farming or trading operations. Hence interventions at the producer level more generally that improve production capacity, may actually help smallholder farmers shift into less complex value chains. However, such interventions could also decrease the welfare of small-scale traders, who may have to adapt in the longer term to other livelihood-earning strategies. Alternatively, helping small producers organize and coordinate the marketing of their production into larger volumes may help them bypass some intermediaries.

4.2 Functionality: Creating the Right Intervention for Each Pathway

Given the participation of different types of actors, making transactions of different sizes, it is intuitive that these value chain pathways may have important differences in their functionality. Hence possible interventions to improve functionality may greatly depend on the pathway served. One possible functionality improvement could be to incentivize market actors to increase the quality of their products. Theoretically, we may expect actors to receive higher prices when they produce higher quality products. Yet in practice, some quality attributes can be challenging to observe or contract on, and hence quality may not always been rewarded with a price premium. Another possible functionality improvement could be to discourage anti-competitive behavior. Such behavior can have many negative effects, for instance may discourage entry by new players into the market or impede technological progress. Hence we now explore the functionality elements of quality recognition and competitiveness, to demonstrate the potential for differences between pathways.

4.2.1 Quality Recognition

We first note that there is evidence in general in this setting that actors award higher quality with a price premium. In Senegal, there are three grades of onion quality, which can be assessed mostly by appearance. For the purposes of our analysis, we refer to the top grade as having "good" quality, the middle grade as having "average" quality, and the lowest grade as having "bad quality." Producers, when asked to guess the quality of a picture of an onion, and then guess the price, provided systematically higher prices for onions they believed were "good" quality. This result can be seen in Table 4.

However, we also have a revealed preference measure of prices and quality levels, in our data on transactions. For both producers and banabanas, we look at whether they receive a price premium for higher quality onions, and whether the premium received differs by pathway. (We do not do a similar exercise for rural or urban coaxers, because they are generally only selling the producer's or banabana's onions on consignment.) We can see the results for producers in Table 5. Column 1 regresses an indicator of whether onion was high quality on the actor the producer chose to sell to. We do not see any statistically significant relationship between buyer choice and quality, though there is some suggestive evidence that higher quality onions are likely to be sold further downstream in the value chain. On the other hand Column 2 shows that the unit price for good quality onions is significantly higher than for other onion qualities, suggesting there is indeed a quality price premium of 16%. Column 4 shows that while all producers receive a price premium for selling good quality onions, those that sell directly to urban coaxers, wholesalers, and other downstream actors earn almost double the quality premium than actors that sell to other types. Hence a policy maker looking to introduce quality certification schemes, for example, may want to focus on implementing such reforms in more complex pathways, such as at transaction nodes involving selling to rural coaxers and banabanas.

Table 6 shows a similar analysis, but for banabanas, who sell either through urban coaxers, or directly

to wholesalers/other downstream actors. We note looking at Column 1, that again there is no statistically significant relationship between onion quality and choice of buyer, though there is suggestive evidence that higher quality onions are sold directly to actors further downstream. Again, we see that there is certainly a price premium for producing high quality onions. Yet as opposed to with producers, participating in a less complex chain (that does not involve selling through an urban coaxer) actually leads to receiving a lower quality premium (this can be seen in Column 4). Indeed, Column 3 suggests that banabanas who do not sell through urban coaxers receive lower prices on average. Hence it's very possible that in urban markets, urban coaxers play a large role in helping banabanas to negotiate price, that overpowers any selection effect stemming from banabanas doing smaller trade volumes selling to actors that are further upstream. Hence in this case, a policy maker interested in incentivizing banabanas to really preserve onion quality during transit may want to encourage banabanas to work with urban coaxers to achieve higher price premiums.

4.2.2 Competitiveness

The next question we explore is whether there is evidence of heterogeneity in market competition and/or anti-competitive behavior faced by actors transacting in different pathways. First we consider producers, who can choose to sell through a rural coaxer, directly to a banabana, or directly to a further downstream actor. Producers may suffer on account of anti-competitive behavior, if say buyers collude to offer them lower prices. We can look for suggestive evidence of such activity, and whether it differs by pathway, by looking for proxies describing actors' bargaining power.[5] We explore this question in Table 7. Looking at the first two columns, we note that among producers who do not sell on consignment through a rural coaxer, that there is some evidence that those selling further downstream may have greater bargaining power. Taking the difference between the producers initial ask price and the actual sale price, gives some sense of how much leverage the producer had in negotiations, with a smaller gap being suggestive of higher bargaining power. Producers who sell directly to urban coaxers or wholesalers have a significantly smaller difference between ask and final price compared to those selling directly to banabanas, suggesting those participating in less complex value chains may have more bargaining power, and be subject to less competitive activity.

The last two columns of the table look at these same bargaining power metrics but for transactions where a rural coaxer sells on behalf of a producer. The first thing to note is that there is a similar qualitative pattern, where the difference between the initial ask price and final price is lower when selling to further downstream actors. This suggests that sellers, regardless of their type, may face less anti-competitive behavior when selling further down the chain. Yet, at the same time, we do not see evidence of very economically significant collusive behavior at local markets, at least when considering rural coaxers' perceptions of market dynamics, shown in Table 8. We asked rural coaxers answering the actors survey to tell us how the price changes when there is a change in the number of banabanas (buyers) and rural coaxers (sellers) in a local market. Notably, if markets are competitive, we would expect the price of onions to be higher when there are more banabanas in the market, signaling higher demand, and the price to be lower when there are less banabanas in the market. On the other hand, if banabanas were colluding, we might actually expect prices to be lower when there are more banabanas in the market because it becomes more difficult for banabanas to agree with and maintain a higher purchase price. We see in the top panel of Table 8, that rural coaxers mostly report that prices increase when more banabanas enter the market and decrease when they leave the market, suggest such markets are competitive. On a similar note, we might expect prices to increase when there are less rural

[5] We do not make any causal statements here, given that as we have shown above, there may be selection into the pathways that individual actors participate in, according to production volume for instance).

coaxers present in the market, given this likely indicates a lower supply, and decreases when there are more rural coaxers. Interestingly, the majority of rural coaxers report that prices are unaffected by the number of rural coaxers present in the market. We speculate that this might reflect the fact that supply of onions in this context is potentially very inelastic. There is a limited availability of proper storage facilities for onions and so farmers have a limited post-harvest window to sell onions. Moreover, unlike banabanas, rural coaxers generally operate only in a small number of rural markets; banabanas on the other hand may strategically visit markets in different geographies based on the harvest dates in different areas. Hence it seems plausible that rural coaxers come to the same market(s) each day regardless of the quantity of onions they have to sell, in which case price would not necessarily be responsive to the number of rural coaxers in the market.

We can also see in Table 7, that regardless of buyer type, rural coaxers have a smaller discrepancy between ask price and final sale price than producers who transact without a rural coaxer do. Hence one might conclude that producers who participate in a more complex pathway (employing a rural coaxer) are actually subject to less anti-competitive behavior, because rural coaxers can negotiate a better price on the producer's behalf. Yet we must also consider the dynamics between the producer and the rural coaxer. While rural coaxers are supposed to remit the full sale price (minus a fixed commission) to the producer, the producer is often not physically present during the transaction, and hence cannot verify the actual sale price. We asked both producers and rural coaxers whether rural coaxers cheat farmers by reporting a lower unit price than what was actually received. The results can be seen in Table 9. Given that cheating is an illicit behavior, we thought it best to ask both producers and rural coaxers about this, and to ask using a series of slightly different prompts, to see if we could get some sense of the true magnitude of this behavior. The first column shows the percentage of producers and rural coaxers who answered in the affirmative when asked whether rural coaxers ever cheat farmers by price reporting. Perhaps surprisingly given the nature of the behavior, the majority of both producers and rural coaxers report that this type of cheating behavior occurs. Any participants that answered in the affirmative were also asked for the number out of 3 transactions in which such cheating would likely occur. Notably, there is quite a large discrepancy when asking about the frequency of cheating, with producers reporting cheating behavior to be over twice as frequent as rural coaxers do. Given that mistrustful farmers might overestimate cheating, we also asked how frequently other producers would report being cheated (second order belief elicitation) and how frequently they themselves had been cheated in their three most recent transactions. The frequencies do decrease, but not much; farmers on average believe they personally were cheated in about 50% of their most recent transactions. Rural coaxers may under-report cheating, hence we ask how many producers they believe would report being cheated. The frequencies again decrease, but only slightly; rural coaxers think farmers will report around 30% of their last three transactions to have involved cheating on price reporting. Hence while we can't exactly pin down cheating frequency, it seems probable that this behavior is quite prevalent, occurring in as many as 30-50% of all sales through a rural coaxer. Producers who sell onions through rural coaxers are therefore subjecting themselves to the possibility of an additional source of anti-competitive behavior by rural coaxers, which is not possible in other less complex pathways. This aligns with the general notion that less complex pathways are associated with less anti-competitive behavior.

Finally, we can also look at anti-competitive behavior that may be faced by further downstream actors. To proxy for market power with these actors, we look at reported ease of transaction and an indicator of being satisfied with the final sale price. Given that quality level may have a large bearing on transaction ease, we asked this question separately for each of the three quality levels. Overall, we do not see much systematic evidence that bargaining power among actors varies by pathway. The one exception is that urban

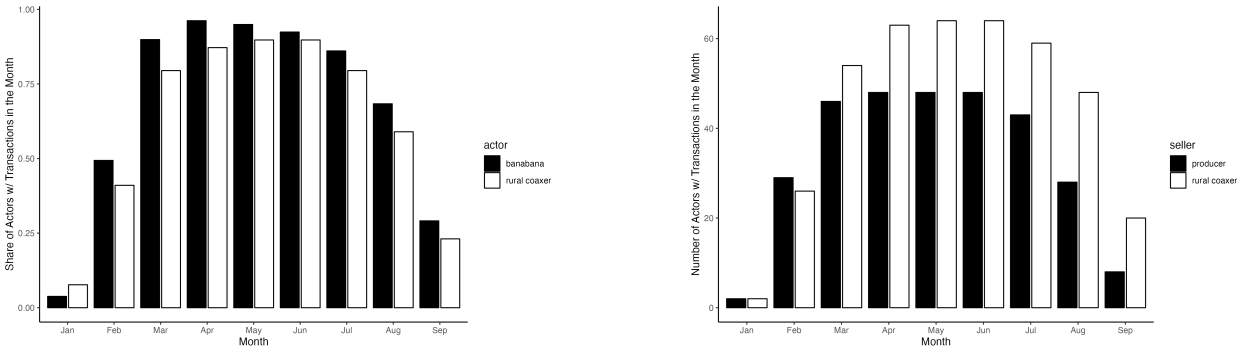
coaxers seem to have a significantly easier time selling medium quality onions to wholesalers than banabanas do (This is perhaps because like in rural markets, coaxers are better able to negotiate with downstream actors. We do not have data as to whether urban coaxers report false prices to banabanas). Hence in the case of the onion value chain in Senegal, reforms to improve market competitiveness may be most beneficial to producers participating in more complex chains.

4.3 Flexibility: Understanding Potential Interactions Between Intervention Pathways

Understanding whether and how value chain activities shift between pathways can be crucial when intervening in a specific pathway or set of pathway. First we note that actors do indeed participate in multiple pathways in the same season; it is not the case that specific actors are inflexibly bound to one pathway in particular. This can be seen in Table 11. The first row shows the percentage of actors that only participate in one pathway in a given season. With the exception of producers, a sizable amount of actors (including the majority of banabanas and urban coaxers) participate in more than one pathway per season. Moreover, the first row of Table 12 shows that around half of all actors report the ability to choose their buyer type. The fraction that report that they actually did change their buyer type between seasons is a bit lower (around 20%), but is still a non-negligible fraction of actors. Hence it seems reasonable to predict that actors can and will change pathways in response to a shock, both within and between seasons.

We can also study existing forms of heterogeneity in time and space to get a better sense of how a shock or intervention might drive actors to re-think their choice of pathway. First, we see systematic changes in the prevalence of activity in given pathways throughout the season. For instance in Figure 5a, we see the fraction of all rural coaxers and the fraction of all banabanas operating in a given month. We can see qualitatively that banabanas tend to enter the market earlier in the season, with participation peaking in April, and declining over time. Rural coaxers on the other hand enter the market more slowly, with their participation peaking in June. This is likely due to differences in supply throughout the season. Earlier in the season less producers are ready to harvest, so banabanas may incur the additional costs to seek out producers at farm gate, in order to ensure they can access part of the limited onion supply. Rural coaxers, on the other hand, may not find it profitable to operate until a critical mass of small farmers are ready to sell or until they themselves have harvested any self-production. Indeed, Figure 5b supports this story, as it shows the number of banabanas actively participating in the market each month, broken down by their upstream source (either rural coaxers or producers). We see that on average banabanas buy straight from producers earlier in the season when supply is more limited, and buy from rural coaxers later in the season. (Though not shown here, this result is also robust qualitatively to only considering banabanas who source both directly from producers and through rural coaxers within the same season. They seem to choose upstream actors at least in part due to temporal shifts in market conditions. Hence we might expect that any policy interventions that change the timing of the availability of supply (like providing storage facilities in rural markets) could also change some actors' choices of pathway.

Figure 5: Temporal Heterogenity in Value Chain Activity



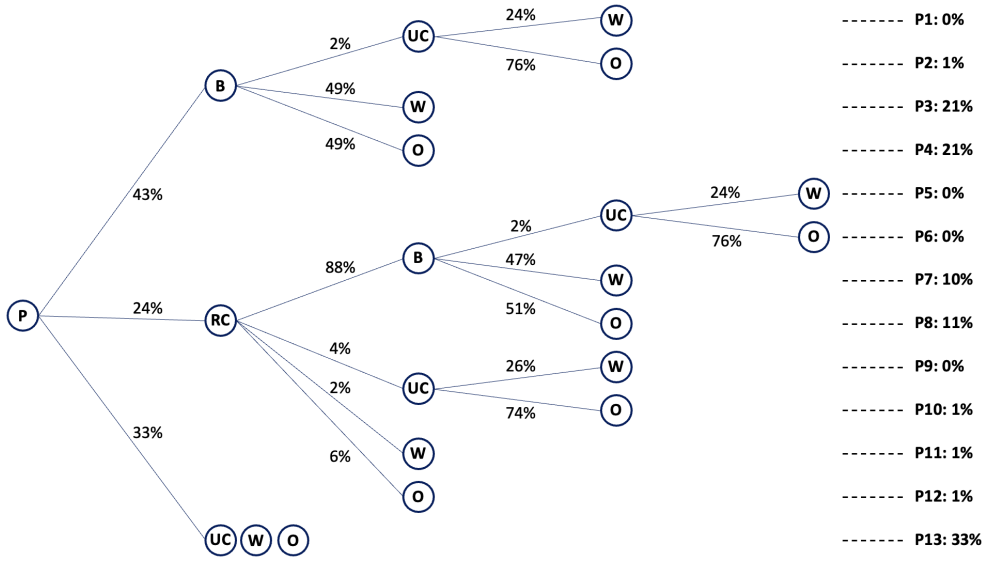
(a) Share of Actors Actively Transacting

(b) Number of Banabanas Sourcing From Different Actors

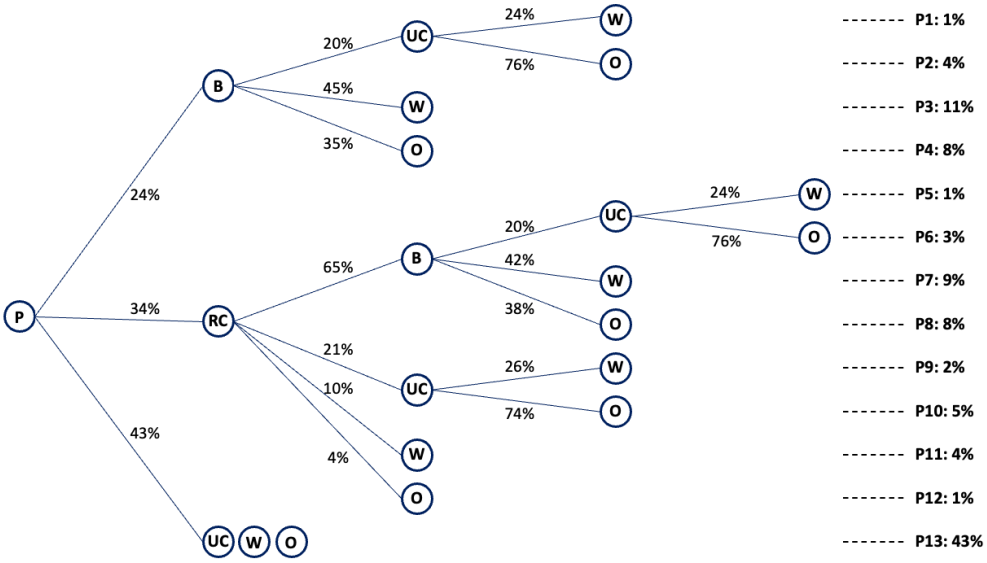
Notes: This figure shows the level of engagement of banabanas and rural coaxers in the onion value chain throughout the season. The sample is restricted to actors included in our phone survey. We ask actors the first month and the last month in which they make a transaction in the value chain and consider them engaged for each month between the first month and the last month. Figure (a) shows the share of actors in our sample with at least one transaction by month of the year and by actor. For Figure (a), bars in white are for rural coaxers while bars in black are for banabanas. Figure (b) shows the number of banabanas in our sample with at least one transaction by month of the year and by actor. For Figure (b), bars in white are for banabanas sourcing from rural coaxers while bars in black are for banabanas sourcing directly from producers. Banabanas are traders that source from rural markets and sell at urban markets. Rural Coaxers are collectors at rural markets.

We can observe systematic differences in value chain activity due to geographical heterogeneity as well. Figure 6 presents a version of Figure 2, but disaggregated by region, for the two main geographical regions with onion production activity. Notably, at the producer node in particular, there are important differences between regions in terms of producer pathway choice. In the Niayes, transactions between producers and banabanas (which generally happen at farm-gate) are much more important than in the SRV, whereas sales directly to urban market actors, such as urban coaxers and wholesalers are less important than in the SRV. Part of this likely has to do with differences in market location; rural villages in the Niayes are closer to urban market centers, which might make it relatively less costly for banabanas to conduct farm-gate transactions with producers. Hence policies that decrease travel cost or improve market access, such as building roads, may lead banabanas to choose a pathway that involves sourcing directly from producers. Additionally, there are differences in the unit of negotiation used in local markets between the SRV and the Niayes. A government policy in 2014 introduced scales at local collection points. Hence actors can deal precisely in price per kilogram when transacting there. In the SRV on the other hand, there are no scales, and hence actors usually negotiate at the bag level, supposing a standard bag hold about 25 kg. However, this bag level negotiation may serve to shortchange producers who are told their bags are not full enough, and hence sell bags containing more than 25 kg without receiving any additional compensation [Bernard et al., 2017]. Large producers in the SRV who have the means to travel to an urban market may be more incentivized to do so, given that urban markets have scales. This way they will not be underpaid by selling in a local market. This example provides additional suggestive evidence of a policy that provides market infrastructure (such as provision of scales) could potentially shift activity between pathways.

Figure 6: Percentage of Overall Volume Transacted in Different Pathways by Region



(a) Niayes



(b) SRV

Notes: Figures (a) and (b) display the 13 different pathways through which onion goes from production areas to consumption areas, respectively for onion sourced from the production area of the Niayes and onion sourced from the Senegal River Valer (SRV). For each node of the each pathway, the number in black represents the weighted share of aggregate sales going through that node. For each of the 13 pathways, the share of overall volume going through that pathway is shown next to P1-P13 on the right hand side of the figure. Producers are denoted with the letter "P". Rural Coaxers, which are collectors at rural markets, are denoted with "RC". Banabanas, which are traders that source from rural markets and sell at urban markets, are denoted with the letter "B". Urban Coaxers, which are collectors at urban markets, are denoted with "UC". Wholesalers at urban markets are denoted with the letter "W". Actors further downstream of the onion value chain (e.g. semi-wholesalers and retailers) are denoted with the letter "O".

5 Conclusion

As agri-food markets in sub-Saharan Africa evolve, and policymakers seek to support this agricultural transformation, it becomes increasingly vital to have a common foundation to describe value chain activity. Such a foundation needs to be able to account for key features of current value chains in the developing world, and especially for the co-existence of various types of transaction structures, which may nonetheless share common actors and common characteristics of the product being sold. We propose a framework that characterizes value chains as a system of pathways that describe sequences of transactions between actors. We then use pathways to describe the overall structure of value chain activity, and use nodes as a way to assess functionality at key decisions points for actors operating along these pathways. We believe that such an approach provides a high-level enough view of value-chain activity such that prioritization between pathways for policy intervention can be done, while making salient for policy-makers the potentially complicated interactions of activity in different pathways. At the same time, the framework encourages careful consideration of each actor's micro-level activity to truly be able to parse out relevant parameters describing how actors transact between individuals. We also see this framework as inherently adaptable based on the location along the value chain of interest (e.g.; upstream, midstream, downstream activity) and the type of functionality issues policymakers may want to address. For instance, a growing body of evidence on the financial needs of midstream actors could focus on functionality issues associated with various actors credit constraints [Ambler et al., 2022a].

At the same time, the process of developing a proof-of-concept empirical test of this framework reinforces some of the inherent challenges in studying value chain activity. Choosing a sample of market actors when the population is not well-defined requires us to make assumptions about where we are likely to find representative actors, and with limited resources, strategically sample such actors. This is perhaps not the most appealing proposition to a rigorous empirical researcher, who is hoping for instance to run a randomized experiment. Yet given the importance of value chain development in current policy agendas, a sample chosen based on scoping interviews and market visits may provide a sufficiently useful characterization of value chain activity for the purpose of formulating intervention strategies. Additionally, the geographic concentration of onion production in Senegal provides the opportunity to define geographically-based market clusters that capture a significant part of upstream activity. This may be challenging in settings where value chain activity is less geographically concentrated. Additional scoping work to understand how production moves spatially may be required in order to define market clusters.

Overall, we think our proof-of-concept empirical exercise highlights some of the key trade-offs and considerations that a policymaker looking to support domestic onion value chain development in Senegal might want to consider. Our results highlight the clear trade-off between intervening in more complex value chains, which often are the only ones accessible to smallholders, but whose current production currently accounts for a smaller fraction of overall food supply. Indeed, we also see some evidence that these more complex value chains function "worse" in that they may provide lower incentives to produce quality and potentially subject producers and small-scale traders to anti-competitive behavior. Hence policy-makers may want to intervene in the midstream to improve the functionality of these chains, or simply support smallholder producers in increasing their production. However, as we highlight in our analysis, given that actors do indeed shift between pathways, increasing production may cause producers to shift into less complex chains to the detriment of small-scale traders who also may be relatively poor. At the same time our studies of functionality and flexibility also suggest some key ways to support development in less complex value chains, for instance improving market infrastructure like scales and roads. While there isn't necessarily an obvious

policy prescription when these findings are all taken together, the findings should at least help policymakers to make a well-informed decision.

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6 Tables

Table 1: Producer Pathway Choice and Sales Volume

	RC	BB	UC/W/O	RC	BB	UC/W/O
	(1)	(2)	(3)	(4)	(5)	(6)
Sales (tons)	−0.004	0.001	0.009***			
	(0.003)	(0.004)	(0.001)			
Sales Quartile 2				−0.077	0.158	−0.083
				(0.045)	(0.083)	(0.060)
Sales Quartile 3				0.051	0.060	−0.063
				(0.043)	(0.042)	(0.067)
Sales Quartile 4				−0.169	0.122	0.200
				(0.098)	(0.082)	(0.096)
Cluster FE	Y	Y	Y	Y	Y	Y
Weighted Mean Dep. Var.	0.45	0.41	0.19	0.45	0.41	0.19
Observations	638	638	638	638	638	638
Adjusted R^2	0.075	0.048	0.124	0.082	0.058	0.088
P-value [Quartile 2 vs. Quartile 3]				0.67	0.72	0.64
P-value [Quartile 3 vs. Quartile 4]				0.60	0.93	0.36

Notes: This table regresses an indicator of whether a producer has reported transacting with the actor type in the column heading during the 2019-2020 or 2020-2021 season on different sales volume variables. Columns 1-3 use total volume sold as the independent variable, which is winsorized at the 99th percentile. Columns 4-6 use quartile bins based on sales volume, as the independent variable(s), with the lowest quartile being the omitted group. Observations are weighted for sampling representatives and standard errors are clustered at the geographical cluster level. Rural Coaxers, which are collectors at rural markets, are denoted with "RC". Banabanas, which are traders that source from rural markets and sell at urban markets, are denoted with the letter "BB". Urban Coaxers, which are collectors at urban markets, are denoted with "UC". Wholesalers at urban markets are denoted with the letter "W". Actors further downstream of the onion value chain (e.g. semi-wholesalers and retailers) are denoted with the letter "O". * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 2: Differences in Characteristics of Producers Selling to Different Buyer Types

	RC Only	**BB Only**	**UC/W Only**	**Mixed**
	(1)	(2)	(3)	(4)
Panel A: Demographics				
Age (yrs)	46.2	47.83	48.53	43.02
	(14.33)	(13.57)	(13.51)	(11.79)
Experience (yrs)	17.31	16.8	19.38	18.36
	(11.14)	(11.69)	(11.39)	(14.25)
Is male (0/1)	0.95	0.95	0.92	1
	(0.22)	(0.22)	(0.28)	(0)
Has attended school (0/1)	0.63	0.44***	0.68	0.56
	(0.48)	(0.5)	(0.47)	(0.5)
Panel B: Production				
Land owned (ha)	2.78	3.62***	4.1***	2.81
	(2.66)	(3.6)	(3.85)	(2.46)
Belongs to an OP (0/1)	0.63	0.61	0.79***	0.71
	(0.48)	(0.49)	(0.41)	(0.46)
Hires labor (0/1)	0.59	0.46***	0.74**	0.78**
	(0.49)	(0.5)	(0.44)	(0.42)
Gets seeds via credit (0/1)	0.2	0.23	0.3**	0.49***
	(0.4)	(0.42)	(0.46)	(0.51)
Cannot afford better seeds (0/1)	0.58	0.61	0.5	0.38***
	(0.49)	(0.49)	(0.5)	(0.49)
Can easily learn about local prices (0/1)	0.58	0.61	0.75***	0.86***
	(0.49)	(0.49)	(0.44)	(0.35)
Production (tons)	8.29	9.35	18.16***	34.45***
	(9.68)	(10.82)	(23.59)	(28.44)
N	269	238	95	36

Notes: This table displays weighted averages over various producer demographic characteristics and variables related to production activities. Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct column means, with two exceptions: the "Land owned (ha)" variable, for which 58 observations are missing, and the "Hires labor (0/1)" variable, for which 72 observations are missing. Weighting adjusts for the probability of being selected in the sample. The land area and production variables are winsorized at the 99th percentile. Column (1) includes producers that sold *only* to rural coaxers at rural markets during the 2019/2020 season. Column (2) includes producers that sold *only* to banabanas at farmgate during the 2019/2020 season. Column (3) includes producers that sold *only* to urban coaxers and wholesalers at urban markets during the 2019/2020 season. Column (4) includes producers that sold to more than one actor type during the 2019/2020 season. Rural Coaxers, denoted with "RC" in the column headers, are collectors at rural markets. Banabanas, denoted with the letter "B" in the column headers, are traders that source from rural markets and sell at urban markets. Urban Coaxers, denoted with "UC" in the column headers, are collectors at urban markets. Wholesalers are denoted with the letter "W" in the column headers. Stars indicate that the weighted average indicator value is statistically different from the mean in the "RC Only" column. * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 3: Differences in Characteristics of Downstream Actors Sourcing from Different Pathways

	RC Only	**Prod Only**	**Both**
Panel A: Demographic			
Age (yrs)	41.14	43.38	41.47
	(10.43)	(11.78)	(9.67)
Experience (yrs)	12.25	16.3*	12.71
	(8.43)	(9.91)	(7.74)
Is male (0/1)	0.96	1.00	1.00
	(0.19)	(0.00)	(0.00)
Can read or write (0/1)	0.89	0.86	0.89
	(0.31)	(0.35)	(0.32)
Has attended school (0/1)	0.68	0.78	0.6
	(0.48)	(0.42)	(0.5)
Panel A: Value Chain Activity			
Can easily learn about prices (0/1)	0.86	0.89	0.82
	(0.36)	(0.31)	(0.39)
Learn about prices from local actors (0/1)	0.43	0.32	0.38
	(0.5)	(0.47)	(0.49)
Has information about prices before transactions (0/1)	0.89	0.97	0.96
	(0.31)	(0.16)	(0.21)
Works in other VCs (0/1)	0.61	0.78	0.71
	(0.5)	(0.42)	(0.46)
Largest reported sale (tons)	7.85	48.21***	24.24**
	(6.04)	(64.23)	(43.09)
N	28	37	45

Notes: This table displays weighted averages over various demographic characteristics and proxies of value chain activities. Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct column means. The sample includes banabanas, urban coaxers and wholesalers. Banabanas are traders that source from rural markets and sell at urban markets. Urban Coaxers are collectors at urban markets. Column (1) includes banabanas, urban coaxers and wholesalers that sourced *only* from rural coaxers at rural markets during the 2019/2020 season. Column (2) includes banabanas, urban coaxers and wholesalers that sourced *only* from producers at farmgate during the 2019/2020 season. Column (3) includes banabanas, urban coaxers and wholesalers that sourced *only* from both rural coaxers and producers during the 2019/2020 season. Rural Coaxers, denoted with "RC" in the column headers, are collectors at rural markets. Stars indicate that the average indicator value is statistically different from the mean in the "RC Only" column. * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 4: Producer Price Reports of Onion Based on Perceived Quality

Variable	Good	Average	Bad
Local Min. Price	212.48	175.12***	138.21***
	(7.65)	(6.16)	(13.53)
Local Max. Price	248.87	195.26***	163.83***
	(10.7)	(6.21)	(13.29)
N	317	241	33
Dakar Min. Price	280.91	250.88***	168.96***
	(7.23)	(6.98)	(14.36)
Dakar Max. Price	321.7	272.25***	193.52***
	(8.99)	(6.92)	(12.68)
N	289	222	31

Notes: This table displays surveyed producers' average price estimates for an onion presented in an image, dis- aggregated by the producer's perceived quality level of the pictured onion. Specifically, producers were asked to provide a minimum and maximum price that one could receive for the pictured onion in a local market (top panel) and in Dakar (bottom panel). Column (1) includes prices given by producers who judge the onion to be of good quality. Column (2) includes prices given by producers who judge the onion to be of average quality. Column (3) includes prices given by producers who judge the onion to be of bad quality. Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct each mean. Observations are weighted for sample selection probability. Observation numbers differ between panels due to missing data (some producers did not provide a price estimates for both local markets and Dakar). Stars indicate that an average price is significantly different than the average price in the preceding column (e.g. stars in the "Average" column denote the weighted mean in that column being statistically different for the mean in the "Good" column). * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 5: Quality Premium Received by Producers by Pathway

	I(Quality == Good)	Price (FCFA/kg)		
	(1)	(2)	(3)	(4)
I(Quality==Good)		36.343***		30.694*
		(8.709)		(14.012)
I(Buyer == Banabana)	0.049		8.315	17.839
	(0.044)		(12.962)	(25.806)
I(Buyer = UC/Wholesaler)	0.105		41.044*	3.834
	(0.073)		(16.728)	(25.212)
I(Quality == Good)*I(Buyer == Banabana)				−11.997
				(24.478)
I(Quality == Good)*I(Buyer == UC/Wholesaler)				38.512*
				(16.817)
Time of Season FE	Y	Y	Y	Y
Cluster FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Mean Dep. Var - Rural Coaxers	0.9	224	224	224
Observations - All	325	325	325	325
Observations - Rural Coaxers	130	130	130	130
Adjusted R^2	0.054	0.278	0.272	0.289
P-value [Rural Coaxer vs. Banabana]				0.56
P-value [Rural Coaxer vs. UC/Wholesaler]				0.00
P-value [Banabana vs. UC/Wholesaler]				0.00

Notes: This table shows the results of regressions related to the the quality of onion sold and the price received by producers in their transactions. Column (1) shows segregated differences in quality by actor type and displays the results of a regression where the dependent variable is a dummy variable for whether the onion sold is of good quality, and the independent variables are dummy variables for each buyer type. Column (2) shows the unsegregated price/quality premium and displays the results of a regression where the dependent variable is the unit sale price and the independent variable is a dummy for whether the onion sold is of good quality. Column (3) reflects segregated differences in price by actor type and shows the results of a regression where the dependent variable is the unit sale price and the independent variables are dummy variables for each buyer type. Column (4) shows the price/quality premium by buyer type and displays results of a regression where where the dependent variable is the unit sale price and the independent variables are dummy variables for each buyer type along with interaction terms between buyer type and a quality indicator. The reference buyer type in the four regressions is the rural coaxer. Geographical cluster-robust standard errors are listed in parentheses. The data used includes the most recent transaction in the 2020-2021 season reported by producers in the actors' survey, transactions (without missing data on the transaction date) involving producers recorded in the transaction survey, the most recent truckload reported by banabanas on the actors' survey in the 2020-2021 season (in cases where the banabana purchased directly from a producer), up to 3 transactions reported by banabanas, urban coaxers and wholesalers in the actors survey in the 2019-2020 season (in cases where they purchased directly from a producer). Transactions with unit sale prices less than 100 FCFA/kg or above 1000 FCFA/kg are excluded from the data. In the producer module on the actors' survey, prices and qualities are reported by the producer. In the transaction survey, there may be prices and qualities reported by the buyer, seller, and/or intermediary (such as a coaxer). In cases where different actors provide different price information for the same transaction, the maximum reported price is used. In cases where different actors report different quality levels, we defer to the seller's report, to be most comparable with the actors' survey data. In the modules for banabana, urban coaxers and wholesalers in the actors' survey, prices and qualities are reported by the buyer. For the 2020-2021 season, banabanas are asked separately about the unit price paid for bags of each quality level present in their most recent truckload, and hence we count their reports about each quality level present as an individual transaction for the purpose of this regression. Time of season fixed effects are coded as "early" if the transaction took place in January or February, "peak" if the transaction took place in March or April, and "late" if they took place after April. Cluster fixed effects indicate the cluster of the surveyed actor (if known), or an "urban" cluster if the cluster of the actor is unknown and the transaction took place at an urban market. The bottom panel of the table lists the p-values of an F-test of the differences between the price/quality premium coefficient estimates associated with selling to the 3 different buyer types. Stars indicate that a coefficient is significantly different from zero. * indicates, $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 6: Quality Premium Received by Banabanas by Pathway

	I(Quality == Good)	Price (FCFA/kg)		
	(1)	(2)	(3)	(4)
I(Quality == Good)		52.964***		87.800***
		(5.247)		(10.378)
I(Buyer == Wholesaler)	0.085		−30.610*	−8.557
	(0.059)		(13.673)	(8.813)
I(Quality == Good)*I(Buyer == Wholesaler)				−38.768**
				(11.094)
Time of Season FE	Y	Y	Y	Y
Region FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Mean Dep. Var. - Urban Coaxers	0.7	284.1	284.1	284.1
Mean Dep. Var. - Wholesalers	0.61	251.1	251.1	251.1
Observations - All	310	310	310	310
Observations - Urban Coaxers	50	50	50	50
Observations - Wholesalers	260	260	260	260
Adjusted R^2	0.219	0.264	0.195	0.288
P-value [Urban Coaxer vs. Wholesaler]				0.00

Notes: This table shows the results of regressions related to the the quality of onion sold and the price received by banabanas in their transactions. Column (1) shows segregated differences in quality by actor type and displays the results of a regression where the dependent variable is a dummy variable for whether the onion sold is of good quality, and the independent variable is a dummy variable for whether the buyer is a wholesaler. Column (2) shows the unsegregated price/quality premium and displays the result of a regression where the dependent variable is the unit sale price and the independent variable is a dummy for whether the onion sold is of good quality. Column (3) reflects segregated differences in price by actor type and shows the results of a regression where the dependent variable is the unit sale price and the independent variable is a dummy variable for whether the buyer is a wholesaler. Column (4) shows the price/quality premium by buyer type and displays results of a regression where the dependent variable is the unit sale price and the independent variables are dummy variables for each buyer type, along with interaction terms between buyer type and a quality indicator. The reference buyer type in the four regressions is the urban coaxer. Geographical cluster-robust standard errors are listed in parentheses. Data used include the most recent purchase in the 2020-2021 season reported by banabanas in the actors' survey, data on up to 3 transactions from the 2019-2020 season reported by banabanas in the actors' survey, and transactions involving banabanas as the seller recorded in the transaction survey, and data on up to 3 transactions from the 2019-2020 season reported by banabanas in the actors' survey (where they report buying from banabanas). These do not include transactions with prices less than 100 FCFA/kg or more than 1000 FCFA/kg. In the actors' survey, prices and quantities are reported by the banabana. In the transaction survey, there may be prices and qualities reported by the buyer, seller, and/or intermediary (such as a coaxer). In cases where different actors provide different price information for the same transaction, the maximum of reported prices is used. In the most recent transaction data on the actors' survey, banabanas are not asked directly asked which type of actor they sold to, but rather whether they sold on consignment or directly. If they reply that they did sell on consignment, we suppose this was sold through an urban coaxer, and otherwise that they sold directly to a wholesaler or other actor. In the data on transactions from the 2019-2020 season, banabanas are asked the type(s) of actors they sold an entire truckload to. We code the indicator to be 1 if a type of actor was mentioned as one of the actor types sold to. We exclude from the analysis transaction which are marked as being sold both to an urban coaxer and another actor. The bottom panel of the table lists the p-value of an F-test of the differences between the price/quality premium coefficient estimates associated with selling to the 2 different buyer types. Stars indicate that a coefficient is significantly different from zero. Time of season fixed effects are coded as "early" if the transaction took place in January or February, "peak" if the transaction took place in March or April, and "late" if they took place after April. * indicates, $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 7: Bargaining Power Indicators for Producers and Rural Coaxers by Linkage Type

Seller type:	**Prod**	**Prod**	**RC**	**RC**
Buyer type:	**BB**	**UC/W**	**BB**	**UC/W**
Final price (FCFA/kg)	235.32	230.33	198.79	237.69***
	(38.82)	(44.25)	(52.74)	(46.95)
Ask price - final price	57.33	14.22**	18.21	9.52***
	(36.83)	(10.75)	(16.22)	(13.53)
Final price was fair (0/1)	0.91	1.00	0.92	1.00
	(0.30)	(0.00)	(0.27)	(0.00)
Negotiations were easy (0/1)	0.72	0.5	0.61	0.77
	(0.46)	(0.58)	(0.49)	(0.43)
N	37	26	207	26

Notes: The table displays weighted averages for variables related to the bargaining power of producers and rural coaxers by linkage type. Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct column means. The data is from the transactions' survey. Each column corresponds to a given seller type and a given buyer type. Rural Coaxers, denoted with "RC", are collectors at rural markets. Banabanas, denoted with the letter "BB", are traders that source from rural markets and sell at urban markets. Urban Coaxers, denoted with "UC", are collectors at urban markets. Wholesalers at urban markets are denoted with the letter "W". Stars indicate that a weighted average indicator value is statistically different from the mean in the "All" column. * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 8: Rural Coaxers' Perceptions of Market Dynamics

	Price Increases	Price Constant	Price Decreases
# BB increases	**0.67**	0.29	0.04
	(0.07)	(0.07)	(0.03)
# BB decreases	0.04	0.44	**0.51**
	(0.03)	(0.07)	(0.08)
# RC decreases	0.27	**0.67**	0.07
	(0.07)	(0.07)	(0.04)
# RC increases	0.09	**0.71**	0.20
	(0.04)	(0.07)	(0.06)
N	45	45	45

Notes: The table displays information about rural coaxer's reports of how prices change when demand for onions changes (proxied by the number of banabanas) and when the supply of onions changes (proxied by the number of coaxers). Each row corresponds to the scenario highlighted in the first column of the row. For each row/scenario, each column shows the share of rural coaxers that agree with the price change highlighted in the column header. Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct each mean. The numbers in bold suggest the majority response we would expect in a perfectly competitive market. Banabanas, denoted with "BB", are traders that source from rural markets and sell at urban markets. Rural Coaxers, denoted with "RC", are collectors at rural markets.

Table 9: Reported Cheating Behavior by Producers and Rural Coaxers

	RC's Cheat (Indicator) (1)	RC's Cheat (Freq.) (2)	Prod Say RC's Cheat (Freq.) (3)	Self Cheated (Freq.) (4)
Prod Say:	75.4%	66.9%	65.4%	48.8%
	(2.38)	(2.41)	(2.76)	(2.79)
N	648	349	371	415
RCs Say:	57.8%**	26.9%***	30.7%***	
	(7.45)	(5.52)	(6.93)	
N	45	20	28	

Notes: This table displays producers' (top panel) and rural coaxers' (bottom panel) perceptions on how frequently rural coaxers cheat producers by reporting false prices. Column (1) reports the share of producers and rural coaxers who think that rural coaxers cheat when they transact with producers. Column (2) shows the self-reported share of transactions for which producers and rural coaxers think rural coaxers cheat on producers. Column (3) shows the self-reported share of other producers' transactions for which rural coaxers cheat on these other producers. Column (4) shows the self-reported share of own transactions where the producer was victim of cheating from rural coaxers. Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct each mean. Note that estimated cheating frequency of actual cheating (as opposed to reported cheating) is only reported when actors claim that some cheating does indeed occur. Means in the producer row are weighted to be representative of sampling probability. Stars indicate the value in the second row is significantly lower than the value in the top row of the corresponding column in a weighted t-test of means. * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 10: Actors' Ease of Sale Perceptions by Quality and Linkage Type

Seller type:	**All**	**RC**	**RC**	**RC**	**BB**	**BB**	**UC**
Buyer type:	**All**	**BB**	**UC**	**W**	**UC**	**W**	**W**
Can easily sell good quality	0.96	0.95	1.00	0.94	0.97	0.96	0.96
	(0.20)	(0.23)	(0.00)	(0.25)	(0.18)	(0.2)	(0.20)
Can easily sell medium quality	0.6	0.55	0.5	0.44	0.52	0.66	0.88***
	(0.49)	(0.5)	(0.53)	(0.51)	(0.51)	(0.48)	(0.33)
Can easily sell bad quality	0.26	0.24	0.20	0.25	0.29	0.30	0.28
	(0.44)	(0.43)	(0.42)	(0.45)	(0.46)	(0.46)	(0.46)
Happy w/ price of good quality (%)	82	83	82	86	76	78	83
	(25)	(22)	(23)	(18)	(29)	(30)	(14)
Happy w/ price of medium quality (%)	65	60	55	62	61	67	71
	(28)	(24)	(29)	(27)	(36)	(34)	(15)
Happy w/ price of bad quality (%)	33	25	34	29	25	35	46
	(32)	(28)	(39)	(34)	(35)	(36)	(29)
N	184	38	10	16	31	73	25

Source is transaction data. For each seller type, stars denote being significantly different from "All" column.

Notes: The table displays averages over indicators of the ease at which actors can sell onion of different quality (top panel) and their satisfaction with the sale price of onion of different quality (bottom panel). The three rows in the top panel show the share of sellers that responded with "Easy" or "Very Easy" to the question "What is the ease at which you can sell onion of quality X?", where X is good, medium or bad. The three rows in the bottom panel show the mean share of transactions for which the seller is happy with the sale price for an onion of quality X, where X is good, medium or bad. Each column corresponds to a given seller type and a given buyer type. The "All" column includes data on all rural coaxers, banabanas, urban coaxers and wholesalers. Rural Coaxers, denoted with "RC", are collectors at rural markets. Banabanas, denoted with the letter "BB", are traders that source from rural markets and sell at urban markets. Urban Coaxers, denoted with "UC", are collectors at urban markets. Wholesalers at urban markets are denoted with the letter "W". Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct column means. Stars indicate that a weighted average indicator value is statistically different from the mean in the "All" column. * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.

Table 11: Participation in Multiple Nodes by Actor Type

Source/Actor Type	**Prod**	**RC**	**BB**	**UC**	**W**
1 Source , 1 Buyer (%)	94.4	52.6	19.2	28.0	61.5
1 Source , 2+ Buyer (%)	5.6	47.4	32.1	56.0	0.0
2+ Source , 1 Buyer (%)			15.4	0.0	38.5
2+ Source , 2+ Buyer (%)			33.3	16.0	0.0
N	638	38	78	25	26

Notes: This table shows the share of actors that acquired onion from one vs. multiple seller types and sold onion to one vs. multiple buyer types in the 2019-2020 season, by the actor type indicated in each column heading. Rural Coaxers, denoted with "RC", are collectors at rural markets. Banabanas, denoted with the letter "BB", are traders that source from rural markets and sell at urban markets. Urban Coaxers, denoted with "UC", are collectors at urban markets. Wholesalers at urban markets are denoted with the letter "W". Buyer types for producers are rural coaxers, banabanas, urban coaxers, wholesalers and others actors further downstream of the chain. Averages for producers are weighted to reflect the probability of being sampled. Buyer types for rural coaxers are banabanas, urban coaxers, wholesalers, and others actors further downstream of the chain. Source types for banabanas are producers and rural coaxers. Buyer types for banabanas are urban coaxers, wholesalers, and others. Source types for urban coaxers are producers, rural coaxers, and banabanas. Buyer types for urban coaxers are wholesalers and others. Data from the original actors survey is used for producers and urban coaxers, while phone survey data is used for rural coaxers and banabanas.

Table 12: Actors Ability to Change Buyer Types

	All	**RC**	**BB**	**UC/W**
Can choose buyer type	0.47	0.51	0.41	0.49
	(0.5)	(0.5)	(0.49)	(0.5)
Did/will change buyer type	0.21	0.28**	0.16	0.17
	(0.41)	(0.45)	(0.37)	(0.37)
Did/will change location	0.15	0.20*	0.11*	0.13
	(0.36)	(0.4)	(0.31)	(0.34)
N	648	289	262	124

Notes: The table displays weighted averages over indicators of whether producers can choose their buyer type, whether they have or plan to switch the buyer type relative to the previous year, and whether they have or plan to switch the location type relative to the previous year. Standard errors are listed in parentheses, and "N" denotes the number of observations used to construct column means. Weighting adjusts for the probability of being selected in the sample. Rural Coaxers, denoted with "RC", are collectors at rural markets. Banabanas, denoted with the letter "BB", are traders that source from rural markets and sell at urban markets. Urban Coaxers, denoted with "UC", are collectors at urban markets. Wholesalers at urban markets are denoted with the letter "W". The "All" column includes data on all producers, whereas the other columns include only producers that have reported transacting with the actor type in the column heading during the 2019-2020 or 2020-2021 season. Stars indicate that a weighted average indicator value is statistically different from the mean in the "All" column. * indicates $p < 0.1$, ** indicates $p < 0.05$ and *** indicates $p < 0.01$.