

Market Integration and Price Transmission in Major Onion Markets

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ABSTRACT

Onion is a bulky, perishable and politically sensitive vegetable, and its prices in India swing sharply between seasons and between markets. Whether a shock in one wholesale market is passed on to others, how quickly, and how completely, matters to growers, traders and the officials who decide on stock limits and export rules. This narrative review examines how market integration and price transmission have been defined and measured, and what the published work suggests for major onion markets. It draws on the econometric literature on unit roots, cointegration, error-correction and threshold models, on studies of asymmetric transmission, and on research on information, transport and trade policy in agricultural markets, and it reports no new price data. The main finding is that conclusions depend heavily on the method chosen, on whether prices are daily, weekly or monthly, on how markets are grouped in space, and on whether policy interventions such as export bans and stock limits are treated as structural breaks. Data quality, missing observations and the inability to separate transfer costs from market power add further doubt. Integration is best regarded as a matter of degree, and reports of strong or weak transmission should be read alongside the design that produced them. The review closes with a checklist for more transparent studies of onion and other perishable crops.

Keywords: Onion markets; Market integration; Price transmission; Cointegration; Threshold models; Asymmetric adjustment; Narrative review

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1. Introduction

Few vegetables attract as much attention from consumers and policymakers as the onion. It is a daily staple in Indian kitchens, it is grown by very many small farmers, and its price can double or halve within weeks. When it rises sharply, it makes news and sometimes moves governments to act; when it collapses, growers are left with a crop that costs more to harvest and carry than it fetches. The question that links these episodes is simple to state. When a shock occurs in one market, how far,

how fast and how evenly is it felt in others?

Economists describe this question with two related ideas. Market integration concerns whether prices in separate places share a common long-run path, so that arbitrage by traders keeps them from drifting apart [1, 2]. Price transmission concerns the dynamics: the speed and completeness with which a change in one price, at one place or one stage of the supply chain, shows up in another [3, 4]. The two are not identical. Markets may be linked in the long run and still adjust slowly, or

adjust quickly in one direction and sluggishly in the other.

A considerable body of work has applied time-series methods to these questions, beginning with correlation of price levels and moving through cointegration, error-correction and threshold models [5, 6, 7]. The results are often presented as if they measured a fixed property of the markets. This review argues for a more cautious reading. What a study finds about onion markets depends on how prices were sampled in time and space, on which statistical model was fitted, on whether government interventions were modelled, and on how reliable the underlying price records are. The aim is a fair account of what is known and what is merely repeated.

The article is a narrative review. It draws on published work in agricultural and development economics and in econometrics, and it deliberately reports no new price data and no numerical estimates from individual onion studies. Where evidence on onion is thin, we say so, and we describe what a convincing study would need to show, instead of quoting figures that we could not check against their sources.

2. Literature Review

2.1 Concepts: Integration, Arbitrage and the Law of One Price

The starting point is the law of one price: if a homogeneous good can be moved between two places at a known cost, the price gap should not exceed that cost for long, because traders would profit by buying where the good is cheap and selling where it is dear [2, 8]. In practice goods are not homogeneous, costs are not known, and traders do not respond instantly. Integration is therefore best seen as a tendency, not a switch. Early tests asked whether prices in a set of markets responded to a price in a central market, and treated a full and timely response as evidence of integration [1].

Two warnings recur in the literature. First, a high correlation of price levels does not demonstrate integration, because two unrelated series that both trend upwards can appear tightly linked [9]. Second, price co-movement does not by itself tell us whether trade is flowing. Markets that share a common supply shock, such as a regional monsoon failure, can move together without any trade between them, and markets that trade heavily can show an ambiguous price gap if transfer costs vary [10]. A careful study therefore says what it is testing: a long-run relationship, an arbitrage condition, or a pattern of leadership. This is why

the same pair of markets can look tightly linked in one report and loosely linked in the next.

2.2 Unit Roots and Cointegration

Most modern work begins by asking whether each price series is stationary or has a unit root, meaning that shocks leave a permanent mark. The standard tools are the Dickey-Fuller family of tests [11, 12], the Phillips-Perron correction for serial correlation [13], and the KPSS test that reverses the null hypothesis [14]. These tests have well-known weaknesses: they have limited power against persistent but stationary alternatives, and their results change if a structural break is ignored [15]. Prices of a perishable crop that are shaped by seasonal arrivals and sporadic policy shocks are exactly the kind of series on which such problems bite.

If prices are non-stationary, the next question is whether a linear combination of two or more of them is stationary, which is the definition of cointegration. The two-step residual-based method [5] and the system approach based on maximum likelihood [6, 16, 17] are the workhorses. The system approach can handle several markets at once and can test the number of independent long-run relations, but it is sensitive to the choice of lag length and deterministic terms. A third route, the bounds approach, allows the analyst to proceed when it is unclear whether the series are stationary or not [18]. Table 1 sets out the main approaches and their main weaknesses, so that each claim can be read against its assumptions.

Table 1. Main approaches to testing market integration and what each can and cannot show.

Approach	Main idea	Chief limitation
Correlation of price levels	Prices that move together are linked [1]	Common trends can produce spurious links [9]
Cointegration	Long-run equilibrium between price series [5, 6]	Assumes constant adjustment and no breaks
Error-correction model	Speed of return to equilibrium after a shock [5, 19]	Usually symmetric and linear
Threshold models	No adjustment until the gap exceeds transfer costs [7, 25]	Choice of regimes, many parameters
Parity bounds	Price gap compared with transfer cost [8, 43]	Needs good transfer-cost data
Granger causality	Which market leads which [44]	Predictive, not structural

Note: Qualitative summary of the methodological literature; the approaches are not mutually exclusive.

2.3 Error Correction, Asymmetry and Speed of Adjustment

Cointegration says that a long-run link exists. The error-correction representation says how quickly a gap between prices is closed, and in which market the adjustment occurs [5, 19]. In a study of two onion markets, for example, it tells us whether the price in the smaller market follows the larger one, or the reverse, or both. This is the form in which most applied claims about transmission are made, and it carries the assumption that the speed of adjustment is the same whether the gap is positive or negative and whether it is small or large.

That assumption is often wrong. Many studies across products and countries report that prices respond differently to increases and decreases, with retail or downstream prices rising more readily than they fall [4, 20]. Reasons proposed include market power, adjustment costs, search costs and the inventory behaviour of traders, and the literature does not agree on which dominates [21]. For a perishable crop the asymmetry may have a physical origin as well: a trader holding stock that is rotting cannot wait for a better price, so falls may be passed on faster than rises. Studies of spatial transmission in maize in Ghana and of pork in Switzerland show how the same idea has been tested in different settings [22, 23].

How the speed of adjustment is described deserves a word. A coefficient on the error-correction term says what fraction of a gap is closed in one period, so its meaning depends on the period. A slow coefficient on daily data and a faster one on monthly data can describe the same market. Some studies convert the coefficient into the time that half of a shock takes to disappear, which is easier to interpret but inherits every assumption of the model. Impulse-response and spillover approaches offer an alternative description that is less tied to a single coefficient [16, 24].

2.4 Threshold and Regime-Switching Models

If trading is costly, there is a band within which a price gap is not worth exploiting. Inside the band, prices in two markets can wander without any pull toward each other; outside it, arbitrage pulls them back. Threshold cointegration builds this idea into the model [25, 26], and applications to agricultural markets have found that adjustment often appears only when the price gap is large [7]. Tests for a threshold in a vector error-correction setting exist [27], as do models in which the economy switches between regimes governed by an unobserved state [28].

These models are attractive for onion because the transfer cost is not constant. It depends on the season, the state of the roads, the quality of the lot and the number of trucks available, all of which vary. A threshold model replaces a single speed of adjustment with at least two, which is closer to what traders describe. The price of that realism is more parameters, more choices about the number of regimes and the variable that defines them, and greater demands on the data. Where observations are few, a threshold model can fit noise, and a finding of a threshold should be treated as a hypothesis rather than a measurement. A market that has had time to adjust behaves differently from one caught mid-adjustment.

2.5 Structural Breaks, Policy and Volatility

Government interventions affect the series that economists model. Export restrictions and related measures are known to change the relation between domestic and world prices, often insulating one while exacerbating the other [29, 30], and the transmission of world prices to domestic ones has long been known to depend on policy [31]. In the case of onion, bans on export, minimum export prices, limits on how much a trader may stock and release of buffer stock have all been used at various times. Each can alter the speed of transmission or break the long-run relation altogether. A test of cointegration that ignores such events may reject integration for a reason that has nothing to do with trade costs, and tests that allow a shift in the relation or in the trend can give a different answer [32, 33].

Volatility is a related theme. Storage links prices over time, and for a crop that can be stored only for a limited period the link is weak and nonlinear [34]. Measures of how volatility spills over between markets provide another way to describe integration, one that does not require the series to be cointegrated [24]. These alternatives are useful in onion, where the dominant feature of the data is often a spike rather than a smooth trend, but they too rest on modelling choices that must be reported.

2.6 Information, Infrastructure and Market Structure

Statistical findings need an economic reading, and the literature on why markets are or are not integrated is therefore relevant. Better roads reduce transfer costs, and evidence on the effect of distance and road quality on marketing margins comes from several settings [35]. A historical study of railways in colonial India found that lower trade costs narrowed price gaps between regions

and raised real incomes [36]. Information matters as well: studies of mobile phones in Niger and of fishing in southern India show that prices converged more closely once sellers could see them in more than one market [37, 38], and research on direct access to farmers in central India points the same way [39].

Competition among intermediaries is the last piece. Work on imperfect competition shows that apparent integration can hide the exercise of market power, and apparent segmentation can reflect efficient adjustment to transfer costs [2, 8]. Studies of potato trade in West Bengal highlight the role of information gaps between farmers and middlemen in shaping margins [40], and work on trader entry shows that the response of prices to distant shocks depends on how easily new traders can enter [41]. Liberalisation of agricultural trade is often argued to improve integration, and applied work on Ethiopia shows how that claim can be examined with the tools described above [42].

3. Materials and Methods

3.1 Scope and Question

The review asks a single question in two parts: how have integration and transmission been defined and tested in agricultural markets, and how robust are the conclusions that bear on major onion markets in India? The question was divided into sub-questions that any empirical study would have to answer: what prices were used and at what frequency, how markets were chosen and grouped, which models were fitted and how their assumptions were checked, how policy events were handled, and how the findings were interpreted. None of these choices is difficult to make, but each one is easy to leave unstated.

3.2 Literature Assembly

The review draws on peer-reviewed work in four areas: the theory of spatial arbitrage and integration; time-series econometrics for unit roots, cointegration and threshold adjustment; empirical studies of price transmission in food and agricultural markets; and research on information, infrastructure, trade policy and competition. Sources were chosen for relevance, influence in the field and clarity of method. Studies of other commodities and countries are used for what they teach about method, not as evidence about onion.

We did not run a formal systematic search and we do not claim one. This is a narrative synthesis, and the choice of sources reflects the authors' judgement. The practical consequence is that the review is a better guide to how studies should be

designed and read than to the exact size of any transmission coefficient, and it avoids quoting numerical estimates from individual onion studies that could not be checked against the primary papers for this article.

3.3 Appraisal Framework

To judge how far a report can be trusted, we used a short framework with four questions. Are the price series suitable for the method, with stationarity examined appropriately and breaks allowed for [11, 15]? Is the model form compatible with what is known of the market, in particular with the possibility of thresholds and asymmetry [21, 25]? Are transfer costs and policy regimes accounted for [8, 29]? And are the data described well enough that a reader could judge their quality? Table 2 lists the main reasons why two studies of onion can disagree.

Table 2. Why a study of onion markets can reach a different answer from another.

Source of difference	What varies	Possible effect on findings
Time aggregation	Daily, weekly or monthly prices	Adjustment looks faster or slower
Spatial aggregation	Mandi, district, state or region	Local shocks averaged out
Policy regime	Export bans, stock limits, duties [29, 30]	Apparent structural break
Data quality	Gaps, grade mixing, reporting errors	Biased tests, low power
Model form	Linear or threshold, symmetric or not [4, 21]	Different adjustment speed
Deterministic terms	Trend, season, break dates [15, 33]	Unit-root and cointegration results change

Note: Drivers are those discussed in the cited methodological and policy literature; direction of bias depends on the case.

4. Results

4.1 What Determines the Link Between Two Onion Markets

Onion is a bulky, perishable crop that can be held only for a limited time under ordinary storage. Harvest is concentrated in a few seasons, and production is geographically concentrated, so that supply to a given consumption centre often comes from several distant regions in turn. As a result the identity of the market that sets the price changes through the year. A pair of markets that are tightly linked while the same region supplies both may be only loosely linked when supply shifts to another region. A model with a single fixed relation across the whole sample cannot represent this.

The layers between farm and wholesale also matter. A shock at the farm gate passes through village traders, a regional wholesale market, longer-distance transporters and a terminal market before it reaches the retail price (Figure 1). At each layer there are costs, margins and delays, and each may adjust at a different pace. A study that observes only two wholesale prices sees the combined effect of all the layers between them and cannot say where a delay arises. Such differences look small in a single week, but they decide how long a glut or a shortage lasts.

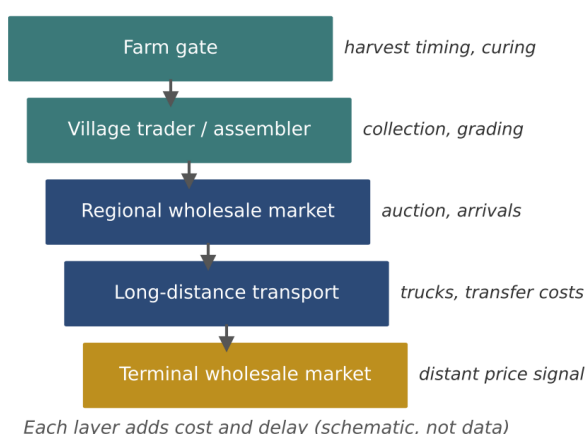


Figure 1. Layered view of what lies between a farm-gate shock and a distant wholesale price (schematic, not data).

Storage complicates the picture further. Onion can be cured and held in ventilated structures for part of the year, and a trader who stores is in effect trading across time as well as across space. When stocks are drawn down, prices in a distant market may be set by what is in store locally and not by what is arriving from elsewhere, and the link to other markets weakens until fresh supply resumes. Work on commodity price behaviour shows why storage makes price dynamics nonlinear: stocks cushion some shocks and cannot cushion others [34]. A model that ignores storage will treat these swings as changes in integration.

4.2 Time Aggregation and Frequency

The frequency of the data influences the answer. Aggregating daily prices to weekly or monthly averages smooths out short-run movement and can make adjustment appear faster than it is, because lags shorter than the sampling interval are hidden. Conversely, daily series from regulated markets may contain days without arrivals or with a posted rather than a transacted price, which adds noise. The same caution applies to onion, where trading in many markets follows a weekly rhythm and arrivals bunch around particular days.

Two studies that use the same pair of markets but different frequencies can therefore report different speeds of adjustment without either being wrong. The honest comparison is between designs, not between headline coefficients. A reader who wants to compare estimates across studies should first check that the sampling interval, the price definition and the sample period are aligned. Read this way, a failure to find a link in a short, patchy series is not evidence that none exists.

4.3 Spatial Aggregation and Choice of Markets

The choice of markets is the second major source of variation. A study that picks one very large wholesale market and a few of its neighbours will probably find strong links, because large markets are hubs and neighbours trade with them. A study that picks markets scattered across states may find weaker links, because they are connected only indirectly and because policy and seasonality differ. Averaging across markets in a district or state can hide local disruptions, and it can also produce a series that no actual trader faces.

Selection of markets is seldom random. Researchers use markets for which data are available and long, which tends to favour the larger and better-organised ones. Findings from such markets may overstate integration in the system as a whole, since the thin and remote markets that are most affected by transfer costs are the least observed [35, 41]. The point is not to criticise the practice, which is often unavoidable, but to flag that conclusions apply to the markets studied and are not automatically national.

4.4 Model Choice, Thresholds and Asymmetry

Linear models with constant adjustment are the default, and they can mislead when adjustment is in fact regime-dependent. If prices respond only when the gap between markets exceeds the cost of moving onion, a linear model averages the strong response outside the band with the absence of response inside it, and reports a weak, slow average [7, 26]. A threshold model can recover the pattern, but it demands a long series and gives results that depend on how the regimes are defined (Figure 2). Asymmetric adjustment adds another dimension, since price rises and falls may be transmitted at different rates [20, 23]. Neither description is wrong, but each answers a different question.

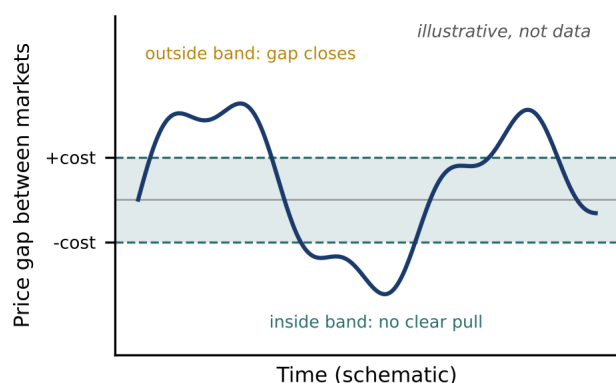


Figure 2. Idea of a threshold model: little response inside the band, adjustment outside it (schematic, not data).

The practical result is that a given dataset may support quite different narratives under different specifications. A linear model may suggest slow integration; a threshold model, rapid adjustment once a gap is large; and an asymmetric one, quick pass-through of falls and slow pass-through of rises. Each is a legitimate description of one aspect of the data, and the competing conclusions are a feature of the evidence rather than an error to be resolved by choosing the most appealing. The point is not that a study is poor, only that its conclusion travels less far than its abstract suggests.

4.5 Policy Interventions, Data Quality and Interpretation

Interventions are the third challenge. Bans on export remove a source of demand and can cause domestic prices to fall relative to world prices [29, 30], while stock limits can discourage the storage that otherwise links prices across time [34]. When such measures are in force, domestic markets may appear more tightly linked to one another, since all are cut off from the same external demand, while their link to external prices is broken. When they are lifted, the relation can shift again. Treating an intervention as a dummy variable or a break date can help, but only if its timing and intensity are known [32, 33].

Data quality limits all of this. Wholesale price records are usually modal or average prices reported by market committees; grades and varieties are mixed; days of closure create gaps; and reporting practices differ between markets. Interpolating missing observations, a common remedy, invents precisely the smoothness that tests rely on. Measurement error in one series can lower the apparent speed of adjustment, while mixing of grades can create apparent price differences that are not arbitrage opportunities at all. In many studies these problems are

acknowledged in a sentence; here they deserve a place alongside the model choice (Table 3).

Taken as a whole, the literature supports only a cautious statement. Onion markets that share a supply region or a major hub are likely to be linked in the long run; the speed and symmetry of adjustment, however, depend on season, direction of the shock, transfer costs and policy regime. How large the transmission is, and how fast, cannot be read from any single study. The best summary is that integration is a matter of degree and context, and that studies which report one number for it are reporting one realisation of a design. That is a modest claim, and it is the one the literature can currently bear.

Table 3. Checks that make a study of price transmission easier to trust.

Question	Why it matters	Where to look
Are prices stationary or not?	Wrong tests give wrong inference [11, 14]	Unit-root tables, break-robust tests
Is the lag length justified?	Residual correlation distorts tests [16]	Diagnostics reported
Were policy dates modelled?	Bans can mimic non-integration [15, 32]	Dummy or break specification
Is the price comparable?	Grade, quality and unit differ	Data appendix
Are transfer costs considered?	Gap may be cost, not friction [8, 10]	Cost assumptions stated
Is asymmetry tested?	Rise and fall may differ [20, 22]	Asymmetric terms reported

Note: A reading guide drawn from the cited literature, not a reporting standard.

Figure 3 gathers these threads into a single qualitative matrix. It does not rank studies and carries no numbers; its purpose is to show that each design decision tends to bear on one or two aspects of the conclusion, so that the aspects most at risk can be identified before the results are read.

5. Discussion

5.1 Interpretation and Practical Reading

The main finding of this review is conditional. Evidence from agricultural markets in general suggests that price gaps between markets narrow when transport improves and information flows [36, 37, 38], but it also shows that the adjustment is neither fast nor symmetric in all cases [4, 21]. For onion, where seasonal shifts in supply and recurrent policy change are the rule, a single estimate of integration is unlikely to describe the whole period of a long series. Nothing in this reading argues against empirical work; it argues for saying plainly what each design can and cannot

show.

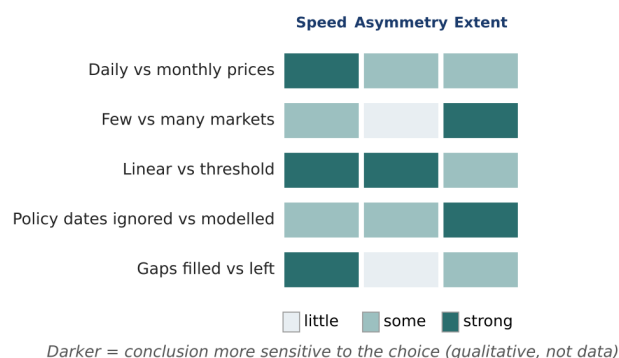


Figure 3. Qualitative matrix of how modelling choices bear on the conclusions of a study (schematic, not data).

A second conditional concerns the reading of weak transmission. It is tempting to treat slow or partial transmission as proof of inefficiency or of market power. The literature cautions against that step. Slow adjustment may be an efficient response to transfer costs, perishability, or uncertainty, and apparent segmentation may reflect a price gap within the arbitrage band [2, 8, 10]. Distinguishing these explanations requires information on costs, trade flows and trader behaviour, not just on prices.

A third point concerns policy. Because interventions can break long-run relations, a study that treats a period containing several interventions as one regime may attribute to the market what is really the effect of the rule. This matters for officials who rely on such studies when they judge whether a measure worked, since an intervention can alter the very relation used to evaluate it [29, 43]. The responsible reading is to ask how the result changes when the intervention is modelled explicitly. These points apply with equal force to other perishable crops, not only to onion.

A fourth consideration is who bears the consequences of poor transmission. If a fall in a terminal market is passed back quickly to the farm gate while a rise is passed back slowly, growers lose in both directions, and the asymmetry literature offers several candidate reasons without settling which applies [4, 20]. If information is poor, farmers may sell to the first trader who arrives and accept a margin that reflects ignorance as much as cost [39, 40]. These distributional questions cannot be answered by testing for cointegration alone, though a careful transmission study can narrow the range of plausible explanations.

Three findings would change this reading. A long, high-quality, high-frequency price record for several onion markets, with policy dates known, showing stable adjustment across regimes would suggest that the fragility described here is smaller than we have argued. Evidence that trade flows track price gaps closely would strengthen the arbitrage interpretation of thresholds [10]. And a comparison of the same data under several specifications, reported openly, would show how much of the variation between studies is due to method.

5.2 Limitations

This is a narrative review and shares the limitations of that form. The selection of sources reflects judgement, no formal search or quality scoring was done, and the review does not quote numerical estimates from individual onion studies, because these could not be checked against the primary reports for this article. A reader who needs an estimate of transmission for a particular pair of markets should consult the original studies directly, applying the appraisal questions above, or wait for a formal systematic review that applies explicit inclusion criteria.

The review also draws on evidence from other commodities, countries and historical periods, which are imperfect proxies for present-day onion markets in India. Studies of fish, grain, pork and potato describe goods with different storage and trading characteristics. We have used them to frame hypotheses and to illustrate methods, and the conclusions should be read in that light. Reviews of this kind are more useful when they say where the evidence stops than when they smooth it over.

5.3 Implications for Study Design

A study that could add to knowledge would state the price definition, grade and unit, and the frequency and period of the data. It would test stationarity with methods that allow for breaks [14, 15], report the lag-selection procedure, and examine whether the cointegrating relation is stable [16, 32]. It would compare linear and threshold specifications on the same data, test for asymmetry, and show how the key results change across specifications [26, 27]. It would state what is assumed about transfer costs and why.

On the policy side, the study would list the interventions in force during the sample, with dates, and model them as breaks or regimes instead of leaving them to the error term [28, 33]. It would report diagnostics for residuals, discuss the possibility of omitted common shocks such as

weather, and avoid reading leadership between markets as proof of causation in a structural sense [44]. These requirements are demanding, but they distinguish a result that can be relied on from one that only demonstrates that a method can be run.

5.4 Directions for Future Work

Three needs stand out. First, a formal systematic review of onion price transmission studies, with transparent search and appraisal, ideally supported by a comparison of results under common specifications. Second, studies that bring price data together with trade-flow, arrival and transport-cost data, so that integration and the mere co-movement of prices can be told apart [8, 10]. Third, work on information and market structure in onion trade, drawing on the experimental and quasi-experimental methods used for other crops [39, 40].

5.5 Practical Reading for Traders and Officials

For a trader or an adviser, the sensible position is neither to dismiss econometric findings nor to treat them as laws. A claim that prices in one market lead another is a statement about a sample, and it may not hold in the next season. Officials weighing a stock limit or an export measure can ask whether the evidence they are shown separated the effect of the measure from the underlying seasonal pattern, whether alternative models were tried, and whether the data cover the markets that are actually affected.

Such questions do not require econometric training. They require the study to be written in a way that makes the design visible. A short table of design choices, similar to the checks gathered in Table 3, would let a non-specialist judge in a few minutes how much weight a claim deserves. The broader question of how closely onion markets are integrated will be settled by transparent, comparable studies and not by any single headline figure [3, 24].

There is also a role for modesty in how findings are reported to the press and to the public. A statement that onion prices in one city are driven by another is easy to repeat and hard to qualify. A more accurate statement would give the period, the frequency of the data and the method, and say that adjustment may differ between seasons and between rises and falls. Such qualification is not hedging for its own sake; it is the information a reader needs to decide whether the result applies to the question in front of them.

6. Conclusion

Onion markets are plausibly linked in the long run, and the econometric literature offers a rich set of tools for describing how shocks travel between them. The evidence, as we can responsibly summarise it, does not support a single statement about how strong or how fast the transmission is. Results depend on the method, on the way time and space are aggregated, on how policy interventions are treated, on the quality of price records, and on whether asymmetry and thresholds are allowed. Readers should treat headline claims of tight integration or of pervasive segmentation with caution until they meet the standards described here.

For the practitioner the message is practical rather than discouraging. Studies can be read with a short list of design questions, and those that answer them openly are more useful. For the researcher, the opportunity is a set of transparent, well-documented comparisons across specifications, with policy dates and transfer costs stated, that turn a pile of divergent estimates into a coherent picture of how onion markets actually work.

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9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

A.P. conceived the review and wrote the sections on onion markets and policy. S.H. wrote the sections on price-transmission concepts and asymmetry. L.M. wrote the sections on econometric methods and data. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No human participants or animals were involved and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

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