A treatment effect model to fit the fair-price-shop intervention approach of West-African food reserve policies: an application to Benin Republic food reserve policy fair-price-shop program

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Abstract:

Abstract Since the 2007-2008 world food crisis and accounting for the recurrent food crises which have affected West-Africa region within the last two decades; West-African countries have re-launched procurement programs and rebuilt food stocks. In Benin the procurement program was launched in 2008-2009. It is a state intervention on cereals market through the food reserve system. The food reserve policy operates two programs: a) market access program and b) food subsidy program implementing the fair-price-shop approach. The stratified random sampling technic was used and consumers' households were clustered into participants and non-participants in the fair-price-shop program. Data were collected in 2014, 6 years after the start of the food reserve policy. Qualitative and quantitative methods were used and 210 respondents were surveyed. A treatment effect model was developed to accommodate the program operation rules; it accommodates simultaneous effect and variables of different types. The Multivariate Endogenous Treatment Effect model reveals that Fair-price-shop intervention approach as safety net program is effective at stabilizing maize market price, facilitating access to staple in shortage times and at selecting the periods for stocks release. Further it informs also, about the effectiveness of the program design in targeting the appropriate beneficiaries. Keywords: food reserve policy, fair-price-shop approach, Multivariate Endogenous Treatment Effect model.

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1. Introduction

In the 1980s, food markets liberalization was on the top of the political development agenda. Expectations were a free market with prices regulated by food supply and demand. But is has been shown by Barrett (1997) that liberalization impacts differently staple food prices. Further the imperfect nature of liberalization hampers private investments; which face constraints such as (1) lack of credit, (2) arrival of food aids, (3) unpredictability of continued state intervention (Jayne et al., 2002). To overcome the unbalanced effects of liberalization, Coulter & Onumah (2002) suggested government commitment to develop credit inventory systems to solve collateral problem, to allow less food aids and to minimize its intervention on food markets. But private trade and storage have limited capacity to handle exceptional years of glut or scarcity. Thereby it cannot store a large quantity of grains which can be used to overcome country level shortage. Accordingly the ultimate consequence of agricultural markets liberalization weaknesses is the increasing percentage of developing countries population food insecured (Nyanteng et al., 2003). Therefore, a credible state strategy for price stabilization is desirable.

In West-African region, the resurgence of strategic food reserve in most African countries follows 2007-2008 world food crisis, which reveals free market inability to absorb shocks and balance grain markets. Drawing lessons from that, and seeing the increasing share of food insecured, states have decided to rely on their own grain stocks to control price fluctuations and ensure food access to citizens. In the region, established grain reserves have common features and similar objectives but management and operations differ according to countries specific policies. Most countries have adopted models away from the parastatal approach and tending towards partnership with private sector to procure the reserve and food subsidy program as safety net to ensure stocks rotation.

Despite the change of approach of the west-African stabilization policies over the last decade, there has been relatively little empirical analysis on the effectiveness of the renewed mechanisms. The current study intends to evaluate the Fair-price-shop intervention approach. It is a food subsidy program implemented by most West-African countries such as: Burkina-Faso, Mali, Niger, Nigeria and Benin (Amani, S. 2014; **Casey, K.** et al., 2016). The fair-price-shop program of Benin food reserve policy is the case study.

2. The fair-price shop program

Benin Food Reserve Policy (FRP) operates through two complementary programs: (1) Market-based procurement program and (2) Fair Price Shops (FPS) program. The FPS program constitutes the rotation system of the food reserve. It is a food subsidy program which focuses on poor urban consumers. Urban consumers being net buyers of agricultural commodities, they are highly vulnerable to price fluctuations. Therefore, to reduce price

variations effects on consumers' households in lean time, the food reserve releases maize stocks into the Fair-Price-Shops network. The program operates by engaging poor urban consumers in the purchase of selected staple at subsidized price in the program shops. The shops are supplied through the food reserve stocks releases. The releases are triggered when consumer prices are higher than the program celling price, revealing staple shortage on markets. Accordingly in shortage period, subsidized staple food (e.g. maize, rice, gari, etc.) are available in the Fair-Price-Shops.

Then through releases of subsidized food products in the trade system, the program objectives are:

- to reduce the overall market price of each subsidized commodities,
- to facilitate food access to vulnerable consumers households during markets shortage,
- to foster local food production consumption.

The current study focuses on maize as the most traded and consumed agricultural commodity in West-Africa. The study aims at evaluating the Fair-Price-Shops program simultaneous effect on: i) maize market prices, ii) consumers' households total maize supply and iii) consumers' satisfaction.

3. Methodology

3.1.Study area and data collection

Data were collected in two cities of northern Benin. The republic of Benin is located in tropical west Africa, between 6°30 and 12° North Parallels and 1° and 3°40 East Meridians. The cities surveyed are Parakou and Djougou and in each city three districts were selected. A total of 210 consumers households were sampled using stratified random sampling procedure. The clusters were constructed based on knowledge of the food subsidy program and enrollment in the Fair-price-shops. All respondents having knowledge of the program were selected and those purchasing in the shops are clustered in the treatment group; while the control group includes those not purchasing in the shops. The program operates following self-enrolment rule.

3.2.Analytical approach

In the current evaluation the outcome variables are identified and there are of continuous and dichotomous types. They are simultaneously impacted by the same treatment, referring to consumer purchase of subsidized maize in the program shops. Therefore a model which could accommodate both the types of the variables and the simultaneous effect of the program is required.

First a mean comparison test is run. The objective is to inform about the trends of the selected outcome variables and to refer to them for verifying the validity of the multivariate model developed below.

The structural econometric models (SEM) are known to accommodate several endogenous variables of same or different natures (i.e. continuous, dichotomous, count, etc.). SEM accommodates also simultaneous effects among endogenous variables or from exogenous to

endogenous variables (Kline, 2011). Further, SEM accommodates controlling for selection bias by including individuals' specific parameters in the model (Heckman and Robb, 1986).

But in the endogenous treatment effect frame, to our knowledge, there is no model which accommodates the simultaneous effect of a treatment (or policy) on outcome variables of different types. The extended endogenous treatment effect model presented below is developed to account for these specific features of the Fair-price-shop approach, implemented as safety net program.

3.3.Model specifications

In the Structural Equation Model (SEM) frame, Heckman (1976, 1978) and Maddala (1983) have developed a treatment effect model which accommodates endogenous selection issue (Stata 2015). This model was used by Skrondal et al., (2004). Taking advantages of SEM features, we extended the conventional model to fit two additional outcome variables of different types (i.e. continuous and dichotomous). Then we obtain a multivariate endogenous treatment effects model (METE). Fitted with the study variables, we have the following mathematical form:

3.3.1. Outcome equations

$$\begin{cases} Price\_Mkt_i = n_1 X_{1i} + \varphi_1 FPS + u_{1i} \\ TQty\_FRMkt_i = n_2 X_{2i} + \varphi_2 FPS + u_{2i} \\ Satisfaction_i = n_3 X_{3i} + \varphi_3 FPS + u_{3i} \end{cases}$$

Selection equation

$$FPS_i^*(Purchase) = \begin{cases} 1, & if \ \gamma w_i + \varepsilon_i > 0 \\ 0, & otherwise \end{cases}$$

Where X stands for the set of covariates determining the outcome variables and n its vector of coefficients. Here X corresponds to households a socio-economic characteristic. u is the outcome equations vector of error terms. *FPS* stands for the binary-treatment variable. φ_1, φ_2 and φ_3 are the parameters measuring the average treatment effects on the selected outcome variables: market price (*Price_Mkt*), total quantity ($TQty\_FRMkt$) and satisfaction ($Satisfaction$), respectively. In the selection equation, FPS^* refers to an *ith* consumer decision to purchase in the program shops, w stands for the set of factors determining consumers purchase decision (i.e. socio-economic variables) and ε is the error term.

The selected outcome variables referring to consumers' welfare indicators are defined as follow:

- Maize market price refers to the average consumer price in retails markets over year *(Price_Mkt*);
- Total quantity is the total amount of maize purchased from both market and Fair-Price-Shops (*TQty_FRMkt*). It is the average amount of maize supplied over a year;
- *Satisfaction* refers to the availability of the product (i.e. Maize) in the shop when needed by the beneficiaries (*Satisfaction*).

Following SEM rules (Stata, 2015), the current model includes: a latent variable labelled (C); llAttendance and ulAttendance which are the lower and upper limits of participation variable. One of them is used as dependent variables of the selection equation. The selected outcome variables are observed in all cases (i.e. attendance or not/purchase or not). And as in the conventional endogenous treatment model of SEM, the coefficient on the path treatment variable to outcome variable is the average treatment effect (ATE) (Stata, 2015). Accordingly, the paths and their respective ATE are: FPS => Price_Mkt: φ_1; FPS => TQty_FRMkt: $\varphi_2$and FPS => Satisfaction φ_3(Figure 1).

3.3.2. Analysis hypotheses

The model was used to test four hypotheses (i.e. H1-H4) evaluating the Fair Price Shops program impacts on consumers. Table1 summarizes the hypotheses of consumers purchase decision model.

Table1: Hypotheses of consumers purchase decision model

Models	Hypotheses	Accepted if	Purposes
Selection equation Consumers purchase decision	**H1:** purchase decision is driven by higher educational level, consumption demand and housing rent.	Full model consistent & $\gamma' > 0$	Evaluate the effectiveness of the program design in targeting poor urban households
Outcomes equations	**H2:** purchase in FPS reduces maize price costs	$ATE_{Price\_Mkt} < 0$	Evaluate the effectiveness of the program mechanism in controlling maize market price
Impacts of purchase in FPS on consumers welfare	**H3:** purchase in FPS increases households' total supply of maize.	$ATE_{TQty\_FRMkt} > 0$	Evaluate the effectiveness of the program mechanism in facilitating access to food
	H4: purchase in FPS increases households' likelihood not to face food shortage.	$ATE_{Satisfaction} > 0$	Evaluate the effectiveness of the program mechanism in selecting period of stocks releases

Source: Author's specifications

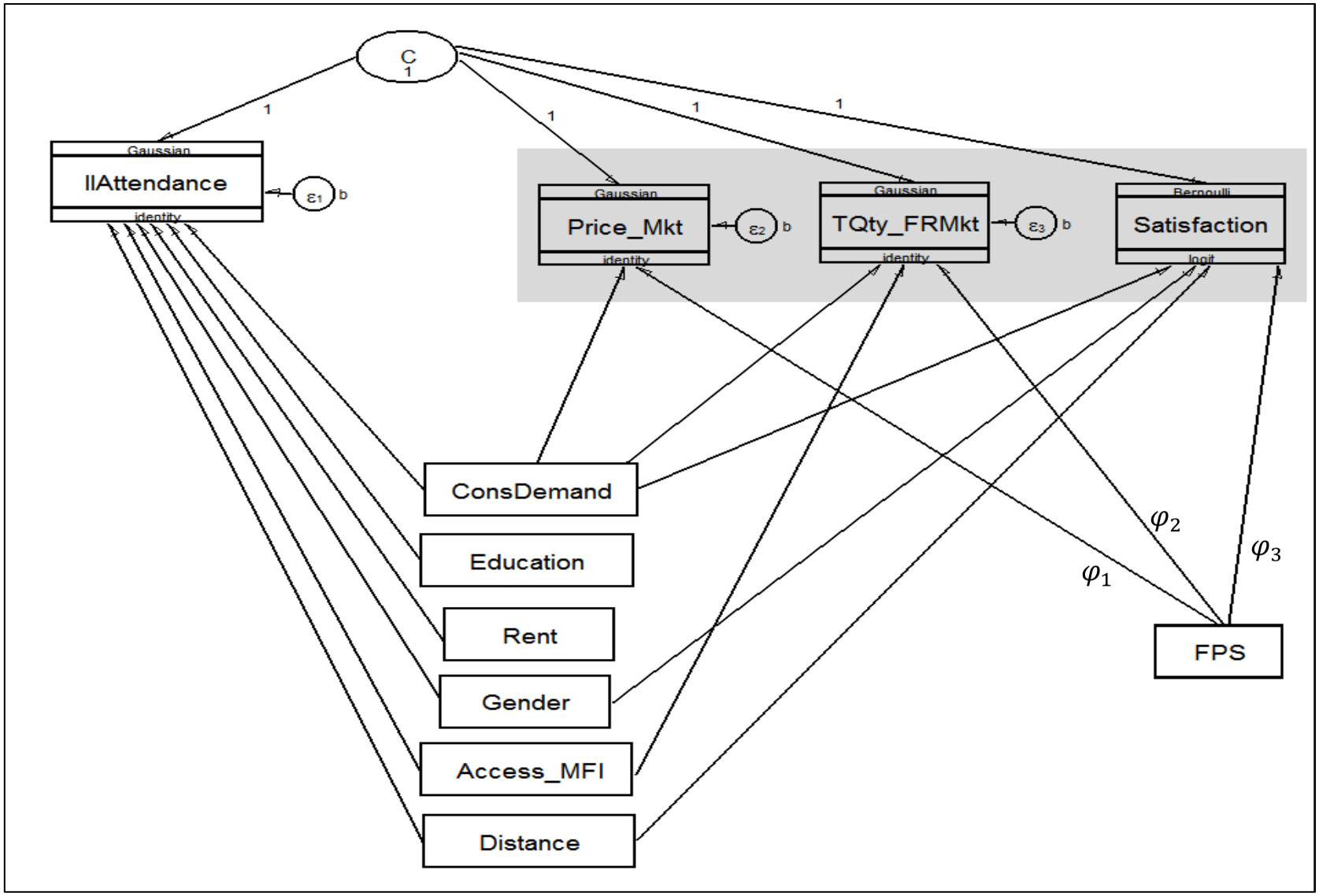

Figure 1: Multivariate endogenous treatment effects of consumer purchase
Source: own conception

3.3.3. Specification of the variables in the model

The variable referring to purchase decision in the selection equation is also used as treatment variable in each outcome equation. The outcome variables (i.e. market price, total quantity of maize and satisfaction) refer to consumers' welfare indicators. Table2 presents the variables used in the model.

Table2: Variables codes and definitions

Codes	Definitions	Units/Types
FPS	Consumer decision to purchase in FPS	Yes/No
Price_Mkt	Consumer maize markets price	Fcfa/kg
TQty_FRMkt	Total household supply of maize	kg
Satisfaction	Perception of maize availability in shops during markets shortage	Yes/No
Gender	Household head gender	1 if male
Education	Highest education level	Years
Access_MFI	Access to microfinance institutions	Yes/No
ConsDemand	Household maize consumption	Adult Equivalent
Rent	House rent	Fcfa/Month
Distance	Distance to the nearest fair price shop	Kilometer

Source: Author's specifications

3.3.4. Estimation procedure in SEM frame

The Generalized Structural Equation Model (GSEM) is used instead of the Structural Equation Model (SEM). Indeed GSEM accommodates response variables from different family (e.g. Gaussian, Bernoulli, Poisson, Ordinal, etc.). These types of models are called mixed models. GSEM fits also different levels of variable desegregation and also non-linear relations between variables (Kline, 2011). These features match with the current models which take advantages of GSEM capacity to fit multilevel mixed model. Two estimations methods are provided by gsem: maximum likelihood (ML) and quasi-maximum likelihood (QML). QML uses ML to fit the model but relaxes the conditional normality assumption for estimating the standard errors. In the current study QML estimator was used.

Stata commands for multivariate endogenous treatment effects model

METE estimates can be retrieved in gsem estimation method, using the following Stata 14.1 commands:

- correlation coefficient ρ_i can be retrieved using Stata command *nlcom*. In a Heckman selection model the same command gives sigma and rho values, but in the endogenous treatment effect frame it provides only rho.
- ATE in each outcome equation can be retrieved using Stata command *lincom*. Without the option *eform*, it estimates the coefficient of the binary-treatment variable (i.e. ATE). With *eform* option, it gives the exponentiated coefficient of the same variable (Stata, 2015).

Normally, Stata command for estimating ATE is *margins r*. But in a multivariate frame the command does not recognize to which outcome to refer to when running the estimation.

4. Results

4.1. Comparison group validity

To generate consistent counterfactual variables, there are at least three main requirements :the comparison group i) has, on average, the same characteristics as the treatment group; ii) reacts the same way as the treatment group, if it was given the same treatment; and iii) remains unaffected by the program, no contamination. Here comparison tests results of treated and comparison groups are presented in Table 3. The control group is valid if individuals' socio-economic and demographic characteristics are, on average, statistically similar in both groups.

The comparison reveals that the treated and control groups have on average the same characteristics. Therefore, consumers in both groups are similar and it could be assumed that the comparison group presents the same trend as the treated group if it was treated.

To meet the no-contamination requirement, two factors have been accounted for. The first is the social environment, in fact in urban context, social networks are less strong than in rural areas; therefore the possible transfer of subsidized food stocks from treated households to non-treated is limited, if not non-existing. The second factor is to account for family ties in constructing both groups' samples. Indeed is more likely that subsidized maize transfer occur among persons from the same family. Accordingly it is expected that the comparison group be cleaned from all direct effects of the program. Therefore the counterfactuals constructed from this comparison group are valid.

Table 3: Comparison of treated and control groups characteristics

	Groups		
Variables	Treated	Control	
	Mean values		t value
Age (Years)	36.740	35.681	-0.64
Education (Years)	6.630	7.390	1.141
Household size (Number of persons)	5.600	5.200	-0.983
Consumption (Adult equivalent)	4.658	4.737	0.213
Income (Fcfa/Month)	90371.670	90412.880	0.006
Rent (Fcfa/Month)	6980	7945.455	0.963
Savings (Fcfa/Year)	80000	79954.550	-0.002
	Percentage of total respondents (%)		Chi2 value
Gender			
Male	22.86	24.76	
Female	27.62	24.76	0.011
Access MFI			
Yes	9.52	10.48	
No	38.10	41.90	0.000

Source: Author's estimation

4.2.Evaluating the fair-price-shop program

4.2.1. Mean comparison test

Table 4 presents the comparison test of the outcome variables. Among the three variables, two are of continuous nature and one is binary (e.g. Satisfaction), therefore the mean comparison test approach is limited.

Table 4: Treated and control groups mean comparison test

Indicators	Treated	Control	Differences	t value
Price_Mkt	179.25	180.4545	1.204	0.225
TQty_FRMkt	184.03	177.2636	-6.766	-0.553
Satisfaction	--	--	--	--

Source: Author's estimation

The comparison test reveals that treated consumer's maize market price is less than the one of control group consumers. Further, the overall maize supply in treated consumers' households is higher than non-treated consumers' households. Due to selection bias, the estimated differences are biased. However this approach informs about the trends of the selected variables.

To control for selection bias as well as accommodate the simultaneity effect of the program and the different nature of the outcome variables, the Multivariate Endogenous Treatment Effect (METE) model is used to estimate the unbiased impact measures.

4.2.2. Evaluating with METE

The model outcomes are presented in Figure 1. And the estimation results are summarized in Table 5. The estimates of the selection equation reveal that, purchase decision of subsidized maize is related to households maize consumption demand, households head education level and gender; as well as housing rent, access to microfinance institutions (MFI) and distance to the nearest Fair-Price-Shop. In fact, for an increase in the consumption demand of maize by one adult equivalent, the probability of purchasing in FPS is reduced by 2.4% (see Figure 1). This result confirms field observations. Indeed in the program, the amount of staple a consumer can buy is restricted and varies for each subsidized products. Then maize consumers' purchases are restricted to 1 bag of 50 kg per family within a month. The rule intends to ensure, to a wide number of consumers, access to the minimum amount required to overcome shortages.

Housing rent is proxy for estimating households' expenses beside food related expenses. The choice of housing rent was guided by the fact that, as most developing countries, in Benin the most important expense after food is housing (AGVSA, 2014). The estimates show that higher education and higher rent reduce the probability of purchasing subsidized maize, respectively. In most countries a better socio-economic status is reflected through better livelihoods and for instance, better houses. Therefore rich consumers are less interested to enroll in the program. This result reveals that the program design is efficient in targeting poor consumers.

Further, the negative correlation between maize consumption demand and the likelihood of purchasing in the program shops shows that targeted consumers are urban households with up

to 7 family members (AGVSA, 2014). Households having access to MFI are less likely to attend the program shops. And for distances up to 5km, men household head are most likely to be in charge of purchasing maize in the fair-price-shops.

The outcome equations present the estimates of the average treatment effect of consumer enrolment on the aforementioned outcome variables. Consumer purchases in the Fair-Price-Shops (FPS) reduce maize market price (φ_1 = -1.3, p>10%) throughout a year. In fact, when a consumer buys in FPS, maize cost is reduced by 1.3 Fcfa per kilogram, for an average market price of 180.45 (±38.73) Fcfa per kilogram. To support this result, the average difference between market and subsidized prices (ΔPrice) for the treated group reveals that a treated consumer saves 36 (±9.40) Fcfa per kilogram. Indeed, the FPS are opened for six months in a year. Then within this period treated consumers maize expenses are reduced by 36 (±9.40) Fcfa per kilogram for an average market price of 180.45 (±38.73) Fcfa per kilogram. Then on the treated consumers the FPS program has significantly reduced or stabilizes maize prices. Therefore the Fair-Price-Shops program is efficient at stabilizing maize market prices and consumers benefit from reduced prices.

Regarding the total amount of maize purchased in a year (i.e. from both market and program shops); purchases from FPS increase treated consumers total maize supply (φ_2 =6.8, p>10%). Therefore treated consumers' households' total maize supply has increased by 6.8 kg compared to control group average supply which is about 177.26 (±81.32) kg. Accordingly the program is effective at facilitating staple food access to treated consumers.

Regarding consumers' satisfaction, the likelihood of treated consumers of having maize in the program shops during shortage is (φ_3 =1.5%, p<1%) higher compared to the reference group. This result supports the difference in the total amount of maize consumed in both groups respectively. It also informs on the effectiveness of the FPS program at selecting appropriate periods for releasing maize stocks in fair-prices-shops.

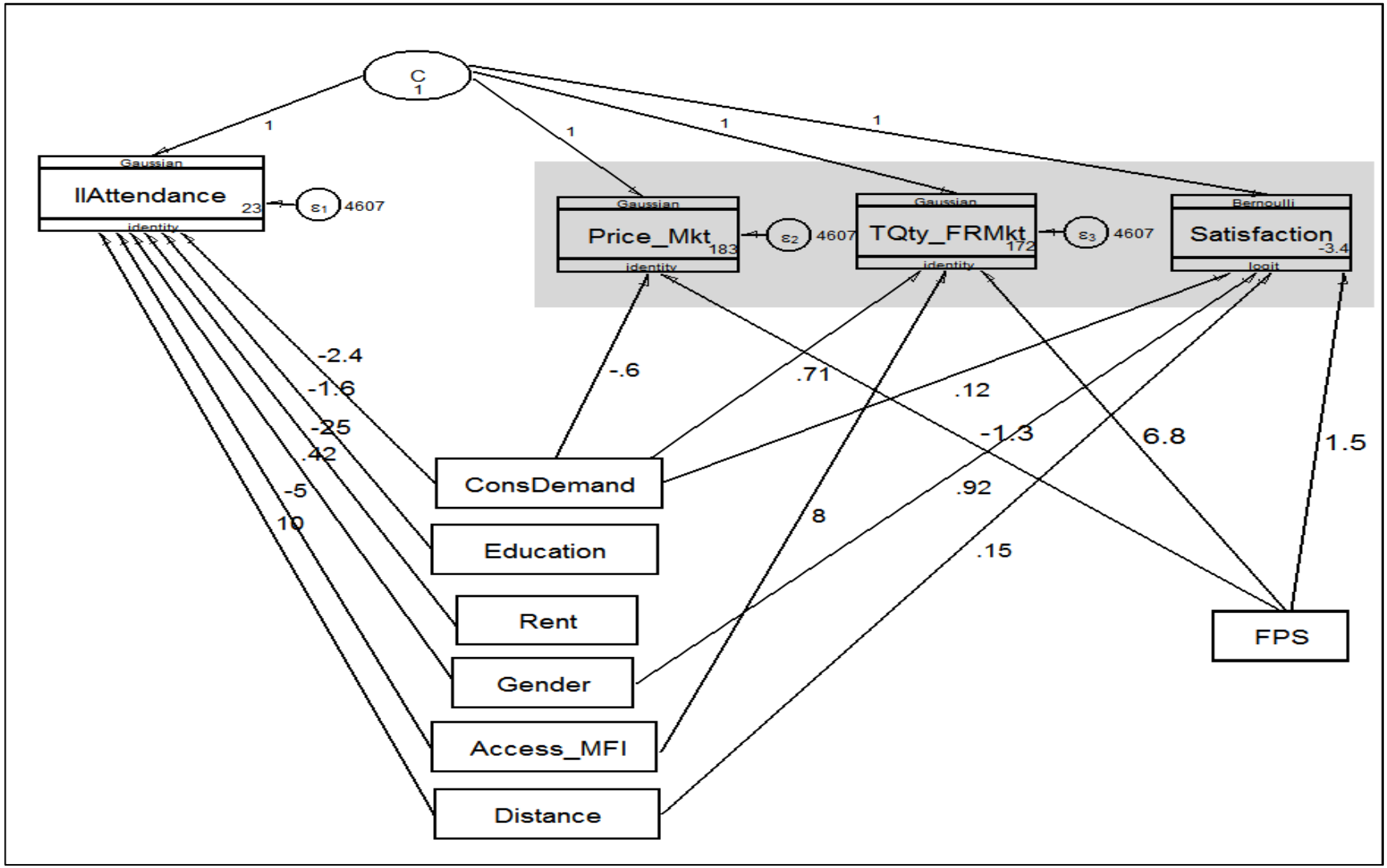

Figure 1: Results of the fair-price-shop program impacts on consumers welfare purchase
Source: own conception

Table 5: Results of the fair-price-shop program impacts on consumers welfare

Variables		Coef.	Robust Std. Err.
Purchase <-			
	ConsDemand	-2.398	2.477
	Education	-1.586	1.358
	Rent	-25.250*	13.056
	Gender	0.416	12.733
	Access_MFI	-5.004	15.406
	Distance	10.128*	5.994
	C	1	(constrained)
	_cons	22.965	20.769
Price_Mkt <-			
	FPS	-1.274*	5.330
	ConsDemand	-0.595	0.891
	C	1	(constrained)
	_cons	183.286***	6.014
TQty_FRMkt <-			
	FPS	6.799*	12.226
	ConsDemand	0.712	2.870
	Access_MFI	7.991	14.399
	C	1	(constrained)
	_cons	172.302***	13.593
Satisfaction <-			
	FPS	1.526***	0.422
	ConsDemand	0.115	0.070
	Gender	0.916**	0.407
	Distance	0.150	0.169
	C	1	(constrained)
	_cons	-3.448***	0.572
var(C)		1	(constrained)
var(e. Purchase)		4607.121	515.926
var(e. Price_Mkt)		4607.121	515.926
var(e. TQty_FRMkt)		4607.121	515.926

Note: *, **, *** significant at 10%, 5%, and 1%, respectively.

Source: Author's estimation

5. Conclusion

There are several models to implement food subsidy policy. The current program implements the design of Fair-Price-shop as mechanism to control staple food price with the main objective of facilitating access to staple and support poor consumer in bridging markets food shortage.

Summarizing the evaluation outcomes, the Fair-Price-Shops mechanism implemented is revealed to be effective at selecting the program eligibility criterion. This allows defining and covering the appropriate target group which is, in our case, poor urban consumers. Further the results inform about the effectiveness of Fair-Price-Shop mechanism at controlling maize market price with a significant reduction of consumers' price throughout a year. The benefits of this reduction are noticed through the increase of the amount of maize supplied by the target group households. Finally the study informs that the periods selected by the program to operate the Fair-Price-Shops match the beneficiaries' expectations.

The study main limitation in the context of price stabilisation policies is the use of cross-sectional data. For further studies should be conducted using time series data. However, the choice of cross-sectional data was guided by the objective of evaluation not only the impacts of the program, but also the mechanism through which the program is implemented. And for that purpose, respondents' participation data were need and to date the Food Reserve Agency of Benin (ONASA) do not have appropriate data records which could be used in academics.

6. References

Amani, S. (2014). Supporting Public Procurement from Smallholder Farmers. P4P Global Learning Series World Food Program, 28.

Agvsa (2014). Global analysis of vulnerability and food security. World Food Program, Benin Country Report, 146.

Barrett, C.B. (1997). Liberalization and food price distributions: ARCH-M evidence from Madagascar. Food Policy 22(2), 155–173.

Casey, K. and Commandeur, D. (2016). Structured Demand Markets and Smallholder Farmers: Relevance and Access. Procurement governance for home grown school feeding project learning series, Stichting Nederlandse Vrijwilligers (SNV), 23.

Coulter, J. and Onumah, G.E. (2002). The role of warehouse receipt systems in enhanced commodity marketing and rural livelihoods in Africa. Food Policy 27, 319-337.

Heckman, J.J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. Annals of Economics and Social Measurement 5(4), 475-492.

Heckman, J.J. (1978). Dummy endogenous variables in simultaneous equation system. Econometrica 46(4), 931-959.

Heckman J.J. and Robb R. (1986) Alternative Methods for Solving the Problem of Selection Bias in Evaluating the Impact of Treatments on Outcomes. In: Wainer H. (eds) Drawing Inferences from Self-Selected Samples. Springer, New York, NY

Jayne, T.S., Govereh , J., Mwanaumo, A., Nyoro, J.K. and Chapoto, A. (2002). False promise or false premise? The experience of food and input market reform in Eastern and Southern Africa. World Development 30(11), 1967–1985.

Kline, r. (2011). Principles and Practice of Structural Equation Modeling, Third Edition. New York, Guilford Publications.

Maddala, G. (1983). Limited-Dependent and Qualitative Variables in Econometrics. Cambridge University Press, New York.

Nyanteng, V. K. and Asuming-Brempong, S. (2003). The role of agriculture in food security in Ghana. In Roles of Agriculture Project International Conference, 20-22.

Stata (2015) Stata: Release 14. Statistical Software. College Station, TX: StataCorp LP. 583 pages.

Skrondal, A. and Rabe-Hesketh, S. (2004). Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models. Boca Raton, FL: Chapman & Hall/CRC.