Welfare Effects of Higher Energy and Food Prices in Botswana: A SAM Price Multiplier Analysis

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Abstract

Using a social accounting matrix (SAM) multiplier framework, the paper examines the welfare effects of higher prices of internationally traded energy and food commodities on economic sectors in Botswana. These are adverse supply–side shocks to Botswana since the country is a net importer of energy and food commodities. The findings indicate that the effects of these shocks are heavily concentrated on very few production sectors; only agriculture, electricity, non-diamonds mining, water and government sectors are affected the most. Moreover, households in the rural areas are hurt much more than those in urban areas. These insights underscore the need for government to deliver on investments that are intended to increase agricultural yields and domestic energy production and to ensure that efficiency gains in food and energy supply chains are achieved. In addition, there is a need to review the adequacy and targeting of existing social safety nets.

Key Words: Social Accounting Matrix; Multiplier analysis; Welfare; Botswana
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Introduction

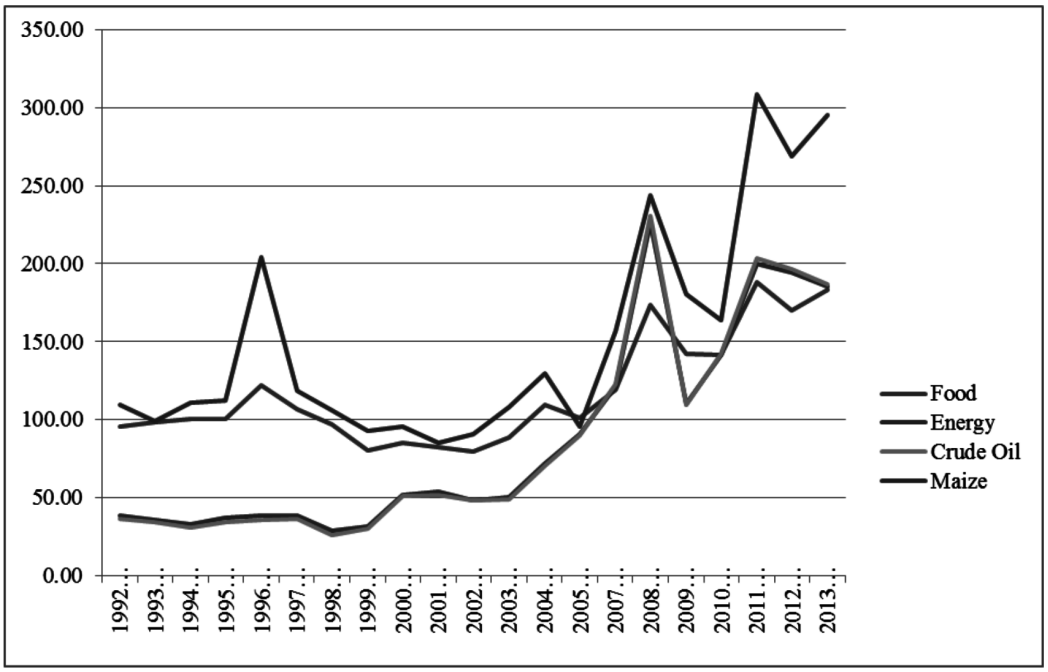
International prices of energy and food commodities have risen since 2000. The increases were dramatic between 2005 and 2008 and between 2010 and 2012. As figure 1 shows, global food and energy prices increased by 118 percent and by 347.6 percent during the period between 2003 and 2008, respectively. The corresponding increases during the period between 2010 and 2013 were 29.5 percent and 68.6 percent. Projections of IMF (2013), World Bank (2013) and Food and Agriculture Organisation (FAO, (2013)) show that world prices of energy and food commodities will decline by almost three (3) percent and by two (2) percent respectively in the near-term. Despite their envisaged decreases, world food and energy prices will remain elevated and closer to their historical peaks (World Bank, 2013; FAO, 2013). This is because some of the factors causing this twin crisis are structural in origins. Whereas structural factors contributing to energy price shocks include scarce supplies and buoyant demand from emerging market economies those contributing to higher food prices include global warming and the shift to foodgrain-fed bio-fuels (World Bank, 2013; Kebakile, 2008; Grynberg and Motswapong, 2009).

Botswana has allowed energy and food prices to be transmitted to domestic markets in the form of higher retail prices. According to Grynberg and Motswapong (2009), the increases in global prices of these commodities are partially passed-through to domestic markets. In fact, the May 2013 consumer price index data released by Statistics Botswana shows that the prices of these commodities remain elevated.

Higher global prices are cause for concern for Botswana since the country is a net importer of energy and food commodities. Hence, these higher prices are negative terms-of-trade shocks to the country. The economic problems they pose include rising import bills, increasing energy and food insecurity situation and unsustainable growth of public expenditure particularly on social safety nets. Indeed, economic theory suggests that the adjustment costs of elevated prices are potentially large for a net importer. Also, it argues that the effects are likely to be distributed disproportionately across economic sectors, with the brunt of the impact most likely to be borne by intensive consumers of these commodities.

The economic effects on Sub-Saharan African countries of higher global food and energy prices have been analysed using either a partial equilibrium modeling approach (e.g., Simler, 2010) or a social accounting matrix framework (e.g., Ngunou *et al*., 2008; Parra and Wooden, 2008; Puskas, 2012). One major conclusion emerging from these studies is that the impact of these shocks differs across countries depending upon economic structural features. Another key conclusion emanating from these studies is that it remains an open question as to whether households in rural areas are affected more than those in urban areas or not. However, these studies either examined the effects of global food prices or of global food prices on economy. There is, therefore, a need to understand the combined effects of global food and energy price-shocks.

Figure 1: Selected IMF Food and Energy Commodity Price Indices (2005 = 100)



Source: IMF (2013)

The objective of this paper is to contribute to the literature by exploring the combined effects of increases in international prices of energy and food commodities on welfare. To analyse the combined net effects of these shocks, a simple social accounting matrix framework is used. This simple general equilibrium framework has an advantage over partial equilibrium modelling approach in that it allows for both direct and indirect effects of price changes to be captured in the analysis. Moreover, unlike the standard Leontief input-output models, it allows analysis to be extended beyond the production linkages to include issues of income distribution, employment and households' welfare. It also has a virtue over computable general equilibrium (CGE) models of being capable of determining absolute prices, which is the issue of interest here.

The rest of the paper proceeds as follows. Section 2 presents the database and describes key aspects of the model as well as documents how the model is implemented. The simulations are constructed and results reported in section 3. Concluding remarks are contained in section 4.

Data and Model

SAM-price modeling framework is used considerably to examine the effects of various price shocks in Africa (see Ngunou *et al*., 2008; Parra and Wooden, 2008; Townsend and McDonald, 1997). A distinguishing feature of this class of simple general equilibrium models is that changes in exogenous price of a sector affect absolute prices of productive sectors, but leave quantities unaffected. Another characteristic of these models is that they extend the standard Leontief input-output models by making at least one institution endogenous. This added feature renders analysis to be extended beyond the production accounts to include consumption accounts. The present analysis uses a SAM-price modeling framework developed by Roland-Holst and Sancho (1995). This model is SAM-based. Hence, presenting the SAM database is a logical starting point.

Database

The SAM used in the analysis is for Botswana in 1996. This is the most recent SAM built by Central Statistics Office[4] (2002) specifically to support multiplier analysis. Available SAMs for 2004, such as that produced for Global Trade Analysis Project, have a supply and use structure that allows secondary production, a feature that is not accommodated in a SAM multiplier analysis. Besides resource constraints, input-output versions derived from the 2004 SAMs will provide less inter-industry transactions than the 1996 SAM.

The aggregated 1996 SAM used in the analysis has 43 accounts. Of these, 3 are for households, 5 accounts each for government, enterprises, investment, redistribution and the rest of the world and 6 out of 7 for primary factors of production are labour and the 7th is for capital. Furthermore, of the 23 accounts for production sectors, 5 are for agriculture, 7 are for agro-industries and 2 are for energy sectors. It is this characterisation of agriculture, agro-industry and energy sectors that render this SAM apt for the present analysis.

Needless to point out, a SAM database is not an economic model. Even though it identifies the transactors in an economic system, it does not spell out the behavioural relationships underlying the transactions values. The next sub-section describes the process of transition from a SAM databases to an economic model.

SAM-Price Multiplier Model

There is a vast technical literature on how SAM databases are transformed to SAM multiplier models (e.g., Miller and Blair, 2009; Pyatt and Round, 1979; Roland-Holst and Sancho, 1995; Parra and Wooden, 2008). Hence, the presentation of the model here focuses on key aspects only.

A point of departure in the transformation of a SAM database to a model is to specify the behavioural assumptions. Three critical assumptions of this model are as follows. First, prices are determined independently of quantities. Second, the input coefficients of producers and consumption patterns of households are fixed and, thus, there are no behavioural changes. Finally, an economy experience excess capacity. Under these assumptions, changes in exogenous prices result in adjustment of endogenous prices but leave quantities supplied and demanded unaffected.

The focus of SAM framework is on activity of endogenous sectors. These are assumed to undertake economic activities. Cognisant of this, the SAM accounts are subdivided into endogenous and exogenous sectors, depending upon the objective of the analysis. Exogenous accounts are those for which expenditures are set independently from income. For this analysis, the 1996 SAM accounts are partitioned such that the accounts for industries, primary inputs and households are endogenous and the remaining accounts are exogenous. In the partitioned SAM, the endogenous accounts occupy the leading rows and columns. This subdivision renders producer prices, primary factors' prices and households' cost-of-living indices endogenous and the world prices of commodities and taxes exogenous. Hence, possible price shocks to endogenous sectors include changes in the world prices of commodities. To the extent that this subdivision facilitates simulations of increases in global prices of energy and food commodities, it is suitable for this analysis.

Endogenous sectors produce output and consume output of each other. This information forms the basis for constructing the model and is contained in the inter-industry or input-output

[4] This is now called Statistics Botswana

transactions table. Conventionally, the row entries of this table describe the distribution of a sector's output throughout the economy and the column elements show the output from other sectors required by a particular sector to produce its output. A feature of SAM is that income and expenditure equate for each account. Hence, the row and column totals are equal.

The Roland-Holst and Sancho's (1995) SAM-price multiplier model exploits this property and recasts the material balance expression for the standard Leontief models to the price dual as follows. Assume that the inter-industry transactions are described by means of a matrix $\boldsymbol{A}$ of technical coefficients. Each element, $\boldsymbol{a}_{ij}$, of the matrix represents the costs of input from sector *i* needed to produce output of sector *j*. Because of the general equilibrium nature of the model, each sector's expenditure on output of other sectors plus on imports, taxes and transfers equals the income of the sector's output sold to other sectors. Let $\boldsymbol{P}$ be the vector of expenditures of productive sectors and $\boldsymbol{v}$ be the vector of exogenous expenditures of sectors. Roland-Holst and Sancho (1995) show that each of the endogenous sectors has an implicit cost or price index that is linked to the rest of prices. Here, the notion of price is taken in the same broad sense that the notion of income of a sector or institution has on a SAM framework. Indeed, the interpretation of most of the prices is relatively straight-forward (Parra and Wooden, 2008). For instance, the prices of activities are taken as producer prices and the prices of households are cost-of-living indices since they are computed as a weighted average of all the commodities and services that households purchase plus the tax payments. The SAM-price multiplier model is expressed by the equation below as

$$P = v'\left[I - A_n\right]^{-1}$$
$$P = v'M_p.$$
$$\Delta P = \Delta v' M_p$$

Where Δ denotes change and $\boldsymbol{M}_p$ is the price multiplier matrix and is obtained by reading across the rows of the standard Leontief inverse, $[I - A_n]^{-1}$, , of the endogenous income determination model (Roland-Holst and Sancho, 1995). The equation shows that the effect on prices of endogenous sectors triggered by a unit change in the exogenous price in a given sector is determined by the price multiplier ($\boldsymbol{M}_p$). The overall effect of a shock on each sector is a product of the price multiplier and the size of the shock ($\boldsymbol{v}$). Thus, the model captures how producers, primary inputs and households are affected by world price increases.

Model Implementation

The model is parameterised to the 1996 Botswana SAM. Following the standard practice in calibration, all bench-mark prices are set to one. It is operationalised in Microsoft Excel using the programming formula adapted from McDonald (1999). All the computations and policy simulations are performed in Microsoft Excel. In calibrating the model, Botswana economy is assumed to be in long-term equilibrium in 1996. Hence, the 1996 SAM transactions values are taken as realizations of the variables of the model.

Simulation and Results

In order to accomplish the objective, the model is used to simulate a series of global energy and food price shocks. The effects of the shocks are then determined from a comparative static analysis as the difference of the values of indicators between the post-shock and pre-shock equilibrium solutions. This section provides a detailed description of how the effects are derived and presents the simulation results.

Simulations

Before being used to simulate global price shocks, the model replicated the long-term equilibrium values of the endogenous variables given by the base year data. These are the pre-shock equilibrium values of the variables. Running the model without any shock reproduced the bench-mark values. Then, a series of world energy-price and food-price shocks are introduced to the model. Whereas energy-price shocks are modelled as increases in the global energy price in the electricity sector, food-price disturbances are introduced as increases in global prices of cereals in the traditional and arable sub-sectors. The focus on the latter is informed by the stylized fact that the output of these sectors is consumed mostly by households in rural areas where the majority of the population live. Contrary to existing SAM multiplier analysis in SSA economies, these price shocks operate simultaneously, as has actually been the case, rather than sequentially. Hence, the experiments capture the net effects of these shocks. Running the model with the higher global prices reproduced the post-shock equilibrium values for the endogenous variables that are compared against their corresponding long-term equilibrium values. The resulting differences in the levels of key indicators are taken solely as the effects of global energy-price and food-price shocks.

Even though the focus of this paper is on global prices that occurred between 2005 and 2013, the model used is parameterised to the 1996 SAM. Therefore, the model-based estimates give a picture of what would have happened in 1996 had food-price and energy-price increased in similar proportions to the recent world prices' increases of these commodities.

Results

The results reported in this sub-section are from a simulation of a 40 percent increase in global energy-price in the electricity sector and 45 percent increases in food-prices in the traditional and freehold arable sub-sectors. Though these shocks represent the average annual increases in global prices over the period between 2008 and 2012, the magnitudes of the shocks do not matter much because the linkage effects are linear and there are no behavioral changes.

Since Botswana is a net importer of food and energy, higher global prices of these commodities are negative supply-side shocks and are, therefore, expected to have detrimental effects on economic sectors. The anticipation is also for the impact to be spread in proportion, whether directly or indirectly, to the extent of dependence on food and energy. The picture emerging from the simulations conforms broadly to these expectations. Detailed results are reported in the table 1. The results in column 2 are reported as changes from the base year values. These refer to both absolute changes and percentage changes since all base year prices are set to one in calibration.

Column 2 reveals that the combined impact of energy-price and food-price disturbances is to raise producers' prices of all activities. This indicates that activities are invariably affected by these higher global prices. However, the effects are unevenly distributed. Unsurprisingly, the sectors directly hit by global price increases are the worst affected. These are electricity and arable agricultural sectors. The sectors experience the largest increases in producer prices that range from 41.2 percent in the electricity sector to 50.4 percent in freehold crop farms. Of those indirectly hit by the price shocks, only freehold livestock farms, non-diamonds mining, government and water sectors are affected considerably. These sectors experience increases in their producers' prices of greater than 2 percent. The remaining sectors record increases of less than 2 percent, with the services' sectors observing the least increase of less than 1 percent. It

is worth noting that the food processing sectors are relatively unaffected by increases in food-grain prices. This is scarcely surprising given the underdeveloped nature of the food system as the decomposition results reveal.

Estimates from an exercise that decomposes the price-transmission matrix are reported in columns 3-5. These enable one to understand which price transmission channel is responsible for exacerbating the combined effects of energy-price and food-price shocks. The figures clearly suggest that the net impact of these disturbances on the food and mining industries are overwhelmingly amplified by inter-industry interactions. This suggests that these activities have weak forward linkages to the rest of the economy or are less integrated. Inter-industry channel explains, for instance, 80 percent of the P3.24 increase in producer price of the non-diamonds mining. Conversely, the effects on producers' prices in the services' sectors are largely explained by the closed-loop channel. This refers to change in exogenous price going round the system and back to its point of origin in a series of repeated and dampening cycles. This result means that the services' sectors are depended particularly upon the electricity sector. The inter-industry mechanism accounts for half of the overall impact in the remaining sectors. For example, 50 percent of the P6.27 increase in the producer price of freehold livestock sector is due to inter-industry interactions.

Turning to primary factors of production, the estimates reported in column 2 show that the effects on factors' prices are straightforward. The combined impact of the global price increases is to invariably raise prices of primary inputs, though at different proportions. Whereas wages for all types of labour uniformly increase by 2.2 percent, the price of capital rises marginally by only 0.2 percent. These figures indicate that labour is the most affected. Over 70 percent of increases in factor prices are explained by the open-loop channel. This implies that primary inputs are dependent upon activities.

It is also instructive to report the impact of these shocks on households. After all, the principal objective of undertaking policy analysis is to understand effects on human welfare. The household sectors' results shown in the table clearly suggest that households in rural areas are, in proportional terms, hurt much more than those in urban areas. As apparent in the table, all cost-of-living indices increased, albeit at different proportions. The increases in consumer prices range from a low of 1.8 percent for urban households and a high of 2.7 percent for rural households. These figures clearly suggest that the welfare loss is largest for rural households and lowest for urban households. Note that the indicator for welfare used is the consumer price index, where a rise in this measure indicates the amount of additional income needed to purchase the original consumption basket. The losses in households' welfare are largely due to open-loop effects. For instance, the open-loop channel accounts for 87 percent of the P2.73 increase in consumer price index of rural households. The extent of the welfare deterioration reflects the households' consumption patterns. Households in rural areas have a larger food share in consumption expenditure. These insights uphold the evidence from both standard economic theory and empirical studies showing that when households in rural areas are net consumers they are worse off when prices - particularly of food commodities – increase (Woden and Saman, 2008). The reason for this is that they are often constrained by input costs and distance to markets and, hence, are generally unable to produce marketable surplus required to exceed their food expenditures.

Table 1: Effects of Increases in International Prices of Energy and Food commodities

Account	Overall Effect	Decomposition		
		Transfers Effects	Open-Loop Effects	Closed-Loop Effects
Prof. & Tech Employees - Cit.	2.19	0.00	85.02	14.98
Admin &Manag. Employees- Cit	2.18	0.00	85.01	14.99
Clerical Employees - Citizens	2.18	0.00	85.02	14.98
Skilled Manual - Citizens	2.19	0.00	85.02	14.98
Non- Citizens	2.23	0.00	76.57	23.43
Unskilled Employees	2.18	0.00	85.02	14.98
Gross Operating Surplus	0.15	0.00	85.08	14.92
Urban Households	1.76	0.00	83.05	16.95
Rural Households	2.73	0.00	86.65	13.35
Non-Citizen Households	2.23	0.00	76.57	23.43
Trad. Agric - Livestock	0.62	65.45	0.00	34.55
- Crops	48.36	6.32	0.00	0.62
Freehold Farms - Livestock	6.27	49.92	0.00	50.08
- Crops	50.43	6.31	0.00	4.47
Hunting, Fishing & Gathering	0.00	15.57	0.00	84.43
Mining – Diamonds	0.59	60.23	0.00	39.77
Other mining	3.24	80.00	0.00	20.00
Meat Processing	1.69	57.70	0.00	42.30
Dairy & Other Agric. Processing	1.44	65.91	0.00	34.09
Beverages	0.79	57.96	0.00	42.04
Textiles	1.30	52.49	0.00	47.51
Chemicals	0.93	41.45	0.00	58.55
Metal Products	0.64	47.02	0.00	52.98
Bakery & Products	0.79	41.87	0.00	58.13
Leather, Wood and Paper	1.00	41.48	0.00	58.52
Village Industries	0.42	56.03	0.00	43.97
Other Manufacturing	1.71	79.17	0.00	20.83
Water	2.24	53.36	0.00	46.64
Electricity	41.23	1.29	0.00	1.69
Construction	0.84	31.18	0.00	68.82
Trade	1.12	43.87	0.00	56.13
Hotels & Restaurants	1.06	49.09	0.00	50.91
Transport	0.67	30.95	0.00	69.05
Communications	0.99	28.59	0.00	71.41
Financial Services	0.90	28.78	0.00	71.22
Government	2.29	57.69	0.00	42.31

Source: Model simulations

Conclusion

This paper explored the effects of higher prices of internationally traded energy and food commodities using an energy-food-economy SAM multiplier framework. This framework has the advantages of capturing changes in absolute prices and of allowing both direct and indirect effects of price changes to be factored in the analysis. The motivation for the present analysis is the concern that the world price increases registered since 2005 are adversely affecting Botswana since it is a net importer of energy and food commodities.

The simulation results clearly suggest that higher global prices of energy and food commodities are affecting all economic sectors and that their effects are quite large. As expected, their consequences are unevenly distributed across economic sectors, in proportion to their degree of dependence on energy and/or food commodity. Besides directly affected sectors, only freehold livestock farms, non-diamonds mining, government and water sectors are most affected. Moreover, households in rural areas are hurt, in proportional terms, substantially much more than those in the urban areas. This is because rural households in Botswana are net consumers and have a higher share of cereals in consumption expenditure. This is consistent with theoretical and empirical evidence indicating that when households in rural areas are net consumers they become worse off when prices increase. Considering that the majority of the population, more especially the poor, resides in rural areas, these higher commodity prices may be driving many into poverty or causing unsustainable growth in public expenditure on social protection.

These conclusions highlight the need for government to ensure programmes intended to increase agricultural yields and domestic energy production bear fruits. Delivering on this development objective will increase food and energy security considerably and, hence, reduce over-dependence on imported supplies. Moreover, the insights suggests the need to ensure that measures aimed at increasing efficiency in - both domestic and import – supply chains of energy and food commodities achieve their intended results and, thereby, reduce marketing margins. The other emerging implication is that there is a need for regular monitoring of the situation and for review of not only the adequacy of existing social protection measures, but also their targeting. The latter may obviate unsustainable expenditure growth on social safety nets.

Notwithstanding, the conclusions of this paper should be treated with caution. As mentioned earlier in the paper, the analytical framework used to derive the results hinge crucially on three crucial assumptions. First, exogenous increases in prices result in changes in prices, but leave quantities supplied and demanded unaffected. Second, the linkages are linear and, therefore, there is no behavioural change. Finally, the economy experiences excess capacity. Because of these assumptions, the model used is likely to overstate the impact of the price shocks. These constraints underpin the need for future research to use SAM-based methods that can accommodate behavioural changes and resource constraints such as CGE models. Though the CGE analysis is likely to change the quantitative insights it is highly unlikely to change the qualitative predictions. More importantly, it will not determine absolute price changes. Given that the focus of the present analysis is on absolute prices, the SAM multiplier framework used is the appropriate method for this paper. Another issue that arises is the extent to which the base year database used for the analysis captures the current structure of the economy. In the absence of latest data, the conclusion of this analysis, arguably, are the better pointers. Therefore, all these comments should not undermine the validity of these conclusions.

Considering the projections that indicate that higher food and energy prices are likely to be sustained for a longer period, there is a need for future research to analyse the long-term or dynamic effects of these prices.

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