IMF Working Paper

Agricultural Market Integration in India

by Michal Andrle and Patrick Blagrave

INTERNATIONAL MONETARY FUND

IMF Working Paper

Research Department & Asia and Pacific Department

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Prepared by Michal Andrle and Patrick Blagrave[1]

Authorized for distribution by Ranil Salgado

July 2020

Abstract

We assess the degree of cross-market price discrepancy (a proxy for market integration), its evolution over time, and proximate determinants, using monthly price data for 21 agricultural goods and 60 markets in India. Econometric analysis shows that cross-market price integration is positively associated with the level of transportation infrastructure, and distance between market pairs. There is no robust evidence that price integration has increased in recent years, suggesting that any positive effects of recent policy initiatives are either small, outweighed by the identified determinants of integration, or yet to come.

Contents

I. INTRODUCTION

In general, market integration is an important economic concept, on both equity and efficiency grounds. Regarding equity, if prices are systematically higher in some markets than others, this could imply greater spatial inequality of economic wellbeing across markets/regions, insofar as wages do not adjust to account for differentiated costs of living. On efficiency grounds, significant price variation across markets/regions could imply a higher cost of living in some areas, making production in these areas costlier. In India, the analysis of agricultural market integration is especially relevant, as food comprises a large share of the consumption basket.[2] As such, reducing cross-market agricultural price dispersion would be desirable, on both equity and efficiency grounds.

In India, several initiatives in recent years have aimed at promoting agricultural market integration. First, the electronic National Agriculture Market (eNAM) platform's stated vision and mission is to "promote uniformity in agriculture marketing by removing information asymmetry and promoting real time price discovery based on actual demand and supply… [and] promote a common online market platform to facilitate pan-India trade in agriculture commodities, providing better price discovery…" In addition, suggested revisions to the Agriculture Produce Market Committee (APMC) laws, by way of the model Agriculture Produce and Livestock Marketing Act, sought to loosen restrictions on how agricultural products are sold/traded within India. Ongoing efforts to expand and improve India's road network—including through the government-sponsored Bharatmala Pariyojana—could contribute to greater market integration. Most recently, the economic relief package announced by the Modi government in May 2020 featured reforms aimed at liberalizing the agricultural sector, including amendments to the Essential Commodities to enable better price realization by farmers, and agriculture-marketing reforms to liberalize farmers' options in selling their products.

There exists a substantial literature on market integration in general, and in India specifically. In a cross-country study, Baquedano and Liefert (2014) document the degree of integration between prices in urban markets and global prices, finding that these are co-integrated, but that transmission is incomplete and domestic prices often take time to respond to global shocks. Crucini, Telmer, and Zachariadis (2005) use a retail-pricing model to demonstrate the role of distance, and the presence of borders, in explaining price dispersion across a large number of markets, countries, and goods. Numerous studies focus on integration within domestic markets. Examining the case of Brazil, Goes and Matheson (2017) find that the law of one price holds for tradeable goods, but is less likely to hold for non-tradeables, and that price convergence across Brazilian markets occurs slowly, indicating only limited domestic market integration. In the case of China, Xu and Voon (2003) show that markets are

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[2] Food and beverages account for 45.9 percent of the consumer price index (CPI) basket in India.

relatively integrated, and that cross-province price integration has increased over time, but that province-specific factors still play a role.

Studies on India have primarily focused on integration in agricultural markets. Chatterjee and Kapur (2016) find substantial regional (spatial) variation in the degree of price integration. Regarding the role played by policies, there is evidence that integration is higher for commodities which were historically free from inter-state movement restrictions (Sekhar (2012)), a finding which resonates with Jha, Murthy, and Sharma (2008) who show that rice market integration was historically limited (pre-1999), owing to government intervention in markets which limited cross-market price convergence. A more recent study of rice-market integration shows that there is now a long-run relationship between rice prices across markets (Ghosh and Ghoshray, 2018), and a Reserve Bank of India study (2019) argues for the importance of infrastructure, information flow, and irrigation facilities in reducing cross-market markups. Finally, Reddy (2016) in a study of the role of e-markets in Karnataka, India, finds that groundnut prices were less variable in e-markets than non-e-markets.

Beyond studies looking at agricultural price integration, Das and Bhattacharya (2008) show that regional relative price levels are mean-reverting in India, with cross-region price discrepancies being also a function of distance. Reserve Bank of India (2018) also finds evidence that state-level inflation converges to the national average. Mahbub Morshed, Ahn, and Lee (2006) examine inflation rates across 25 major Indian cities, finding that these are quick to revert to a common trend, and that this common trend mirrors that of the India-wide CPI.

The analysis presented in our paper exploits a large monthly dataset on agricultural price movements for 21 different commodities and 60 different markets (mandis) in India. The measure of market integration we consider is the cross-market price differential across each market pair in our sample. Using these data, we conduct two exercises. First, we consider the evolution of this market-integration variable over time and across commodities, as it provides a rough proxy for whether market integration has improved in recent years (which could possibly be attributed to policy initiatives). On this point, we show that some markets have persistently higher price markups than others—consistent with results in the existing literature—and that the degree of market integration shows no evidence of having increased in recent years. This finding suggests that policies promoting integration have not yet had an effect, or that 'traditional' determinants of integration dominate the effect of any recent policy initiatives.

The second strand of analysis in our paper documents the proximate determinants of agricultural market integration in India. This is done for a group of 5 agricultural commodities considered to be staples in the Indian diet: onions; potatoes; rice; tomatoes; and

wheat.[3] Considering both cross-sectional and panel regressions, we document a positive relationship between cross-market price integration (that is, a reduction in price differentials) and infrastructure quality, as well as geographical proximity (distance).

In the following section, we document stylized facts regarding our agricultural-price dataset and assess the evolution of cross-market price discrepancies over time. Then, in section III we present econometric analysis which documents a positive relationship between market integration and geographical proximity, as well as quality of infrastructure (with appropriate control variables). Section IV concludes.

II. STYLIZED FACTS

Our dataset covers monthly prices of 21 agricultural goods and 60 agricultural markets (known in India as mandis).[4] We begin by presenting three stylized facts pertaining to price dispersion across India's agricultural markets, to help understand the nature and scope of the data.

First, the degree of price dispersion differs greatly across goods. In Figure 1, standardized prices[5] across mandis are considered for each of the 21 agricultural goods in our sample. The solid line in the figure shows the India-wide mean price for each commodity, at each point in time, whereas the lighter gray lines correspond to the standardized price in each specific market over time. For dietary staples such as tomatoes and onions, there is evidence of periodic (in some cases seasonal) spikes which are common across all markets, and the cross-market dispersion appears quite low over time. In a sense, this suggests that the relative law of one price broadly holds in India and can be taken as *prima facie* evidence that agricultural markets are well integrated in India, for some commodities at least. By contrast, some other goods (loose tea; various oils) have much greater cross-market dispersion over time. Finally, for goods which are less perishable and more easily stored (rice, packed salt; and wheat) the India-wide mean price tends to be comparatively stable, though periodic market-specific fluctuations are observed.[6]

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[3] The consumption of these goods is relatively ubiquitous throughout India, which motivates the decision to focus empirical analysis on price dispersion among this set of goods. Results are robust to focusing on these goods individually, in which case we also control for variation in production patterns across regions.

[4] Data on agricultural retail prices for 21 different commodities and up to 60 different mandis are obtained from the Department of Consumer Affairs, via CEIC.

[5] Each line in the chart shows a standardized price over time, for a given mandi, according to $z_t = (X_t - \mu)/\sigma$, where X is the price, μ the mean, and σ the standard deviation specific to the mandi and good considered.

[6] These fluctuations may result from state level bonuses over minimum support prices (MSPs) in some periods.

A second stylized fact is that some mandis have systematically higher prices, irrespective of the good being considered (Figure 2). This is especially evident for two of the most geographically isolated markets: Port Blair, which is the capital city of the Andaman and Nicobar Islands, a union territory of India located in the Bay of Bengal, and Aizawl, the capital of the state of Mizoram, which is located in the far east of India. Given the difficulty of transporting commodities to more remote markets, it is no surprise that these markets would be more costly to supply, in the cases where there is no production of a given commodity nearby. By comparison, the market with the lowest markup (in fact, most goods are priced at a discount) vis-à-vis India-wide averages is Jaipur. The finding that geographical proximity plays a role in determining price integration is a common result in the literature (for example, see Crucini, Telmer, and Zachariadis (2005), Das and Bhattacharya (2008), among others).

Figure 1. Standardized Prices
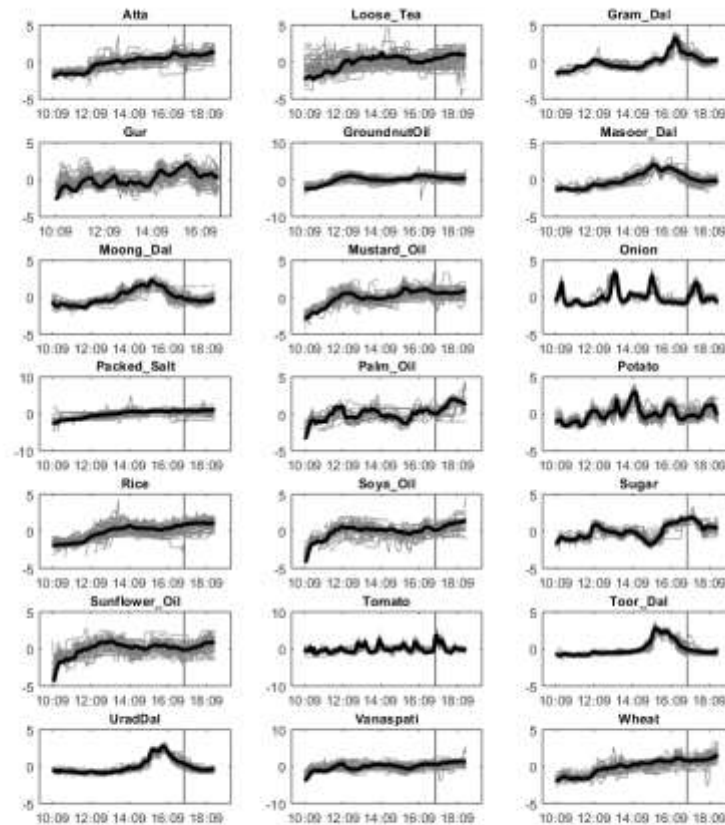
Note: Solid line depicts India-wide mean standardized price, while lighter gray lines show standardized prices for each market over time.

Source: Indian Department of Consumer Affairs, CEIC, and authors' calculations.

Figure 2. Distribution of Markups with respect to Nation-Wide Average
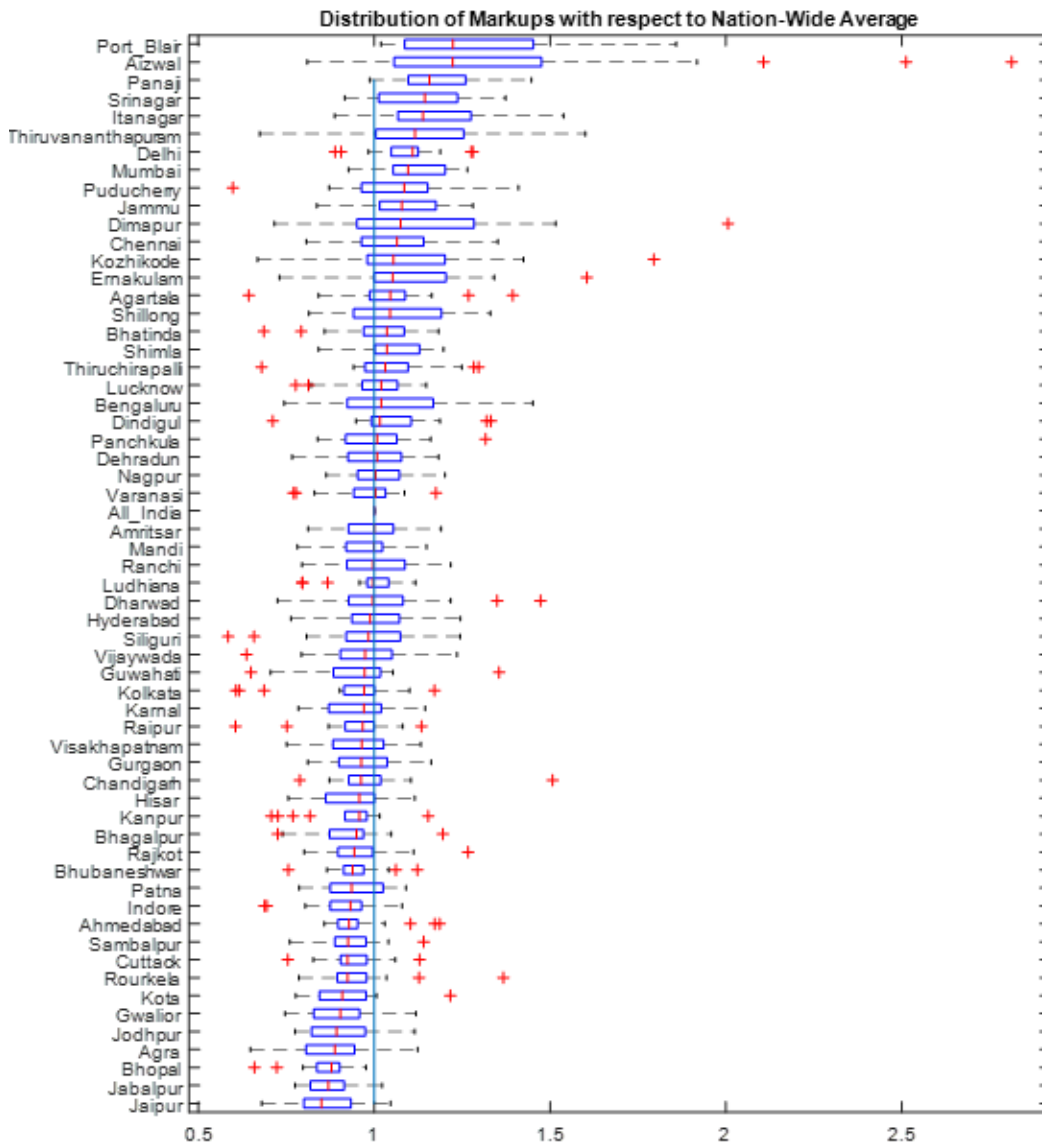
Note: Histogram of relative prices. In each box the central mark denotes the median and the box edges indicate the 25th and 75th percentiles of the distribution. The "whiskers" extend to the extreme data points still not considered outliers, whereas the red `+' markers indicate the outliers.

Source: Indian Department of Consumer Affairs, CEIC, and authors' calculations.

Considering each market pair (i,j) as a unit observation, a third stylized fact depicts the relationship between cross-market price markups and two plausible proximate causes: distance and a measure of infrastructure development. To document the relationships, we estimate robust locally-weighted polynomial regressions (lowess), see Cleveland (1979). The strength of this approach is that the local regression can capture the non-linear nature of bivariate relationships in a flexible, non-parametric way and is also less sensitive to outliers.

Figure 3 summarizes the lowess smoother regression results, showing only results for tomatoes (results for all five staple commodities are shown in appendix figures A1-A3). These graphs show a scatter plot, fitted with lowess regressions, for price markups and three candidate determinants: distance, and two measures of infrastructure—road and rail densities. In the first graph, there is a clear positive correlation between the cross-market price markup between any two markets in our sample and the distance between them (in km). This relationship is quite stable across all values of markup and distance. Second, the relationship between markups and the average value of road density between the two markets shows evidence of a negative relationship—greater road density tends to reduce cross-market markups—though only to a certain degree. That is, increases in the density of road networks from low levels are associated with reductions in markups, though this relationship fades beyond a certain point, suggesting diminishing returns to road construction in increasing integration. The third chart echoes this finding, showing instead the relationship between the mean value of rail density and price markups between each market pair in our sample.

Road and rail densities are highly correlated across the market-pair observations in our sample. Markups across the five staple goods considered in our analysis are generally quite highly correlated, suggesting an important role for market-specific conditions in driving markups.

Table 1. Correlation Matrix

	Road	Rail	State GDP	Distance	Onion	Potato	Rice	Tomato	Wheat
Road	1.00								
Rail	0.66	1.00							
State GDP	-0.04	0.35	1.00						
Distance	0.03	-0.12	-0.03	1.00					
Onion	-0.07	-0.28	-0.20	0.25	1.00				
Potato	0.12	-0.01	-0.02	0.39	0.38	1.00			
Rice	0.07	-0.08	-0.02	0.23	0.17	0.39	1.00		
Tomato	-0.08	-0.22	-0.23	0.47	0.58	0.29	0.11	1.00	
Wheat	0.13	-0.02	0.10	0.55	0.06	0.50	0.26	0.24	1.00

Source: Authors' calculations.

Figure 3. Selected LOWESS Smoother Plots
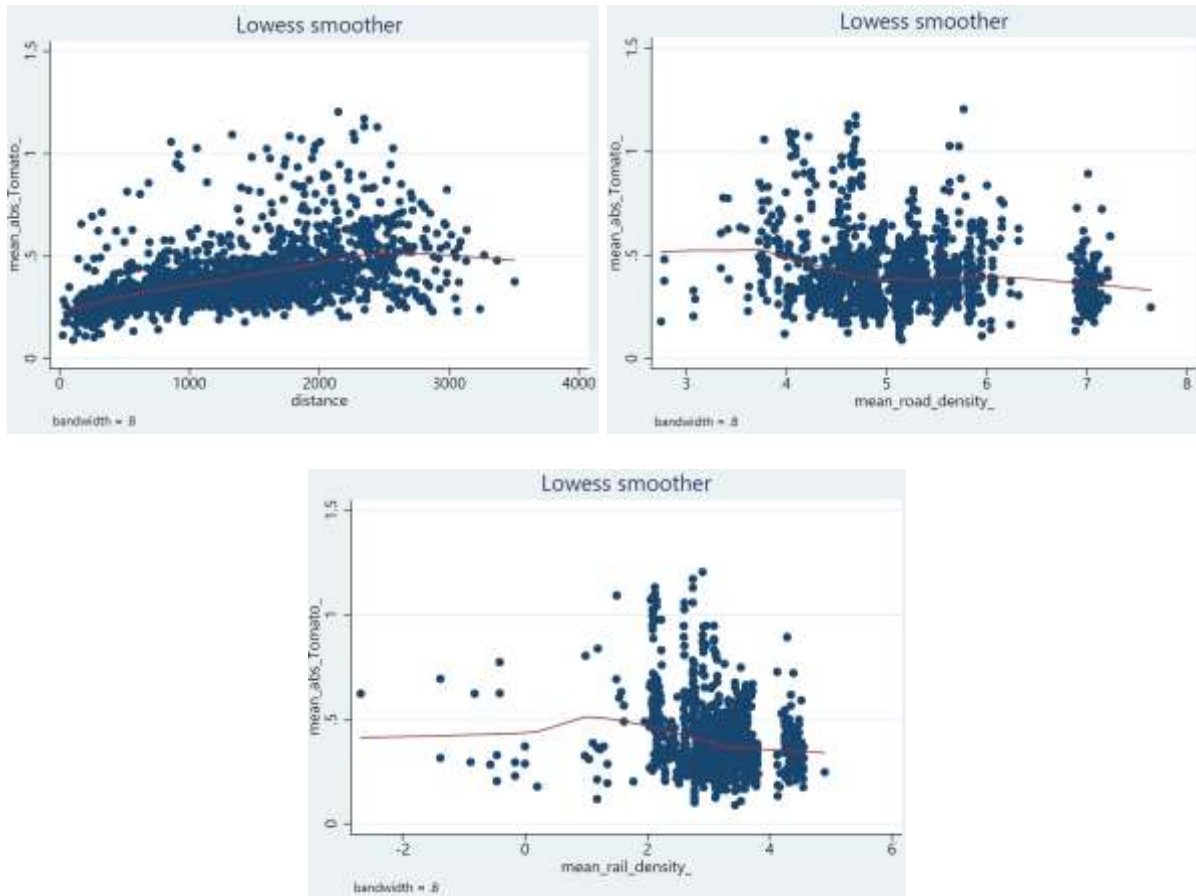
Source: Authors' calculations

III. EMPIRICAL ANALYSIS

This section considers two distinct strands of analysis: one linking agricultural market integration to a set of proximate determinants, and another considering the evolution of market integration over time.

A. Determinants of agricultural market integration

Regression analysis focuses on the relationship between cross-market price markups (our proxy for market integration) and proximate factors. Analysis is conducted for five staple commodities: onions, potatoes, rice, tomatoes, and wheat using data from 2009m1 through 2018m12. As discussed previously, numerous studies on India have been conducted, though many of these have focused on one commodity (commonly rice). Our study examines a broader basket of commodities, choosing to focus on those which are consumed widely across India. However, in each case production locations and harvest times vary across the country, implying a substantial need for cross-state-border trade (see Subramanian, 2016,

among others). We estimate the following equation separately for each of the five commodities:

$$MKP_{ij,c} = \alpha_c + \beta_1 DIS_{ij} + \beta_2 TRANS_{ij} + \beta_3 URBAN_{ij} + \beta_4 SGDP_{ij} + \gamma_{c,t} + \varepsilon_{i,t,c} \qquad (1)$$
$$\textit{for c = \{onion; potato; rice; tomato; wheat\}}$$

where $MKP_{ij,c}$ is the cross-market price difference (markup) between markets i and j,[7] for commodity c; DIS_{ij} is the distance between markets (in log units of kms); $TRANS_{ij}$ is a measure of transportation infrastructure, given by the average value of road and rail density measures (road km per 100 square km; rail km per 1,000 square km) for the two markets, i and j, expressed in log units; $URBAN_{ij}$ is the percentage of the population classified as living in an urban setting; $SGDP_{ij}$ is the log level of GDP in the state where each market is located (average value across both markets).[8]

Equation 1 is first estimated as a cross-section, treating each market-pair as one unit of observation (which entails using the average values of each market-pair variable over the sample period, in which case there are no time (t) subscripts in the equation). This is our preferred specification, because distance and our measure of urbanization are time-invariant, and transportation infrastructure and state GDP change only slowly, implying that there may be little additional information on the determinants of cross-market price integration to be obtained from having multiple observations over time. Nevertheless, we also estimate this regression in a panel setting (using random effects[9])—in the case of the panel specification only, the term $\gamma_{t,c}$ in equation 1 is operational and captures time fixed effects.

Presented in Table 2, results from the cross-section regression show a strong relationship between cross-market price markups and: (i) distance between the market pairs; (ii) density of transportation infrastructure (average value of road and rail densities, between market pairs); and (iii) urbanization.

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[7] Markups are given by $(price_{i,t} - price_{j,t})/((price_{i,t} + price_{j,t})/2)$

[8] Data on transportation are obtained from the Indian Ministry of Road Transport and Highways and the Indian Ministry of Railways, via the CEIC database. Urbanization data are obtained from the Center for Monitoring the Indian Economy (CMIE) and state GDP is from the Central Statistics Office, via CEIC database.

[9] Hausman testing shows no systematic difference between random- and fixed-effects specifications.

Table 2. Cross-Section Regression

	(1) Onion	(2) Potato	(3) Rice	(4) Tomato	(5) Wheat
DIS (i,j)	**0.038*****	**0.070*****	**0.028*****	**0.085*****	**0.116*****
	(0.004)	(0.004)	(0.003)	(0.004)	(0.005)
TRANS (i,j)	**-0.068*****	**-0.015****	**-0.010****	**-0.064*****	-0.009
	(0.008)	(0.007)	(0.004)	(0.009)	(0.007)
URBAN (i,j)	**0.109*****	**0.104*****	**0.029*****	**0.125*****	**0.089*****
	(0.012)	(0.011)	(0.008)	(0.014)	(0.012)
SGDP (i,j)	**-0.031*****	-0.002	-0.000	**-0.043*****	**0.027*****
	(0.005)	(0.005)	(0.004)	(0.006)	(0.006)
Constant	**0.352*****	**-0.431*****	-0.055	**0.243*****	**-1.234*****
	(0.084)	(0.082)	(0.058)	(0.093)	(0.106)
Observations	1,540	1,540	1,540	1,540	1,403
R-squared	0.171	0.180	0.058	0.325	0.342

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: Authors' calculations

To facilitate interpretation of coefficients, Table 3 presents standard deviations and mean values for each variable used in our regressions. Beginning with distance (*DIS*), a one-standard-deviation increase in distance between markets (0.73 log units, as applied in the regressions) would be roughly equivalent to a 500km increase in distance between markets (assessed at the average distance value in our sample). Taking the example of tomatoes, this would correspond to an increase in the markup of about 0.06, which is about 15 percent of the average markup for tomatoes (about 0.4). So, a 500km increase in distance between markets would increase the markup by approximately 15 percent, *ceteris paribus*.

Table 3. Variable mean and standard deviations

	Onion markup	Potato markup	Rice markup	Tomato markup	Wheat markup	Distance (ln km)	Transport (ln density)	Urbanization	State GDP (ln)
Standard Deviation	0.14	0.15	0.10	0.16	0.16	0.73	0.64	0.34	0.74
Mean	0.27	0.33	0.20	0.40	0.24	7.02	4.14	3.48	14.30

Source: Authors' calculations.

Next, the coefficient estimates on transportation infrastructure indicates that a one-standard-deviation (0.64 unit) increase in the density of transportation infrastructure would reduce the markup of tomato prices between markets by about 0.04, or about 10 percent of the average markup value, *ceteris paribus*.

The remaining two coefficients in the regressions, urbanization and the log level of state real GDP, are primarily included as controls. We would expect local market prices to vary

according to demand, which is proxied by income level (state real GDP). A highly urbanized state may be logistically easier to supply (which would tend to reduce markups) than one whose population is more dispersed, or a higher degree of urbanization may imply that consumers (and markets) are further removed from the location of production (implying higher markups). Regression results suggest that states with more urbanized populations tend to exhibit higher price markups.

Regression results using the panel specification (Table 4) corroborate those from the cross-section analysis. This is not surprising, given that the key explanatory variables are either time invariant (distance) or very slow to change (infrastructure).

Table 4. Panel Regression

	(1) Onion	(2) Potato	(3) Rice	(4) Tomato	(5) Wheat
DIS (i,j)	**0.050*****	**0.068*****	**0.022*****	**0.085*****	**0.114*****
	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)
TRANS (i,j)	**-0.037*****	-0.009	**-0.032*****	**-0.078*****	**-0.033*****
	(0.008)	(0.007)	(0.008)	(0.010)	(0.012)
URBAN (i,j)	**0.114*****	**0.110*****	**0.029****	**0.147*****	**0.136*****
	(0.013)	(0.012)	(0.012)	(0.016)	(0.017)
SGDP (i,j)	**-0.023*****	-0.002	-0.001	**-0.058*****	**0.037*****
	(0.006)	(0.005)	(0.005)	(0.007)	(0.007)
Constant	-0.087	**-0.325*****	0.091	**0.348*****	**-1.438*****
	(0.091)	(0.087)	(0.074)	(0.105)	(0.113)
Observations	66,178	66,103	66,228	62,463	48,757
Number of pairs	1,475	1,475	1,475	1,475	1,320

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: Authors' calculations

B. Evolution of agricultural market integration over time

Price dispersion between mandis has generally increased since early 2017, which runs counter to our prior that nascent initiatives to encourage agricultural market integration would have played a positive role.[10] OLS regressions of price markups vis-à-vis the

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[10] The selection of a cutoff date corresponding to the passage of initiatives aimed at boosting agricultural-market integration is necessarily arbitrary, since a number of initiatives have been undertaken at varying times, including passage of some measures at the state level. Although 2017m1 is chosen as the cutoff date before/after which integration is examined in this section, the results are robust to shifting this cutoff date forward or backward by up to a year.

nationwide average (for each market and time period) show a larger markup in the period from 2017 onwards, for 4 of the 5 staple commodities considered (Table 5). Of course, this could simply reflect the small sample period considered, which also corresponded to the implementation of demonetization, and production dynamics (with 2016-17 and 2017-18 being record production years for some commodities).

A comparison of the distribution of markups across mandis, for each commodity, for two sub-samples—before and after the beginning of 2017—suggests considerable similarity (Figure 4). If market integration had improved, this would have led to a narrower distribution in the more recent period, after the reforms. The finding is robust to different sample cutoff periods, and other refinements, suggesting little evidence of increased integration over time.

Table 5. Markups before/after 2017m1

Markup pre/post 2017m1	(1) Tomatoes	(2) Onions	(3) Potatoes	(4) Rice	(5) Wheat
i.Post-2017m1	**0.006****	0.002	**0.054*****	**0.006***	**0.007****
	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)
Constant	**0.395*****	**0.272*****	**0.320*****	**0.199*****	**0.251*****
	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	133,697	146,014	145,824	146,069	104,314

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: Authors' calculations

The two-sample Kolmogorov-Smirnov test for a change in the distribution, based on the maximum deviation along the empirical cumulative distribution function, does not provide strong evidence about the change of the distribution. The test is, however, known to have low power as it tests against all possible types of differences between the two distribution functions and is sensitive to outliers, see Gail and Green (1976).

While the difference between the price dispersion before and after the reforms is not robustly identified yet, as time unfolds the identification may grow stronger as the number of data points for the post-reform regime increases.

Figure 4. Distribution of cross-market price markups before/after 2017m1
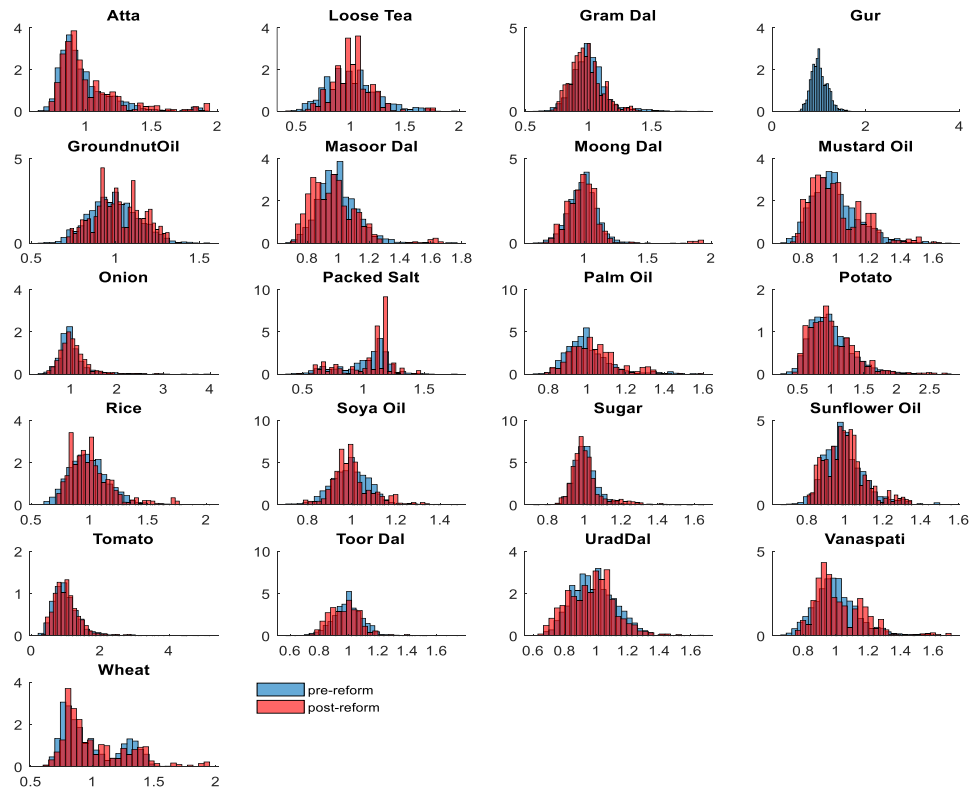
Source: Authors' calculations

IV. CONCLUSION

Agricultural market integration has potentially important implications for economic wellbeing across different regions, and also economic efficiency given the large share of food in the Indian consumption basket. Our analysis shows that integration is driven primarily by geographical proximity and infrastructure development, suggesting that policies seeking to enhance integration should focus on facilitating cross-market trade, through infrastructure (a direct implication of our results) and also other means such as reducing restrictions on the movement of goods, and information sharing (an implication of other studies in the literature, most notably Reserve Bank of India, 2019). Reforms to liberalize the agricultural sector undertaken in the context of the recent COVID-19 economic relief package go in this direction.

Although our study does not focus directly on the absolute level of market integration in India (vis-à-vis peer countries, for example), prices for many commodities appear to evolve similarly over time across markets—this is particularly true for such goods as dal, tomatoes, onions, and potatoes—providing suggestive evidence that the law of one price holds for

many goods in India. Nevertheless, our examination of market integration over time in India suggests that agricultural market integration has not increased in recent years. This may imply that policies to enhance integration—such as the adoption of the eNAM platform, and revisions to APMC laws which seek more flexibility in cross-market movement of goods—have not yet been effective in reducing price markups across markets (though Reddy, 2016, provides some evidence on their efficacy at the state level). Alternatively, it may simply be the case that the primary determinants of market integration (distance; infrastructure; other market-specific factors not well identified by our study) play a dominant role, and these are either constant (distance), or very slow to change. Additional analysis, based on a longer post-reform sample period, would be needed to draw more definitive conclusions.

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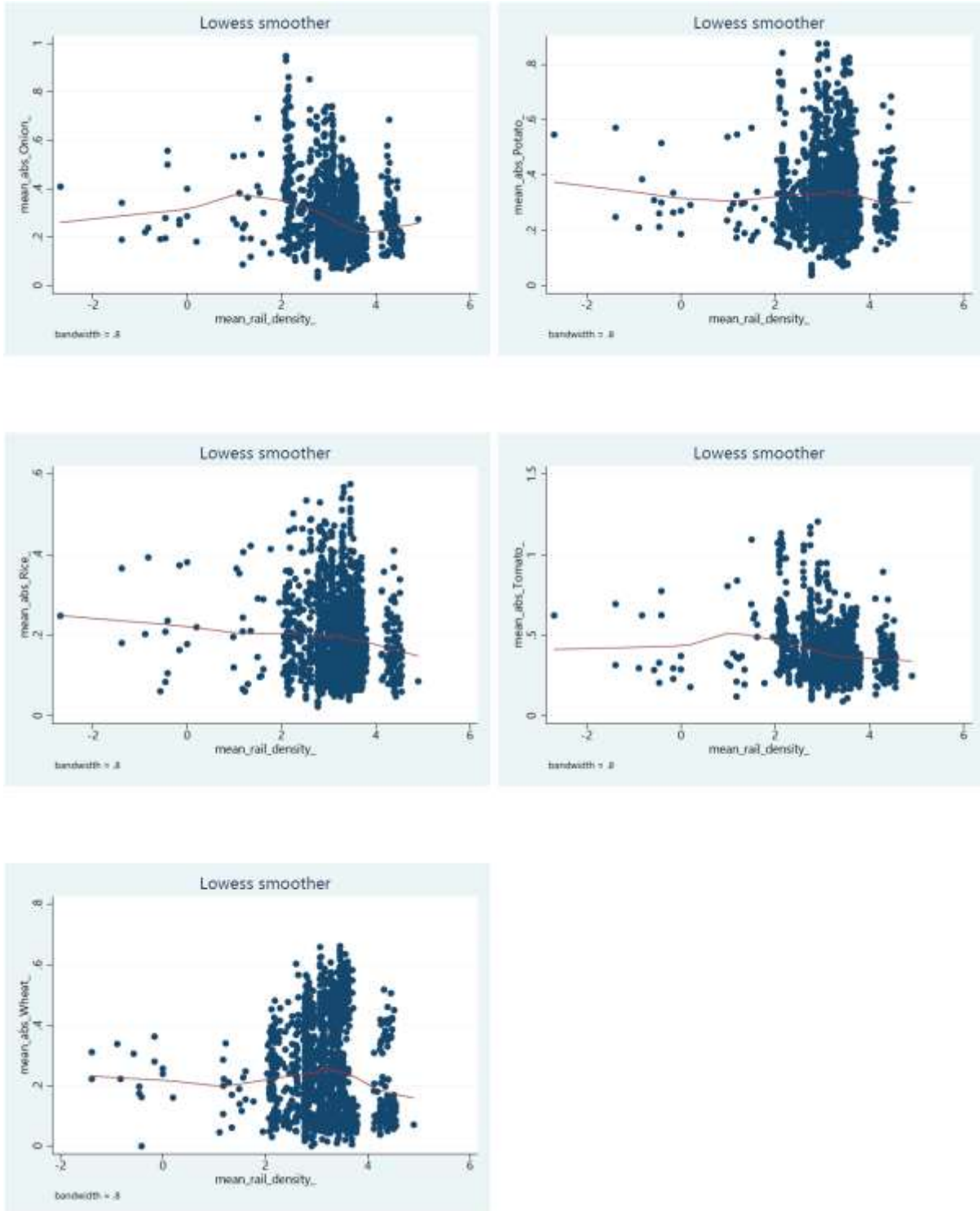
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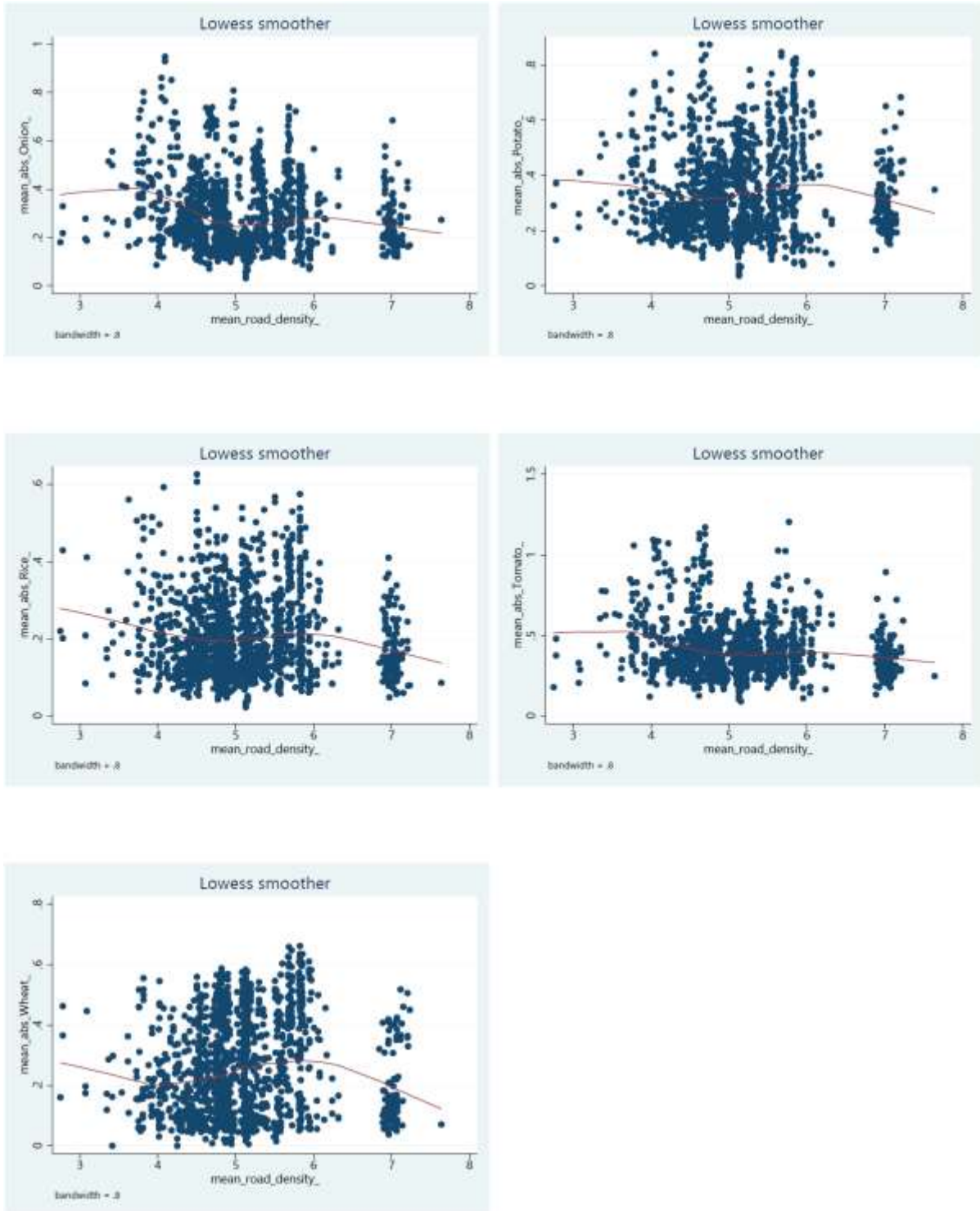
VI. APPENDIX

Figure A1. LOWESS Smoother Relationship between Distance and Markups
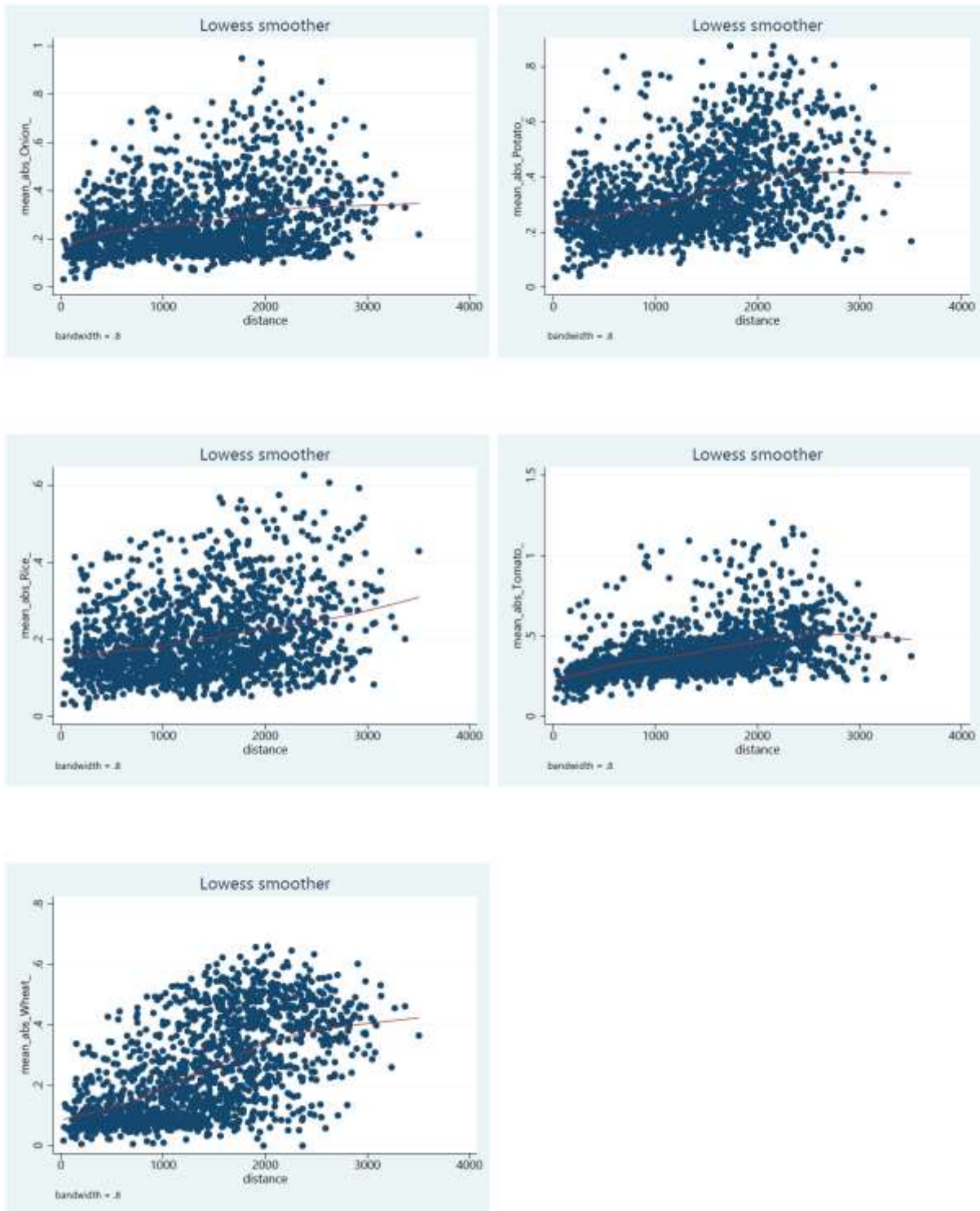
Source: Authors' calculations

Figure A2. LOWESS Smoother Relationship between Rail Density and Markups

Source: Authors' calculations

Figure A3. LOWESS Smoother Relationship between Road Density and Markups

Source: Authors' calculations