# Lecture 5: Supply responsiveness

Supply responsiveness

* Spatial & Temporal Price Analysis
* Market Integration
* Parity Bounds Model (supplemental)

*Readings*

* Barrett C. (2008) “Spatial Market Integration” in Durlauf, S., and Blume, L., ed. New Palgrave Dictionary of Economics. <http://www.dictionaryofeconomics.com/article?id=pde2008_S000448>
* World Food Program (2008) “PDPE Market Analysis Tool: Market Integration.” <http://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp187901.pdf>
* Lentz, E.C. (2011) “LRP: Monitoring and Analyzing Data 25 March 2011.doc”. Draft. <http://dyson.cornell.edu/faculty_sites/cbb2/MIFIRA/apps/>
* Lentz, E.C. (2011) “Lentz 11 LRP Price Analysis - How Prices Change.ppt” <http://dyson.cornell.edu/faculty_sites/cbb2/MIFIRA/apps/>
* Lentz, E.C. (2011) “Lentz 12 LRP Price Analysis – Approaches to Analysis.ppt” Draft. <http://dyson.cornell.edu/faculty_sites/cbb2/MIFIRA/apps/>
* “Maize Kenya price series detrend and deseasonalize.xls” <http://dyson.cornell.edu/faculty_sites/cbb2/MIFIRA/apps/>

*Supplementary Readings*

* Fackler, P.L. and B.K. Goodwin (2001) “Spatial Price Analysis,” in G. Rausser and B. Gardner, eds., *Handbook of Agricultural Economics*, Amsterdam: Elsevier.

 [doi:10.1016/S1574-0072(01)10025-3](http://dx.doi.org/10.1016/S1574-0072%2801%2910025-3)

<http://www.sciencedirect.com/science/article/pii/S1574007201100253>

This lecture focuses on market integration tools/analytics. Market integration analysis can explain how well prices for the same commodity across different markets are spatially connected or how prices for a commodity within a market over time are related.

Analysts with less familiarity with price analysis should review the document and accompanying powerpoints created in 2011 for the LRP Learning Alliance on monitoring and analyzing price data. See:

* Lentz, E.C. (2011) “LRP: Monitoring and Analyzing Data 25 March 2011.doc”. Draft.
* Lentz, E.C. (2011) “Lentz 11 LRP Price Analysis - How Prices Change.ppt” Draft.
* Lentz, E.C. (2011) “Lentz 12 LRP Price Analysis – Approaches to Analysis.ppt” Draft.

In addition, the spreadsheet “Maize Kenya price series detrend and deseasonalize.xls” works through an example of how to deflate, deseaonalize, and then correlate historical maize price series across several markets in Kenya.

*How does analyzing market integration assist in answering the relevant MIFIRA sub-question?*

*1c. How much additional food will traders supply at or near current costs?*

Spatial and temporal price analysis tools, such as those typically used in market integration studies, can shed considerable light on the likelihood that traders can readily access food in other, larger markets without driving up local food prices significantly.

*2a. Where are viable prospective source markets?*

Markets with which the target recipient market is already well linked are typically not good candidates for local or regional procurement that aims to supplement food availability in the recipient market.

*2b. Will agency purchases drive up food prices excessively in source markets?*

Spatial and temporal price analysis tools, such as those typically used in market integration studies, can shed light on the likelihood that cash or voucher transfers might drive up food prices significantly in recipient markets (see question 1c), as well as help us understand likely food price effects in potential source markets by informing our understanding of supply responsiveness.

*2c. Will local or regional purchases affect producer prices differently than transoceanic shipments?*

Spatial and temporal market integration analysis helps us to identify whether demand or supply side interventions (LRP or transoceanic shipments, respectively) will have differential price effects in local markets, with possible implications for local growers and processors.

If we seek to understand how local supply might respond to an increase in local demand due, for example, to cash transfers or the provision of food vouchers, or a decrease in local demand due to the provision of food aid, the first question to explore is how well integrated the local market is with external markets, either within the country or beyond the target country’s borders. If local retailers and wholesalers can readily draw on other markets with which the local market is already well-integrated, this sharply limits the likely price effects of any local demand stimulus caused by food security interventions. Similarly, food distribution mainly displaces net food imports into the market (i.e., increases outflows or decreases inflows) if the local market is well-integrated with other, larger markets.

By contrast, interventions in spatially (or intertemporally) segmented markets tend to have greater price effects in equilibrium. In this lecture we explore these effects and how one measures and tests for market integration.

The basics of these effects are readily understood through a simple supply-and-demand graphic like that below. Imagine cash or voucher transfers shift just the local demand curve. Price will almost surely rise because of the limits to purely local aggregate supply response, especially in the short run. But if the market is well integrated with external markets, the local market faces a far more elastic supply because there are more places from which it can draw a commodity to meet increased local demand. Similarly, if food is distributed locally, thereby shifting both market demand and supply curves, prices will change far less in a market that is integrated with external markets than in an autarkic/segmented local market.

Market integration thereby plays a fundamental role in managing risk associated with demand and supply shocks, including those due to unanticipated food security interventions. Well-integrated markets facilitate adjustment in commodity trade across space and in storage over time, thereby reducing price variability faced by consumers and producers. In many low-income areas, however, poor communications and transport infrastructure, limited rule of law, and restricted access to commercial finance sharply limit the degree to which markets function as effectively as textbook models typically assume. A longstanding literature documents both the institutional constraints to market development (see, for example, related books by Jean-Philippe Platteau 2000 and Marcel Fafchamps 2004) and the considerable commodity price variability across space and seasons in developing countries, with various empirical tests of market integration suggesting significant and puzzling foregone arbitrage opportunities (see the survey paper by Fackler and Goodwin 2001).

Price

Quantity

Slocal

Sexternal

Dlocal

Paut

Pint

*The Theory of Market Integration*

Ultimately, we want to establish whether commercial market intermediaries are likely to respond to a demand or supply shock by adjusting flow volumes and the extent to which prices will change as a result. There are two distinct concepts of “market integration” in the literature.

1. One conceptualization focuses on ‘tradability’, the notion that a good is traded between two markets or that market intermediaries are indifferent between exporting from one place to another and not doing so. Tradability signals the transfer of excess demand from one market to another, as captured in actual or potential physical flows. Positive trade flows are sufficient to demonstrate spatial market integration under the tradability standard. Note, however, that the tradability view of market integration does not require that prices comove across markets.
2. An alternative – and in the food security literature, more common – conceptualization focuses instead on price comovement and tends to ignore physical commodity flow patterns. The core idea here is one of ‘competitive spatial equilibrium’ reflected in zero marginal profits to arbitrage (i.e., buying low in one market in order to sell high in another). In spatial equilibrium the dispersion of prices in two locations for an otherwise identical good is bounded from above by the cost of arbitrage between the markets when trade volumes are unrestricted and bounded from below when trade volumes reach some ceiling value (for example, associated with a trade quota). This gives rise to a “price band” that relates a central market price (Pc, which could be the global market price – we will talk about import parity prices next lecture), to the local market price.

The price band is depicted in the attached figure. Given fixed and variable costs of trade, spatial equilibrium implies that the local market price will not rise above Pi, at which point local traders would import without limit from the central market, and will not fall below Px, at which point local traders would export without limit to the central market. If the market indeed operates competitively and there is trade between markets (or if traders are indifferent between trading or not), then Pc will comove perfectly with local market prices.

Quantity

Pc

Px

Variable cost

Pi

Fixed cost

Supply

Demand

Nontradables price band

Conversely, if the costs of trade with the central market are so great that the price band becomes quite wide, the local market may be segmented from the central market in spatial equilibrium. That implies that local demand and supply conditions determine local market prices. In the case of segmented markets, there would be no price comovement between the local price and Pc.

The spatial equilibrium concept of market integration thus depends on central market prices, local supply and demand conditions (and thus what the local market-clearing price would be in the absence of trade, often called the “autarkic price”), marketing costs (transport, credit, labor, security, tariffs and other taxes, risk premia, etc.), and trade flows.

Note that if markets are well integrated, then trade volume adjustments absorb all demand and supply shocks because imports or exports adjust volumes at the edge of the price band. But if markets are not well integrated, then local prices have to adjust to accommodate demand and supply shocks, including those created by food security interventions such as cash, voucher or food distribution.

The most common technique for trying to establish whether markets are integrated or segmented, following the concept of spatial equilibrium, is to study price comovement. This is mainly a matter of expediency because price series are typically far easier to find than cost series and it can be difficult and time-consuming to estimate local demand and supply curves.

*Spatial price analysis*

In practical terms, time series of prices are typically the best a field analyst can access on short notice. So the first step is to acquire and examine the price time series one can obtain. Governments typically track prices routinely in major urban areas. FEWS NET, FAO GIEWS and others commonly track and publish these prices, as do some newspapers and web sites (e.g., the Regional Agricultural Trade Intelligence Network on east Africa, <http://www.ratin.net/>).

* 1. *Price data*

The first task is to make sure that data are comparable. Find out how, where and when the data are collected. In particular, make sure the commodity measured is really the same across markets and/or over time. Common errors include:

* comparing retail series in one market against wholesale series in another. Wholesale price series are typically preferable because we are ultimately most interested in trader responses.
* comparing raw commodity prices (e.g., paddy, granular maize) with processed products made from those commodities (e.g., polished rice, maize meal).
* failing to convert prices to a common currency and to a common physical unit of account (e.g., tons) so that the prices are expressed identically (e.g., US$/metric ton).
* having different frequency data – e.g., monthly from one place, weekly from another – and not matching up periods correctly.
* being unclear as to whether the price series are day-specific observations (i.e., a price recorded on a particular day or a price that is the average of multiple observations during a single day) or a period average (i.e., the mean of daily observations over a period). The latter naturally smooths out much price variation.

Once comparable data have been compiled, a range of available tools – with various levels of complexity –can be used to analyze the series.

* 1. *Statistical methods for assessing market integration*

The first step in any statistical analysis is to quickly graph one’s data. Plot the time series and look for patterns and outliers. It can be beneficial to get an early, intuitive sense of what the data reveal before one gets bogged down in statistical computations.

Market integration can be assessed quickly and easily by analyzing price time series from different markets and looking for common patterns. Note that the simple bivariate correlation coefficient between prices in two markets (1 and 2) – ρ=COV(p1,p2)/STD(p1) STD(p2) – is a widely used but deeply flawed indicator. It tends to overstate market integration by conflating the presence of a common trend – due to generalized inflation in the economy, seasonality patterns, etc. – with price comovement due to market interlinkage through trade or information flows.

Instead, detrend the price series for general inflation using the national consumer price index (CPI) available from the Central Bank or most statistical or donor agencies. Detrending price series means removing correlation across price series due to a common factor, such as inflation. The simplest way to detrend data is to take the first difference by subtracting one month’s price from the previous month’s price and then correlating Δp1 and Δp2 instead of price levels. The year when a CPI=100 is referred to as a base year. Adjusting prices in other years by multiplying the current year price times the base year CPI dividing by the current year CPI is the price in base-year money. For example, assume the base year is 2005 and the CPI in 2005 is 100. In 2010, the CPI is 150. If maize is $400 per metric ton in 2010, and the cost of a metric ton of maize purchased in 2010 in 2005 dollars is $267.

To correct for the effects of common seasonality, compute an index for each month, lumping all locations’ prices and years together, and then deflate each observation by the appropriate month’s index. The detrending is important so as to remove spurious correlation due to general macroeconomic conditions and seasonality common to all markets under study.

Having detrended and deseasonalized the data, plot the series to get a good visual depiction of the price series’ relationship. If the prices commove closely (i.e., the series move parallel to one another), this signals close price correspondence irrespective of inflation and seasonality and serves as a strong, albeit casual, indicator of likely market integration. The bivariate correlation coefficient among detrended, deseasonalized series provides a decent indicator of market integration. Timmer et al. (1983, p. 21) suggest that 90% is a good measure for “high” correlation of prices between markets, although there is no magic cut-off point.

Where price series are available from multiple markets, it helps to generate the full matrix of these correlations. This process can highlight where market integration is especially strong and places that may be more segmented from central markets and thus may need somewhat different responses. The table below reports a sample matrix of bivariate correlation coefficients among Malawian markets, based on first-differenced price series (from Barrett et al. Food Security 2009).

**Kasungu-Lilongwe Plains Livelihood Zone Price Correlations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *Lilongwe* | *Dowa* | *Ntchisi* | *Kasungu* |
| Dowa | 0.88  |  |  |  |
| Ntchisi | 0.69  | 0.87  |  |  |
| Kasungu | 0.68  | 0.74  | 0.84  |  |
| Mchinji | 0.80  | 0.83  | 0.79  | 0.77  |

Source: Barrett (2009), *Food Security*

A somewhat more statistically sophisticated approach uses multivariate regression methods to control for multiple prospective confounding factors at once. Say one wants to control for seasonality (represented by 12 dummy variables, dm, one per month), the general consumer price index (CPI, capturing changes in the prices of substitute and complementary consumer goods), and the price of fuel as the main cost traders incur in moving commodity across space. The basic relationship between the monthly price at time t in markets 1 and 2 can be written mathematically as:

$p\_{mt}^{1}= βCPI\_{t}+\sum\_{m=1}^{12}ϕ\_{m}d\_{m}+δp\_{t}^{fuel}+λp\_{mt}^{2}$.

If one estimates the multivariate regression represented by this equation, the estimate of the parameter λ is an estimate of the partial correlation between the prices in markets 1 and 2 once one controls for common exogenous factors (i.e., things correlated with the prices in both markets that don’t capture the true causal relationship in price movements between them). If the estimate of λ is statistically significantly different from 0 but not statistically significantly different from 1, this can be taken as a reasonable indicator of market integration.[[1]](#footnote-1) It means that when the price in market 2 changes, it tends to lead to a similar magnitude change in the price in market 1, even controlling for confounding factors, which implies a reasonably free flow of information and goods between the markets.[[2]](#footnote-2)

If price time series are available for multiple markets, as is commonly the case, then repeat the exercise for each market pair to create a matrix of partial correlations among spatial markets. This exercise can be used to identify which markets are especially well integrated and which ones are relatively segmented. Since appropriate food security response depends on market conditions, exploring possible variation across space in market integration is important.

* 1. *Limitations of the analytic:*

Note that prices do not fully characterize the relationship between markets. Therefore, simple spatial price analysis must be interpreted with caution, especially when:

- trade flows are discontinuous, as is commonly true of rural places that export to urban central markets in the immediate post-harvest period, are autarkic for a period of several months thereafter, and then import food from urban storage facilities in the pre-harvest “lean season” (a phenomenon known as “flow reversals”).

- the costs of spatial arbitrage change significantly (and non-randomly) over time, perhaps due to changes in fuel costs, taxes, infrastructure loss, or other factors affecting food marketing.

*Summary*

To get a clearer sense of how local prices are likely to shift in response to cash, voucher or food distribution in a recipient market, or in response to agency procurement in a source market, it helps to have a good sense of how well a target recipient (distribution) or source (procurement) market is integrated with broader central markets in the country or region. In the next lecture we look at the specific case of integration with the global market.

***Supplemental Information***

*Parity Bounds Model*

Recent innovations in market integration testing include variations on a method called a “parity bounds model” (PBM) that statistically estimates the price band and the frequency with which price series are consistent with (i) market integration under spatial equilibrium, (ii) market segmentation in equilibrium – i.e., marketing costs exceed intermarket price differences – and (iii) market disequilibrium, meaning that there seem to be extraordinary profits to spatial arbitrage due to any of several factors, including noncompetitive behavior, information problems, unobserved costs of commerce, etc. These methods are almost certainly beyond the capacity of MIFIRA analysts working with limited data, statistical skills and time.

But the intuition behind the PBM method can be instructive and worth keeping in mind. By way of example, Moser et al. (*Agricultural Economics* 2009) study seasonal rice price relationships among roughly 1400 communes in Madagascar and find striking differences in the nature of market integration depending on the distances involved. As summarized in the accompanying table, connections between markets within subregions are very strong, with nearly 70% of market pairs in integrated equilibrium. But linkages from rural markets to provincial capitals or to the national capital were very rarely integrated, in the latter case due to very high transport costs while the observable costs of commerce could not explain price dispersion at the intermediate, regional scale.

*Commune-level rice market integration in Madagascar*

|  |  |  |  |
| --- | --- | --- | --- |
| Market condition | **Subregion** | **Region** | **National** |
| **Integrated equilibrium** | **68.9%** | 5.5% | 12.8% |
| **Segmented equilibrium** | 21.5% | 31.1% | **83.0%** |
| **Disequilibrium** | 9.6% | **63.4%** | 4.3% |

Source: Moser (2009), Spatial Integration at Multiple Scales

These findings illustrate a couple of useful points worth bearing in mind during a MIFIRA analysis. First, the nature of market integration can vary dramatically across scales, depending on the distances (and associated marketing costs) involved and the nature of local competition among traders. Second, for any given scale of analysis there is almost always some variation in market integration; one place is not always the same as another. Look for geographic heterogeneity in market integration relationships, as the best food security programming response in one place is not necessarily the best response in another.

1. In economics, this is known as a test of the “law of one price,” the idea that prices move one-for-one between two markets once one controls for confounding factors. [↑](#footnote-ref-1)
2. Even more sophisticated versions of this multivariate regression approach rely on advanced time series methods known as error correction models to allow for lagged responses, adjustments to temporary disequilibrium in the inter-market price relationship, and statistical considerations associated with the properties of the regression errors terms. Such methods are typically beyond the time, data, and technical skills capacity of development organizations. The initial use of this method to explore developing country food market integration (in Bangladesh) was by Martin Ravallion (1986 *American Journal of Agricultural Economics*). More advanced variants of the technique employ price, transactions cost and trade data (e.g., Stephens et al. “Spatial Price Adjustment With and Without Trade,” *Oxford Bulletin of Economics and Statistics*, 2012, <http://onlinelibrary.wiley.com/doi/10.1111/j.1468-0084.2011.00651.x/abstract;jsessionid=5D185475BA8822C114131A92295EB463.d04t03?systemMessage=Wiley+Online+Library+will+be+disrupted+24+March+from+10-14+GMT+%2806-10+EDT%29+for+essential+maintenance&userIsAuthenticated=false&deniedAccessCustomisedMessage>= ). [↑](#footnote-ref-2)