SPATIAL integration of the rice market: emprirical evidence from mid-west and far-west Nepal and the Nepalese-Indian border

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ABSTRACT

This paper studies the integration of rice markets in the mid-west and far-west districts of Nepal. The data were drawn mainly from the World Food Programme (WFP) database on Nepal. Results indicate that the rice markets of the hinterland are poorly integrated with the regional market of Nepalgunj. In contrast, price fluctuations are transmitted, both in the short and medium run, across the Indian-Nepali border between Nepalgunj and the Indian border districts of Rupedia and Jogbani. Large price differentials relative to transport costs indicate market inefficiencies in the mid-west and far-west districts of Nepal. Moreover, the poor road infrastructure determines the price differentials. Poor infrastructure impedes price correlation and convergence between these districts. Given its open-door policy with India and the ongoing efforts to further align trade policies with the World Trade Organization, the findings suggest that Nepal would maintain its partnership with India and build an effective market surveillance system that covers the Indian border markets as well, to ensure food security in the short run. However, substantial investment in transport infrastructure is required to improve market integration and accessibility in the long run, especially in the hilly and mountainous areas.

INTRODUCTION

Over the past two decades, Nepal's extensive trade liberalization on both fronts, domestic and external, has made its tariffs among the lowest in South Asia (Pyakuryal, Thapa and Roy 2005). Nepal has implemented several policy reforms, downsizing its public distribution system and removing a host of agricultural subsidies, in order to move its agrarian economy towards a more market-oriented system (Box 1). Since the accession of Nepal to the World Trade Organization's (WTO) membership in 2004, further trade reforms have been prepared in order to better align the trade regime with WTO recommendations. Hence, by 2010, all duties and charges other than customs duties are expected to be phased out.

While research findings suggest that liberalization has resulted in drastic changes favorable to the commodity trade patterns between Nepal and India, its impact on agriculture has been mixed in terms of productivity and income growth (Sharma 1994; Chapagain 2000; Upadhaya 2000; ANZDEC 2002; Pyakuryal, Thapa and Roy 2005). The annual growth of the agriculture sector has remained below 3% over the past years (2002-2006), resulting in the slow growth of per capita incomes in rural areas. Records show that per capita income has inched upward by only 1.4 percent per year, relying increasingly on remittances. On the average, agriculture productivity remains quite low by South Asian standards, with cereal yields estimated at about 2t/h. Despite a significant improvement of the living standards for Nepal

Box 1: Nepal-India trade agreements

Bilateral treaties on trade and an agreement for cooperation to control unauthorized trade govern trade relations between Nepal and India. Nepal signed its first Trade and Transit Treaty with India in 1950. The treaty was renewed in 1960, 1971, 1978 (when trade was de-linked from transit), 1991, 1996 and 2002. The key features of the treaty are:

- Exemption from basic customs duties and quantitative restrictions on imports of primary products on a reciprocal basis;
- Access for selected Nepalese manufacturing exports to the Indian market free of basic customs duties and quantitative restrictions;
- Preferential entry on manufacturing goods imported from India to Nepal, without any quantitative restrictions.

The Nepal-India Trade Treaty renewed in 2002 introduced several new provisions, including a) more stringent rules of origin, b) trade restriction quotas, c) clear specification of safeguard clauses, and d) submission of information regarding the basis of calculating rules of origin to the Indian government by Nepal on an annual basis.

Source: Action Aid (2006), Nepal Import Surge, a Case Study of Rice

as a whole[1], income distribution remains uneven, with the hill and mountain areas of the mid-west and the far west regions, lagging behind in terms of per capita income[2]. The food commodity trade has compensated partially for the sluggish performance of the agriculture production. According to Pyakuryal, Thapa and Roy (2005), agricultural trade increased from an average of 9.1% of agricultural gross domestic product (GDP) in the first part of the 1990s to 13% in the second part. Imports from India have played a major role in the trade patterns, as about 60% of the landless households depend on cheaper rice from India. The import of food grains from India has increased since the price of rice in India is 12% lower (mainly due to subsidies on fertilizers and electricity for irrigation). However, the authors conclude that rice import has been a source of distress for net producers and sellers of rice in the Terai.

These results raise important questions about the matter of spatial market integration in the trade operating among districts as well as with India. As seen above, previous studies have documented the impact of trade liberalization but very little evidence is known about the spatial market integration of rice, the main staple food in Nepal. Rice makes an important contribution to the food security situation of households in Nepal, as it constitutes the most preferred food commodity, and is grown by 76% of Nepali households. An efficient rice supply over space should favor the sharing of risk across districts by smoothing idiosyncratic price variations. The spatial price behavior in regional rice markets is an important indicator of overall market performance. Markets that are not integrated may convey inaccurate price information distorting the marketing decisions of rice producers and traders, thereby contributing to inefficient product movements.

The spatial integration of the rice market is of major importance in Nepal, given the difficult terrain, the long distances between market sources of the Terai and the mid- and far western districts, and the implications of these factors for food security. The analysis of the rice market price integration aims to examine in greater detail whether and to what extent price transmission can be considered as efficient across different locations within this region and adjoining districts. Given the landlocked nature of Nepal, the major role played

1 The Nepal Living Standard Survey (NLSS) 2003/2004 estimates that 31% of the population lives below the poverty line, an 11% decline from 1995/1996, with an increase of the per capita consumption (in nominal terms) from 6,802 Nepali Rupee (NRs) in 1995/96 to NRs15,848 in 2003/04.

2 Ministry of Finance (2005), Economic Survey, Kathmandu, Nepal.

by the Indian border markets is taken into account in this analysis.

This paper is organized as follows. The next sections briefly review the literature on commodity market price integration, presenting the basic rationale behind the main analytical techniques, and present the data and their limitations. Next, the price integration techniques to test rice price integration (including co-integration) among the far and mid-western districts of Nepal is applied. Then, the market integration analysis to test market efficiency, using transaction costs is presented. Finally, a summary of the findings and discussion on some implications for the food security situation in the region under consideration follows.

A BRIEF LITERATURE OVERVIEW

Spatial Market Integration Techniques

According to Barrett and Li (2002), market integration is most usefully defined as tradability or contestability between markets. This definition includes the market clearance (spatial equilibrium) process in which the demand, supply, and transaction costs in distinct markets jointly determine prices and trade flows, as well as the transmission of price shocks from one market to another, or both. Barret (2005) defines the notion of tradability as the fact that a good is traded between two economies or that market intermediaries are indifferent between exporting from one market 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, though prices may not be equilibrated across markets. Spatial market integration conceptualized as tradability is only consistent with market efficiency when prices equilibrate across markets while trade occurs.

Existing approaches to testing spatial market integration may be divided into two broad categories. The first category of techniques uses the law of one price to test for the perfect co-movement of prices. These techniques assume that if markets are integrated, price changes in one market will be transmitted on a one-for-one basis to other markets either instantaneously (e.g., Ravallion's tests for short-run integration) or over a number of lags (e.g., Ravallion's test for long-run integration). In practice, techniques for testing price co-movements are based on Granger-causality and co-integration procedures. These techniques allow for price co-movement to be less than perfect and allow for prices to be simultaneously determined. The literature has pointed out some indicators such as the simple correlation coefficients between city pairs, the co-integration coefficients (which capture the existence of a long-run linear relation between prices), and the parameters representing the speed of adjustment of prices from different regional markets to their equilibrium. Simple bi-variate correlation coefficients are interpreted as a measure of how closely price movements of a commodity at different markets are linked. However, this method can neither measure the direction of price integration between two markets, nor can it account for trade reversals, which are common where infrastructure is poor (Barrett 1996).

In order to take into account the above-mentioned critique, co-integration procedures were developed to allow for the identification of both the integration process (including the speed of adjustment of prices) and its direction between two markets (Granger-causality test). If in the long run they exhibit a constant linear relation, then price series are likely co-integrated (i.e., interdependent). In other words, co-integration indicates non-segmentation between the two series.

Furthermore, co-integration techniques emphasize the identification of the structural determinants of the spatial integration of markets, which are needed for the implementation of investment policies oriented to develop commodity markets. Following this concern, the first step in the analysis consists of identifying an indicator of market integration (e.g., price). The second step in the analysis is oriented to identify the factors that explain the degree of market integration. Goletti et al. (1995) maintain that the degree of market integration is a result of the trade action itself as well as the operational environment, which is determined by the availability of transportation and telecommunication infrastructure and by the policies that affect the price transmission mechanism. Using a regression that links a market integration indicator with infrastructure variables, these authors find that for the rice market in Bangladesh, the main factors that determine the market integration are the transportation (mainly paved roads) and telecommunication infrastructure, distance between localities, price variability, the existence of wholesaler commercialization centers in the localities under study, and the presence of geographical differences between regions. Similar findings were achieved by D'Angelo and Cordano in Peru (2005).

Taking into consideration the possible sources of discontinuity and asymmetry in the responses of commodity market prices, the second category of techniques analyzes the spatial price integration of markets by introducing dynamic transaction costs as elements that affect arbitrage relations between different regions. The different techniques study arbitrage relations between two regions by using, mainly, the price series of a particular product. The analysis framework is based on the law of one price adjusted by transaction costs and assumes that the efficient spatial arbitrage requires that no extraordinary profits could be generated by trading between two markets. In other words, it is necessary that the law of one price, adjusted by transaction costs, is fulfilled.

This approach suggests that transaction costs determine the parity bounds (price efficiency band) within which the prices of a homogeneous commodity in two geographically distinct markets can vary independently (Baulch 1997; Barrett and Li 2002). According to Baulch (1997), when transaction costs equal the inter-market price differential and there are no impediments to trade between markets, trade will cause prices in the two markets to move on a one-for-one basis and the spatial arbitrage conditions are binding. When transaction costs exceed the inter-market price differential, trade will not occur and the spatial arbitrage conditions will not be binding. When the inter-market price differential exceeds transaction costs, the spatial arbitrage conditions are violated whether or not trade occurs. In that case, there may be impediments to trade that weaken market integration.

Some Limitations of Spatial Market Integration Techniques

Co-integration techniques are considered unreliable if transaction costs are non-stationary (Barrett 2001; Barrett and Li 2002; Fackler and Goodwin 2002). Failure to find co-integration between two price series may be consistent with market integration (Barrett 1996). In other words, rejection of the co-integration hypothesis may not necessarily mean lack of market integration; it can just be a reflection of transfer costs being non-stationary. A review of the conclusions of several co-integration-based studies seems to go largely against this contention (Rashid 2004). Instead of finding lack of integration, most of the studies have concluded in favor of market integration. A second criticism against the co-integration method is that it cannot distinguish various arbitrage conditions, such as autarky, efficient arbitrage, and arbitrage failure.

A major limitation of the parity bound analysis is the lack of series on transaction costs. In general, these series are generated by extrapolation techniques that may not reflect the speed of the price adjustment when there exist profitable trade opportunities. Furthermore, this framework does not account for trade reversals. According to Barrett (2005), it also relies on arbitrary distributional assumptions in estimation and typically ignores the time-series properties of the data, not permitting analysis of the dynamics of inter-temporal adjustment to short-run deviations from long-run equilibrium, and potentially important distinctions between short-run and long-run integration, as attempted by price equilibrium approaches.

Despite recent statistical sophistication mentioned in the previous section, there is no single best approach that addresses all the shortcomings of the spatial market integration techniques. There are several factors that affect the degree of market integration and generate discontinuities in the price responses to exogenous shocks (Baulch 1997; D'Angelo and Cordano2005).

The first one is the presence of high transaction costs relative to the price differential between two regions, which determines the existence of autarkic markets. The second factor is the presence of barriers to entry, risk aversion, and information failures. Some characteristics of the agricultural production, commercialization, and consumption, such as an inappropriate transportation infrastructure, entry barriers, and information failures, may turn the arbitrage process into a less smooth process than assumed by traditional models of market integration.

A commonly-mentioned source of asymmetry in the price response to shocks is the market power. For example, the oligopolistic intermediaries in a commodity market may react collusively faster to shocks that reduce their profit margins, generating asymmetries in the transmission of those shocks to other segments of the market. As a result, an increase in the central market prices would be spread to the regional markets in a faster way than would a decrease in such prices. The existence of imperfect competition in relevant segments of the markets may cause high price differentials between markets that cannot be attributed to transaction costs. For example, the presence of search costs on imperfect regional commodity markets is considered as a source of asymmetry or discontinuities in the prices adjustment process that occurs as a response to exogenous shocks (Blinder et al. 1998). In many regions, some firms can exercise local market power, due to the absence of other firms located in spatial proximity that could compete with them. The consumers that face these dominant firms face high search costs to get all the information about prices offered by other firms. Under these conditions, dominant firms may raise their prices quickly when the dominant market's prices increase, whereas they could reduce them by little, or not at all, when prices in the central market decrease.

Inventory accumulation has also been documented as a source of discontinuities in the adjustment of prices between markets. According to this argument, variations in prices send signals to inventory holders, thus leading them to accumulate or reduce stocks. The expected increase in the dominant market's price in the next periods constitutes an incentive for traders to increase inventory holdings, therefore inducing them to buy big quantities of a certain agricultural product in the present. But the increase in local market stocks pushes prices down, so the actual increase is not as high as originally expected. If, on the other hand, the dominant market prices were expected to decrease, there would be an incentive for traders to reduce their inventory stocks—a response that would moderate the magnitude of the price fall in the next periods. Under the argument of inventory holdings, regional market prices would not fully adjust to changes in the dominant market prices.

Another argument that explains the presence of discontinuous or asymmetric price responses is the existence of menu costs, understood as those costs that result from the re-pricing and information process that producers face in the presence of exogenous variations. If variations in the costs of the commodity were perceived by the agents as temporary, the menu costs might constitute an incentive not to adjust prices even when a change in the product costs has actually occurred.

DATA SOURCES AND LIMITATIONS

The rice prices used in this paper are drawn from the Food Security Monitoring and Analysis System of the WFP country office in Nepal. The data cover 17 districts in the mid- and far- western region of Nepal, from January 2003 to December 2005[3]. Additional monthly price data were collected for Banke (Nepal) and the Indian border districts of Rupedia and Jogbani from January 2001 to December 2004. These data were compiled from various issues of the Statistical Information on Nepalese Agriculture of the Ministry of Agriculture. The price data were divided by the consumer price index to correct for inflation and avoid spurious results.

When comparing prices across the borders, it is necessary to account for changes in the exchange rates and to make the price comparisons denominated in the same currency. Nepali/Indian Rupee exchange rates data were collected from January 2001 to December 2004 to meet this requirement.

In the absence of a series on transport costs, the single time transport cost of 2005, collected from WFP, was extrapolated from January 2003 to December 2005, by deflating by the monthly consumer price indices. As suggested by Baulch (1997), the extrapolation of transfer costs at a single point in time can be envisaged if the information on the different component of transfer costs is accurate. Aside from agricultural productivity (including quality aspects)[4], the main costs explaining the difference between source markets (i.e., export

[3] The concerned districts are Banke, Achham, Baitadi, Bajhang, Bajura, Dadeldhura, Darchula, Doti, Dailekh, Dolpa, Jajarkot, Jumla, Mugu, Rukum, Salyan, Surkhet and Pyuthan.

markets or surplus-production areas) and destination markets (i.e., import markets, deficit-production areas, or consumption markets), are transport costs, unloading costs, processing costs, interests to be paid on loans, margins, and losses[5]. WFP transport costs are based on tenders submitted by transporters on a competitive basis. They include overland and internal transport costs, storage costs, and handling (including loading and unloading) costs. They can therefore be considered as a good proxy indicator of transfer costs. Data on distance were collected for 14 districts in the mid- and far- western region to match with available road transport costs. Data on road distances were computed by WFP based on data from the Department of Roads.

It is worth noting that price, exchange rates, and transport costs variables are used in logarithm form throughout this paper. The log-transformation displays the advantage of making the series scale invariant and easing the interpretation of the changes as growth rates.

The small sample size (mainly the time dimension) is, however, a major limitation of the data set. While it is of interest to compare price movements at short horizons for a relatively high frequency of data, e.g., monthly (Haldrup 2003), such type of long-series data is hardly availabl. According to Haldrup, increasing the frequency of observations can only partially compensate for a short span of data. The reason is that new problems such as seasonality arise when the frequency of observations increases. However, the issue of seasonality cannot be fully addressed by choosing voluntarily a small series of observations. Seasonality was partially dealt with by introducing seasonal dummy variables in auxiliary regressions to control for the harvest season and road availability. The use of seasonal dummies will also reduce the number of lagged variables needed in the regressions. They, therefore contribute to improving the degree of freedom of the regressions. In the absence of seasonal dummy variables, the small sample size (i.e., below 30 observations) requires using appropriate critical values for hypothesis testing. The econometric results should be interpreted with caution, despite these attempts to reduce data limitations.

The price integration analysis within Nepal is based on the trade directions summarized in the map below.

TESTING RICE PRICE INTEGRATION

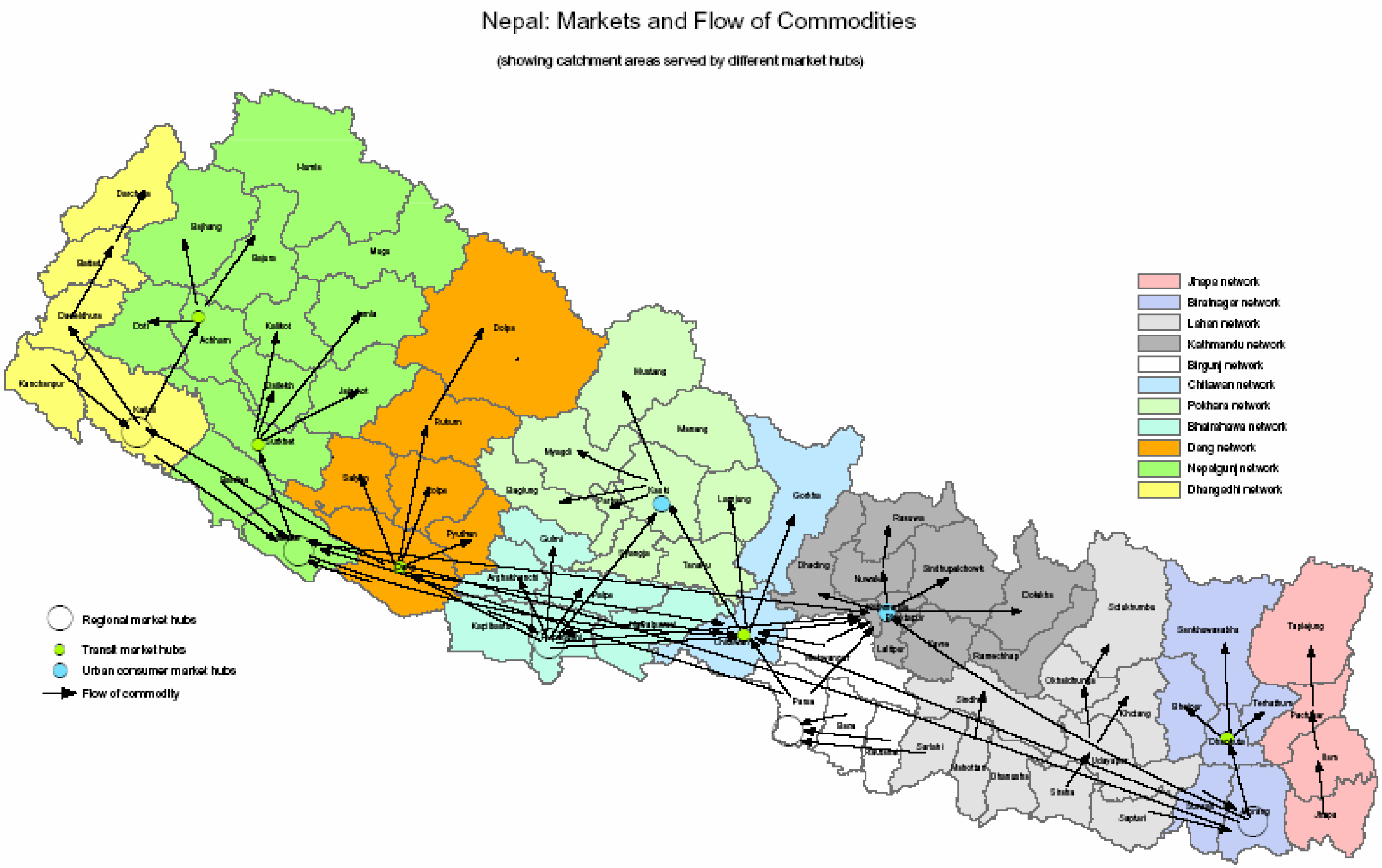
Annex 1 indicates limited correlations between the far- and mid-west market prices in Nepal, suggesting price dispersion is likely to allow high profit opportunities. Most of the pair-wise correlation coefficients are below 50 percent, some being negative. Negative correlations suggest prices between two markets move in opposite directions. As shown in the rest of this section, this is likely to be due to the hilly and mountainous terrain which tends to isolate markets from each other.

Using the Augmented Dickey-Fuller unit root test, 12 price series (out of 19) are non-stationary (Annex 2). Although there is no reason to believe that the stationary series (I(0)) are structurally different from the non-stationary (I(1)) ones, the co-integration test will exclude the stationary series. According to Granger (1981), it is not advisable to run a co-integration test of a I(0) variable on a I(1) variable or vice versa because the relationship is not balanced.

The results indicate very limited price co-integration between districts in the far- and mid-west of Nepal, suggesting the far-west and mid-west markets do not operate as a unified rice market (Annex 3). On the other hand, the regional market of Banke and the Indian border districts are likely inter-dependent. Out of 136 regressions, only 45 are balanced with non-stationary price series on both sides of the regression equation. Of these 45 regressions, 12 are co-integrated, that is only 9% of the 136 pair-wise co-integration regressions. In other words, prices in any given district can drift apart from prices in most other districts in the far-west

4 Quality differentials are not considered as a significant issue since grains are generally considered as homogeneous commodities.

5 Transfer costs also include other costs such as information costs and policy-induced costs since such costs involve the moving of goods from one place to the other (Chowdhury, Negassa, and Torero 2005).



Map 1. Food grain market networks (WFP and FAO, 2007)

and mid-west areas of Nepal. The limited number of co-integrated prices occurs mainly between the transit market price of Sanfebagar in Achham and its surrounding districts. The co-integration regression suggests there is no price co-integration between the regional market of Nepalgunj (Banke) and the transit markets of Surkhet and Achham. In the meantime, the rice price in Banke is likely co-integrated with the prices in the Indian border districts of Rupedia and Jogbani, as suggested by the price patterns (Figure 1). The co-integrating parameters and the adjustment parameters are statistically significant for both Rupedia and Jogbani, suggesting that the rice price in Banke is more likely to adjust significantly to price changes in the Indian border market prices of Rupedia and Jogbani (Annex 3).

In order to assess whether price movements follow well-defined patterns, from production/supply centers to consumption/demand centers, a Granger causality test between each pair of price series is applied using the Ravallion model (see Box 2). Alternatively, an error correction model is estimated on each co-integrated pair of price series (Pi and Pj) (Table 1). The first difference of Pi is Granger-caused by the first difference of Pj in the error correction model if the coefficient of the latter is statistically significant.

The estimations suggest a lack of clear pattern of the impact of price shocks as there are very few price series that Granger-cause each other. Granger-causality is statistically significant for only 4 regressions out of 28.

The results suggest that markets close by are more likely to Granger-cause each other. The rice price in Bajhang is Granger-caused by the price series in the neighboring districts of Bajura and Darchula. The price series in Banke (Nepalgunj) is Granger-caused by the price series in Rupedia, the adjoining Indian border district. In the meantime, the price series in Banke Granger-cause price series in Jogbani (India). These results suggest two-way trade flows between Banke, Rupedia and Jogbani. Actually, Banke (Nepalgunj) is one of the four major customs points (i.e., along with Biratnagar, Birgunj, and Bhairahawa) where most of the formal importation of rice and paddy into Nepal takes place. Over 90 percent of all rice imports through

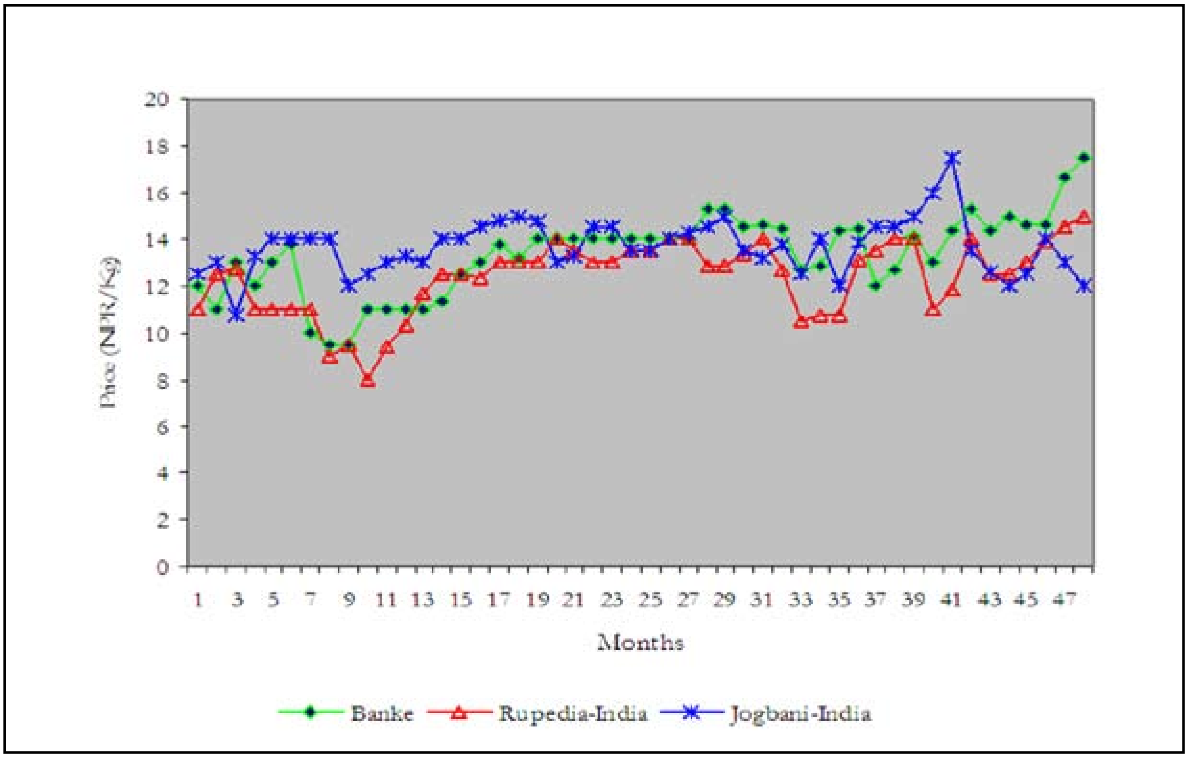


Fig. 1. Monthly price patterns of rice between Nepali/Indian border districts (Jan. 2001-Dec. 2004).

Box 2: Formulation of the spatial market integration model.

As summarized by Sadoulet and de Janvry (1997), the basic model of Ravallion (1986) consists in taking into account the structure of price determination across markets. This model considers a radial distribution of markets where one central market (r) is related to n feeder markets not directly related to each other.

(1) $P_r = P_r(P_1,\ldots,P_n, X_r)$ central market price,
(2) $P_i = P_i(P_r, X_i)$, $i = 1,\ldots,n$ feeder market prices,

where the X are market-specific seasonal and exogenous variables which affect price formation. For estimation purposes, the dynamic structure of the feeder market price equations is specified as a function of past prices with a general structure of l lags as follows:

(3) $P_{it} = \sum \alpha_{ij} P_{i,t-j} + \sum \beta_{ij} P_{r,t-j} + \gamma_i X_{it} + e_{it}$, $i= 1,\ldots,n$. In first sum, $j = 1,\ldots,l$. In the second sum, $j = 0,\ldots,l$

Estimation of this equation, typically with monthly price quotations, can be used to test the following hypotheses about market integration:

Segmentation of market i: present and past central market prices do not influence the ith local market.
[note: pls correct typo errors in the preceding line)
In this case: $\beta_{ij} = 0$, $j = 1,\ldots,l$.

Short-term market integration: a price increase in the central market is fully and immediately passed on the ith market without lagged effects. In this case, $\beta_{i0} = 1$, $\beta_{ij} = \alpha_{ij} = 0$, $j = 1,\ldots,l$.

Long-run market integration: under long-run equilibrium, a permanent price change in the central market is fully passed over time to the feeder markets, but potentially through lagged effects. The test of long-run market integration consists of testing: $\sum \alpha_{ij} + \sum \beta_{ij} = 1$.

If the market structure is not one of radial central-feeder markets, but more generally of pair-wise interlinked markets, the test of integration is done by evaluating all pair -ise price relationships (i,j) in the spatial relations. Assuming there is only one lag, the feeder market price equations simplify to:
[Note to Berns: Pls make sure the entire contents of the box is printed; bottom part is missing]
(4) $P_{it} = \alpha_i P_{i,t-1} + \beta_{i0} P_{rt} + \beta_{i1} P_{r,t-1} + \gamma_i X_{it} + e_{it}$,

which can be written in first differences as:

(5) $\Delta P_{it} = (\alpha_i-1)(P_{i,t-1} - P_{r,t-1}) + \beta_{i0} \Delta P_{rt} + (\alpha_i + \beta_{i0} + \beta_{i1} -1) P_{r,t-1} + \gamma_i X_{it} + e_{it}$.

This relates the change in local price to past spatial price differentials, the current change in central market price, and market-specific exogenous variables. Since there is less multicollinearity in this first difference equation (5) than in the price equation (4), it is this equation that is estimated. The tests of market integration are then:
Market segmentation: $\beta_{i0} = \beta_{i1} = 0$.
Short-run market integration: $\beta_{i0} = 1$, $\beta_{i1} = \alpha_i = 0$.
Long-run market integration: $\alpha_i + \beta_{i0} + \beta_{i1} – 1 = 0$.

There is a simultaneity problem in the estimation of the ΔP_{it} equation (5) since ΔP_{rt} is by definition endogenous as it is related to price formation in the local markets. Ravallion thus uses an instrumental variable approach to predict ΔP_{rt} in a two-stage least squares (TSLS) estimation.

Source: Sadoulet E. and A. de Janvry (1997): Quantitative Development Policy Analysis, The Johns Hopkins University Press, Baltimore and London, 127-129.

Table 1. Error correction models: results of pair-wise price regressions.

Dependent Variable	Estimators						R-Square
$DP_{i,t}$	C	$P_{ij,t-1}$	$DP_{i,t-1}$	$DP_{i,t-2}$	$DP_{j,t-1}$	$DP_{j,t-2}$	
Achham	-0.008	-1.063***	0.004		-0.393		0.57
Bajhang	-0.022	0.403	-0.367		-0.015		0.48
Achham	-0.003	-0.740	-0.03	0.163	0.897	0.294	0.43
Dadeldhura	0.007	-0.327	-0.092	-0.052	0.513	0.135	0.50
Achham	-0.006	-0.799*	-0.081		0.168		0.50
Darchula	-0.011	0.441	0.003		-0.107		0.24
Bajhang	-0.025	-0.222	-0.446*		-0.202**		0.55
Bajura	-0.005	1.111**	-0.131		0.372		0.57
Bajhang	-0.017	-0.190	-0.439*		-0.012		0.48
Dadeldhura	0.011	-0.296**	-0.191		0.182		0.51
Bajhang	-0.021	0.492	-0.726**		-0.719***		0.69
Darchula	0.010	1.077***	-0.219		-0.265		0.61
Bajhang	-0.027	-0.260	-0.401		-0.268		0.45
Jumla	-0.007	0.973***	0.215		-0.057		0.51
Bajhang	-0.025	0.050	-0.67***		-0.059		0.47
Rukum	0.002	0.570**	0.043		0.209		0.32
Bajura	-0.006	-1.066***	-0.084		0.733		0.65
Doti	0.023	-0.293*	0.235		0.078		0.28
Bajura	-0.001	-1.013	-0.012		-0.276		0.59
Surkhet	-0.017	0.064	-0.461		-0.096		0.43
Doti	0.035*	-0.192***	-0.101		0.062		0.56
Rukum	-0.017	-0.373	-0.106		0.456		0.36
Doti	0.004	-0.745***	0.225		0.715		0.48
Surkhet	-0.020	-0.170	-0.423		0.058		0.41
Banke	0.008	-0.352**	0.060	-0.114	-0.256	-0.256*	0.20
Rupedia (India)	0.005	0.645***	0.275	0.231	-0.160	-0.220	0.29
Banke	0.009	-0.001	-0.129	-0.273	0.148	0.071	0.11
Jogbani (India)	0.000	-0.044***	0.131	0.156	0.034	0.329***	0.44

(*), (**), (***) are significance levels of 10%, 5% and 1%, respectively. N=18

Source: Author's estimates.

formal channels take place through these customs points[6].

Unfortunately, there is no time series on trade flows and even when they are, such data are usually reported on an annual basis from official sources, hence making it difficult to compare with monthly price data. Caution is therefore required in the interpretation of the Granger-causality results. Another limitation of these results is due to the fact that regressions are carried out on small samples, making results sensitive to the number of distributed lags that are used.

An attempt to capture the impact of isolation on both the price correlation and the co-integration suggests that poor road infrastructure may lead to high transaction costs, thereby making arbitrage unprofitable and isolating markets (Fafchamps and Gavian 1996). Both the price correlation and the co-integration coefficients (dependent variables) are regressed on road distance and a dummy variable which takes the value 1 when there is a motorable road and 0 otherwise. Road distances explain only 5% of the variance of the price correlation coefficient, suggesting additional determinants of the price correlation could be added to the regression. After controlling for heteroskedasticity, distance has a negative impact, though statistically insignificant, on the price correlation coefficient

[6] Unrecorded or informal trade is an important feature of Nepal's trade with India (Action Aid 2006). The open and porous border has paved the way for a huge amount of informal trading across the border. The extent of informal trading in agricultural produce is estimated to be much higher than that of formal trade. Informal trade towards Nepal from India is dominated by agricultural products, mainly food items.

(Annex 4). Using the co-integration coefficients as dependent variables, the regression indicates that road distances and the dummy variable of motorable road availability explain about 52% of the co-integration statistic. After controlling for heteroskedasticity, the square distance has a negative but statistically insignificant impact, suggesting that beyond a threshold (maximum), distant markets are less likely to be co-integrated. The regression indicates also a positive and statistically significant impact of motorable road availability on the co-integration statistic, suggesting markets that are linked by motorable roads are more likely to be co-integrated (i.e., inter-dependent).

Tests of short- and medium-run price transmission processes indicate the Banke regional market (Nepalgunj) is likely integrated both in the short-and medium-run, with the Indian border markets of Rupedia and Jogbani (Table 2). Using the Ravallion model, a pair of equations is jointly estimated, using Three Stage Least Squares (TSLS), with one or two lags. Ravallion's model suggests adding control variables that can have a possible effect on price fluctuations. The exchange rate of the Nepali Rupee against the Indian Rupee is a major determinant of trade flows across the border because the former is pegged to the latter. A dummy variable representing the period of rice harvest in Nepal is also added to capture the possible effect of the harvest on rice price fluctuations. The first test (i.e., the null hypothesis that markets are segmented) suggests price integration between Banke, Rupedia, and Jogbani. The second test (i.e., the null hypothesis that markets are jointly integrated in the short run) suggests short-run integration between Banke and Jogbani. The third test (i.e., the null hypothesis that markets are jointly integrated in the medium run) suggests medium-run integration, i.e. price movements tend to converge after a couple of month between Banke, Rupedia and Jogbani.

Overall, the results of the various estimations and tests conducted so far should be interpreted with caution as they reflect only co-movements in prices, not market efficiency which is part of the market integration analysis. The patterns of price co-movements are considered as a good indicator of market efficiency only if goods always flow in the same direction (Baulch 1997). With transportation and other transaction costs, flow reversals cause prices to switch between import (trade destination) and export (trade source) parity prices (Fafchamps

Table 2. Short- and medium-run price integration: Ravallion Model Estimations and Tests.

n=36	Dependent Variable $DP_{i,t}$	Estimators $P_{i,t-1}$	$P_{i,t-2}$	$DP_{j,t-1}$	$lnforex_t$	$harv_t$	C	R-Square
Equation 1[a/]	Banke (Nepal)	-0.29*	-0.23	-0.16	1.93	0.03	0.42	0.25
Equation 2	Rupedia (India)	-0.33**	-0.35**	-0.03	1.07	0.02	1.21**	0.34

Tests on Parameters

	Null Hypothesis	Chi2	Prob>Chi2	Comment
Test 1	$\alpha3=\beta3=0$	1.89	0.389	Segmentation rejected
Test 2		-	-	First difference of prices in district j in period t dropped
	$\alpha1=\alpha2=\alpha3=\beta1=\beta2=\beta3=0$	35.85	0.000	Lack of lagged price transmission not rejected
Test 3	$\alpha1+\alpha2+\alpha3=\beta1+\beta2+\beta3=1$	137.19	0.000	Medium run integration not rejected

n=46	Dependent Variable $DP_{i,t}$	Estimators $DP_{j,t}$	$P_{i,t-1}$	$DP_{j,t-1}$	$lnforex_t$	$harv_t$	C	R-Square
Equation 1[a/]	Banke (Nepal)	-0.32	-0.20*	0.01	0.32	0.04	0.35	0.15
Equation 2	Jogbani (India)	-0.16	-0.54***	0.02	0.27	-0.005	1.28**	0.28

Tests on Parameters

	Null Hypothesis	Chi2	Prob>Chi2	Comment
Test 1	$\alpha1=\beta1=\alpha3=\beta3=0$	1.86	0.762	Segmentation rejected
Test 2	$\alpha1=\beta1=1$	24.71	0.000	Short run integration not rejected
	$\alpha2=\alpha3=\beta2=\beta3=0$	11.95	0.018	Lack of lagged price transmission not rejected
Test 3	$\alpha1+\alpha2+\alpha3=\beta1+\beta2+\beta3=1$	24.69	0.000	Medium run integration not rejected

a/ $\alpha1$, $\alpha2$, $\alpha3$ are the coefficients of the first three variables of equation 1

$\beta1$, $\beta2$ and $\beta3$ are the coefficients of the first three variables of equation 2

(*), (**), (***) significance levels of 10, 5 and 1 percent, respectively

Note: DPj,t = First difference (D) of prices (P) in district j in period t; Pi,t = Prices (P) in district i in period t; Inforex = Log-Foreign exchange Nepali/Indian Rupee; harv = dummy for rice harvest= 1 or 0 otherwise.

and Gavian 1996). In the presence of transactions costs, standard tests of market integration may conclude erroneously that markets are unrelated.

AN ATTEMPT TO CAPTURE MARKET EFFICIENCY

If markets are efficient and spatially integrated, price differentials across districts should reflect trade patterns: prices should increase as one moves away from supply/production centers due to increased distance and transport costs. To check whether this occurs, and assuming the regional market of Banke (Nepalgunj) is the source market, we compute the average price differentials and transport costs between Banke and the far- and mid-western districts, using sample averages.

The results summarized in Table 3 suggest there is a positive relationship between price differentials, road distances, and transport costs, though the correlation is low. There is a relatively high correlation (47%) between transport costs and motorable road distance. However, only one-third of the variance of the price is explained by transport costs, and the role of distance is even lower, accounting for only 10 percent of the variance of the price. Some high-price districts such as Jajarkot and Rukum are near the regional market of Banke and the transit market of Surkhet, as opposed to the low price district of Baitadi in the far-west. High price districts (Jajarkot and Rukum) are also right next to low-price districts (Salyan and Pyuthan), suggesting distance and road transport costs are not enough to explain price differentials in the far- and mid-west of Nepal.

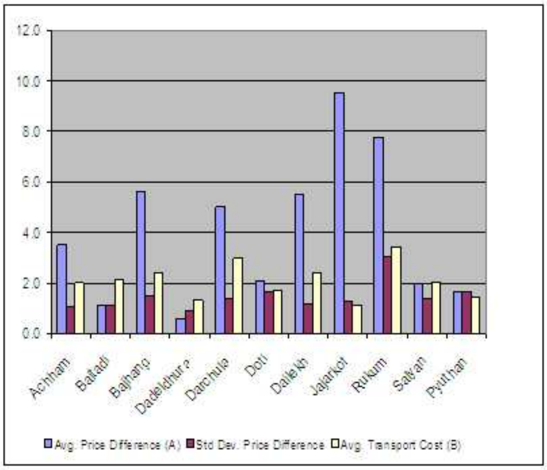
The sample averages used in this section can only be considered as a proxy indicator to measure market efficiency, as they ignore seasonal and geographical patterns (such as the cropping patterns, weather conditions, the terrain, geographical location, and the long- standing conflict) which affect price differentials across districts.

To investigate further the issue of market efficiency, we examine the evolution of price differentials relative to transportation costs. According to Baulch (1997), two markets may be said to be spatially integrated if, when trade takes place between them, price in the importing market equals price in the exporting market plus the transportation and other transfer costs involved in moving food between them. Whenever the price differential between the two markets falls below the transfer costs, there is no incentive to trade and spatial arbitrage conditions can no more be considered as a key to traders' decision- making. When, on the other hand, the price differential exceeds transfer costs, there are likely impediments to trade, though trade may occur. In such a context, markets cannot be considered as integrated.

The results summarized in Table 4 provide additional indication that market inefficiencies are likely an issue in the mid- and far- west districts

Table 3. Comparison of price differentials with transport costs (averages).

	Avg. Price Difference (A)	Std Dev. Price Difference	Avg. Transport Cost (B)	(A)/(B)	Distance (km)
Achham	3.52	1.08	2.01	1.75	477
Baitadi	1.14	1.11	2.13	0.53	399
Bajhang	5.61	1.50	2.41	2.33	745
Dadeldhura	0.61	0.90	1.32	0.46	316
Darchula	5.01	1.38	2.99	1.68	510
Doti	2.10	1.68	1.72	1.22	377
Dailekh	5.54	1.19	2.41	2.29	173
Jajarkot	9.55	1.31	1.15	8.31	245
Rukum	7.75	3.05	3.45	2.25	333
Salyan	1.98	1.39	2.01	0.99	303
Pyuthan	1.66	1.66	1.44	1.16	212
	Price/Transport		Price/Distance		Transport/Distance
Corr. Coef.	0.33		0.10		0.47



Source: Author's estimates.

of Nepal. In most of the cases, the monthly price differentials are higher than the transport costs between Banke and the inland districts, suggesting trade is likely occurring between markets despite impediments and lack of market integration. In addition to the negative impact of poor road infrastructure (shown in Section 4), trade impediments are likely due to the negative impact of the long-standing conflict on food trade in the mid- and far-western districts. A study conducted jointly by WFP and the Food and Agriculture Organization (FAO) concluded that market functioning has weakened in conflict-affected areas due to market shutdowns; the induced shortage of goods and services; the physical damage of goods and foodstuff incurred during transport on unsafe roadways; the obstruction of production, processing, transportation and trading of agricultural commodities; the damage to physical infrastructure; and the price instability due to taxation, donation and transport strikes, blockades and bandhs (WFP/FAO 2007).

Finally, the attempt to capture market efficiency remains limited by the lack of trade survey to support the empirical evidence. The high frequency of months in which price differentials are lower than the transport costs in the cluster districts of Dadeldhura and Baitadi suggests that trade flows are likely limited between these districts and Banke, as they depend primarily on the regional market of Attaria/Dhangadhi, a major rice-growing area in the far-western region of Nepal. The interpretation of the relatively balanced number of months in which price differentials are higher or lower than transport costs— between the adjoining districts of Banke, Salyan and Pyuthan— would also require further research on potential trade reversals. Although the hypothesis of trade reversals can be put forward because these districts are located in the major agricultural area surrounding the district of Dang in the mid-west, any consistent conclusion can be drawn in the absence of a trader survey. The lack of such vital information constitutes therefore a limitation to this paper.

CONCLUDING REMARKS AND POLICY IMPLICATIONS

This paper has assessed the performance of the rice market in mid-west and far-west Nepal. The objective was to analyze how price transmission, across different locations, operates within this

Table 4. Patterns of price differentials compared with transport costs (frequencies).

	Cases (out of 18 Obs.) Above		Cases (out of 18 obs.) Below	
	Number	%	Number	%
Banke-Achham	17	94.4	1	5.6
Banke-Baitadi	2	11.1	16	88.9
Banke-Bajhang	18	100.0	0	0.0
Banke-Dadeldhura	7	38.9	11	61.1
Banke-Darchula	17	94.4	1	5.6
Banke-Doti	11	61.1	7	38.9
Banke-Dailekh	18	100.0	0	0.0
Banke-Jajarkot	18	100.0	0	0.0
Banke-Rukum	17	94.4	1	5.6
Banke-Salyan	9	50.0	9	50.0
Banke-Pyuthan	12	66.7	6	33.3
Sum Cases	146	73.7	52	26.3

Note: Pls replace “Sum Cases” above with “Total No. of Cases”
Source: Author’s Estimates.

region and the role played by the adjoining district markets of India in the rice supply. By examining the nature of relationships among different markets, the paper also aimed to improve the understanding of the rice market operation in a highly vulnerable region characterized by a difficult terrain, frequent droughts, and a long-lasting conflict. Such information could contribute to decision-making relative to the formulation of effective rice marketing policies.

Various empirical techniques, using econometric tests of price transmission across markets, were reviewed and used to assess the efficiency of the spatial integration of rice markets. To our knowledge, this is the first time that such an empirical analysis has been attempted for Nepal.

The results indicate that the rice markets in mid-west and far west Nepal exhibit a limited degree of spatial integration with the regional market of Nepalgunj. In other words, price fluctuations are unlikely to spread from the source market of Nepalgunj (Banke) to distant markets of the far- and mid-western districts. The results also show that price fluctuations are transmitted across the Indian-Nepali border between Banke and the Indian border districts of Rupedia and Jogbani, with some degree of short- and medium- run convergence. An attempt to capture the impact of isolation (through road distance and availability) on both the price correlation and the price convergence, suggests that poor road infrastructure is likely an underlying cause of high transaction costs, thereby making arbitrage unprofitable for traders and isolating markets. As backed by theory, there is a positive relationship between price differentials, road distances and transport costs, though it appears to be a weak correlation. This finding suggests the existence of market inefficiencies in the mid- and far-western districts of Nepal. However, these results should be interpreted cautiously as the time frame used in this paper was very short and similar follow-up studies are needed as the price data base builds up in WFP's food security monitoring system in Nepal. Detailed structure, conduct and performance market surveys could throw new light on market efficiency, especially on key factors determining traders' decision to move rice across districts. Such a study would be particularly relevant in the context of the ongoing peace building efforts.

Despite these limitations, there is one important policy implication arising from the results, namely: any market intervention in isolated districts would have limited effects across the markets because of the lack of market integration. As a short-term measure, this result could justify government and humanitarian interventions in the far- and mid-west isolated districts to ensure that rice is available to households at a reasonable cost. However, the sustainability of such interventions in the long run is in question because of the high budget costs. Given the limited capacity of the government to supply food commodities to isolated markets at a subsidized cost, food aid plays a key role in the far- and mid-west districts both by providing food to households and building feeder roads.

In the long run, substantial investment in road infrastructure is required to improve the integration of markets. Market integration will play a crucial role in improving the food security situation of the mid- and far-western regions of Nepal which account for the highest number of cereal-deficit districts of the country. Price increases due to supply shortfalls in this region could be reduced by market integration which would therefore mitigate the negative effects on households' food access. Better road infrastructure, among other factors, could have positive effects on the food security situation of the mid- and far-western districts by improving the transport of food commodities from the regional market of Nepalgunj to food-deficit areas, at lower costs of access to markets, and with less delay.

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Annex 1. Price correlation coefficients.

	Banke	Achham	Baitadi	Bajhang	Bajura	Dadel-dhura	Darchula	Doti	Dailekh	Dolpa	Jajarkot	Jumla	Mugu	Rukum	Salyan	Surkhet	Pyuthan
Banke	1.00																
Achham	0.23	1.00															
Baitadi	-0.13	0.33	1.00														
Bajhang	-0.06	0.49	0.14	1.00													
Bajura	0.32	0.36	-0.09	0.33	1.00												
Dadeldhura	-0.20	-0.64	0.09	-0.17	0.05	1.00											
Darchula	-0.04	0.52	0.00	0.77	0.71	-0.11	1.00										
Doti	0.14	-0.22	0.01	-0.72	-0.30	0.17	-0.68	1.00									
Dailekh	0.17	0.33	0.41	0.36	0.25	0.31	0.35	0.06	1.00								
Dolpa	0.12	0.04	-0.46	0.24	0.41	-0.07	0.20	-0.19	-0.20	1.00							
Jajarkot	0.52	0.22	-0.16	0.11	0.00	-0.17	0.09	0.24	0.41	0.05	1.00						
Jumla	-0.07	0.63	0.24	0.63	0.41	-0.21	0.58	-0.25	0.47	0.32	0.14	1.00					
Mugu	0.38	0.69	0.25	0.43	0.27	-0.24	0.35	-0.04	0.56	0.30	0.47	0.51	1.00				
Rukum	-0.38	0.30	0.28	0.28	0.16	0.14	0.41	-0.14	0.52	0.01	-0.09	0.52	0.47	1.00			
Salyan	-0.01	0.32	0.12	0.56	0.55	0.15	0.68	-0.32	0.46	0.48	0.30	0.65	0.52	0.42	1.00		
Surkhet	0.01	0.27	0.06	0.70	0.51	0.06	0.82	-0.73	0.29	0.05	0.09	0.32	0.24	0.26	0.53	1.00	
Pyuthan	-0.11	0.30	0.54	0.35	0.03	0.15	0.33	-0.01	0.74	-0.15	0.38	0.47	0.42	0.39	0.63	0.20	1.00

Annex 2. Price integration tests (augmented Dickey-Fuller unit root tests).

Variable Name	Order of Integration	Significance Level (%)
Banke	I(1)	5
Achham	I(1)	5
Baitadi	I(0)	1
Bajhang	I(1)	1
Bajura	I(1)	1
Dadeldhura	I(1)	1
Darchula	I(1)	1
Doti	I(1)	5
Dailekh	I(0)	5
Dolpa	I(0)	1
Jajarkot	I(0)	1
Jumla	I(1)	5
Mugu	I(0)	10
Rukum	I(1)	1
Salyan	I(0)	10
Surkhet	I(1)	5
Pyuthan	I(0)	5
Rupedia (India)	I(1)	1
Jogbani (India)	I(1)	5
Log Foreign Exchange	I(1)	1

Annex 3. Pair wise (Johansen) cointegration tests.

District 1	District 2	Lag Order	Cointegration Rank	Cointegrating Coefficient	Adjustment Parameter[a/]
Banke	Achham	2	0		
Banke	Bajhang	1	0		
Banke	Bajura	2	0		
Banke	Dadeldhura	2	0		
Banke	Darchula	1	0		
Banke	Doti	1	0		
Banke	Jumla	1	0		
Banke	Rukum	3	0		
Banke	Surkhet	2	0		
Achham	Bajhang	2	1	-0.8955 (***)	Achham: -1.06***
Achham	Bajura	2	0		
Achham	Dadeldhura	3	1	1.5391 (***)	
Achham	Darchula	1	1	-0.7565 (***)	Achham: -0.80***
Achham	Doti	1	0		
Achham	Jumla	2	0		
Achham	Rukum	1	0		
Achham	Surkhet	1	0		
Darchula	Doti	1	0		
Darchula	Jumla	1	0		
Darchula	Rukum	1	0		
Darchula	Surkhet	1	0		
Jumla	Rukum	2	0		
Jumla	Surkhet	1	0		
Jumla	Surkhet	1	0		
Bajhang	Bajura	1	1	-0.6511 (***)	
Bajhang	Dadeldhura	1	1	2.4345 (**)	Dadeldhura: -0.30**
Bajhang	Darchula	1	1	-0.9314 (***)	
Bajhang	Doti	1	0		
Bajhang	Jumla	1	1	-1.1482 (***)	
Bajhang	Rukum	1	1	-1.6067 (***)	
Bajhang	Surkhet	1	0		
Bajura	Dadeldhura	2	0		
Bajura	Darchula	1	0		
Bajura	Doti	1	1	0.9526 (***)	Bajura: -1.07***; Doti: -0.29*
Bajura	Jumla	1	0		
Bajura	Rukum	2	0		
Bajura	Surkhet	1	1	-1.5751 (***)	Bajura: -1.01**
Dadeldhura	Darchula	1	0		
Dadeldhura	Doti	1	0		
Dadeldhura	Jumla	2	0		
Dadeldhura	Rukum	3	0		
Dadeldhura	Surkhet	1	0		
Doti	Jumla	1	0		
Doti	Rukum	1	1	1.6432 (***)	Doti: -0.19***
Doti	Surkhet	1	1	1.6551 (***)	Doti: -0.74***
Rukum	Surkhet	1	0		
Banke	Rupedia (India)	2	1	-1.0948 (***)	Banke: -0.35**
Banke	Jogbani (India)	2	1	15.7065 (***)	Jogbani: -0.04***

Annex 4. Estimation of correlation and cointegration coefficients on road distances.

Dependent Variable: Pairwise Correlation Coefficient	**Coefficient**	**Standard Error**	**t-Student**	**P>|t|**	**[95% Conf. Interval]**	
Log-Distance Between 2 Markets	-1.0627	0.7191	-1.48	0.142	-2.4856	0.3601
Log-Square Distance Between 2 Markets	0.1046	0.0655	1.60	0.113	-0.0250	0.2341
Motorable Road Availability (Dummy)	-0.0333	0.0574	-0.58	0.563	-0.1468	0.0803
Intercept	30.0158	20.7000	1.45	0.149	-10.9428	70.9743
Number of Observations = 132	F(3,128) = 2.58		Prob > F = 0.0563			
R-squared = 0.0571	Adjusted R-squared = 0.035		Root MSE = 3.2919			

Dependent Variable: Pairwise Correlation Coefficient	**Coefficient**	**Standard Error**	**t-Student**	**P>|t|**	**[95% Conf. Interval]**	
Log-Distance Between 2 Markets	-1.1312	0.7075	-1.60	0.112	-2.531	0.2685
Log-Square Distance Between 2 Markets	0.1112	0.0643	1.73	0.086	-0.0160	0.2384
Intercept	31.701	20.4418	1.55	0.123	-8.7435	72.1456
Number of Observations = 132	F(2,129) = 3.72		Prob > F = 0.0268			
R-squared = 0.0546	Adjusted R-squared = 0.0399		Root MSE = 3.2835			

Dependent Variable: Cointegration Coefficient	**Coefficient**	**Standard Error**	**t-Student**	**P>|t|**	**[95% Conf. Interval]**	
Log-Square Distance Between 2 Markets	-0.0841	0.0514	-1.64	0.136	-0.2004	0.0322
Motorable Road Availability (Dummy)	2.1753	0.7816	2.78	0.021	0.4072	3.9433
Intercept	2.1805	1.5360	1.42	0.189	-1.2942	5.6553
Number of Observations = 12	F(2,9) = 4.86		Prob > F = 0.0371			
R-squared = 0.5192	Adjusted R-squared = 0.4123		Root MSE = 1.0463			