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Decomposing Producer Price Risk: A Policy Analysis Tool With An Application to Northern Kenyan Livestock Markets

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Abstract: This paper introduces a simple method of price risk decomposition that determines the extent to which producer price risk is attributable to volatile inter-market margins, intra-day variation, intra-week (day of week) variation, or terminal market price variability. We apply the method to livestock markets in northern Kenya, a setting of dramatic price volatility where price stabilization is a live policy issue. In this particular application, we find that large, variable inter-market basis is the most important factor in explaining producer price risk in animals typically traded between markets. Local market conditions explain most price risk in other markets, in which traded animals rarely exit the region. Variability in terminal market prices accounts for relatively little price risk faced by pastoralists in the dry lands of northern Kenya although this is the focus of most present policy prescriptions under discussion.

Producer price volatility concerns producers and governments in a wide range of industries and nations. In settings where producers have little or no access to financial markets through which they can effectively hedge against price risk, governments are often keen to find cost-effective means to reduce producer price volatility. Yet such volatility can arise from any of several sources, so identification of effective intervention strategies depends fundamentally on locating the source(s) of variability in producer prices. This paper introduces a simple method of price risk decomposition intended to serve as a policy analysis tool for precisely that purpose. This method determines the extent to which producer price risk is attributable to volatile inter-market margins, intra-day variation, intra-week (day of week) variation, or variability in terminal market price. We apply the method to livestock markets in northern Kenya, a setting of dramatic price volatility where price stabilization is a live policy issue.

The remainder of the paper proceeds as follows. Section I introduces our price risk decomposition method. We then demonstrate its utility with an application to livestock markets in the drylands of northern Kenya in a series of three sections. Section II describes the context and some of the current policy debate surrounding livestock price stabilization in Kenya. Section III presents the data and key limitations of this particular sample. The empirical results appear in Section IV along with discussion of these estimates. Section V concludes.

I. A Producer Price Risk Decomposition Method

Our method involves a straightforward decomposition of price risk into four key components. The first component reflects that portion of producer price variability that is due to prevailing transactional institutions and associated information advantages (intra-day, intra-market variance). Even within well-developed markets, there can be significant intra-day trading

risk, as a vast literature in empirical finance shows in studies of capital markets. In less-favored lands, poor communications and marketing infrastructure can create enormous informational disparities among buyers and sellers in the same location that can easily persist over the course of several hours. Many people speculate that, per the predictions of economic theory, auctions (of any of several designs) will generally dampen price variability relative to the price distributions arising in dyadic markets in which buyers and sellers search and negotiate bilaterally or with the assistance of brokers. The intra-day, intra-market component of price variability is meant to reflect these local level, institutional and informational factors that may contribute to producer risk exposure.

The second component of producer price risk we study reflects intra-week variability due to market thickness and day-of-the-week effects (inter-day, intra-week, intra-market variance).[1] Like the intra-day, intra-market component just discussed, this component reflects in part institutional arrangements. In the main, however, it reflects the depth of the market, how many buyers and sellers arrive, inconsistently and perhaps irregularly, to transact at a common location. Where the density of buyers and sellers is great, one would expect daily trading volumes and thus prices to be relatively more stable, ceteris paribus, than in markets where the density is low, leading to sharp proportional day-to-day changes in bid or offer volumes. This inter-day, intra-market component thus reflects primarily local market density.

The third component of our measure relates to variability in the costs of spatial arbitrage (intra-week, inter-market variance). The literature on agricultural marketing, market integration testing and spatial price analysis pays considerable attention to transport costs and intermarket price differences, commonly known as “basis” (Ravallion 1986, Barrett 1996, Fackler and Goodwin 2001). The intuition for this goes back at least to the seminal work on spatial markets

equilibrium by Enke (1951), Samuelson (1952) and Takayama and Judge (1971). These literatures focus squarely on mean basis levels, not on basis volatility, but it is a very natural extension to look instead at the variance of the basis series. Intermarket price differentials capture both features of the spatial marketing infrastructure that connects distant markets and the degree of competitiveness in intermarket arbitrage. If one market enjoys vigorous competition among traders while another does not, or if the costs of moving cargo between markets varies considerably due to changing road conditions, fuel availability, banditry, etc., then basis may prove quite volatile. As a consequence price signals originating in destination markets due to demand shocks or policy interventions may transmit to satellite markets only noisily, if at all.

The fourth component into which we disaggregate producer price risk relates to terminal (destination) market price variability effects (inter-week, intra-market variance at the terminal market). These effects capture standard seasonality effects in consumer demand patterns, seasonality in supply from competitor supplier markets, other shocks to demand due to, for example, changing prices for complementary or substitute goods, and macroeconomic phenomena such as exchange rate volatility or business cycle effects on employment or incomes. It has long been recognized that in developing countries, agricultural price stabilization programs have typically been designed chiefly for the benefit of urban consumer populations by governments aiming to stem prospective food crises – and attendant political unrest – in capital cities, as manifest in striking urban bias in the geography of food storage and transport infrastructure (Barrett 2002). Standard interventions such as buffer stock schemes, panseasonal pricing, open market interventions by parastatal marketing authorities have been implicitly aimed at stabilizing this last component of prices.

One can easily compute the proportion of total producer price risk that is attributable to each of these four components, thereby locating the source(s) of aggregate price risk. Since the nature and policy implications of these four components of producer price risk are markedly different, such information is essential to proper targeting of any public interventions intended to stabilize producer (or consumer) prices.

The mental image one should have in the back of one's head as we develop this method runs as follows. There is a producer looking to sell a fixed quantity of a good in a local market on a given day. He is uncertain as to what price his particular transaction will fetch that day in that market, but he has a conditional distribution for the price in his head for this particular good-day-market combination. We wish to understand the conditional variance of the transaction price as a measure of producer price risk, and, especially, to establish which component(s) of price risk account for most of the subjective price variability in order that policymakers might be able to target interventions toward the primary source(s) of producer price risk.

The producer price risk decomposition method works as follows. Let i index individual transactions, t index individual days, and w index weeks. Let p be the price in the source market in which the producer sells and p^* be the price in the destination/terminal market in which a buyer in the source market ultimately resells.[2] By creatively adding and subtracting zeroes, we can decompose the source market price for any individual transaction as follows:

$$p_{it} = \left(p_{it} - \bar{p}_t\right) + \left(\bar{p}_t - \bar{p}_w\right) + \left(\bar{p}_w - \bar{p}_w^{\,*}\right) + \left(\bar{p}_w^{\,*} - \bar{p}^*\right) + \bar{p}^* \qquad (1)$$

$$= I_t + M_t + B_t + T_t + \bar{p}^* \qquad (2)$$

$I_t \equiv (p_{it} - \bar{p}_t)$ represents the deviation between individual and mean prices in the source market on a particular day ($\bar{p}_t$), attributable largely to prevailing transactional institutions and associated information advantages (e.g., auctions versus dyadic negotiation). $M_t \equiv (\bar{p}_t - \bar{p}_w)$ is the deviation

of the daily mean price from the weekly mean price in the same market, capturing intra-week variability in market thickness and day-of-week effects. $B_t \equiv (\bar{p}_w - \bar{p}^*_w)$ captures weekly mean inter-market basis (weekly mean price differentials between spatially distinct markets), the result of variation in the costs and performance of inter-market arbitrage. Finally, $T_t \equiv (\bar{p}^*_w - \bar{p}^*)$ is the deviation between mean terminal market price in the current week and the annual average terminal market price, $\bar{p}^*$ capturing variability in the terminal market.

Since $E(I_t) = E(M_t) = E(T_t) = 0$, the unconditional expected value of this relation reflects the conventional spatial market equilibrium relationship, wherein the intermarket price differential is simply the expected basis, $E(B_t)$:

$$E(p_{it}) = E(B_t) + \bar{p}^*. \tag{3}$$

This also allows decomposition of the source of price risk faced by producers coming to market:

$$V(p_{it}) = V(I_t) + V(M_t) + V(B_t) + V(T_t) + 2[COV(I_t, M_t) + COV(I_t, B_t) + COV(I_t, T_t) + COV(B_t, M_t) + COV(T_t, B_t) + COV(M_t, T_t)] \tag{4}$$

Expression (4) leads to an intuitive simplification into the four risk sources discussed previously:

$IR_t \equiv V(I_t) + COV(I_t, M_t) + COV(I_t, B_t) + COV(I_t, T_t)$ is informational/institutional risk

$MR_t \equiv V(M_t) + COV(I_t, M_t) + COV(M_t, B_t) + COV(M_t, T_t)$ is local market risk

$BR_t \equiv V(B_t) + COV(B_t, M_t) + COV(I_t, B_t) + COV(B_t, T_t)$ is basis risk

$TR_t \equiv V(S_t) + COV(T_t, M_t) + COV(T_t, B_t) + COV(I_t, T_t)$ is terminal market risk

Substituing these four variables into equation (4) and dividing by $V(P_{it})$ yields a straightforward decomposition of price risk:

$$1 = ir_t + mr_t + br_t + tr_t \quad (5)$$

where the lower case variables are price risk shares by source. By construction, these four unitless risk variables sum to one, offering a simple, intuitive, proportional measure for assessing the source of observed price volatility. These measures are unitless, so one can do comparative analysis with them across different commodities within a location or across different countries and currencies. The intuitive nature of the decomposition, the ease of the computations, and the broad comparability of the measures make this a potentially quite useful policy analysis tool.

II. Northern Kenyan Livestock Markets

We apply this method to northern Kenyan livestock markets. The region's poor soils and by low, highly variable rainfall patterns preclude significant crop cultivation. Livestock production systems predominate because animals can be moved in response to spatiotemporal variability in economic, environmental, epidemiological and security conditions.[3] Livestock provide herders not only with meat, milk and blood for sustenance, but also, through livestock sale, with a means for financing basic needs expenditures such as grains, school fees or medical expenses. Livestock prices are therefore a primary determinant of pastoralist wealth and welfare.

Pastoralist herders residing in the arid and semi-arid lands (ASAL) of northern Kenya are among the poorest subpopulations in sub-Saharan Africa by standard income or expenditure measures, they suffer high rates of malnutrition and illiteracy, and they are vulnerable to regular drought, civil unrest and other serious shocks. The producer population of northern Kenya is thus of considerable interest to government and to international donors and charities for humanitarian reasons. So for multiple reasons, there exists considerable interest in the vulnerability and welfare of the pastoralists in the Horn of Africa, including northern Kenya.

Markets pose a significant obstacle, however, due to high transactions costs, difficulties in contract enforcement, physical insecurity, and poor infrastructure. Low and variable producer prices are among the most serious concerns of pastoralists and partially explain the extremely low marketed offtake rates among ASAL pastoralists, which typically languish between 1.5 and 3.5 percent of beginning period cattle stocks and are basically nonresponsive to variation in mortality risk or rangeland carrying capacity (Chabari and Njiru 1991, Bailey et al 1999, Smith et al. 2000, 2001, McPeak and Barrett 2001, Barrett et al. 2001). Low, unresponsive marketed offtake rates result in considerable loss of wealth through livestock mortality. More frequent and severe climatic shocks in the past two decades have pushed an increasing number of pastoralists deeper into abject poverty, prompting huge flows of international humanitarian aid into the ASAL (McPeak and Barrett 2001).

Many current strategies for reversing this crisis hinge on getting pastoralists to depend *less* on aid and *more* on markets, which in turn depends in part on reducing the extraordinary price volatility that is widely believed to dampen market participation rates. Livestock prices in northern Kenyan are highly variable for a given type of animals (e.g., an excellent condition adult ewe), with an unweighted (across species and gender) mean coefficient of variation of 0.511, quite a high measure by the standards of either livestock markets in high-income countries or grains markets in east Africa. Very few pastoral households enjoy access to formal risk management instruments such as credit or insurance. Futures markets do not exist. Any near-term dampening of ASAL livestock producer price risk must therefore come through policy or project interventions such as road improvements, the introduction of auctions, local market infrastructure upgrades, price broadcasting services, or the reintroduction of a parastatal

livestock marketing authority. In order to identify suitable interventions, however, one must locate the sources of price risk more precisely.

Given other work on livestock markets in Africa (Sandford 1983, Kerven 1992, Fafchamps and Gavian 1997, Bailey et al 1999), we would expect basis risk associated with imperfect spatial arbitrage to emerge as a significant source of price risk. Based on direct observation and pastoralists' own statements (Smith et al. 2000, 2001) we also suspect weak local market institutions account for a nontrivial share of producer price risk in the northern Kenyan ASAL. Because both pastoralists and traders anticipate regular changes in climate and demand due to festivals and holidays, and because of the seemingly weak transmission of excess demand from the principle terminal market, Nairobi, to northern markets 400-600 kilometers away, we do not expect terminal market variability to be a prominent source of price risk.

Our conjectures not withstanding, current policy debates in Kenya surrounding livestock markets focus almost entirely on terminal market variability and how this might be dampened through reactivation of a closed parastatal marketing authority, the Kenya Meat Commission, as a buyer of last resort in the terminal marketshed, through creation of a Red Sea Livestock Marketing Authority to facilitate increased exports from Kenya, and the rest of the Horn of Africa, to the Arabian peninsula, or both. If one objective of livestock marketing intervention is producer price stabilization in the net exporting ASAL regions of the north, are these instruments – or others like them that aim to stabilize terminal market prices – the right policy lever?

Ultimately, the sources of price risk, and thus the appropriate policy remedy for perceived excessive price volatility, are an empirical question and might well differ across markets. The task to which we now turn involves applying the earlier method to data from

northern Kenyan livestock markets, primarily as a demonstration application of the policy analysis tool, but equally to address current questions surrounding these markets.

III. Data

From January 1996 to December 1997 staff from the GTZ-Marsabit Development Project (GTZ-MDP) collected several thousand observations on livestock transactions in three different markets in Kenya, two source markets in the north, Marsabit and Moyale, and the main terminal market, Dagoretti, in the capital city, Nairobi, the largest market in East Africa. Observations from Dagoretti serve as the terminal market prices with respect to both up-country markets. During the period of data collection, Marsabit and Moyale were the two main towns of a vast Marsabit District, which stretched north from Samburu to the Ethiopian border, which Moyale town straddles. Both towns host daily, dyadic markets in which herders and traders bargain one-on-one with relatively few brokers or other third party market intermediation. Little investment has been made in marketing facilities. Marketplaces are large fields near town, with minimal supporting institutional or physical infrastructure. Marsabit and Moyale are about 540 and 800 kilometers, respectively, from the capital city and no paved roads exist in this area. Transport costs are therefore extremely high and risks of vehicle break down are great. More seriously, banditry and cattle rustling are widespread and play a critical role in influencing pastoralists' and traders' decisions to participate in markets because animals are commonly trekked to and from remote production areas and markets (Barrett et al. 2001, Chabari and Njiru 1991).

The data were collected opportunistically and therefore do not comprise a random sample. Further, because of nonconstant enumerator availability and the need for sufficient observations within a day and across continuous periods, usable sample sizes vary considerably

across markets. GTZ-MDP's enumerators were trained to observe livestock transactions under negotiation, to examine independently from nearby the animal over which the bargaining was occurring, recording gender, species, and subjective categorical body condition quality data on the animal's body condition (poor, fair/good, or excellent). If and when a sale was consummated, the enumerator then recorded the final sales price and interviewed the buyer to determine the means by which the animals were to be evacuated from market, and the destination and planned use of the animal.[4] The enumerators were well versed in livestock marketing and trained to use quality criteria that were consistent across enumerators, markets and seasons. The animals were not weighed, so analysis can only be done on a per head basis, not per unit live weight. When an enumerator was on site, s/he typically was able to record information on 20-30 livestock transactions per day in each market.[5]

IV. Empirical Results and Discussion

The price data just described limit the extent to which one can derive clear policy-relevant findings because we have only very crude proxies for animal weight and health, which are crucial attributes. As we show below, this seems to matter for inference from the data. As one begins to disaggregate the data by body condition categories, the results sometimes change in ways that suggest the ir measure may be biased upwards due to unobserved heterogeneity in animal quality. For example, if different quality animals are commonly sold at different times during the day and there are distinct types of buyers for each quality category, then assortative matching could lead to intra-day price variability. Consider the case of larger, stronger animals sold early in the day to traders who ship these prime animals to distant markets that day, versus smaller and weaker animals purchased later in the day by local butchers for slaughter and sale on

the local meat market or by local herd owners looking to restock or build herds at low cost. These latter actors perform a "buyer of last resort" function for lower quality animals. Unfortunately, our data do not permit proper control for potential assortative matching problems that could be associated with unobserved heterogeneity in animal quality and thus price.

Similarly, it is possible that we inflate the br measure by comparing different quality animals across markets. If different breeds have different intrinsic characteristics that affect price, and if breed composition varies across spatially distinct markets and over time, then variability in market-specific quality mix can create another form of unobserved heterogeneity that may be particularly picked up in the estimated share of producer price risk due to basis risk.

These are inherent limitations about these data, but not about the method we aim merely to demonstrate in this section. Moreover, these data provide the best available evidence on livestock markets in northern Kenya, so if one wishes any sort of empirical analysis to inform current policy debate in Kenya, this is unfortunately the best evidence available. Application of this method to other, more complete data sets is left to future work and other researchers.

Results from the price risk decomposition technique applied to the data from Marsabit and Moyale appear in Tables 1 and 2, respectively. Several intuitive findings emerge immediately. First, terminal market variability accounts for a negligible proportion of producer price risk. Although proposals periodically emerge to reinstate panseasonal pricing that once prevailed under state monopsony and although there is significant predictable seasonal variation in livestock prices due to the region's bimodal rainfall (Barrett et al. 2001), there seems to be little empirical justification to worry about terminal market risk. Indeed, because variability in the terminal market uniformly covaries negatively with basis,[6] terminal effects are stabilizing on balance (i.e., contribute negatively to producer price risk) in one-third of the gender-species-

market-specific series we study. Current policy proposals aimed at stabilizing Nairobi livestock prices appear unlikely to dampen appreciably the producer price risk faced by ASAL pastoralists.

Size, condition and species are important variables in determining whether animals move only within local markets or instead to terminal markets. Males tend to be of larger size than females of similar condition and are therefore more commonly sold for slaughter in Nairobi, while the latter will tend to be earmarked for local butcheries or for restocking local herds, especially if fertile and in good condition. Indeed, males typically account for three-quarters or more of total market transactions, while markets in fertile females are very thin (Barrett et al. 2001, McPeak and Barrett 2001). Such patterns help explain sources of price risk.

Inter-market basis risk (br) proves most influential in those markets in which animals are overwhelmingly destined for slaughter in terminal markets.[7] This describes markets for males of each species in Marsabit, as well as poor condition (generally infertile and nonlactating) cows there (Chabari and Njiru 1991, Barrett et al. 2001). Unless the prospective unobserved heterogeneity bias discussed previously is particularly great, basis risk is the most important source of producer price risk in almost every case of spatially traded livestock. This serves to underscore the crucial role of physical infrastructure, rural law and order, and competition within the marketing channel in creating an attractive marketing environment for pastoralists.

Trade in good condition females of each species is mainly for local stock replacement and breeding. As a result, inter-market basis matters relatively little since the animals rarely leave the area. Between them, ir and mr consistently account for at least two-thirds of price risk. Female goats in Moyale are a notable exception that proves this rule, because in that area pastoralists raise goats mainly for export-oriented sale in order to finance the purchase of cows.

When trade is highly localized, price variability emerges naturally from weakness in local markets; the broader economy and volatility in spatial arbitrage have limited impact.

The covariances between I, M, B and S exhibits some interesting patterns as well. As was mentioned already, COV(B,S) < 0 in every case. As terminal market prices reach seasonal or business cycle highs, inter-market basis falls, likely reflecting heightened competition. This effect is also uniformly the greatest among the six covariances, typically by an order of magnitude. The COV(B,M) term is typically positive and second largest in magnitude. As inter-market basis increases, inter-day differences within the week in source markets tend to rise as well. This likely reflects the adverse effects of higher spatial arbitrage costs on the number of market participants, with transactions prices varying more day-to-day in markets made thinner by high costs of spatial arbitrage. By contrast, I_t is effectively orthogonal to the other three terms. In every case, its covariance with each other risk source accounts for less than one millionth of total producer price variance.

Finally, our results underscore the intuitive importance of controlling for product quality in order to guard against aggregation bias. The final, italicized row in each block of Tables 1 and 2 reports the price risk decomposition results from pooling observations across all body conditions. The apparent share of informational/institutional (intra-day, intra-market) risk consistently increases relative to the condition-specific estimates, often quite considerably so. Since the categorical quality measures available to us surely mask within-category variation and since observed prices are per head, not per kilogram, and there is without question unobserved weight variation, our estimates likely already overstate the importance of informational-institutional risk, further underscoring the relative importance of basis and local market risks in explaining producer price volatility in northern Kenyan livestock markets.

V. Conclusions

This paper introduces a simple, intuitive method of producer price risk decomposition. Applied to a rich, albeit imperfect set of transactions-level data from livestock markets in northern Kenya, the statistical results prove quite consistent with qualitative descriptions of the functioning of these markets. Large and variable inter-market basis is the single most important factor in explaining producer price risk in animals typically traded between markets. Local market conditions explain most price risk in other markets, in which traded animals rarely exit the region. Price fluctuations in the terminal market accounts for relatively little price risk faced by pastoralists in the dry lands of northern Kenya. The practical policy implication of these findings is that high, volatile costs of spatial arbitrage and intertemporally inconsistent competitiveness within and between markets appear the main source of the livestock price volatility that concerns poor pastoralist populations in the northern rangelands. It seems unlikely that one can effectively mitigate the problem of extraordinary livestock producer price risk in northern Kenya without directly improving inter-market arbitrage, whether through efforts to reduce and stabilize transport costs, to improve physical security, or to stimulate new entry into the sub-sector.

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Table 1: Price Risk Decomposition – Marsabit Data

Species Gender • Condition	**ir**	**mr**	**br**	**sr**
Cattle				
Female (Male)				
•Good	0.2724 (0.1279)	0.3721 (0.1944)	0.2365 (0.4640)	0.1189 (0.2136)
•Fair	0.1188 (0.0236)	0.2031 (0.1413)	0.5726 (0.7321)	0.1054 (0.0856)
All	*0.3693 (0.4083)*	*0.3650 (0.2628)*	*0.2099 (0.3414)*	*0.0558 (-0.0125)*
Goats				
Female (Male)				
•Good	0.3092 (0.1604)	0.4052 (0.2597)	0.2307 (0.5966)	0.0548 (-0.0167)
•Fair	0.3656 (0.6686)	0.3526 (0.1044)	0.3283 (0.1981)	-0.0465 (0.0289)
All	*0.5305 (0.2432)*	*0.2826 (0.2866)*	*0.1733 (0.4801)*	*0.0136 (-0.0099)*
Sheep				
Female (Male)				
•Good	0.5487 (0.3496)	0.2584 (0.3142)	0.1715 (0.3988)	0.0214 (-0.0627)
•Fair	0.5052 (0.2070)	0.2180 (0.2693)	0.2078 (0.3143)	0.0690 (0.2093)
•Poor	0.1962 (0.0336)	0.3127 (0.4808)	0.3078 (0.4009)	0.1833 (0.0847)
•*All*	*0.6545 (0.6670)*	*0.1822 (0.1725)*	*0.1503 (0.1140)*	*0.0130 (0.0464)*

Female(Male): Cattle[N^{All}=647(681), N^{Good}=355(345), N^{Fair}=109(58)]; Goats[N^{All}=572(198), N^{Good}=394(151), N^{Fair}=163(45)]; Sheep[N^{All}=1281(1010), N^{Good}=644(368), N^{Fair}=447(350), N^{Poor}=234(289)].

Table 2: Price Risk Decomposition – Moyale Data

Species Gender • Condition	**ir**	**mr**	**br**	**sr**
Cattle Female (Male)				
•Good	0.2731 (0.7785)	0.4487 (0.1600)	0.3500 (0.0779)	-0.0718 (-0.0164)
All	*0.2981 (0.7841)*	*0.4896 (0.1605)*	*0.3291 (0.0689)*	*-0.1169 (-0.0136)*
Goats Female (Male)				
•Good	0.1203 (0.3557)	0.3366 (0.3179)	0.6153 (0.2019)	-0.0722 (0.1243)
All	*0.1519 (0.3511)*	*0.2089 (0.3182)*	*0.6224 (0.2322)*	*0.0167 (0.0985)*

Moyale Female (Male): Cattle [N^{All}=364 (792), N^{Good}=364 (792)]; Goats [N^{All}=39 (145), N^{Good}=39 (145)]

Notes

[1] The distinction between the first and second components of the decomposition does not depend on the existence of daily markets. It can readily be generalized to lower frequency (e.g., weekly) markets. we are indebted to Arie Kuyvenhoven for emphasizing this point to us.

[2] We maintain the radial markets assumption common to the literature on spatial market integration (Ravallion 1986). This assumption indisputably holds in this empirical application since there is a regular flow of animals from northern Kenya to the Nairobi terminal market with no seasonal flow reversal. The only interruptions to the flow occur during periods of quarantine due to animal health concerns.

[3] Precious few alternative, remunerative livelihoods exist in the area, sharply limiting capacity to diversify income or assets (Little et al. 2001).

[4] Barrett et al. (2001) study the price formation process in these data in detail.

[5] Data was also recorded for camel, donkey and poultry transactions, and for sheep in Moyale. But we are unable to use those series due to low numbers of usable observations, often times due to systematically missing information on one or two variables. The analysis is therefore restricted to cattle, goats and sheep.

[6] The covariance of basis and terminal market prices as a proportion of total producer price variance ranged from –0.069 for male goats in good condition in Marsabit to -0.517 for male sheep in fair condition in Marsabit.

[7] We could not identify an appropriate statistical test with which to make robust inferences from the sample descriptive statistics br, ir, mr and sr to differences in population among these producer price risk components. Such tests invariably assume independence, which clearly does not apply in the present setting. As merely suggestive evidence, the Bartlett and Levene tests of

homogeneity of variance (Snedecor and Cochrane 1989) across B, I, M and S overwhelmingly reject the null hypothesis that the variances are the same. For each market-species-condition series, the p-value of the test statistic was less than 0.001.