PRICES AND MARKETS IN GHANA

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ABBREVIATIONS

BCEAO	Banque Centrale des Etats de l'Afrique de l'Ouest
CFA	Communauté Financière Africaîne
FAO	Food and Agriculture Organization
GFDC	Ghana Food Distribution Corporation
GLSS	Ghana Living Standards Survey
IMC	Index of Market Connectedness
MT	Metric Tons
PPMED	Policy Planning, Monitoring, and Evaluation Department (Ministry of Agriculture)

FOREWORD

This paper is the third in the CFNPP Working Paper series to focus on Ghana. In it, the authors provide a rigorous analysis of monthly food commodity prices in Ghana during the period 1970 to 1990, focusing particular attention on the periods before and after Ghana's economic recovery program. The study includes an investigation of time trends and seasonal price patterns both between and within markets, as well as analyses of intercommodity price transmittal and market integration.

Price movements have important impacts on households, especially as measured in terms of transitory food security. This is especially the case for poor households whose consumption is more price-responsive and who are less able to draw upon savings and other assets to buffer the fluctuations in seasonal and inter-annual prices. In order to understand more fully the role of markets in affecting food security, and the related issue of whether and why there are market failures that reduce the ability of the household to access sufficient food, the study focuses on the issue of how well commodity markets are functioning. In addition, the paper examines whether any discernible changes have occurred in price movements and efficiency of markets since economic reform commenced. This is especially important since an important element of reform is reducing the threat to food security represented by factors such as high marketing margins and poor regional integration. As such, the current effort has wide relevance for any discussion of price, storage, or trade policy in Ghana, and provides a valuable complement to CFNPP's continuing research on policy reform and poverty in sub-Saharan Africa.

Ithaca, New York
May 1991

David E. Sahn
Deputy Director, CFNPP

1. INTRODUCTION

Food security, defined in one context as the access by all people, at all times, to enough food for an active healthy life (Reutlinger and van Horst Pellekaan 1986), has both chronic and transitory components. The former pertains to the ability of households and individuals to command enough resources to acquire adequate food under normal market conditions. To a large degree, then, its opposite, food insecurity, overlaps – indeed, provides a functional definition for – the concept of poverty. Transitory food security, however, reflects both fluctuations in markets, hence food prices, and shocks to incomes, which, in the absence of smoothly functioning credit, insurance, and savings institutions, temporarily impair a household's ability to obtain food.

Pursuing the concept of transitory food security further, one notes that some transitory fluctuations are largely predictable – for example, seasonal patterns of crop availability. Others, such as floods and droughts, as well as movements in commodity prices for exports, are less regular. The various institutional and household measures that can mitigate the impacts of such fluctuations depend on the nature and source of the transitory insecurity.[1] This study examines transitory food insecurity in Ghana as manifested in price movements in various markets (see Map). The impacts of such movements are, of course, greater for those households with fewer assets (see, for example, Sen 1981), and, therefore, the concept of transitory food security is not operationally distinct from chronic food security. This paper, then, accompanies an investigation of household food security and poverty in Ghana.

The paper begins with a discussion of time trends and seasonal price patterns.[2] Section 3 shows a model of multicommodity market integration, and the following section presents the results of an analysis using this model. The main policy conclusions are summarized below:

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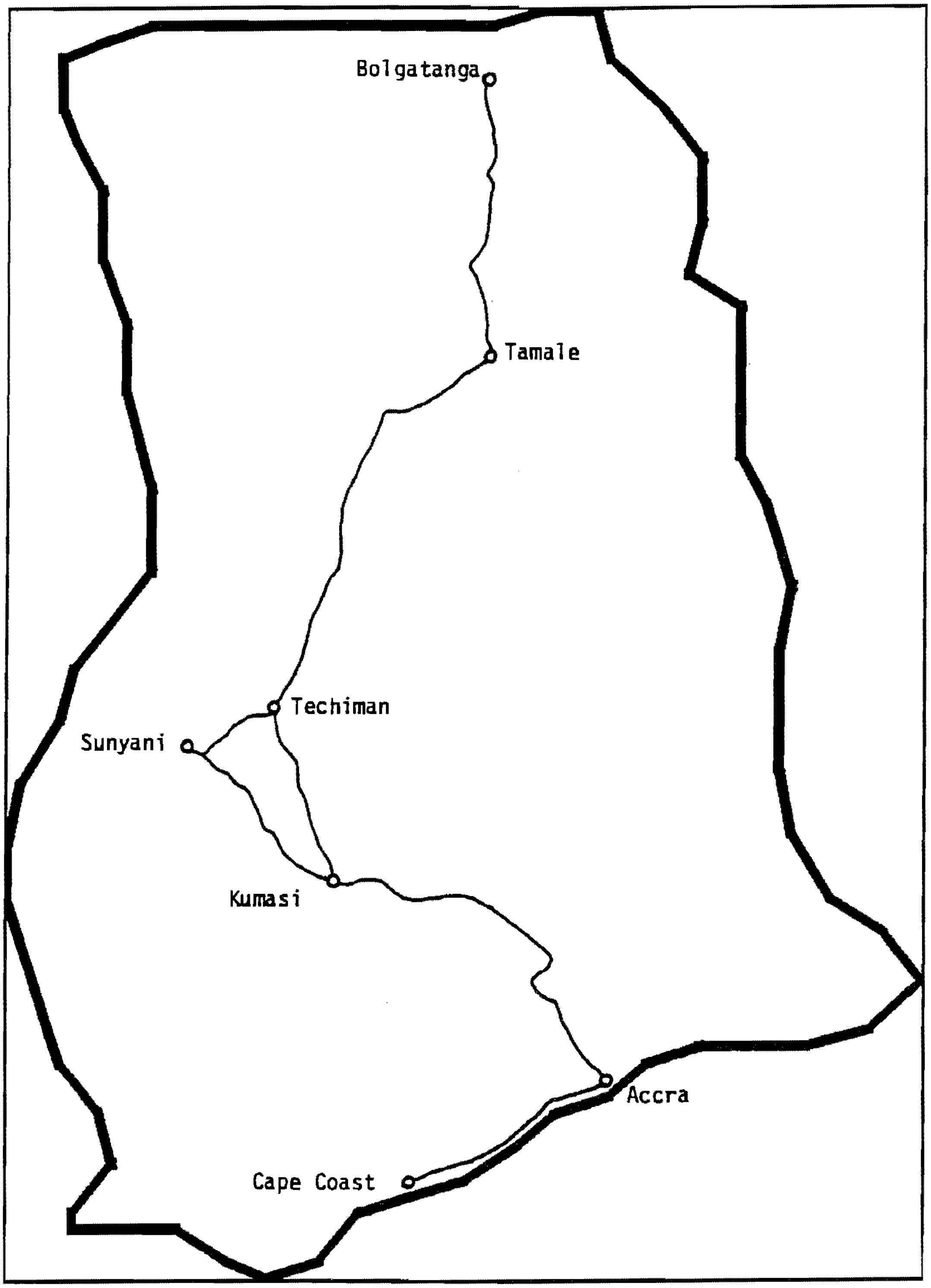
1 This study will further discuss some of these measures. For more on seasonal fluctuations, see Sahn (1989). Josling (1981) discusses trade policies to mitigate interyear fluctuations, while Pinckney (1989) and Siamwalla (1988) discuss public storage and policies.

2 The production system in Ghana and the major marketing channels need no description. Various World Bank and government documents, as well as Asante et al. (1989) and Stryker (1990), among others, adequately describe both.

Map of Ghana Indicating Transport Routes Linking the Major Markets



1. Most grain markets in Ghana, as elsewhere, appear integrated with each other. Such interconnected markets weaken the rationale for separate regional stabilization policies.

2. Price shocks (and stabilization) are apparently transmitted across commodities – that is, a rise or decline in maize prices strongly influences subsequent movements in sorghum and millet prices. This cross-commodity integration implies that either trade or storage of maize will also influence commodities that are only locally traded.

3. Rice markets do not function as well as maize and coarse grain markets. In particular, transmittal of price movements between Accra (where rice is largely imported) and the forest and Savannah zones is relatively poor. This variation reflects differences in quality. In addition, transportation costs are likely to segregate effectively the Savannah market from the coast.

4. Although cassava price movements are not countercyclical to grain prices, they have the potential to dampen either seasonal or interyear movements of weighted food budgets more than do yam or plantain prices. The variability of food prices, however, depends on the variability of prices of individual commodities, as well as their covariance. Prices are more variable in Brong-Ahafo than in the Savannah or the coastal zones, despite the surpluses in the region.

5. There is strong statistical evidence that both wholesale and retail real prices of all commodities have declined since 1984. This result holds even when the extraordinary movement in maize prices between April and July 1990 is included in the regressions. Contrary to conventional wisdom, this decline began in the 1970s (in keeping with world price movements). For most commodities except rice and yams, however, the rate of decline accelerated after 1984.

6. Various pieces of information available in the Ghana Living Standards Survey (GLSS) and other surveys support the view that sales of maize to neighboring countries are significant. The price spread between major markets in Ghana appears sufficient to justify the cost of transport. Moreover, the price spread appears to have increased between June 1988 and December 1989.

7. Although the exact level of cross-border trade cannot be accurately determined, it appears to be at least as great as the level of uniform harvest losses. The latter may, in fact, be exaggerated in FAO and other balance sheets. If so, the current expansion of government storage capacity may have, at best, a limited potential to reduce storage costs nationwide.

2. PRICE MOVEMENTS BEFORE AND AFTER THE ECONOMIC RECOVERY PROGRAM

Conceptually, it should be a simple matter to indicate any trends in prices, even in the context of appreciable interyear variability. Data availability and quality, however, often leave such investigations open to question. For example, Tabatabai (1988) found two series from the same government ministry that indicate either increases or decreases in wholesale prices in the 1970s. Many price series that are available are discontinuous. Most are unweighted averages over regions and seasons or both. Others make little distinction between official prices and those at which goods are available to most consumers.[3]

For the analysis presented here, monthly food prices from a number of rural and urban markets were obtained from Ministry of Agriculture regional offices.[4] These monthly market prices (rather than regional or national averages) for January 1970 to July 1990 are the units of analysis.[5] Depending upon the commodity, up to 36 rural and urban markets are included in the analysis.

The first step of the analysis is to test the statistical significance of time trends in prices, using a set of regressions with the logarithm of real prices from the various urban and rural markets regressed on time (in months) and other variables. These prices were deflated by urban and rural CPI indices, respectively. Separate time variables for 1970 to 1982 and after 1983 indicate trends in prices in these periods. Observations from 1983 were excluded in this exercise, not only because of the special circumstances in government staffing and in the functioning of markets in that year, but also because the test of preadjustment and postadjustment patterns might be sensitive to the choice of whether 1983, a famine year, should be considered as preadjustment or postadjustment.

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[3] For example, one price series reported by the Statistical Service shows an apparent *decline* in the real retail price of maize in Accra during both 1982 and 1983 relative to 1980 and 1981. This is hardly consistent with the famine that most of the population confronted in 1983.

[4] Disaggregated price data for much of the 1970s and early 1980s are currently unavailable in Accra, although regional offices sometimes retain the original coding sheets in their storerooms.

[5] Only data for maize prices extend beyond April 1990. None of the conclusions discussed in the paper regarding maize prices were found to be sensitive to inclusion or exclusion of prices covering May to July 1990, although nominal maize prices doubled in that short period.

WHOLESALE PRICE TRENDS

Most wholesale food prices exhibit a statistically significant downward trend in both the preadjustment and postadjustment periods. For example, the trend coefficients for maize in Table 1 imply that the average *monthly* real decline in the wholesale price of maize was 0.06 percent a month (0.7 percent a year) in the prerecovery period and 0.13 percent a month (1.6 percent a year) after the initiation of the recovery. Only cassava prices fail to show an appreciable downward movement. In the earlier period, the downward trend was particularly pronounced for rice (nearly 4 percent a year), as well as for millet and gari. The former pattern is consistent with both international trends and an increasingly distorted currency, although this clearly cannot be a full explanation, as millet is not generally a traded commodity.

It is particularly noteworthy that not only is the monthly time trend significantly negative over the entire period, but the downward trend in wholesale prices is significantly steeper between 1984 and 1990 for all commodities, except rice and yams, as well. One plausible explanation for this acceleration is a period of favorable weather, although yield increases, particularly for maize, could also put downward pressures on prices.[6] A further explanation may be found in falling marketing costs; although fuel prices have increased since 1984, trucks and spare parts have been more readily available and more funds have been available for road construction and repairs. Note that these factors are not mutually exclusive. They may all play some role in the explaining the consistent pattern.

The pattern in millet prices provides some evidence regarding the role of transport. The regression for millet in Table 1 deals only with the Savannah zone. A similar regression covering 2,038 market observations nationwide indicates a virtually identical trend in the earlier period, but finds that the downward movement in millet prices since 1984 in the nationwide sample is twice that of the Northern and Upper Regions. This trend is consistent with improvements in transportation from the geographically-restricted producing regions to other markets that have been made in the second half of the decade.

To a large degree, the exception of rice in the overall pattern reinforces, rather than contradicts, the general results. Rice is the only commodity studied that is consistently imported or exported. One would expect, therefore, that the changes in policies regarding the exchange rate determination since 1983 would affect this commodity in a

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[6] Regressions for plantain prices are not reported, as few observations of prices prior to 1980 were available. A significant upward trend, however, occurred in plantain prices after 1983, possibly because less of the crop was planted after the bush fires.

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Table 1 – Regressions Indicating Price Trends of Food Prices in Ghana, 1970-1990

Independent Variable	Wholesale Price of:							Retail Price of:	
	Maize[a]	Sorghum	Millet[a]	Cassava	Gari[b]	Yam	Rice	Maize[a]	Gari
(Constant)	3.163	3.910	3.724	2.065	3.548	4.132	4.382	3.237	3.042
	(108.173)	(84.590)	(72.619)	(18.155)	(56.361)	(85.035)	(114.524)	(42.872)	(38.797)
Time trend prior to 1983	$-5.918x^{-04}$	$-5.505x^{-04}$	$-1.582x^{-03}$	$7.283x^{-04}$	$-1.034x^{-03}$	$-7.542x^{-04}$	$-3.260x^{-03}$	$-9.717x^{-04}$	1.922^{-04}
	(-3.001)	(-1.834)	(-4.220)	(0.955)	(-2.498)	(-2.549)	(-13.356)	(-2.468)	(0.413)
Time trend after 1984	$-1.349x^{-03}$	$-1.710x^{-03}$	$-2.099x^{-03}$	$-2.647x^{-05}$	$-1.659x^{-03}$	$-8.656x^{-04}$	$-1.445x^{-03}$	$-1.908x^{-03}$	$-1.193x^{-03}$
	(-12.664)[c]	(-9.665)[c]	(-9.918)[c]	(-0.053)[c]	(-7.644)[c]	(-4.820)	(-10.585)[d]	(-9.261)[c]	(-4.325)
Urban	$4.875x^{-03}$	0.019	$5.811x^{-03}$	0.089	-0.052	0.181	$6.589x^{-03}$	-0.023	0.166
	(0.398)	(1.292)	(0.321)	(2.900)	(-1.792)	(9.988)	(0.448)	(-0.476)	(5.057)
Upper Region	-0.023	-0.165	–	0.569	-0.224	0.071	-0.101	0.045	0.369
	(-1.671)	(-9.671)	–	(7.055)	(-1.965)	(3.396)	(-6.077)	(1.452)	(10.233)
Northern Region	-0.185	-0.279	-0.043	0.769	–	-0.303	-0.057	-0.151	–[b]
	(-8.374)	(-12.473)	(-2.033)	(9.937)	–	(-10.990)	(-2.251)	(-3.474)	–
January	0.235	-0.212	-0.059	0.061	0.145	0.133	-0.126	0.225	0.117
	(8.107)	(-6.050)	(-1.442)	(0.857)	(2.191)	(3.185)	(-3.654)	(3.919)	(1.799)
February	0.249	-0.150	$-8.794x^{-03}$	0.045	0.097	0.121	-0.086	0.247	0.084
	(8.619)	(-4.279)	(-0.214)	(0.638)	(1.494)	(2.861)	(-2.462)	(4.310)	(1.297)
March	0.345	-0.149	0.020	-2.122^{-03}	0.122	0.134	-0.081	0.334	0.064
	(11.828)	(-4.223)	(0.490)	(-0.030)	(1.847)	(3.182)	(-2.275)	(5.782)	(0.987)
April	0.428	-0.116	0.076	0.057	0.132	0.216	-0.062	0.435	0.083
	(14.584)	(-3.294)	(1.823)	(0.800)	(1.952)	(5.120)	(-1.743)	(7.531)	(1.267)
May	0.486	-0.058	0.126	0.144	0.130	0.317	-0.051	0.495	0.154
	(16.669)	(-1.652)	(3.003)	(2.038)	(1.940)	(7.308)	(-1.415)	(8.773)	(2.363)
June	0.493	-0.036	0.146	0.079	0.140	0.337	-0.053	0.497	0.142
	(16.900)	(-1.027)	(3.446)	(1.124)	(2.127)	(7.594)	(-1.482)	(8.709)	(2.178)
July	0.354	-0.025	0.121	0.034	0.075	0.287	-0.027	0.409	0.071
	(12.034)	(-0.714)	(2.796)	(0.489)	(1.142)	(6.392)	(-0.740)	(7.138)	(1.092)

(continued)

Table 1 (continued)

Independent Variable	Wholesale Price of:							Retail Price of:	
	Maize[a]	Sorghum	Millet[a]	Cassava	Gari[b]	Yam	Rice	Maize[a]	Gari
August	0.126 (4.288)	0.010 (0.287)	0.086 (2.000)	0.074 (1.061)	0.015 (0.226)	0.132 (3.038)	$5.887x^{-03}$ (0.164)	0.159 (2.745)	0.078 (1.182)
October	0.025 (0.841)	-0.045 (-1.241)	-0.047 (-1.075)	-0.026 (-0.365)	-0.014 (-0.205)	-0.044 (-1.039)	-0.055 (-1.552)	$8.806x^{-03}$ (0.152)	0.018 (0.279)
November	0.083 (2.777)	-0.123 (-3.440)	-0.091 (-2.077)	-0.052 (-0.738)	-0.047 (-0.706)	0.055 (1.303)	-0.105 (-2.899)	0.110 (1.884)	-0.061 (-0.930)
December	0.098 (3.264)	-0.283 (-7.842)	-0.190 (-4.452)	-0.040 (-0.558)	-0.016 (-0.230)	0.064 (1.508)	-0.165 (-4.573)	0.096 (1.630)	-0.089 (-1.307)
Imported (before 1983)	- -	- -	- -	- -	- -	- -	-0.118 (-2.806)		
Imported (after 1983)	- -	- -	- -	- -	- -	- -	0.280[d] (5.829)		
R^2	0.295	0.251	0.267	0.131	0.189	0.242	0.134	0.364	0.323
N	3,202	2,085	1,232[e]	1,341	664	1,782	2,244	850	770

[a] Savannah Regions only.
[b] No observations available for Tamale.
[c] Indicates that the coefficient is significantly less than the corresponding coefficient for the earlier period (p , 0.01 two-tailed test).
[d] Indicates that the coefficient is significantly greater than the corresponding coefficient for the earlier period (p , 0.01 two-tailed test).
[e] Millet results reported are for Upper and Northern Regions only. Similar trends and significance are observed for the prices from the full sample, although the sales are clearly concentrated in the Savannah Regions.

Notes: T-statistics are in parentheses. The maize series includes data through July 1990 for selected markets; all other commodity series include data through April 1990 only.

different manner than other food crops.[7] The price of rice continued to decline throughout the 1980s, but at a significantly slower pace than in the earlier period. Moreover, the relatively few markets that distinguish imported from domestic rice provide evidence regarding the change of trade regimes since the initiation of the economic recovery period. Imported rice was apparently 10 percent cheaper than domestic rice before 1983 and more than 25 percent more expensive at the wholesale level after 1984. This result is indicated by the variables for imported rice in the regressions in Table 1 and includes control for some regional patterns as well as urbanization.

As Tabatabai correctly observes, declining food prices during contraction could reflect falling real incomes for nonproducers and, hence, reduced demand. Although there are few direct indicators of the distribution of income growth between 1984 and 1990, average per capita income has increased by over 15 percent in that period. The continuing, or accelerated, price decline, then, indicates increased production in the latter period, lower marketing costs, or both.

For net consumers of grains and tubers the decline in food prices has an unambiguous impact on real incomes. The impact on producer incomes, however, is less clear. Not only does it require some assumptions to infer the movement in farm-gate prices from the movement in wholesale prices,[8] but full assessment of trends in farm-gate prices should also consider trends in yields as well. It is possible for farmers, particularly progressive farmers, to increase their incomes, even while prices soften (see Scobie and Posada 1978, for an illustration). However, the necessary data for such an analysis for Ghana are not available.

RETAIL PRICE TRENDS

A regression of retail maize prices on time reveals basically the same pattern as the regression for wholesale prices reported above.[9] A

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[7] While maize is also potentially a tradable good, government restrictions, as well as the distinction between yellow and white maize on the world market, have effectively segmented the local market from the world market.

[8] One reasonable assumption is that marketing margins would decline with improved transport, but the available evidence is too meager to prove this supposition.

[9] In a draft of another paper, the authors reported a decline in wholesale prices in the earlier period with no retail movement. This was interpreted as rising marketing margins before 1983. The principal difference between those preliminary estimates and the current results is that the results reported above include more observations in the 1970s.

(continued...)

similar, but more complete, story is indicated by regressing the ratio of retail to wholesale prices in a given market on a trend variable. A caveat is in order, however. The retail price series is not uniform in terms of the units – bowls, basins, tins, etc. – in which prices are collected. If the number of basins in a bag has changed over time, or in response to economic conditions, the reported retail prices may be misleading indicators of marketing margins. Traders often report that a "bush" weight bag contains more grain than implied by the standard weight. In kilo terms, the average retail price of maize is roughly 5 percent above the wholesale in a given market. If, however, a bag contains more than 100 kilos, the real retail margin will be higher. This is likely to be the case, but there is no way to ascertain empirically whether the weight of a bag has varied in any systematic pattern over the sample period.

As indicated in Table 2, the ratio of retail to wholesale maize prices has declined over time, with the rate of decline somewhat faster before 1983. Since the regressions use corresponding prices from the same locale, the declining margin does not represent changes in transport costs. These transport costs may also have changed in response both to reductions of fuel subsidies as well as in response to improved roads. If so, this would indicate real resource costs rather than an apparent increase or decrease in traders' margins.

Some have argued that trader margins increased before 1983. This argument may be based on a misinterpretation of the costs of commodity transport (that is, by confusing gross with net margins); also, marketing margins decline *in percentage terms* as prices increase; traders' margins reflect fixed as well as proportional costs (Timmer 1974). This is indicated by the negative coefficient on the wholesale price of maize in Table 2. A regression of retail maize prices (not the ratio) on wholesale prices also reveals a less than proportional increase. The dummy variable for the pre-1983 period in this regression shows a greater absolute margin in this earlier period. This is not inconsistent with the observation of a declining ratio since it has been shown that real wholesale prices were also higher. Note, also, that both the retail/wholesale ratio and the absolute margin were apparently smaller between January 1983 and June 1984. These declines are represented by the dummy variable for drought. There is no evidence in the data employed here that indicates that retail merchants exploited the drought emergency.

A similar declining ratio over time and with respect to the wholesale price was observed for those markets from which both retail and wholesale prices for gari are available. There was, however, no significant difference during the drought year.

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[9](...continued)
As such, they more closely correspond to the data set for which wholesale prices are available.

Table 2 — Regressions Indicating Retail-Wholesale Price Margins in Ghana, 1970-1990

Independent Variable	Retail Maize / Wholesale Maize[a]	Retail Maize / Wholesale Maize[a]	Retail Maize[a]	Retail Maize[a]	Retail Gari / Wholesale Gari	Retail Gari / Wholesale Cassava
(Constant)	1.149 (58.434)	1.201 (49.468)	1.127 (3.279)	0.954 (2.767)	1.036 (25.881)	4.476 (14.537)
Time trend prior to 1983	$-9.649x^{-04}$ (-4.958)	$-1.001x^{-03}$ (-1.834)	—	—	$-5.020x^{-04}$ (-1.583)	3.480 (0.162)
Time trend after 1984	$-5.110x^{-04}$ (-5.317)	$-6.001x^{-04}$	—	—	$-4.525x^{-04}$ (-2.901)	-3.820 (-2.789)
Drought period dummy variable	-0.149 (-6.215)	-0.117 (-4.591)	-2.301 (-3.439)	-1.526 (-2.179)	0.033 (0.055)	0.876 (3.695)
Wholesale price	—	$-1.594x^{-03}$ (-3.628)	0.990 (82.395)	0.978 (78.603)	-3.663 (-4.903)	-0.128 (-14.012)
Pre-1983 dummy variable	—	—	—	1.396 (3.497)	—	—
R^2	0.047	0.060	0.904	0.905	0.110	0.316
N	872	872	872	872	233	577

[a] The maize series includes data through July 1990 for selected markets; all other commodity series include data through April 1990 only.

Note: T-statistics are in parentheses.

Table 2 also contains a regression that depicts the ratio of retail gari prices to wholesale cassava prices as a function of time. This is not strictly analogous to the retail/wholesale ratio, as it involves a product transformation. The gari in a given market does not necessarily come through the same market channels as the cassava that is sold in that market. Nevertheless, the negative coefficient on the cassava price may indicate fixed costs of processing. The regression also indicates that gari prices relative to cassava have declined significantly in recent years. Since fuel prices - a principal cost in gari processing - increased in this period, the decline may possibly be in response to a more than offsetting improvement in processing technology.[10] Unlike maize, the gari/cassava price ratio increased in the drought year. Since, as mentioned, gari and cassava are properly treated as distinct commodities, this movement may reflect different demand patterns as well as any possible change in processing costs.

SEASONAL PRICE MOVEMENT

The regressions reported in Table 1 also include 11 separate dummy variables for the month of observation, excluding September. These indicate the detrended seasonal price movement for a commodity. For example, maize prices usually peak in June, and reach a low a few months later in September. Similarly, the price of millet also peaks in June, although the trough does not occur until December, the same month as the lowest price for sorghum. Cassava prices show virtually no seasonal pattern, while prices of yams have a seasonality nearly as pronounced as that of maize. Figure 1 illustrates these patterns graphically, with the figures showing the percentage movement from the reference month (September), not the movement from either the annual average or the lowest price month (except for maize, which has a low in September).

Such seasonal patterns are well known to occur throughout sub-Saharan Africa. The Ghanaian food budget, as well as the diet, however, is generally divided among a number of commodities (Alderman 1990). The consumer, then, can substitute among commodities, thereby mitigating price movements. For a full analysis of the impact of food prices on consumer welfare, then, one needs both a matrix of cross-price elasticities and some information on the covariance of price movements across commodities.[11] Reliable information concerning the former is rather difficult to obtain; the latter is shown in Table 3.

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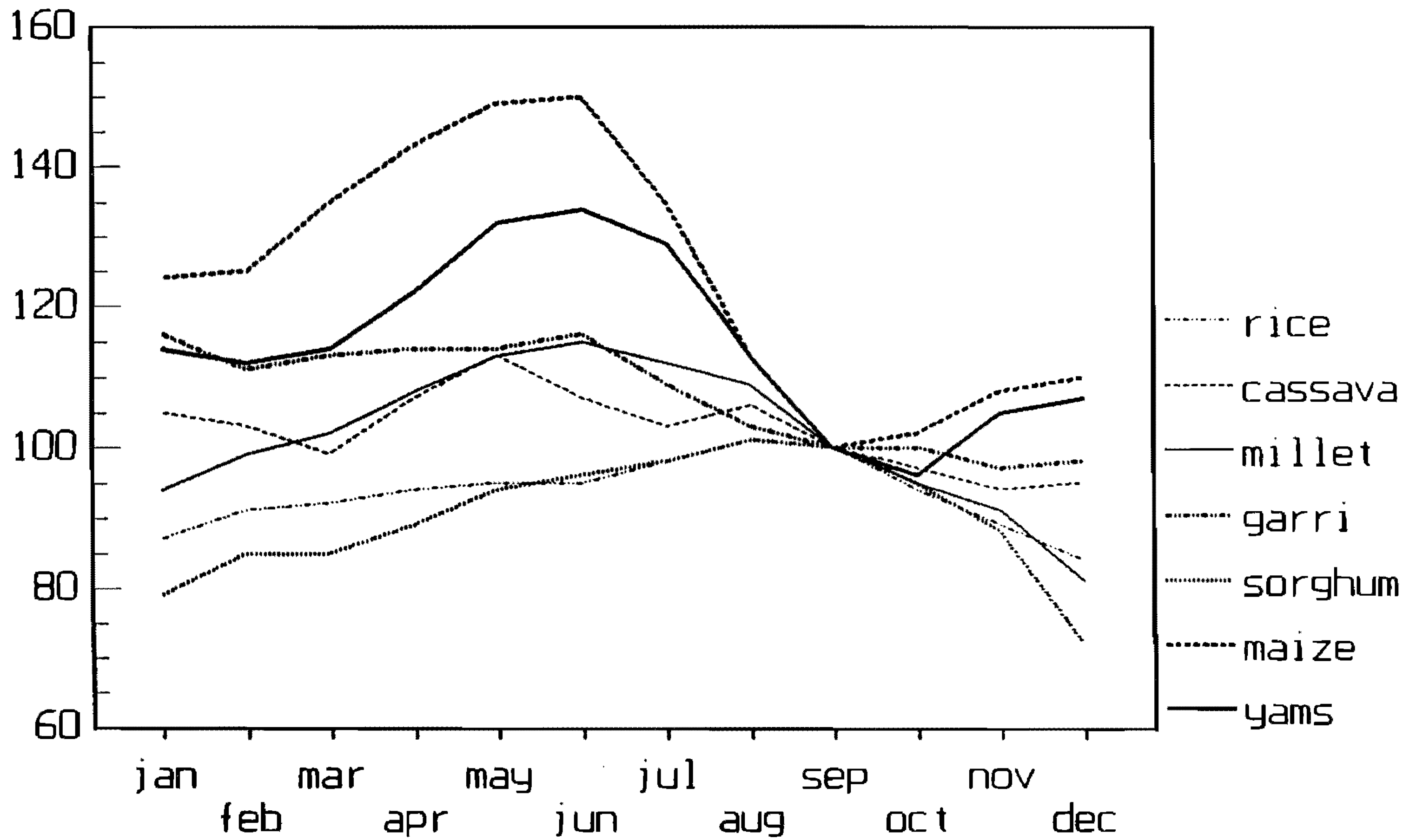
[10] Kreamer (1986) reports that mechanical graters and screw presses, two innovations that are locally produced but based on Nigerian prototypes, have reduced the costs of manufacturing gari.

[11] An alternative approach to the analysis of the impact of maize prices on other food prices is presented below.

Figure 1 – Proportional Variations in Wholesale Commodity Prices



Source: Calculated using coefficients of monthly dummy variables from regressions reported in Table 1.

Table 3 – Correlations of Wholesale and Retail Prices Across Commodities

Correlations	Wholesale									Retail	
	Maize	Rice	Sorghum	Millet	Cassava	Yam	Gari	Cocoyam	Plantain	Maize	Gari
Wholesale											
Maize	1.0000	0.3760[a]	0.5336[a]	0.5680[a]	0.3713[a]	0.5698[a]	0.7843[a]	0.3110[a]	0.3626[a]	0.9502[a]	0.6872[a]
Rice	0.3760[a]	1.0000	0.5342[a]	0.5285[a]	0.2618[a]	0.4131[a]	0.2811[b]	0.5481[a]	0.2401[a]	0.4192[a]	0.5255[a]
Sorghum	0.5336[a]	0.5342[a]	1.0000	0.8812[a]	0.2180[a]	0.4730[a]	0.2222	0.5333[a]	0.3678[a]	0.4344[a]	0.5410[a]
Millet	0.5680[a]	0.5255[a]	0.8812[a]	1.0000	0.1936[a]	0.4738[a]	0.3737[a]	0.5285[a]	0.3565[a]	0.4695[a]	0.5885[a]
Cassava	0.3713[a]	0.2618[a]	0.2180[a]	0.1936[a]	1.0000	0.3560[a]	0.6153[a]	0.5328[a]	0.3418[a]	0.2573[a]	0.5916[a]
Yam	0.5698[a]	0.4131[a]	0.4730[a]	0.4738[a]	0.3560[a]	1.0000	0.5882[a]	0.5549[a]	0.4151[a]	0.5561[a]	0.6123[a]
Gari	0.7843[a]	0.2811[b]	0.2222	0.3737[a]	0.6153[a]	0.5882[a]	1.0000	0.5992[a]	0.2618[a]	0.8835[a]	0.9634[a]
Cocoyam	0.3110[a]	0.5481[a]	0.5333[a]	0.5285[a]	0.5328[a]	0.5549[a]	0.5992[a]	1.0000	0.4774[a]	0.1840[a]	0.6700[a]
Plantain	0.3626[a]	0.2401[a]	0.3678[a]	0.3565[a]	0.3418[a]	0.4151[a]	0.2618[b]	0.4774[a]	1.0000	0.3561[a]	0.5424[a]
Retail											
Maize	0.9502[a]	0.4192[a]	0.4344[a]	0.4695[a]	0.2573[a]	0.5561[a]	0.8835[a]	0.1840[a]	0.3561[a]	1.0000	0.6782[a]
Gari	0.6872[a]	0.5255[a]	0.5410[a]	0.5885[a]	0.5916[a]	0.6123[a]	0.9634[a]	0.6700[a]	0.5424[a]	0.6782[a]	1.0000

[a] 1-tailed significance = 0.001.
[b] 1-tailed significance = 0.01.

Note: N varies; the minimum pair-wise number of cases is 71.

The correlations of real prices in the table reflect, of course, the fact that weather shocks tend to occur simultaneously across the country. As with any correlation, the pair-wise correlations of markets discussed above do not indicate causality. It is plausible, nevertheless, that the movement of one commodity price directly affects others because of the shift of demand induced by substitution. When maize becomes expensive, for example, some consumers shift a portion of their consumption to gari. Such an increase in demand without a pronounced short-term increase in supply[12] would result in higher gari prices.

As indicated in Table 3, the prices of cereal grains tend to be more strongly correlated with those of other cereals than they are with prices of root crops or plantains. Maize prices, however, are also strongly correlated with the prices of gari and yams. On the other hand, cassava prices are relatively weakly correlated with other prices, even those for yams, which fill a similar role in food preparation. While Table 3 indicates that cassava prices do not, in general, move countercyclically with other commodities, consumers can use substitute commodities to buffer their households from price shocks.

This generalization, however, masks some differences in the degree of price correlation across commodities in different markets. Before examining such differences, a look at the actual magnitude of price variability in different markets is useful. The coefficients of variation reported in Table 4 divide the standard deviation of each commodity price series by its average value and, hence, make them comparable. The three markets in this and much of the subsequent analysis were chosen to represent the three main agroecological zones: Savannah, forest, and coastal. However, no single market can fully represent an entire ecological zone; an additional rationale for the choice of markets was the availability of relatively complete price series.

The prices of plantain and root crops appear to be as variable as those of grains, even though these crops are available throughout the year. In general, Techiman prices are, in nondrought years, more variable than the prices in Bolgatanga and Cape Coast. This finding is unexpected since Techiman is more centrally located and, therefore, better placed to be able to stabilize prices through internal trade.

When 1983 is included in the calculation of price variation, the coefficients of variation increase, often markedly,[13] particularly for

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[12] The table reports contemporaneous correlations of prices in a market. Although a number of markets are included in the calculation, the results depict neither correlations between markets nor correlations over time.

[13] Those cases where the coefficients of variation are identical in the two portions of the table are those where no prices were available for 1983.

Table 4 – Coefficients of Variation in Prices

	Wholesale Maize	Retail Maize	Wholesale Millet	Wholesale Sorghum	Wholesale Cassava	Wholesale Gari	Retail Gari	Wholesale Yams	Wholesale Plantains	Wholesale Cocoyams	Wholesale Rice
Real Prices											
Excluding 1983											
Bolgatanga	35	35	37	38	30	–	39	45	45	41	34
Cape Coast	31	35	–	–	33	32	32	32	36	29	32[a]
Techiman	41	40	41	45	61	–	42	39	63	52	32
Including 1983											
Bolgatanga	43	42	39	40	30	–	48	45	45	41	39
Cape Coast	63	68	–	–	33	64	60	32	36	29	32[a]
Techiman	50	41	46	51	63	–	64	59	67	69	36
Real Price-Predicted Price Residuals											
Including 1983											
Bolgatanga	26	21	19	20	20	–	31	29	22	20	23
Cape Coast	53	57	–	–	19	52	51	21	18	18	21[a]
Techiman	32	19	28	31	37	–	56	38	44	50	26

[a] Because a large number of data points in the Cape Coast wholesale rice series were missing, the complete price series for wholesale rice in Makola has been substituted.

Notes: – indicates not available; N varies; the minimum number of cases for any food item is 197 for the series including 1983, and 187 for the series excluding 1983.

Cape Coast maize and gari. Gari prices appear more variable than grain prices when 1983 is included and less variable when 1983 is excluded.

Another way to view the movement of food prices is to examine the variation around the expected seasonal pattern. While Figure 1 depicts the average seasonal movement, prices for some commodities experience a fair amount of variation in any given year. For example, June was the most common peak month for maize prices in all markets studied; but June was the peak month in only 5 of the 16 years in Bolgatanga. Similarly, in a 21-year period in Cape Coast, June was the peak month for maize prices in only 7 years. Peak and trough months for millet and sorghum appear as dispersed as for maize, while the peaks for yam and cassava prices are yet more diverse. Households might be able to offset seasonal patterns using storage, commodity substitutions, and migration, but this irregularity of seasonal peaks makes such planning, where it occurs, difficult.[14]

The coefficients of variation at the bottom of Table 4 show the variation of the deseasonalized prices and indicates that most of the variation exhibited between 1980 and 1989 was not predicted by historic seasonal patterns. The variations of the residuals of real prices from market- specific regressions (which include 11 monthly dummy variables as well as a time trend) are used here as indicators of the unanticipated price variation.[15] A comparison of the middle and lower portions of the table indicates that less than half the variation in reported prices – including both reporting error and unanticipated price movement – is due to seasonal movement.

As mentioned above, the average consumer can reduce the variability in the aggregate cost of food by substituting among commodities according to their relative prices. One way to indicate the variability of the diet is to create a price index using expenditure weights and compare its variability with the individual commodity prices. A commonly used index is Stone's index, defined as $LogP^* = w_i \log(P_i)$, where w_i indicates the share of total food expenditure devoted to the ith food. A modification of this would weight food prices by their proportional contribution to total calories. The latter method should overestimate variability of the cost of calories, inasmuch as the calorie weights are constants while, in fact, the calorie based weight of a given commodity will increase as the price of that commodity decreases.[16] The former – budget share – method will underestimate variability in those cases where the commodity is price inelastic and, therefore, the budget share increases as prices increase.

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14 For a collection of papers on seasonal patterns in agriculture and food, see Sahn (1989).

15 The regressions did not use 1983 observations. Predicted prices for 1983 are based on projections from the other years in the data set.

16 This is strictly true when only two commodities are in the food basket, but generally true as well for most staple commodities.

Both methods nevertheless capture a fair degree of advantage of diet diversification when one desires price stability. Moreover, very little difference is found in either the levels or fluctuations of the two indices for the sampled markets. For example, Table 5 indicates these coefficients of variation for food prices in the 1980s.

The composite measure for food prices is far less variable than the components. Although this follows directly from statistical theory, the difference between the coefficients of variation in Table 5 and those in Table 4 remains important. Looking at the relative positions, one can argue (taking an upbeat perspective) that while prices in Ghana are extremely variable, the average Ghanaian household is protected, to a degree, by the diversity of the diet.

More ominous, however, is the large variation in the real cost of food energy in the decade. This variation is illustrated in Table 6, which reports the cost per 1,000 kilocalories[17] in 1985 cedis for three markets at various times in the decade. The table indicates the extreme price rise in 1983 as well as the increase in 1987. Moreover, the cost of calories differs greatly across markets, with the rank ordering of markets changing over time. More often than not, however, Techiman has the cheapest foods. Similarly, the table shows that the cheapest source of calories varies over time as well as over the three representative markets; five different commodities appear in the table, four in Techiman alone. The cheapest calorie source can cost as little as 43 percent of the composite price of the diet, although the average price of the cheapest source is approximately two-thirds of the composite price and may be as much as 75 percent. At no time does millet, the main source of calories in the Upper East, appear to be the cheapest source.

There is some evidence that food price movement correlates with malnutrition in Ghana (see Figure 2, reproduced from United Nations 1989). Although this is, of course, plausible and consistent with consumer theory, it must be recalled that *incomes* declined during the same period that *prices* increased. It is not clear, then, that the extreme price movement in 1983 should - or could - be countered by price stabilization policies. Moreover, no seasonal pattern in malnutrition was observed in the 1987-1988 GLSS (Alderman 1990). The seasonal pattern in food prices in a normal year also correlates with purchasing power, again making income and employment policies plausible candidates to be considered with, or as alternatives to, price stabilization policies.

Returning to Table 5, the composite price for food appears most variable in Techiman. This is the case even when the comparison is restricted to observations in common and, hence, some of the more extreme 1983 Techiman and Bolgatanga observations are removed. Although this, to

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[17] Given the age distribution of the population in the 1987-1988 GLSS survey, the average Ghanaian requires approximately 2,043 kilocalories a day, using WHO/FAO energy requirements for a moderately active population.

Table 5 – Coefficients of Variation for Food Prices, 1980-1989

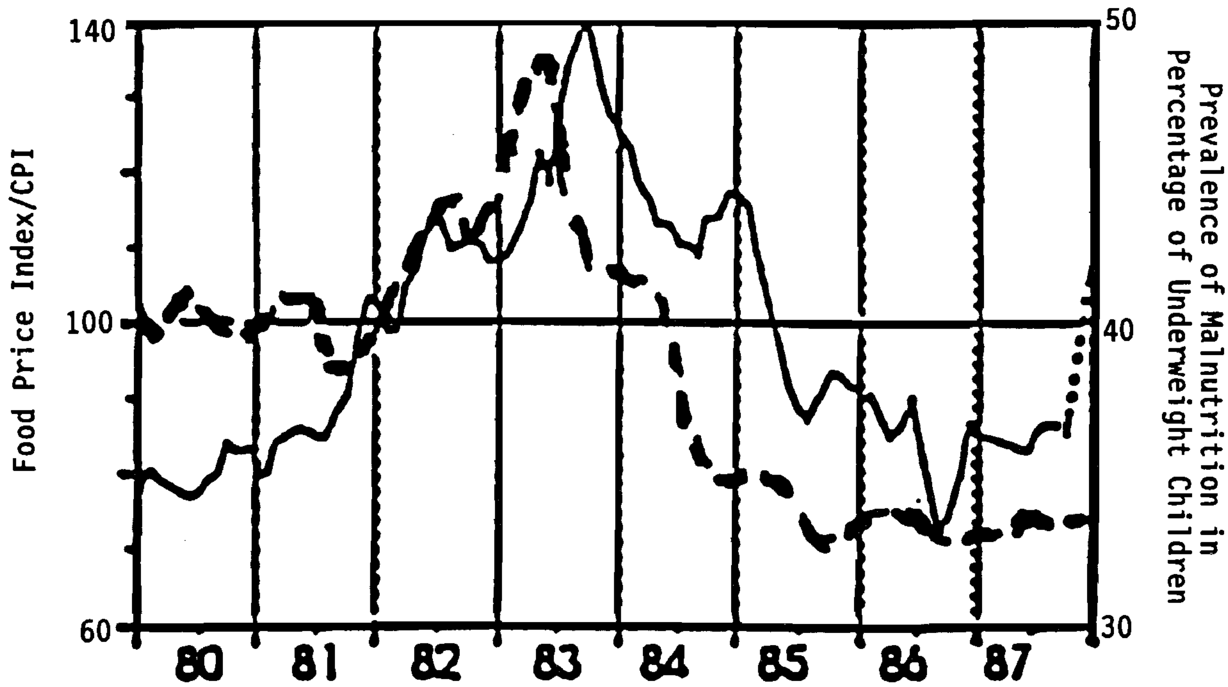
	Bolgatanga	Cape Coast	Techiman
Expenditure weighted index	8.5	9.7	16.8
Calorie weighted index	9.2	8.2	17.2
Expenditure weighted index using only common sample points	5.8	7.0	14.1

Table 6 – Price per 1,000 kcal (1985 Cedis)

		Representative Diet			Cheapest Source		
Year	Month	Bolgatanga	Cape Coast	Techiman	Bolgatanga	Cape Coast	Techiman
1981	6	14.19	9.44	8.33	9.73 (sorghum)	5.50 (cassava)	4.01 (cassava)
1981	12	7.29	7.37	6.25	5.42 (maize)	4.40 (cassava)	3.94 (cocoyam)
1983	6	31.00	– [a]	22.24	21.96 (sorghum)	45.74 (maize)	11.34 (cassava)
1983	12	16.03	–	14.13	10.51 (maize)	13.79 (maize)	8.79 (maize)
1985	6	10.51	6.73	5.83	6.15 (sorghum)	4.81 (gari)	3.43 (cassava)
1985	12	7.65	6.90	4.25	3.91 (sorghum)	4.15 (cassava)	2.28 (cassava)
1987	6	12.15	13.08	12.35	6.19 (sorghum)	10.23 (cassava)	7.76 (sorghum)
1987	12	11.03	11.23	9.18	7.31 (sorghum)	9.75 (maize)	4.80 (cocoyam)
1989	6	8.94	7.37	7.95	5.08 (maize)	4.90 (cassava)	3.45 (maize)
1989	12	5.99	6.19	5.24	4.23 (maize)	4.01 (cassava)	3.49 (maize)

[a] Not available because one or more component prices are missing.

Figure 2 – Relative Price of Food and Prevalence of Underweight Children (from Clinics), 1980-1987, Deseasonalized



Legend: Solid line indicates deseasonalized prevalence curve of underweight children. Broken line represents real food prices.

Source: United Nations, Subcommittee on Nutrition (1989).

a degree, reconfirms the observations on individual commodity price variability discussed above, the average diet in Techiman includes higher shares of plantain, cassava, and cocoyams than do the diets in Cape Coast and Bolgatanga. For example, cereals comprise .438 percent of the calories in Bolgatanga, but only .249 percent in Techiman.[18] Since the prices of tubers and roots are relatively less correlated with the principal staple, maize, than are other grains, one might expect that the diet that has a higher share of such roots would have a lower variability in the composite price of food. The prices of root crops are, however, themselves quite variable and the net impact of the combination indicates variable, although comparatively low, prices in Techiman.

What accounts for this relatively high degree of instability in the composite cost of food? Sample selection bias can be eliminated as an explanation; although the composite price index in Table 5 reports only the 1980-1989 prices - cocoyam and plantain prices for 1970s were unavailable - the relative patterns of commodity price variation for the 1980s are no different than for the longer period reported in Table 4. More likely, the comparatively higher variation in the composite price of food reflects the comparatively stronger correlations of prices in Techiman. In particular, Table 7 indicates that cassava prices are more strongly correlated with grain prices in Techiman than in the other two markets. Similarly, although the correlation of rice and maize are comparatively weak, they are, nevertheless, higher in Techiman. As will be discussed below, while the variability of commodity prices in Techiman is surprising given its central position, the correlation of prices may be in keeping with that position in that a central market may be more responsive to price signals than the periphery.

DEVALUATION AND FOOD PRICES

The trends in prices discussed above do not distinguish the various factors that contribute to the general movement. There is a particular concern in Ghana for distinguishing the relationship of food prices and movements in the exchange rate. Accordingly, a technique was used to study the relationship of a driving variable (in this case the exchange rate) and a dependent variable (the food component of the consumer price index) through an autoregressive moving average procedure (Box and Tiao 1975).[19] The dependent variable is actually the error term from a regression of the change of the logarithm of the national CPI for food on

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[18] These figures are derived using Savannah and forest zone calorie shares, respectively, which were derived from the GLSS survey and reported in Appendix Tables 1 and 2. Weights for all staples (cereals, roots, and plantains) sum to one. The contribution of other foods to either food energy or food expenditure is ignored for these calculations.

[19] The results reported here are from an ongoing study on exchange rate policy currently under way at Cornell.

Table 7 – Commodity Price Correlations for Selected Markets

	Maize Retail	Rice Wholesale	Cassava Wholesale	Gari Retail	Yams Wholesale	Cocoyams Wholesale	Plantains Wholesale
Bolgatanga							
Maize retail	1.0000	0.0217	-0.2187	0.4836[a]	0.5943[a]	0.5129[a]	-0.0940
Rice wholesale	0.0217	1.0000	0.2129	-0.1670	0.1123	0.3656	-0.1114
Cassava wholesale	-0.2187	0.2129	1.0000	-0.0025	0.0476	0.2328	0.4868
Gari retail	0.4836[a]	-0.1670	-0.0025	1.0000	0.4252[a]	0.4003[b]	0.0970
Yams wholesale	0.5943[a]	0.1123	0.0476	0.4252[a]	1.0000	0.6251[a]	0.1963
Cocoyams wholesale	0.5129[a]	0.3656	0.2328	0.4003[b]	0.6251[a]	1.0000	0.1565
Plantains wholesale	-0.0940	-0.1114	0.4868	0.0970	0.1963	0.1565	1.0000
Cape Coast							
Maize retail	1.0000	-0.1375	0.1818	0.5354[a]	0.6495[a]	0.4039	-0.5992[b]
Rice wholesale	-0.1375	1.0000	-0.0196	-0.3165[b]	0.0500	-0.1935	0.2766
Cassava wholesale	0.1818	-0.0196	1.0000	0.5429[a]	-0.0511	0.1121	-0.2591
Gari retail	0.5354[a]	-0.3165[b]	0.5429[a]	1.0000	0.4632	0.3340	-0.6060[b]
Yams wholesale	0.6495[a]	0.0500	-0.0511	0.4632	1.0000	-0.4943	-0.6896
Cocoyams wholesale	0.4039	-0.1935	0.1121	0.3340	-0.4943	1.0000	0.0802
Plantains wholesale	-0.5992[b]	0.2766	-0.2591	-0.6060[b]	-0.6896	0.0802	1.0000
Techiman							
Maize retail	1.0000	0.4663	0.6424[b]	0.6932[a]	0.7233[a]	0.4861	-0.0514
Rice wholesale	0.4663	1.0000	0.1881	0.1231	0.1804	0.5373[a]	0.2950[b]
Cassava wholesale	0.6424[b]	0.1881	1.0000	0.5099[a]	0.4253[a]	0.4587[a]	0.2082
Gari retail	0.6932[a]	0.1231	0.5099[a]	1.0000	0.0487	0.1227	0.5301[a]
Yams wholesale	0.7233[a]	0.1804	0.4253[a]	0.0487	1.0000	0.6270[a]	-0.1015
Cocoyams wholesale	0.4861	0.5373[a]	0.4587[a]	0.1227	0.6270[a]	1.0000	0.2162
Plantains wholesale	-0.0514	0.2950[b]	0.2082	0.5301[a]	-0.1015	0.2162	1.0000

[a] Significant at the 0.001 level (one-tailed).
[b] Significant at the 0.01 level (one-tailed).

Note: N varies.

season dummies and a dummy variable for the drought of 1983 and 1984. This removes the seasonal trend in the price series.

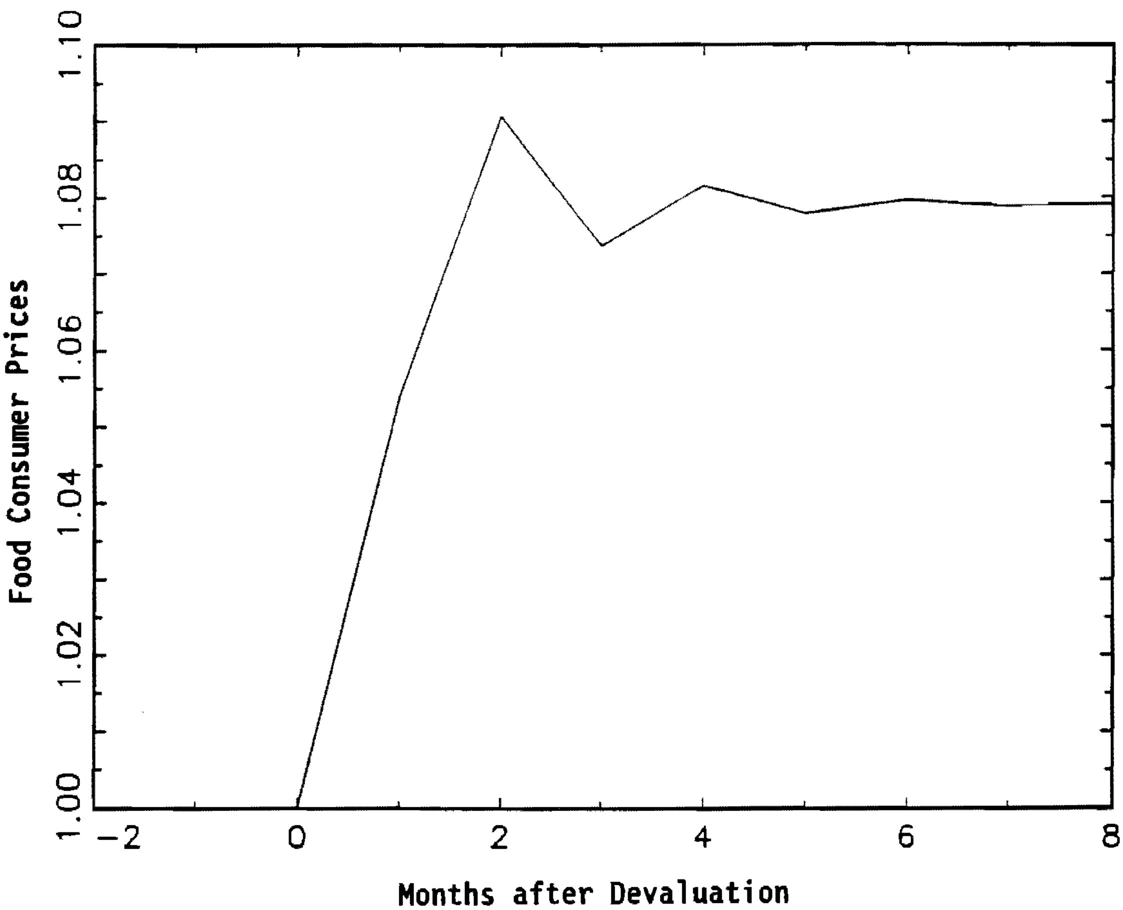
In the second step this variable is regressed on its lagged value and the exchange rate (ER) lagged one and two periods. The estimating equation (standard errors in parenthesis) is:

$$dLN(CPI_{food})_t = \underset{(0.15)}{(-0.46)} * dLN(CPI_{food})_{t-1} + \underset{(0.012)}{(0.05)} * dLN(ER)_{t-1}$$

$$+ \underset{(0.014)}{(0.06)} * dLN(ER)_{t-2}$$

Integrating this function allows one to indicate the magnitude and speed of the response. As is illustrated in Figure 3, the impact of a 100 percent devaluation is only an 8 percent increase in food prices, all of which comes after the first two months. This is clearly a small (but statistically significant) response. The fact that few food commodities are actually traded on international markets as well as the possibility that scarcity costs (shadow prices of foreign exchange) rather than official prices determined the market prices of those foods that were imported may explain the comparatively small magnitude of this relationship. The former issue remains valid even in the 1990s while the latter pertains more to the earlier period, when import quotas and a distorted currency prevailed.

Figure 3 — Response to 100 Percent Devaluation



3. METHODOLOGY FOR ANALYSIS OF MARKET INTEGRATION

A number of studies of market linkages in Ghana use bivariate correlations to assess efficiency (Asante et al. 1989). The limitations of this method in providing market information, however, are widely recognized (Blyn 1973; Harriss 1979). The basic problem is that two functionally isolated markets can appear to be synchronized if prices in each are influenced by a third market or by a common factor. While the weakest studies from this literature fail to consider even weather-related factors, improvements, which refine the process of detrending data (cf. Haugh 1976), are still limited if they are confined to markets rather than to a system of markets. Recent methodological developments have moved in two directions. Delgado (1986) offers a variance components model that allows for a joint test of seasonal differences in the price integration of markets, while Ravallion (1986) places the standard model of market integration into a dynamic context. Timmer (1987) as well as Heytens (1986) offer modifications of Ravallion's model, placing intuitive interpretations on a subset of the model's parameters at a cost in terms of a simplification of the dynamic structure. Our main approach will follow from Ravallion's (1986) and Timmer's (1987) methods.

Recognizing, however, that Timmer's (1974) simpler static model of market margins is more transparent in terms of presenting average marketing margins, a discussion of this model at the outset will be useful. This model is, in fact, the basis for the regressions already reported in Table 2. Moreover, this model is more easily modified than are its successors in order to explore seasonal variations or trends in parameters (margins).

This model, however, is not really designed to study the implicit information flows and competitive structure that underlie market integration. It focuses, rather, on the average costs (which may be high even in an economically efficient series of markets) and on the policy variables that influence these costs. Such costs may change as markets open to imports and, hence, to alternative market channels. In addition, they can indicate the effects of infrastructure investments and decay. Also, they can indicate seasonal changes in the cost of transport. Some understanding of these factors is necessary before a more sophisticated model of integration can be interpreted, as major changes in the costs of marketing can lead to a functional separation of previously linked markets or the converse.

Timmer's (1974) paper presents regressions explaining the margins between urban retail rice prices and rural paddy prices as well as regressions of the former on the latter. His first set of regressions, then, investigates whether the spread between farm gate and the final market in different pairs of markets have seasonal patterns that are interpreted as changes in direction of market flows (or at least suspension) due to price ceilings. A policy dummy variable is also included to allow for the impact of change in government interventions.

In Timmer's second set of regressions, the coefficient of the absolute price of paddy (not the logarithm) indicates the proportional markup in marketing while the intercept denotes fixed costs. In the particular question Timmer addresses, the milling ratio for rice is included (but not identified) in the proportional markup. Note that measuring the proportional markup does not require detrending the data, but estimating the fixed costs does. The regressions actually combine the marketing costs of at least three functions – the physical transformation from paddy to rice, spacial transformation between farmers and consumers (including bulking and debulking as well as transport), and possible short-term storage. There is no intrinsic reason, however, that these processes cannot be separated into components. Table 2 compares wholesale-retail spreads within the same physical locale. The cassava-to-gari model in that table closely parallels Timmer's model in that it also incorporates processing transformations into the cost structure. While a variation of Timmer's (1974) model could be used to compare the spreads between selected markets at different periods, a comparison of wholesale prices across locales is better achieved using a dynamic model.

The structure of Ravallion's approach is comparatively simple, although the estimation is econometrically sophisticated. He posits a central, or reference, market (denoted by subscript 1), the price in which is a function of prices in a number of other markets as well as seasonal or policy variables.

$$P_1 = f_1 \left(P_2, P_3, \ldots P_n, X_1\right) \qquad (1)$$

Prices in the feeder markets are functions of prices in the central market as well as policy and seasonal factors.

$$P_i = f_i \left(P_1, X_i\right) \qquad (i=2, \ldots, N) \qquad (2)$$

Ravallion recognizes that the formulation above is most suited to a radial market structure, although it is adaptable to alternative channels as well. In any case, the key innovation is not the model of price formation per se but the dynamic structure of the estimation, which is indicated in equations (3) and (4).

$$P_{1t} = \sum_{j=1}^{m} \alpha_{1j} P_{1t-j} + \sum_{k=2}^{n} \sum_{j=0}^{m} \beta_{1j}^{k} P_{kt-j} + \gamma_1 X_{1t} + e_{1t} \qquad (3)$$

$$P_{it} = \sum_{j=1}^{m} \alpha_{ij} P_{it-j} + \sum_{j=0}^{m} \beta_{ij} P_{1t-j} + \gamma_i X_{it} + e_{it} \qquad (i=2,\ldots,n) \tag{4}$$

for $n \neq m$ where k indicates markets; j indicates lags.

Ravallion concentrates on equation (4), recognizing that in many circumstances equation (3) will be underidentified. If $\beta_{ij} = 0$ for all values of j in equation (4) then the ith market is segmented from the central market. On the other hand, if $\beta_{io} = 1$, then prices are immediately transmitted. Moreover, if markets are integrated in the long run, then $\Sigma\alpha_{ij} + \Sigma\beta_{ij} = 1$. In addition, this model can also test the possibilities of short-run integration, which are less immediate than instantaneous price transmittal.

Timmer (1987) and Heytens make two modifications of this model. First, they work in the logarithm of prices. This implies ad valorem marketing costs rather than a fee per quantity handled. Secondly, they simplify estimation and interpretation by assuming a single lag structure for price formation rather than the six lags that Ravallion uses. Ignoring the former issue, a little algebraic manipulation allows one to reformulate the model as:

$$\begin{aligned}(P_{it} - P_{it-1}) = (\alpha_i - 1)\ (P_{it-1} - P_{1t-1}) + \beta_{io}\,(P_{1it} - P_{1it-1}) \\ + (\alpha_i + \beta_{io} + \beta_{iI} - 1)\ P_{1t-1} + \gamma X + \mu_{it}\end{aligned} \tag{5}$$

With this expression, one sees that the temporal change in a peripheral market is a function of the spatial price spread in the last period, the temporal change in the central, or reference, market, and the price level in the reference market in the last period. Again, seasonal and policy variables are included. This equation can be further manipulated to derive

$$P_{it} = (1 + b_1)\, P_{it-1} + b_2\,(P_{1t} - P_{1t-1}) + (b_3 - b_1)\, P_{t-1} + \gamma X + \mu_{it} \tag{6}$$

where

$$b_1 = \alpha_i - 1,\ b_2 = \beta_{io},\ b_3 = \alpha_i + \beta_{io} + \beta_{iI} - 1$$

In long-run equilibrium conditions, $(P_{1t} - P_{1t-1}) = 0$. If one assumes also that $\gamma = 0$, then $(1 + b_1)$ and $(b_3 - b_1)$ are, respectively, the contribution of local and central market price history to current prices. In a well-integrated market, the latter will have a comparatively strong influence on the local price level. Timmer suggests that the ratio indicates the relative magnitude of the two influences. He defines this ratio as the index of market connectedness (IMC) with values less than 1 as indicating short-run market integration.[20]

$$IMC = \frac{(1 + b_1)}{(b_3 - b_1)} \tag{7}$$

Clearly this index is useful for comparative purposes, although it is only approximate, not only because of the above-mentioned truncation of the lag structure, but also because the vector of parameters denoted by γ may not be insignificant. Timmer (1987) also argues that b_2 is a measure of the degree to which changes in prices in the reference market are transmitted to other markets. This parameter is expected to be close to 1, although even if markets are perfectly integrated some difference from 1 could reflect a mixture of absolute and proportional marketing costs.

As mentioned, each of these approaches has features that are useful for our study of Ghana. The key is to adapt the models to the specific context under investigation. One particular focus is the Upper East Region, which is relatively poor and considered an area of food insecurity. It has the distinction of being the main millet-consuming region in the country, with sorghum being a secondary grain. Maize is only occasionally grown. The region is linked to the rest of the country by a single trunk road through Tamale and further to the maize-exporting areas of Brong-Ahafo and Ashanti. The road is often impassable during and immediately after the rains. However, because of the linear nature of the trade link and because the Upper East imports maize, we can investigate the potential relation of other grain prices in the Upper East to maize prices using a recursive structure.[21]

We can take equation (1) as explaining the formation of maize prices in the principal maize market, Techiman. This price will be influenced by a number of markets (denoted, say, by 2 through n-1). It is not, however, determined by the price in the Upper East, which, under an analogy with standard models in international trade, can be assumed to be a "small country" price taker. P_1 (the maize price in Techiman), therefore, need not be considered as simultaneously determined in estimations of P_n (the maize price in the main market in the Upper East, Bolgatanga). We do employ an instrumental variables technique, however, as P_1 may still be susceptible to errors in variables.

One can extend the Ravallion single commodity model with the inclusion of the lagged local prices of millet (and/or sorghum). The

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20 The choice of the cut-off is somewhat arbitrary although indicative.

21 The relation of other grain prices to maize prices is an important policy issue inasmuch as the government may intervene in the maize market, but is unlikely to do so in the millet or sorghum markets.

justification again goes back to the standard trade model for an importer. Under competitive assumptions the local price for an imported commodity (maize) is the c.i.f. price; changes in local demand should not influence this price although they will influence the quantity traded. This can be tested statistically. Simultaneity can run the other way; local millet prices can be affected by local demand, hence, by local maize prices. As such, millet prices must be considered jointly determined with maize prices.

Taking one step further, a variation of Ravallion's framework can be modeled, where millet prices are a function of past local millet prices as well as current and lagged maize prices. This model is still feasible if the hypothesis that maize prices are unaffected by movements in millet prices is rejected. In such a case, one cannot use current maize prices but can use lagged local maize prices.[22]

The test for the influence of millet prices on local maize prices closely resembles the test for market segmentation offered by Ravallion. The radial structure assumed by Ravallion basically allows an additional test of segmentation that is less susceptible to misinterpretation of flows from the central market. This returns the discussion to Timmer's 1974 article as well as to Heytens; errors of interpretation are possible if the direction of market flow is occasionally suspended or reversed by markets responding to alternative, albeit transitory, supplies. Foreign aid, as well as irregular imports, could create this pattern. This is particularly relevant to any investigation of rice markets in Ghana, but should also be considered when looking at the flow of maize from the forest zone to the coastal region as well.

The purpose here, of course, is not to study market integration per se, but rather the implications for any stabilization policies. The question is, what effect does government action in one or two commodity markets have beyond the specific intervention?[23] This is the main justification for investigating millet and sorghum prices.

In addition to maize, the Ministry of Agriculture considers rice a potential commodity for market intervention programs. Per capita rice consumption is not high, but there is a potential for using international trade to stabilize markets. This is unlikely with the thin white maize market and even less likely for roots and tubers. How, then, to model

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[22] One could, in principle, substitute an instrumental value for current *local* maize prices, but it is not clear how identification would be achieved.

[23] Ideally, this effort should be augmented with a study that traces the long-run impact of a supply shift of one commodity on all prices. However, not only does this require a set of price and cross-price elasticities, which are unavailable, but this would not trace out the time path.

rice? The majority of production comes from the northern Savannah, although some production comes from the coastal belt as well. Moreover, the quantity imported (including aid) amounts to one-third to one-half of the quantity produced locally.

Two market structures can be considered. One has the Techiman-Sunyani-Kumasi market cluster linked with Accra. Mink (1989), among others, has hypothesized that the Kumasi-Accra link breaks down after harvest, perhaps because of import timings. This hypothesis can be tested in a manner similar to Timmer's 1974 study. Additionally, Bolgatanga (as well as Tamale) can be considered peripheral to Techiman; that is, both Bolgatanga and Tamale can be structured as in model (4) with Techiman modeled as (3). Alternatively, prices in Tamale and in Techiman can be simultaneously determined, using Bolgatanga prices as instruments in the Bolgatanga equation and Accra and Kumasi (and Cape Coast) prices as instruments in the latter.

4. MARKET INTEGRATION

INTEGRATION OF SAVANNAH MAIZE, MILLET, AND SORGHUM PRICES

Using Bolgatanga as a representative market for the Savannah zone and Techiman as the reference market for maize, the first step in applying Ravallion's dynamic model is to instrument the reference Techiman prices. This was done using Sunyani current and lagged prices with a correction for first-order serial correlation.[24] The fit in the instrumenting equation was good, with an r^2 over 0.90. As indicated in Table 8 (test 4), there was no significant improvement in the model when prices were lagged more than four periods, although a restricted model with prices lagged only one period, as in Timmer (1987) and Heytens (1986), was rejected (test 3).

As discussed above, under reasonable assumptions, maize prices in the Upper East, or in any other small importing regions, should be independent of the price of locally-produced substitutes. As indicated with tests 5 and 6, we could not reject the hypothesis that the millet or sorghum prices in the preceding four periods had no influence on maize prices — that is, the four coefficients for lagged millet prices (or for sorghum) were individually and jointly not significant. Although this observation is important, and is discussed further below, it is not a strict test of the hypothesis that the Bolgatanga maize price is determined by the price in Brong-Ahafo alone and, hence, of fully integrated markets.

A test of whether contemporaneous millet or sorghum prices influence maize prices is also needed. Adding current millet and sorghum prices to models 5 and 6, respectively, indicated that contemporaneous millet and sorghum do influence local maize prices even after prices in Techiman are included; current millet and sorghum prices were statistically significant when added to the two models with t values of 12.0 and 7.7, respectively.

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[24] An instrument was used mainly to reduce errors in variables, although Sunyani is more distant from Bolgatanga and hence less prone to reverse causality. Increasing the number of instruments is conceptually sound, but required dropping observations. The correction for serial correlation was deemed warranted by conventional analysis of the Durbin-Watson statistic. This test is not appropriate when lagged values of the dependent variables are included on the right-hand side. Durbin's h statistic was used for initial diagnostics of a model of Bolgatanga maize price with a one-period lag (Durbin 1970). No evidence of serial correlation was revealed with this test, which used instrumented Techiman prices corrected for autocorrelation as the independent price.

Table 8 — Test Statistics for Dynamic Model of Grain Markets in Bolgatanga

Model	Test	F-Statistic
Base: Maize prices as a function of Techiman maize prices and period dummy variables	Significance of model: $P^{BOMZ} = f(P^{TEMZ})$	$F(4,110) = 71.23$
1: Inclusion of 1-period lagged maize prices	$\alpha_{t-1}^{BOMZ} = 0,\ \beta_{t-1}^{TEMZ} = 0$ (Joint significance relative to base model)	$F(2,108) = 49.97$
2: Inclusion of 2-period lagged maize prices	$\alpha_{t-2}^{BOMZ} = 0,\ \beta_{t-2}^{TEMZ} = 0$ (Joint significance relative to Model 1)	$F(2,106) = 1.74$
3: Inclusion of 4-period lagged maize prices	$\alpha_{t-2}^{BOMZ} = 0,\ \alpha_{t-3}^{BOMZ} = 0,\ \alpha_{t-4}^{BOMZ} = 0,$ $\beta_{t-2}^{TEMZ} = 0,\ \beta_{t-3}^{TEMZ} = 0,\ \beta_{t-4}^{TEMZ} = 0$ (Joint significance relative to Model 1)	$F(6,102) = 3.39$
4: Inclusion of 5-period lagged maize prices	$\alpha_{t-5}^{BOMZ} = 0,$ $\beta_{t-5}^{TEMZ} = 0$ (Joint significance relative to Model 3)	$F(2,100) = 0.32$
5: Inclusion of 4-period lagged maize prices and 4-period lagged local millet prices	$\alpha_{t-1}^{BOMI} = 0,\ \alpha_{t-2}^{BOMI} = 0,\ \alpha_{t-3}^{BOMI} = 0,\ \alpha_{t-4}^{BOMI} = 0$ (Joint significance relative to Model 3)	$F(4,98) = 1.23$
6: Inclusion of 4-period lagged maize prices and 4-period lagged local sorghum prices	$\alpha_{t-1}^{BOGC} = 0,\ \alpha_{t-2}^{BOGC} = 0,\ \alpha_{t-3}^{BOGC} = 0,\ \alpha_{t-4}^{BOGC} = 0$ (Joint significance relative to Model 3)	$F(4,94) = 1.70$
7: Inclusion of 4-period lagged maize prices (same as Model 3)	Rejection of hypothesis that $\beta_{t}^{TEMZ} + \beta_{t-1}^{TEMZ} + \beta_{t-2}^{TEMZ} + \beta_{t-3}^{TEMZ} + \beta_{t-4}^{TEMZ} + \alpha_{t-1}^{BOMZ} + \alpha_{t-2}^{BOMZ} + \alpha_{t-3}^{BOMZ} + \alpha_{t-4}^{BOMZ} = 1$	$F(1,102) = 0.38$
8: Millet prices as a function of Techiman maize prices, lagged local millet prices, and period dummy variables. Corresponds to model 3 with millet prices as dependent variable.	Significance of model	$F(12,103) = 32.08$
9: (Same as Model 8)	Rejection of hypothesis that $\beta_{t}^{TEMZ} + \beta_{t-1}^{TEMZ} + \beta_{t-2}^{TEMZ} + \beta_{t-3}^{TEMZ} + \beta_{t-4}^{TEMZ} + \alpha_{t-1}^{BOMI} + \alpha_{t-2}^{BOMI} + \alpha_{t-3}^{BOMI} + \alpha_{t-4}^{BOMI} = 1$	$F(1,103) = 0.15$
10: Sorghum prices as a function of Techiman maize prices, lagged local sorghum prices, and period dummy variables. Corresponds to model 3 with sorghum prices as dependent variable.	Significance of model	$F(12,98) = 41.56$
11: (Same as Model 10)	Rejection of hypothesis that $\beta_{t}^{TEMZ} + \beta_{t-1}^{TEMZ} + \beta_{t-2}^{TEMZ} + \beta_{t-3}^{TEMZ} + \beta_{t-4}^{TEMZ} + \alpha_{t-1}^{BOGC} + \alpha_{t-2}^{BOGC} + \alpha_{t-3}^{BOGC} + \alpha_{t-4}^{BOGC} = 1$	$F(1,98) = 0.002$

Note: Superscripts denote the market and real commodity price as follows: BOMZ = Bolgatanga wholesale maize; TEMZ = Techiman wholesale maize; BOMI = Bolgatanga wholesale millet; BOGC = Bolgatanga wholesale sorghum.

One cannot make an unambiguous statement about the causality of millet and sorghum prices on maize or vice versa. Not only does such a model fail to indicate the direction of causality, but the apparent significance may indicate either a common but unobserved influence or an artifact of the temporal aggregation. The test does indicate that either Bolgatanga is not a price taker in regards to maize, or, more likely, that current market events in Techiman are too slowly or incompletely transmitted to the Upper East. Thus, other commodity prices may convey information about the market that correlates with the price of maize.[25] Again, this is not the case with lagged millet and sorghum prices.

Using the millet price as a dependent variable indicates that movement in maize prices in the reference market (Techiman) largely explains movement in millet prices. More surprisingly, movement in local maize prices adds no additional explanation to the model – that is, when Bolgatanga millet prices are regressed on current and lagged *maize* prices in Techiman, as well as lagged Bolgatanga *millet* prices, the lagged Bolgatanga maize prices do not improve the fit of the model. Thus, local maize prices may not contain information that is not conveyed by Techiman maize prices and lagged millet prices. Similarly, when Techiman and lagged Bolgatanga *maize* prices are included in the model, millet prices add no additional information.

This is an important observation since, in a smoothly functioning market, prices would incorporate all available information. If each commodity price contains all information, two sets of prices *from the same market* would contain the same information. This hypothesis cannot be rejected with the data on millet or maize prices in Bolgatanga.

This condition, however, does not apply to sorghum prices in Bolgatanga. Instead, lagged local sorghum and lagged local maize prices both contain information beyond that contained in the other set of prices when the current price of sorghum is the dependent variable. This is indicated by the joint significance of the respective block of prices when added to a model that includes current and lagged maize prices in Techiman as well as the alternative set of lagged prices from Bolgatanga. This may be explained by the use of sorghum in beer-making in the Upper East. Brewers, most of whom operate on a small scale, likely trade and store only that commodity. Sorghum may then constitute a conceptually separate (although physically contiguous) market.

Complete market segmentation implies that none of the Techiman prices significantly influence Bolgatanga prices. This implication can be rejected for maize, millet, and sorghum in Bolgatanga. On the other hand, short-run integration – indicated by the coefficient of *current* Techiman

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25 This is also indicated by tests of whether $b_t = 1$.

prices being one – is also rejected in all models.[26] Tests of the restrictions necessary for long-run integration are reported in Table 8 (tests 7, 9, and 11). These restrictions are not rejected at plausible levels of significance. These results then support the opinion expressed in Asante et al. (1989) that markets are reasonably well integrated although the methodology is rather different. This raises two questions: how long is "long run," and how powerful is the test of this restriction? Although any model that is imprecisely estimated is unlikely to reject restrictions, the overall significance of the model (and the r^2 of the various models that range between .78 and .90) allays that concern. The former question also has no strict test, but all models with lagged prices are consistent with long-run integration. Tests similar to test 7 cannot reject the restriction of the sum of the price parameters for all models with one through five lagged values for prices. For example, the sum of the price parameters for the maize price model is 1.05 in a single lag model and 0.97 for a five-period lag.

Figures 4 and 5 indicate the speed and magnitude that price movements in the Techiman maize market transmit to millet and sorghum prices in Bolgatanga. These simulations show that a sustained increase of 10 cedis in the price of maize (1985 prices) leads to roughly a similar increase in the prices for the two other grains in the outlying market.[27] This change occurs rapidly and, as indicated in the test of the sums of parameters above, is stable in the long run. A more transitory movement in the price of maize – say, a fluctuation that lasts only one period – will, of course, have a much smaller impact on the other market.

If markets reach an equilibrium in the long run, as implied by the test of restrictions above, the model can be reformulated in first differences (Ravallion 1986). We will, therefore, turn to the model of Timmer (1987) and Heytens. Although this model is based on a single period lag – which is rejected with these data – it provides a useful simplification for discussion. Table 9 presents the indices of market connectedness and parameter of price transmittal discussed above for a series of maize markets, using Techiman as the reference market. The maize markets appear relatively connected, using Timmer's benchmark of 1 as an indicator. Indeed, the connectedness indicator (low when the reference market rather than local conditions influences the local price) is lower for maize than those reported by Timmer for Indonesian maize or by Heytens for yams and gari in Nigeria.

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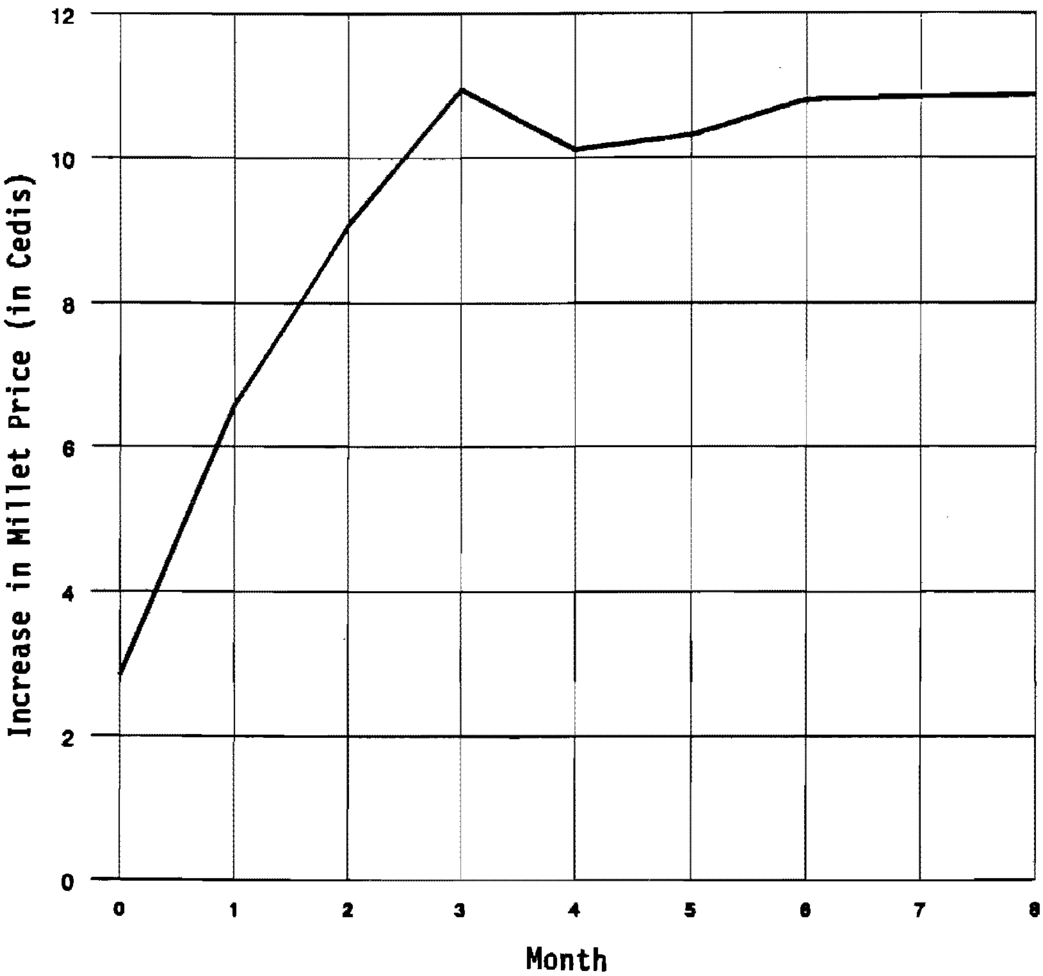
[26] This is a necessary but not a sufficient condition. The hypothesis also implies certain restrictions on other parameters (see Ravallion 1986).

[27] Mean prices for maize, millet, and sorghum in Bolgatanga in the period covered were 29.6, 36.3, and 35.1, respectively.

Figure 4 – Impact on Millet Price of a 10-Cedi Increase in Maize Price



Calculations are based on the following equation, which corresponds to model 8, Table 8 (t-values in parenthesis):

$$P_{mi} = \underset{(0.50)}{2.01} + \underset{(2.50)}{0.284}\,P_{mz_0} + \underset{(1.59)}{0.230}\,P_{mz_{t-1}} + \underset{(1.36)}{0.052}\,P_{mz_{t-2}} - \underset{(0.06)}{0.009}\,P_{mz_{t-3}}$$

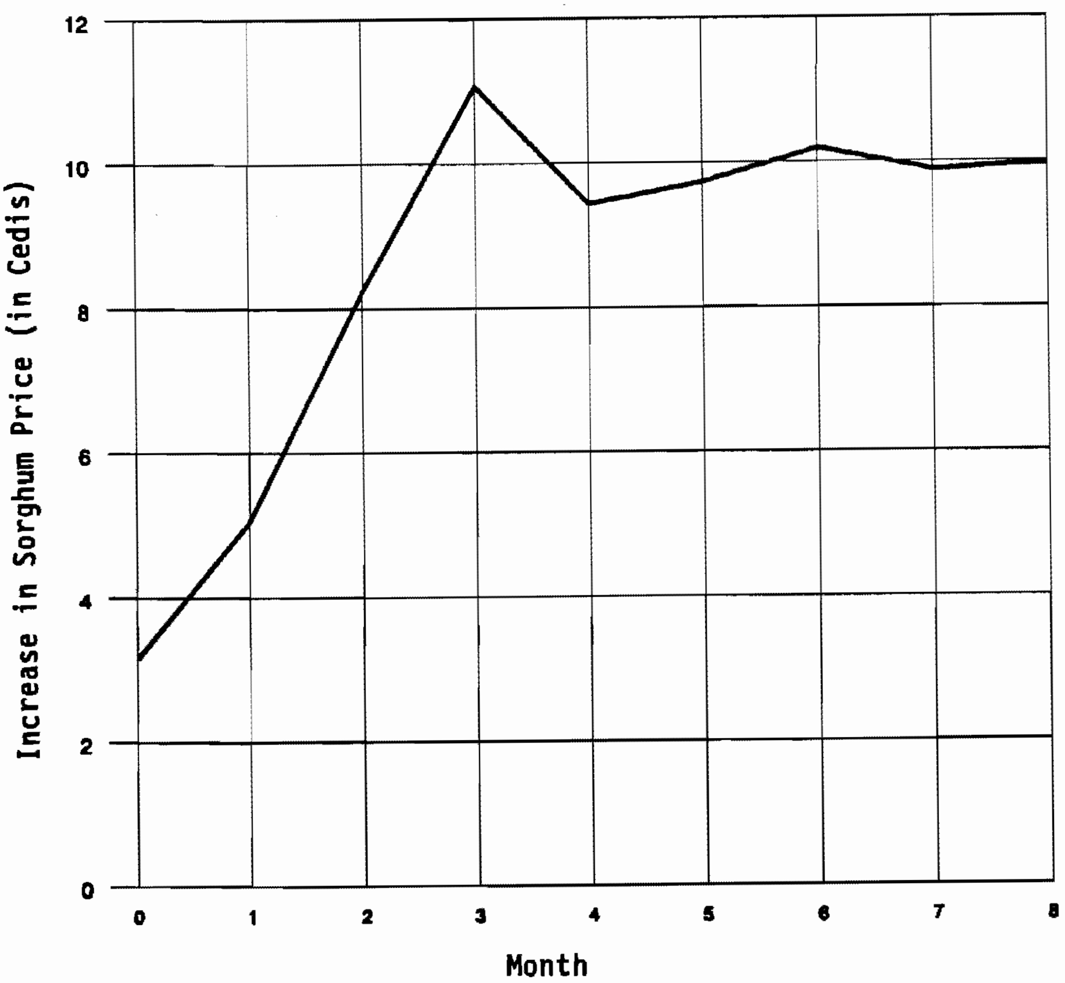
$$- \underset{(2.26)}{0.264}\,P_{mz_{t-4}} + \underset{(5.25)}{0.509}\,P_{mi_{t-1}} + \underset{(0.26)}{0.028}\,P_{mi_{t-2}} + \underset{(1.86)}{0.200}\,P_{mi_{t-3}}$$

$$+ \underset{(0.18)}{0.016}\,P_{mi_{t-4}} + \underset{(0.58)}{1.16}\text{ Rainy Season} - \underset{(0.15)}{0.40}\text{ Drought} - \underset{(0.82)}{1.60}\text{ Post 1984}$$

$R^2=0.79$
$n=115$

where P_{mi} indicates Bolgatanga millet prices, and P_{mz} are Techiman maize prices.

Figure 5 – Impact on Sorghum Price of a 10-Cedi Increase in Maize Price



Calculations are based on the following equation, which corresponds to model 10, Table 8 (t-values in parenthesis):

$$P_{gc} = \underset{(1.04)}{3.55} + \underset{(3.07)}{0.316}\, P_{mz_0} + \underset{(0.42)}{0.055}\, P_{mz_{t-1}} + \underset{(1.52)}{0.198}\, P_{mz_{t-2}} - \underset{(0.38)}{0.050}\, P_{mz_{t-3}}$$

$$- \underset{(3.30)}{0.354}\, P_{mz_{t-4}} + \underset{(4.46)}{0.427}\, P_{gc_{t-1}} + \underset{(1.20)}{0.123}\, P_{gc_{t-2}} + \underset{(2.43)}{0.236}\, P_{gc_{t-3}}$$

$$- \underset{(0.55)}{0.048}\, P_{gc_{t-4}} + \underset{(0.97)}{1.77}\ \text{Rainy Season} - \underset{(0.10)}{0.25}\ \text{Drought} - \underset{(1.50)}{2.54}\ \text{Post 1984}$$

$R^2=0.84$
n=110

where P_{gc} indicates Bolgatanga sorghum (guinea corn) prices, and P_{mz} are Techiman maize prices.

Table 9 - Indices of Market Connectedness and Price Transmittal

Market	Index of Market Connectedness	Parameter of Price Transmittal[a]
Maize[a]		
Sunyani[a]	0.23	0.92 (0.048)
Bolgatanga[a]	1.01	0.33 (0.083)
Cape Coast[a]	0.83	1.23 (0.173)
Kumasi[a]	0.82	0.48 (0.122)
Makola (Accra)[b]	0.51	0.65 (0.093)
Millet[a]	1.76	0.42 (0.106)
Sorghum[a]	1.62	0.37 (0.100)
Rice		
Tamale[a]	2.19	0.19 (0.064)
Bolgatanga[a]	2.71	0.39 (0.120)
Kumasi[a]	4.39	0.18 (0.131)
Makola[b]	11.75	0.20 (0.079)
Bolgatanga[c]	0.87	0.54 (0.134)
Cassava		
Kumasi[a]	0.64	0.051 (0.184)

[a] Reference market is Techiman.
[b] Reference market is Kumasi.
[c] Reference market is Tamale.

Note: Standard errors in parentheses.

If changes in the reference market are fully transmitted to the local market, the parameter of price transmittal will be one.[28] While two of the five parameters of transmittal for maize are not significantly different from one, the others show a lack of long-run connectedness. The low value for Bolgatanga is particularly surprising, inasmuch as the more complete model reported above does indicate long-run integration.

Table 9 also indicates the degree of market connectedness for millet and sorghum. The underlying models link the change in millet and sorghum prices with the change in *maize* prices in Techiman. This transformation may seem curious, especially as the index of market connectedness compares the explanatory power of lagged local millet prices with the difference in the last period of the local millet and the reference market maize price. This index, however, comes from a manipulation of the dynamic model that was outlined and reported above. Millet and sorghum prices are less connected to Techiman maize prices than are maize prices. This somewhat contradicts the results for millet tested in Table 8, although the one-period lag imposes some restriction. However, that an appreciable amount of price transmittal occurs between maize prices in Techiman and millet and sorghum prices in Bolgatanga reinforces the conclusion that any success the government has in moderating maize prices and their fluctuations will have an impact on consumers of other grains.

The models in first differences, as well as the more complete models with multiple lags, do not reveal any consistent seasonal patterns or a significant difference in the drought period of January 1983 through June 1984. Similarly, no time trend in market integration is observed. This, of course, does not imply that there is no seasonal price patterns in Ghana; it only suggests that the links between markets do not appear to vary over seasons. This contrasts with a less complete version where current prices in one market are regressed on current prices in the reference market. Such models show significant seasonal and drought effects. Such patterns seem to be short-run effects only that may affect the speed of price transmittal, but not the degree.

One small exception to this absence of seasonality is the four-period lagged model of maize prices in Cape Coast, with Techiman as a reference market. In this model, a seasonal pattern appears from June through September, corresponding to the principal rains. Since this pattern was not observed in the first difference model, any interpretation would be uncertain. By another criteria, the Cape Coast markets do not differ from the Bolgatanga market. The sum of price coefficients is 0.995 when the drought years are excluded and 1.15 otherwise. As with millet in the Savannah, lagged cassava prices add no information when added to a model with lagged Cape Coast and Techiman maize prices.

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[28] Timmer and Heytens both work in logarithms while the current study uses absolute values. The parameter does not appear to vary according to the transformation.

The models here have been tested using two additional related econometric techniques. Under the hypothesis that markets use information efficiently, two price series of close substitutes should move independently. That is, information about one price should not help predict the movement of the other when the lagged values of that second price are also included in the prediction. Clearly, this hypothesis underlies some of the discussion above. The most common methods for testing this hypothesis, however, employ techniques that test for cointegration of autoregressive series and tests of Granger causality. It is not necessary for this study to discuss such models at length; details are available in the econometric literature[29] as well as from the authors. It is sufficient to note that these techniques verify some of the conclusions stated above. In particular they indicate that price formation within a given market often (but not always) utilizes information efficiently.

PATTERNS IN RICE AND CASSAVA MARKETS

Table 9 also indicates the IMC and price transmittal parameter for a number of rice market links. Mink argues that rice markets in Ghana are not as efficient as those for maize, millet, and sorghum. The results here support his contention. Price transmittal among rice markets is virtually nonexistent; local market conditions dominate the reference market. Similarly, in a four-period lag model similar to the maize models discussed above linking Kumasi and Makola, the coefficients of the price variables sum to 0.71. This indicates that the markets are not integrated in the long run. The sum is only 0.53 in a model with a single lag.

Tamale appears well-integrated with Bolgatanga. Similarly, there is a fair amount of price transmittal, although the coefficient is significantly different from one. One would expect, of course, that the Savannah markets would be insulated from imports to a degree, and hence more closely linked to each other.

In contrast to the maize models, the rice models indicate a seasonal pattern as well as a difference between pre-1983 and post-1983 periods. As Mink (1989) has argued, this seasonal pattern, with larger price spreads in the third quarter, may reflect patterns of food aid and imports, which disrupt the southward flow of locally-produced rice. The trend that indicates larger price differentials over time may reflect the changes in the availability and price of imports since 1984.

Imported rice, apparently, has only a localized impact and domestic price fluctuations do not transmit to Accra, nor even across other internal markets. Given this, as well as the low share rice has in either consumers' budgets or their diets, the government probably cannot use rice

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29 See, for example, Engle and Granger (1987).

imports or storage to stabilize overall food budgets. The intention here is not to suggest that food aid consisting of rice might not help stabilize demands for foreign exchange, but it reinforces the notion that rice imports will have only a small direct impact on household welfare outside of, perhaps, the major metropolitan centers.

Cassava markets, not surprisingly, indicate no price transmittal with *maize* and poor integration across commodities.[30] On the other hand, the parameter of price transmittal when Techiman *cassava* is included in a model explaining Kumasi cassava prices is 0.51 (0.184). The IMC is 0.64; the Kumasi cassava market is apparently linked with that in Techiman, even without much intercommodity price transmittal.

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30 The parameter of price transmittal from Techiman maize to Kumasi cassava is only 0.06. It is 0.08 to Cape Coast.

5. OTHER ISSUES WITH GRAIN MARKETS

CROSS-BORDER TRADE

The integration of regional markets and the degree of price transmittal across commodities in Ghana tends to make the role of a public stock manager somewhat easier. Stabilization policies can be effective, even if the government does not act in all markets or for all commodities. This observation, however, should not provide too much comfort to those who advocate a role for public storage to stabilize prices; storage remains an expensive means to achieve a moderate amount of stabilization (Pinckney 1989, Siamwalla 1988).[31] In Africa, as well as elsewhere, trade also has the potential to stabilize prices. Badiane (1989) discusses this in the context of interregional trade in West Africa.

One condition that enhances such stabilization is that production is more stable at the West African level than at the national.[32] While Badiane indicates that the variability of production in Ghana has been high relative to the rest of West Africa, the correlation with other West African countries is also moderately low. As with the discussion of price stabilization in consumer budgets, these levels imply that the regional variability will be less than Ghana's own variability. Indeed, Ghana indicates a negative correlation with a few countries, including Niger, while correlations with Côte d'Ivoire and Togo are comparatively high. The correlation with Burkina Faso is intermediate between the other countries mentioned. This, however, does not really indicate the potential for interregional trade, as transportation costs effectively isolate many markets from others. It is likely, however, that a fair amount of trade can and does take place even in the context of current barriers.

Figures 6-8 indicate the relative prices of Togo and Burkina Faso and markets in Ghana converted at official and parallel (bureau) exchange rates (Banque Centrale des Etats de l'Afrique de l'Ouest [BCEAO] 1989 and 1990). While maize prices in Techiman are not a perfect indicator for cross-border trade profitability, the trend is indicative of the distortion of real exchange rate in CFA zone countries relative to Ghana.

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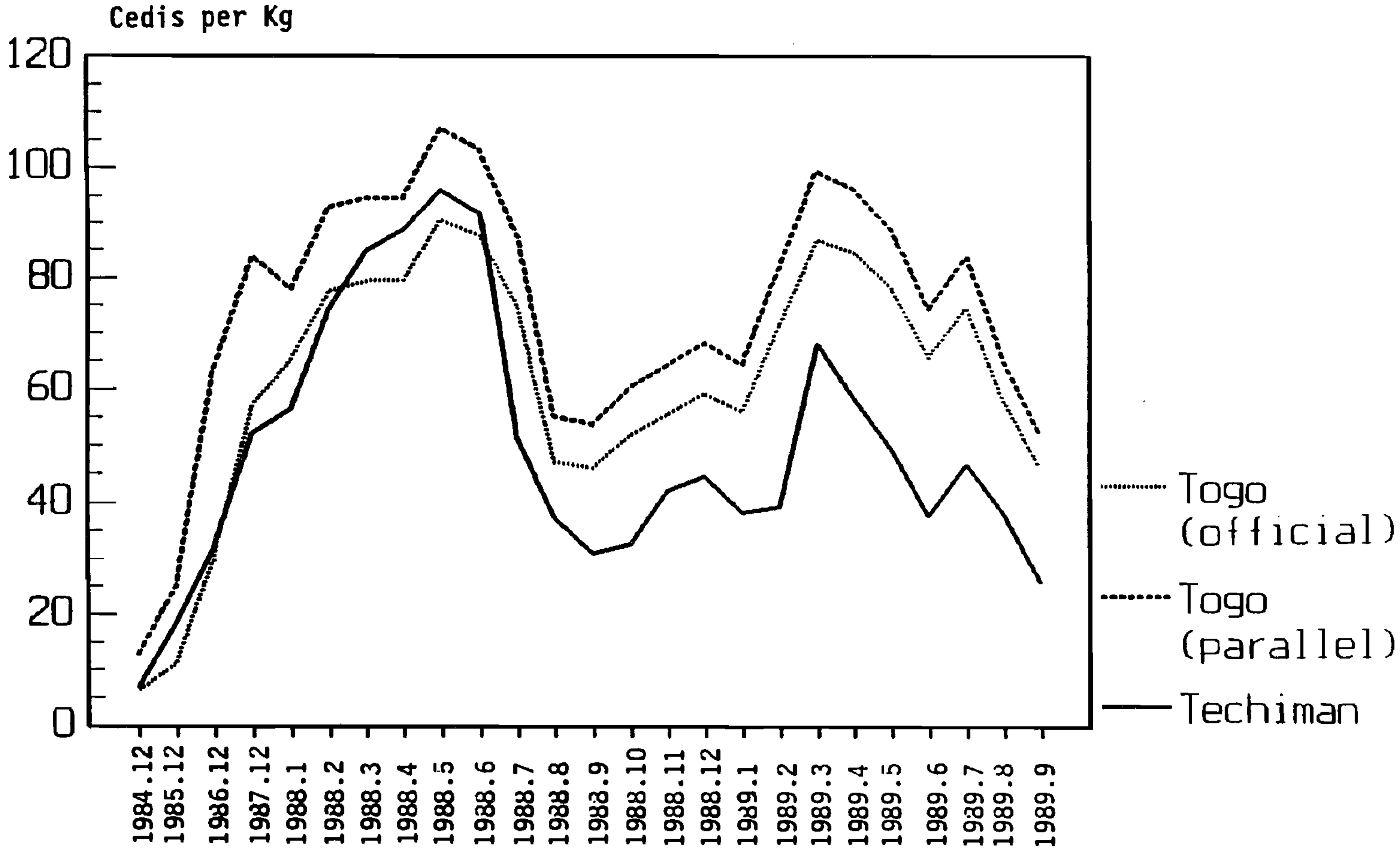
31 A future task in this project will investigate such costs in Ghana.

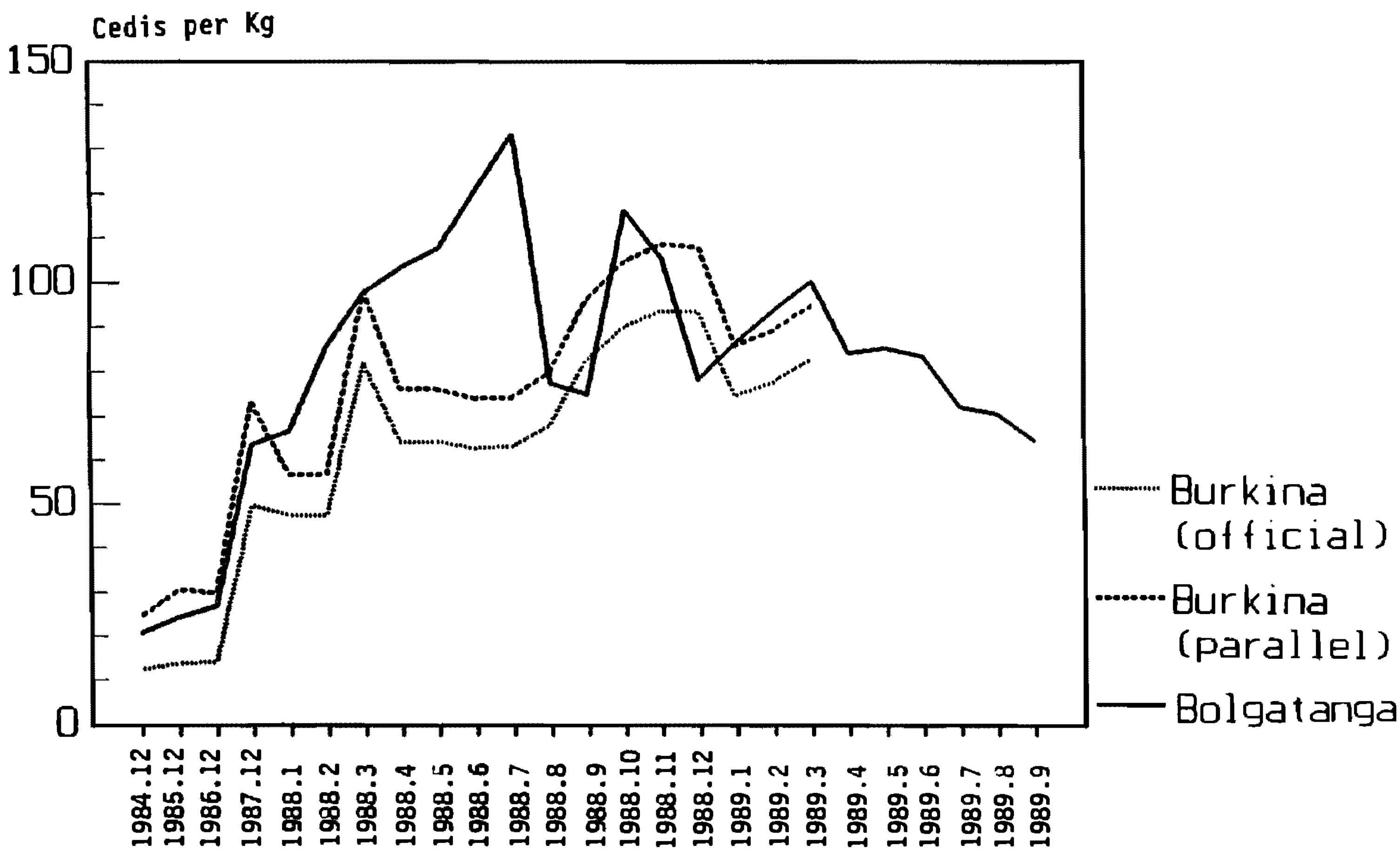
32 Of course, the focus need not be limited to any specific region. However, the world market for many commodities consumed in Ghana, such as millet and white maize, is comparatively thin.

Figure 6 – Maize Prices in Techiman and Togo (1984-1989) (Converted at Official and Parallel Exchange Rates)



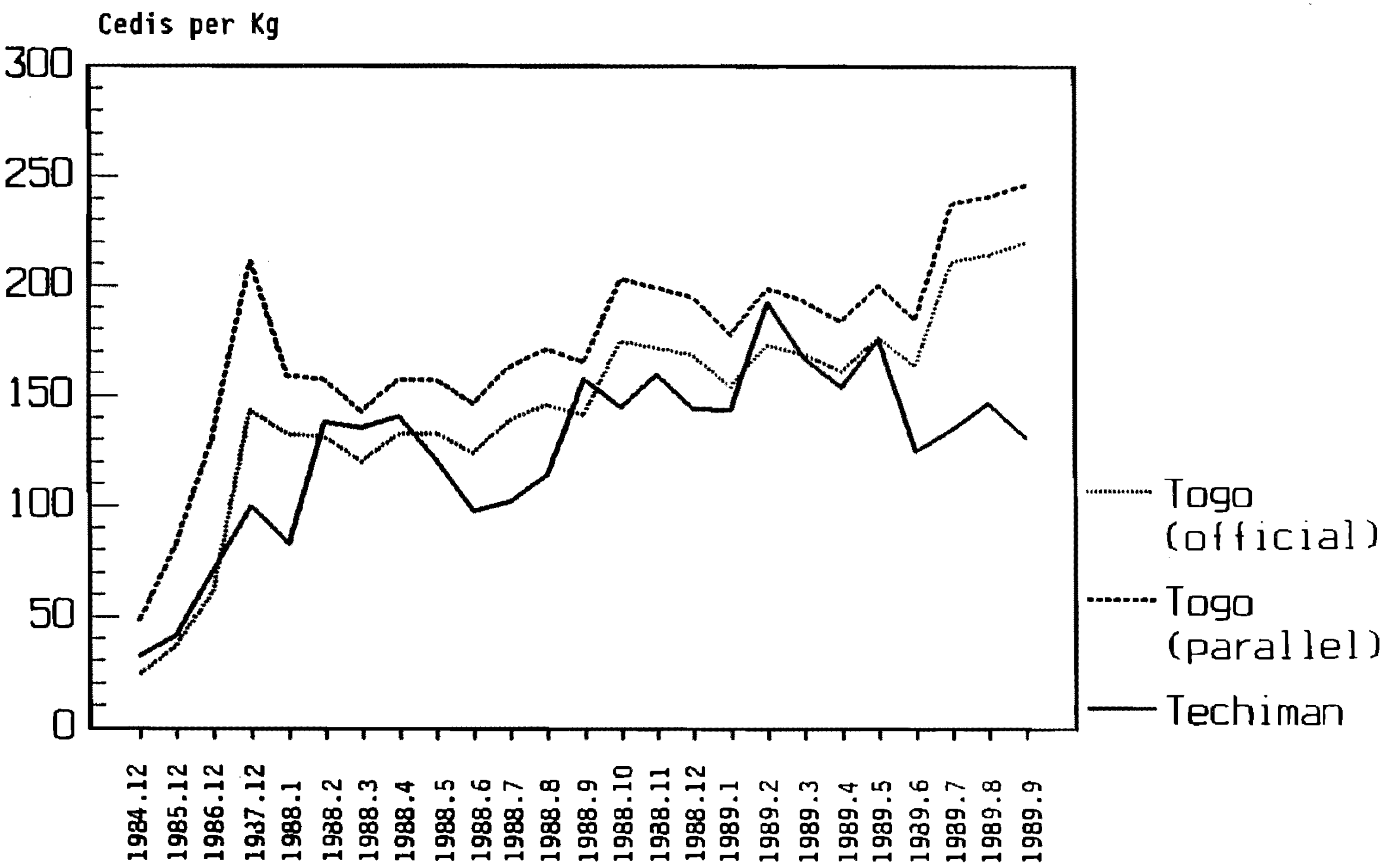
Note: Prices for 1984-1987 are year-end.

Figure 7 – Millet Prices in Bolgatanga and Burkina Faso (1984-1989) (Converted at Official and Parallel Exchange Rates)



Note: Prices for 1984-1987 are year-end.

Figure 8 – Rice Prices in Techiman and Togo (1984-1989) (Converted at Official and Parallel Exchange Rates)



Note: Prices for 1984-1987 are year-end.

The distortion has increased in recent years, hence the profitability of maize exports should increase.

Millet prices are more erratic. For a number of years, prices in Bolgatanga have exceeded those in Ouagadougou. Prices appear to have been fairly similar after the 1988 harvest. No data for late 1989 are available for Ouagadougou, but the Ouagadougou price likely rose relative to Ghana with movement in exchange rates. Similarly, although rice prices showed no clear trend in either Togo or Techiman, cross-border trade was possible in some months – for example, in 1989 and 1990.

Information on the nature of the trade in grain that occurs with Ghana's neighbors is limited and of questionable accuracy. As such trade, nevertheless, has an important bearing on the stability of markets in northern Ghana and Brong-Ahafo, a summary of the available information may be useful. Occasionally trade is officially sanctioned as, for example, triangular trade to Burkina Faso supported by the World Food Programme in 1985. Most trade, however, is unofficial and small-scale and, therefore, hard to quantify. Some (1989) reports results from a survey in 1987 of two market channels: 1) the trade between Bawku and Burkina Faso as well as Cinkanse and Dapaong in Togo and 2) trade from Wa and Lawra to Burkina Faso and Côte d'Ivoire. The surveyors found only a few small warehouses outside of Ghana, but observed that they were set up by Ghanaians. They counted 30 vehicles coming twice a week to Cinkanse. Unfortunately, the estimates of the volume of trade is hindered by the lack of information of the means of estimation and, more significantly, the period for which it pertains. It is not clear, then, over how many weeks the 8000 tons of sorghum and millet were traded, nor what share of the total trade is estimated to be covered by the markets surveyed. The relative amounts of rice and maize (2,500 and 1,500, respectively) may, however, be indicative of comparative grain flows. The study does, however, provide a useful measure of the price spreads at the time of the survey; when sorghum and maize prices were 52 and 48 CFA/kg, respectively, in Burkina Faso, they were 50 and 35 in Lawra, Ghana and 65 and 55 in northern Côte d'Ivoire.

A small survey of 103 wholesale and retail traders in Brong-Ahafo and the Upper East included a question concerning the traders' perceptions of cross-border trade from the market in which they were interviewed. This estimate can have no confidence intervals in the technical sense; not only are there few and variable estimates per market, the traders reported on others' activities, not their own. Nevertheless, summing over markets (covering most of the markets in the two regions) gives an indication of weekly trade in the first half of 1990. While traders believed that only 12 tons of millet and 32 tons of rice were traded weekly from all markets, they estimated that more than 1,500 tons of maize were traded weekly.[33] With all caveats regarding the type of data, cross-border trade in maize appears to have dominated other grain trade in the period discussed. The

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[33] This excludes an extreme observation that 1,800 tons were transported weekly to Côte d'Ivoire on trailer trucks from a single market.

data are not sufficient to document trends, although cross-border trade may have increased after the bumper harvest in 1990. This is consistent with the limited price information available. When annualized, this represents a sizable portion of total marketed surplus.

STORAGE LOSS

On-farm storage losses are commonly assumed to be in the neighborhood of 20-30 percent of production in developing countries. The empirical origin of this range is not known; the assumption is so widespread, however, that it appears to command the respect that in other cultures is reserved for the utterances of the hoary elders. Nevertheless, the number may merely reflect the need of a Food and Agriculture Organization (FAO) official to have a number – any number – to complete food balance sheets in the late 1940s, little knowing how widely he would be quoted. Greeley (1987), however, shows how excessive such estimates are and documents the policy errors that can be made using such an erroneous assumption.

Similarly, Asante et al. (1989) provides evidence that on-farm losses in Ghana are, in fact, not particularly large. These results were duplicated in a subsequent survey of 600 households randomly drawn from the population of the Upper East and Brong-Ahafo.[34] This survey indicated that households reported storage losses on only 2 percent of total production, on average. That is, the absolute quantity of losses at the household level was a small fraction of production, although when sales are considered, losses were a larger share of the amount retained by the household for its own use. Losses were higher for maize (6 percent) and beans (4.5 percent) than for millet and sorghum (1 percent each). Losses were also higher in Brong-Ahafo than in the Upper East.

Table 10 reports very similar results from the 1987-88 GLSS survey. These results are perhaps even biased upward, as the averages include some cases in which total losses were reported as 100 percent.[35] Not only do the relative losses of millet and maize reaffirm the 1990 survey data, the pattern of losses by agricultural zone does as well. Some qualifications are necessary. These data pertain to on-farm storage, which is, in the case of maize, only half of the harvest. Losses in transit will increase the total. The results also do not indicate massive loss or degradation

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[34] Three hundred households were drawn for each region, using a sample frame based on the frame employed in the GLSS. More details of this survey are available in another document prepared for the food security study (Alderman 1991).

[35] The GLSS questionnaire was designed so that total production is indicated by the sum of sales, losses, seed, and home production. Miscoded crop information can, therefore, indicate a complete storage loss. The high loss percentages may also be preharvest losses that were miscategorized.

Table 10 – Average Percentages of Postharvest Loss

Crop	Crop Loss[a]
	(percent)
Maize	
National	8.3
Coastal	6.8
Forest	11.1
Savannah	3.0
Rice	5.3
Millet/sorghum	1.3

Source: Ghana Living Standards Survey (1987-1988).

[a] Computed as portion of total harvested crop lost to insects, rodents, fire, rotting, or other causes, where total crop is the sum of marketed surplus, seed held back, payments or gifts in kind, the portion held back for household's own consumption, and postharvest losses.

of the nutrient value. On the other hand, farmers report that damaged grain is fed to animals and therefore retains economic value. Nevertheless, the basic conclusion remains important. One should not dismiss farmers' own assessment of losses. To do so would increase the risk of investment in inappropriate technology.

FEED USE AND MILLING

Although no exhaustive surveys have been done of feed mills in Ghana, an estimate of commercial use of maize for animal feed can be derived from production records of the main mills in Ghana. Estimates of the annual national use of maize for animal feed from such data are around 16,000 MT of domestic maize (Fudtech 1990a).[36] Despite some uncertainty surrounding the available data, the order of magnitude is such that the substitution of yellow maize for white maize in feed mill operations, as well as other industrial use, during times of local scarcity offers little scope for price moderation. On one hand, if price elasticities are low, even a small change in quantities can have a noticeable change in prices.[37] On the other hand, given the uncertain early estimates of agriculture production, the level of shortfall that is likely to trigger a change in imports of maize for commercial processing will probably dwarf the amount of substitution of yellow maize for white maize.

While yellow maize can substitute for white maize for household use in an extreme emergency, this substitution is probably not due to preferences or political constraints. Nevertheless, yellow maize presents no drawbacks from the standpoint of human nutrition. Moreover, consumer acceptance of yellow maize has grown over time elsewhere in Africa. A nongovernment organization, perhaps, should explore, on a pilot basis, the use of yellow maize in self-targeted subsidy or food supplementation programs. When more is known about consumer attitudes, the studies could be expanded.

The use of maize by feed mills has another curious aspect. The level of locally-milled wheat (126,000 MT per year from 1987 to 1989), coupled with the extraction rate (72 percent), implies that 35,000 MT of bran is available annually (Fudtech 1990b). If the optimal proportion of bran to maize is used in the manufacture of poultry feed, 35,000 MT of bran can support a feed industry that produces over 150,000 MT of feed. Clearly, this amount far exceeds the actual production. The question remains as to

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[36] A small amount of imported yellow maize was also used in 1989.

[37] By definition, a price elasticity is the percentage change in quantity divided by the percentage change in price. If price elasticities are, say, -0.3, a 3 percent change in supply can shift prices by 10 percent, holding population and income constant. Similarly, if own-price elasticities are -0.6, a 3 percent change of supply will shift prices by only 5 percent.

what is the best use of the by-products of wheat milling in Ghana, but the potential for re-export or the acceptability of changes in extraction rates are worth investigating, especially as world grain prices and domestic foreign exchange availability change.

One remaining processing issue is relevant to the discussion of food security. In recent years the gap between rice production and domestic demand was between 25,000 and 50,000 MT. Local production is still quite low, and production levels remain variable as well. PPMED reported production statistics of milled rice in 1986 at 70,000 MT, an increase to 81,000 in 1987, and a further increase to 84,000 MT in 1988. In 1989, however, production fell to only 66,500 MT, partially due to floods in the Northern Region. This shortfall from trend is roughly equivalent to the amount of rice that would be saved if the average milling rates were to rise to levels observed in South and Southeast Asia. While Ghanaian rice mills (whether village small-scale or government mills) convert 50 percent of paddy to rice – and generally fail to find effective markets for the remaining bran – small-scale mills in Asia convert closer to two-thirds, and larger-scale mills can convert more than 70 percent. While one constraint facing Ghanian milling may be the decentralized milling of local production, of greater concern is the tendency of the dry grain to break. Parboiling can reduce this breakage. While it is beyond the scope of this study to evaluate the benefit-to-cost ratio of investment in either small or improved larger-scale mills, the savings from improved milling are greater – as a percentage of production – than the likely savings from reduced on-farm storage losses.

6. CONCLUSION

In recent years the Ghana Food Distribution Corporation (GFDC) has increased its storage capacity to nearly 40,000 tons, or twice the maximum levels of purchases of maize by government agencies in any given year prior to 1990 (Fudtech 1990b). More significantly, it has plans to increase its capacity further to 150,000 tons by 1995. Although complete funding for the entire project is not assured, a sizable share is already under construction. There is not, however, a clearly articulated policy or objective for such storage. Indeed, in the last year, the stated – but largely unattainable – role of the GFDC in regards to maize purchases was to defend a floor price for producers. Currently, however, the GFDC attempts to both purchase and sell at prices determined by the private market.

This policy may reduce the chances of the GFDC acquiring an inventory that it is unable to sell profitably, but it does not provide a rationale for the current construction program. It is of some concern that policy will flow from capacity rather than the other way. A major objective of the ongoing Cornell food security study is to determine the costs and benefits of such storage policies. This paper is one of a series that will further this objective. It does not directly address the issue of the government's role in maintaining food security. Nevertheless, a review of the results discussed above in the context of potential government policies could prove useful.

Real wholesale and retail prices of food have been declining, slowly in the 1970s and more rapidly in the last six years. This is true, on average, even if the short-term conditions that prevailed in mid-1990 are considered. Although this trend would not reduce the concern for high food prices that all governments share, it does indicate that the markets have improved and that the production potential has increased. The other side of the food security equation – household purchasing power – is not addressed in this paper; but if prices continue moderating and markets remain functioning, income and employment policies deserve consideration as a possible entry point for food security intervention.

Furthermore, the study shows that, with the exception of rice, markets in Ghana appear to function reasonably well. Although price signals in the major markets do not transmit instantly to each other, markets do appear to be integrated in the long term. Moreover, prices are transmitted across commodities fairly well; price movements for maize influence price movements for sorghum and millet. Both these observations indicate that price stability in any one market will contribute to the same stability in others. This is not, by itself, justification of stabilization policies either through trade or storage, but it does argue for simplification in any proposed stabilization program.

The market channel for rice appears to break between the Savannah producers and the coastal markets. Food imports, therefore, including food aid, will probably not assist in stabilizing the northern markets. Moreover, studies that estimate the impact of such imports on local producers should disaggregate the coastal market channels from other regions.

Most of the analysis on the functioning of markets was conducted using wholesale prices. An additional point for consideration, then, is the relationship of these prices to other points in the marketing channel. Retail maize prices do not appear inordinately high relative to wholesale prices either currently or in the last decade. While the proportion of retail price attributed to marketing may have been high at various times – a commonly held view that is not directly investigated here – this may reflect real costs of handling and not uncompetitive behavior of retailers. The time trends of the ratio of retail to wholesale prices do not support the view that retailers are able to exploit shortages, at least in major markets. This suggests that improving the technology of marketing, including transport and short-term handling within market centers, is likely to affect market spreads more than would attempts to regulate retailers.

Again, rice may be an exception to this generalization. The margin between retail and wholesale prices may be as high as 40 percent within a given market, particularly Accra. This study, however, was unable to investigate the reasons why the rice market behaves differently from other crops. The available data on retail prices is inadequate for that task. In general, the units used over time and over markets to record retail prices are not uniform, and they are often inconsistent with wholesale information. Rice presents an additional problem inasmuch as the quality, or grades, of rice in a given market also vary more than for other commodities. The data on rice prices do not appear to be consistent regarding which prices for which grades are recorded. The PPMED, then, might review how prices that are currently collected are being used. The PPMED could then design data collection techniques that are fully compatible with these objectives. In many countries, data collection is commonly divorced from analysis, but the Ministry of Agriculture could rectify this situation with comparative ease.

Using three different sources of household- or farm-level data, this study found no appreciable evidence of widespread on-farm losses in storage. Yet the assumption that such losses are high persists. Not only will erroneous estimates of these losses lead to misleading estimates of domestic food availability, but they may lead to inaccurate policy prescriptions as well. In particular, one justification for the level of storage under the GFDC that is offered is that there is a need for more efficient storage. This may be, but a cost benefit analysis of this particular role for government involvement in grain storage (there are other objectives as well) must be based on an accurate assessment of alternatives. In the face of accumulating household-level data, anecdotes or outdated generalizations need not be the basis for the underlying assumptions.

There is even less data on the level of unofficial cross-border trade. The evidence that is available, however, suggests that this trade consists mainly of maize – in keeping with the equally limited information on the spread between prices in neighboring markets. As these levels may be as large or larger than the recent official exports to Angola and, unlike the latter, do not involve implicit subsidies to transport and storage, the government might find some advantage in officially acknowledging this trade, inasmuch as it is already occurring. Legalization of such trade would make information more readily obtainable on it, and this information would be useful for food security planning. Moreover, legalization might allow the imposition of a small export surcharge. A small levy would not discourage trade, but it would provide a potential policy lever in that any export tax can be made variable according to changing circumstances. Even leaving aside this potential, the legalization of cross-border trade offers the possibility of scale economies and, hence, reduced costs of transport. Such cost reductions generally benefit earlier links on the marketing chain.

In summary, this analysis of price data from Ghana does not make a compelling case for increased government involvement. To be sure, prices are variable, over seasons and between years. However, no market failures can be found among the main markets, with the exception of rice, which is a minor component of consumer's budgets and diets. Further research will investigate the margins obtained in the links between farmers and wholesale markets, as well as the financed costs – as opposed to physical loss – that contribute to the seasonal price patterns. Moreover, further research will investigate the relative feasibility of income stabilization, by households themselves as well as by the government and NGOs, compared with price stabilization, as a means to enhance food security in Ghana.

Appendix Table 1 — Rural Budget and Calorie Shares For Major Food Groups and Staples by Agroecological Zone

Item	Budget Shares Coastal (n=514)	Budget Shares Forest (n=937)	Budget Shares Savannah (n=428)	Calorie Shares Coastal (n=514)	Calorie Shares Forest (n=933)	Calorie Shares Savannah (n=429)
Food budget share[a]	0.661	0.698	0.711	–	–	–
Cereals	0.146	0.111	0.325	0.263	0.193	0.634
Maize	0.052	0.042	0.099	0.147	0.118	0.257
Millet/sorghum	0.000	0.001	0.183	0.001	0.001	0.336
Rice	0.015	0.023	0.024	0.016	0.022	0.024
Kenkey/banku/akpler/tuo zaafi	0.056	0.027	0.009	0.076	0.035	0.009
Roots/tubers	0.180	0.254	0.130	0.501	0.600	0.242
Cassava	0.087	0.094	0.042	0.323	0.337	0.102
Gari[b] and other cassava products[b]	0.046	0.011	0.012	0.099	0.024	0.024
Yams[b]	0.011	0.025	0.061	0.016	0.034	0.087
Cocoyams[b]	0.012	0.049	0.007	0.026	0.101	0.014
Plantain[b]	0.021	0.070	0.008	0.030	0.098	0.013
Meats/fish	0.146	0.144	0.078	0.082	0.072	0.036
Fish	0.127	0.110	0.048	0.077	0.063	0.029
Red meats	0.013	0.027	0.023	0.003	0.008	0.006
Poultry	0.007	0.007	0.008	0.002	0.002	0.001
Dairy products/eggs	0.011	0.010	0.003	0.001	0.001	0.000
Oils/fats	0.017	0.015	0.011	0.057	0.049	0.027
Vegetables	0.069	0.082	0.087	–	–	–
Fruits	0.012	0.019	0.007	–	–	–
Other	0.079	0.064	0.070	0.095[c]	0.084[c]	0.060[c]

Source: Ghana Living Standards Survey (1987-1988).

[a] These are shares of total expenditures. To derive share of food expenditure, one would divide the commodity share by the food budget share.
[b] Fufu expenditures were arbitrarily apportioned: 50 percent to cassava and 25 percent each to yam and to plantain.
[c] Consists of calories represented by sugar and groundnuts only. Not comparable to "Other" category in expenditures.

Appendix Table 2 – Urban Budget and Calorie Shares For Major Food Groups and Staples by Agroecological Zone

Item	Budget Shares: Accra City (n=328)	Budget Shares: Non-Accra Coast (n=341)	Budget Shares: Forest (n=388)	Budget Shares: Savannah (n=108)	Calorie Shares: Accra City (n=328)	Calorie Shares: Non-Accra Coast (n=341)	Calorie Shares: Forest (n=388)	Calorie Shares: Savannah (n=108)
Food budget share[a]	0.564	0.582	0.611	0.579	–	–	–	–
Cereals	0.159	0.147	0.127	0.204	0.376	0.312	0.249	0.486
Maize	0.021	0.036	0.029	0.069	0.108	0.136	0.112	0.223
Millet/sorghum	0.001	0.000	0.000	0.066	0.002	0.001	0.000	0.172
Rice	0.029	0.029	0.026	0.034	0.063	0.042	0.034	0.043
Kenkey/banku/akpler/tuo zaafi	0.062	0.051	0.042	0.015	0.122	0.090	0.064	0.025
Roots/tubers	0.090	0.119	0.167	0.106	0.311	0.388	0.468	0.295
Cassava	0.019	0.037	0.050	0.038	0.107	0.183	0.213	0.114
Gari and other cassava prods.[b]	0.023	0.035	0.015	0.020	0.078	0.104	0.046	0.055
Yams[b]	0.018	0.013	0.023	0.036	0.042	0.025	0.044	0.092
Cocoyams	0.003	0.007	0.032	0.003	0.008	0.018	0.072	0.007
Plantain[b]	0.017	0.022	0.044	0.007	0.041	0.041	0.078	0.022
Meats/fish	0.125	0.127	0.128	0.081	0.113	0.097	0.095	0.047
Fish	0.095	0.108	0.089	0.044	0.099	0.091	0.082	0.032
Red meats	0.025	0.014	0.034	0.031	0.012	0.005	0.011	0.013
Poultry	0.006	0.005	0.005	0.006	0.003	0.001	0.001	0.002
Dairy products/eggs	0.027	0.018	0.012	0.007	0.003	0.002	0.002	0.001
Oils/fats	0.021	0.023	0.018	0.015	0.086	0.088	0.074	0.056
Vegetables	0.055	0.069	0.083	0.089	–	–	–	–
Fruits	0.016	0.015	0.016	0.009	–	–	–	–
Other	0.071	0.064	0.060	0.067	0.111[c]	0.113[c]	0.111[c]	0.116[c]

Source: Ghana Living Standards Survey (1987-1988).

[a] These are shares of total expenditures. To derive share of food expenditure, one would divide the commodity share by the food budget share.
[b] Fufu expenditures were arbitrarily apportioned: 50 percent to cassava and 25 percent each to yam and to plantain.
[c] Consists of calories represented by sugar and groundnuts only. Not comparable to "Other" category in expenditures.

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