The Effects of Oil Market Shocks on Sub-Sahara African (SSA) Economies

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ABSTRACT. This paper examines the interaction between oil market shocks (oil supply and oil-specific demand shocks) and the growth rate of Gross Domestic Product (GDP) of thirty countries in Sub-Sahara Africa (SSA), over the period 1961 - 2013. The paper estimates both a structural vector autoregression (SVAR) and a panel vector autoregression (PVAR) model with recursive restrictions and it makes three main arguments: First, it confirms the on going view that oil market shocks are not very relevant in explaining variation in GDP growth rates. Secondly, oil price shocks (increase in prices) have a significant and positive impact on oil-exporting economies. Finally, there is evidence that even though oil market shocks do not explain variation in GDP growth for individual SSA economies, collectively, there is a positive and significant impact on growth.

1. Introduction

For the past half century, understanding the importance of oil price shocks and how they affect macroeconomic variables has received considerable attention - especially for most industrialized nations. However, research findings on the topic still remain ambiguous and open to debate. Some researchers in the discipline uphold the view that, oil price shocks significantly explain variations in macroeconomic performance, but the opposite could be equally true[1]. Hamilton's (1983) paper *"Oil and the Macroeconomy since World War II"* is the key finding that established that oil price shocks cause recessions. In his paper, he indicated that "all but one of the US recessions since World War II have been preceded by a dramatic increase in the price of crude petroleum." Using Granger-causality, he examined the impact of oil price shocks and the US economy in the 1949-1972 and 1973-1980 periods, and found a negative relationship between oil price and macroeconomic performance. Hamilton's findings serve as a benchmark to the literature. Further studies on the topic by Burbidge and Harrison (1984) use VARs to estimate the impact of oil price increases in Canada, Japan, West Germany, UK and the US, and conclude that oil

[1] Some research findings indicates that oil price shocks do not have any significant impact in explaining macroeconomic performance. Extensive literature review show that the discrepancies in research findings are mainly due to data used, methodology and the variables observed in question.

price shocks increase both wages and prices in all the countries. This was an affirmation of Hamilton's findings. Other research findings in support of Hamilton include Hamilton (1985), Mork (1994), Rotemberg and Woodford (1996), Hamilton (1996) and Blanchard and Gali (2007) amongst others. Several papers have supported Hamilton's core findings[2], however Mork (1989) discovered a mishap in the literature, indicating that there is a statistical asymmetry in the impact of oil price increases and declines. Mork found that oil price increases were followed by declines in GDP, however the opposite doesn't hold[3]. Even more detrimental to Hamilton's core findings, is the papers by Darrat et. al. (1996) and Hooker (1996a) that find that there is no statistical evidence of oil price increases leading to a decline in GDP[4]. These findings highlight the oposing view against Hamilton's findings. The differences in the data used before 1980's and after 1980's raised the issue of the Great moderation and how oil price shocks explain macroeconomic performance before the 1980's and not after.

Further contributions to the literature by Bernanke et al. (1997), highligts that it is not merely sufficient to study the effects of oil price shocks in isolation of other shocks affecting the economy. They include monetary policy shocks in a VAR model for decomposing the total economic effects of a given exogenous oil shock into portions attributable directly to the shock and the part arising from the policy response to the shock. Their model finds that, the 1974-1975 recession is not well explained by oil shocks alone but also the response of monetary policy to oil price shocks, albeit large standard errors[5]. Bernake's work provides a more realistic design of the macroeconomy, as several shocks could simultaneously impact an economy. However, Melolinna (2012) indicates that linking the response of monetary policy to oil shocks can be fundamentally misspecified, as the policy shocks assume the same response to oil price innovations regardless of the composition of the shock. This makes Bernanke's claim very much open to debate[6].

In addition to the work done, Barsky and Kilian (2002, 2004) and Kilian (2009) address the need to distinguish between oil market demand shock and oil supply shocks using vector autoregression (VAR). In their contribution, they distinguish between 3 demand and supply shocks: shocks to the current physical availability of crude oil (oil supply shock), shocks to the current demand for crude oil driven by fluctuations in the global business cycle (aggregate demand shocks) and shocks driven by shifts in the precautionary demand for oil (precautionary demand shocks). Likewise, other researchers have tried to better capture the oil demand and oil

[2]Further mention of Hamilton's findings alludes to the fact that there is a negative relationship between oil price shocks and macroeconomic performance.

[3]"Mork (1989) extends Hamilton's (1983) analysis, by including the oil price collapse of 1986 and confirms Hamilton's results by finding a strong negative correlation between oil price increases and the growth of GNP for the US when the sample is extended beyound the 1985-86 oil price decline. The coefficients on oil price increases and oil price decreases were significantly different from each other indicating that the effects of oil price increases and decreases were assymetric."

[4]Darrat et al. proposes a 6 variable VAR over 1960-1993 (more recent data than Hamilton's). Hooker finds that oil price does not Granger-cause changes in US GDP for the period 1973:4-1994:2.

[5]Bernanke et al. (1997) conclude that a substantial part of the recessionary impact of an oil price shock results from the endogenous tightening of monetary policy rather than the increase in oil price.

[6]Hamilton and Herrera (2004), Kilian (2010) and Kilian and Lewis (2010) have challenged the findings of Bernanke et al. (1997)

supply shocks either by imposing sign restrictions[7] as proposed by Uhlig (2005) or by using other measures of real economic activity to depict fluctuations in the oil market business cycle (Melolinna, 2012). More advanced techniques that have been employed to capture the different kind of oil shocks include factor-augmented vector autoregression (FAVAR)[8] and time-varying VAR framework[9].

With the extensive literature on the subject, the findings still remain two-fold: Oil market shocks either influence macroeconomic performance or they do not. These studies have mainly focused on the US economy, European economies or other industrialized economies. Very few studies have focused on developing economies and to my knowledge; no studies have examined the macroeconomic impact of oil price shocks in Sub-Sahara Africa using time-series analysis. The current paper attempts to contribute to the ongoing discussion on the macroeconomic effects of oil shocks in the following ways. First, it introduces a three-variable oil market SVAR to examine the impact of oil market shocks on thirty SSA countries. Secondly, the model takes into account exogenously determined oil supply and demand shocks. Finally, the paper introduces a Panel VAR to examine the overall impact on the SSA region.

The remainder of the paper is organized as follows: Section 2 introduces both the SVAR and PVAR model, data as well as details of the employed methodology. Section 3 deals with the results and section 4 concludes as well as addresses the policy implication.

2. Model

According to Kilian (2009) a common approach in both empirical and theoretical work on oil price shocks is to evaluate the response of macroeconomic aggregates to exogenous changes in the price of oil. However, he suggests that such an approach has flaws due to reverse causality from macro aggregates to oil prices. Worth noting, this may not be the case when evaluating the impact of oil price shocks on small developing economies. For most part, changes in the frequency of oil demand by individual economies in the Sub-Sahara African (SSA) region do not have any significant impact on the overall demand for oil. Therefore does not impact the price of oil in any significant way. The same applies to the determination of world crude oil production levels. Therefore, it is often safe to assume that both the determination of world crude oil production levels (oil supply) and setting of oil prices (oil-specific demand) are exogenous to the individual economies in SSA[10].

The current study uses a simple SVAR and PVAR to capture the impact of oil markets shocks on economies in SSA and on the SSA region, respectively. The model follows closely the work of Kilian (2009) with slight modifications[11]. The idea

[7]Kilian and Murphy (2011, 2012), Lippi and Nobili (2009) and Melolinna (2012)

[8]Aastveit (2013) employs FAVAR to conclude that oil demand shocks are more persistent than oil supply shocks in explaining macroeconomic variables.

[9]Baumeister and Peersman (2012) use time-vaying VAR and find a large role for oil demand shocks in real price variability.

[10]Kilian (2009) identifies three (3) shocks underlying demand and supply in the crude oil market: Shocks to the current physical availability of crude oil (*oil supply shocks*); shocks to the current demand for crude oil driven by fluctuations in global business cycle *(aggregate demand shock)* and shocks driven by shifts in the precautionary demand for oil *(oil specific demand shock)*.

[11]Due to the issue of reverse causality (oil shocks not being exogenous), Kilian (2009) develops a variable to capture demand for crude oil driven by fluctuations in the global business cycle.

is to illustrate how a simple model can be used to infer the impact on economic performance in this region.

2.1. Data. The variables included in the model are global oil production, the real price of oil (West Texas Intermediate) and yearly GDP growth rates for thirty SSA countries[12]. Figure (1) shows global oil production and the price oil and Table (1) show the list of countries and the average growth rates over the sample period. Global oil production data is from the US Department of Energy, Energy Information Administration (EIA), the real price of oil is from the Federal Reserve Bank, St. Louis (FRED) and the GDP data is from the World Development Indicators (WDI). All the data are in stationary form: Global oil production and GDP are measured by year-on-year percentage change and the real price of oil is expressed in (log) levels. The sample period for both models is 1960 to 2013 and there is 1 lag included in the model[13].

2.2. Model 1: The Structural VAR. I consider a VAR(1) model for 30 Sub-Saharan African countries based on yearly data for $X_t = (\triangle prod_t, rpo_t, \triangle gdp_t)'$ where $\triangle prod_t$ is the percentage change in global crude oil production, rpo_t is the (log) real price of oil [14] and $\triangle gdp_t$ is the percentage change in country specific Gross Domestic Product. The sample period for each country is 1960 - 2013[15] and the model is estimated for each country k, where $k = 1,..,30$. The structural VAR representation is given by

$$BX_t = \alpha + \Gamma X_{t-1} + \varepsilon_t \tag{2.1}$$

where ε_t denotes the vector of serially and mutually uncorrelated structural innovations[16]. I impose that B^{-1} has a recursive structure such that the reduced form errors (e_t) can be decomposed according to $e_t = C\varepsilon_t$

$$e_t = \begin{bmatrix} e_t^{\triangle prod} \\ e_t^{rpo} \\ e_t^{\triangle gdp} \end{bmatrix} = \begin{bmatrix} c_{11} & 0 & 0 \\ c_{21} & c_{22} & 0 \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{oil\ supply\ shock} \\ \varepsilon_t^{oil\text{-}specific\ demand\ shock} \\ \varepsilon_t^{country\ specific\ output\ shock} \end{bmatrix}$$

Motivation for the restriction on B^{-1} is implied by the fact that: (1) Crude oil supply shocks are seen as unpredictable innovations to global oil production. Therefore, oil supply does not respond instantaneously to changes in the demand for oil within the same period[17] and does not respond to the country specific output

This variable is not included in both SVAR and PVAR because oil demand and supply are both exogenously determined in these models

[12]Selected countries included in the model is based on the availability of data

[13]Traditional information criteria favor a 4-lag structure. However, the literature on oil market shocks suggest that it is important to have long lag structures in oil market VARs that approximate a year. Since I am using yearly data it fits that I impose a 1-lag structure. In any case, the results are qualitatively robust to longer lag structures.

[14]The rpo_t series is expressed in logs.

[15]The starting date is dictated by the availability of gdp data for the Sub-Sahara African countries.

[16]For the full solution of the model see appendix

[17]As noted, oil production is higly costly and producers set production based on expected future demands. Production levels are not revised in response to high frequency variation in demand

shocks. As mentioned earlier, all the countries in Sub-Sahara Africa are considered in this model as small-open economies. Therefore variation in the country specific demand for out should not have any bearings on the global crude oil production levels.

Innovations in the real price of oil are either explained by crude oil supply shock or demand shocks that are specific to the global crude oil market. Killian (2009) defines the latter shock as "*precautionary demand shocks*" which arises from the uncertainty about shortfalls of expected supply relative to expected demand.

The SVAR model is applied to the thirty SSA countries and the impulse response functions (IRFs) are shown in the appenix.

2.3. Model 2: Panel VAR. Model 2 assumes that there are interdependencies among SSA countries, hence the need to explore how oil market shocks impact the SSA region as a whole. Combining the traditional VAR approach (Sims, 1980) with panel data econometrics I am able to observe the interaction between oil market shocks and output using the same variables as in model (1).

The reduce form of the PVAR model is defined as

$$Y_{i,t} = \delta_{i,t} + A\,(L)_{i,t} + e_{i,t} \tag{2.2}$$

where i $(i = 1, ..., N)$ denotes the country, and t $(t = 1, ..., T)$ denotes time. $Y_{i,t}$ is the vector of stationary variables used in model (1), $A(L)$ represents the matrix polynomial in the lag operator L, $\delta_{i,t}$ denotes the vector of country fixed effects and $e_{i,t}$ is the vector of errors. The vecotor $Y_{i,t}$ is composed by the same variables used in the SVAR: world crude oil production, real price of oil and GDP growth rates.Figure (3) shows the panel data for the 30 SSA countries. Implementing the VAR procedure on the panel data requires imposing the same underlying structure for each cross-sectional unit (country). This constraint may be voilated in practice (Love and Zicchino, 2006). However, the country fixed effects are a way to overcome the restriction on the parameters to the extent that they capture individual heterogeneity (Gnimassoun and Mignon, 2013)[18].

3. Results

To understand the effexts of structural shocks on the endogenous variable (output), I look to the impulse response functions (IRFs) using Choleski decomposition. The IRFs are estimated to expose the response of the model to one standard deviation shock to the structural disturbances. The one standard deviation is computed by bootstrap with a 1000 replication. My impulse responses indicate the point estimate in both models. The IRFs for each of the 30 SSA countries are shown in the appendix. Owen to the differences in data used (yearly vs montly data), I anticipate that my results will be slightly different. However, the major relationship between variables still hold.

[18]Fixed effects estimators in autoregressive panel data models are inconsistent (Nickell, 1981). Fixed effects are correlated with regressors due to lags of the dependent variable. For future research, it will be best to consider the generalized method of moments (GMM) and remove the fixed effects by using a forward mean-differencing procedure (Helmert procedure). In this approach, all the variables will be transformed into deviations from the forward means, and each observation is weighted to standardize the variance. Such a transformation will preserve orthogonality between transformed variables and lagged regressors and allows for the lag regressors to be used as instruments and to estimate the coefficients by GMM (Love and Zicchino, 2006)

3.1. SVAR. I focus on the impulse response functions (IRFs) derived from the estimation of Equation (2.1). Unexpected oil supply shocks cause a sharp increase in global production upon impact[19]. Which is followed by a full decline after one year. This applies to all the 30 countries. Even though, I anticipate that a positive supply shock will lead to a decline in crude oil prices, which it does, the impact seems not to be significant. This is consistent with the view that Kilian's (2009) view that variations in oil production does not explain changes in the price of oil[20]. I also find that oil supply shocks do not have any significant impact on output growth rates for the 30 SSA countries. This is consistent with the literature that crude oil production increases do not necessarily boost economic growth. (Mork, 1989)

On the other hand, the oil-specific demand shock causes a increase in the real price of oil upon impact. The increases seems to be persistent and significant lasting throughout the entire horizon of 10 years, though gradually declining. This seems to be the case for all 30 countries. However, when it comes to the impact of the oil-specific demand shock on country specific output, the results tend to vary. With the exception of Gabon, Nigeria and the Republic of Congo, increase in the real price of oil (oil-specific demand shock) does not impact the economies in any significant way. There is an instantaneous increase in output, in response to the oil-specific demand shock, that lasts between 3 - 10 years depending on the country, but it is not significant for the 27 out of the 30 countries[21]. For Gabon, Nigeria and Republic of Congo, there seems to be an instantaneous and significant increase that lasts for one year, upon impact. These 3 countries are the only oil producing economies in the sample[22]. This seems to be more consistent with the view that oil producing economies benefit more when oil price increases than other countries. For policy purposes, this is of extreme importance since most countries in the region have discovered crude oil deposits and are preparing to start or have currently started production.

The shocks to the country specific output shocks do no explain any movements in the real price of oil or crude oil production.

3.2. PVAR. For the analysis on PVAR, I focus on the IRFs derived from the estimation of Equation (2.2). Graph for the IRF are shown in the appendix. The results, highlight some important facts going on in the region as opposed to studying the individual countries. (1) There is a significant and negative response of the real price of oil to a positive shock in oil production. (2) There is a significant and

[19]Kilian (2009) finds that oil supply disruption causes a sharp decline in global oil production upon impact followed by a partial reversal of that decline within the first year. This seems to be more consistent with the view of oil supply contractions

[20]Kilian (2009) finds that the cumulative effect of oil supply shock on the real price of crude oil is negligible. He finds that variations in the real price of crude oil can be explained with the aggregate demand shocks and oil-market specific demand shocks.

[21]Benin, Botswana, Burkina Faso, Burundi, Cameroon, Chad, Cote D'Ivoire, Democratic Republic of Congo, Ghana, Kenya, Lesotho, Leberia, Madagascar, Malawi, Mauritania, Niger, Rwanda, Senegal, Siera Leone, South Africa, Sudan, Swaziland, Seychelles, Togo, Uganda, Zambia and Zimbabwe.

[22]A country is identified as an oil producing economy if production has been taking place since 1980s. Several SSA countries have recently located oil deposits and are currently oil producing economies (like Ghana, Kenya etc) but I don't consider them to be crude oil producing economies because it was after the year 2000.

positive response of output to positive shock in oil supply. (3) There is a positive response of output to an oil-specific demand shock and (4) there is a decrease in oil production in response to an oil-specific demand shock. These findings, eventhough different from the country specific studies, inform us that overall SSA benefits from positive oil price shocks. More importantly, it is noted that a 20% increase in oil prices leads instantaneously to a 3% increase in growth which diminishes after a year. The results seem to be very striking, especially since I unticipated a more prominent fall in growth in response to a price increase.

4. Conclusion

This paper carries out an analysis of oil market shocks in a traditional VAR and PVAR model, and it highlights three main findings. First, it introduces a simple 3 variable VAR oil market and confirms the fact that oil market shocks are not relevant in explaining variations in GDP growth rates in specific SSA countries. Secondly, positive oil price shocks (oil-specific demand shocks) benefit oil-producing economies in the region more. Three out of the 30 countries, the only oil-producing economies, had instantaneous and significant positve growth rates in response to the the positve price shocks. Finally, the PVAR highlights that overall the region is benefited with positive oil price shocks. This is inherently important as a lot of economies in the region will be oil producing economies in the future.

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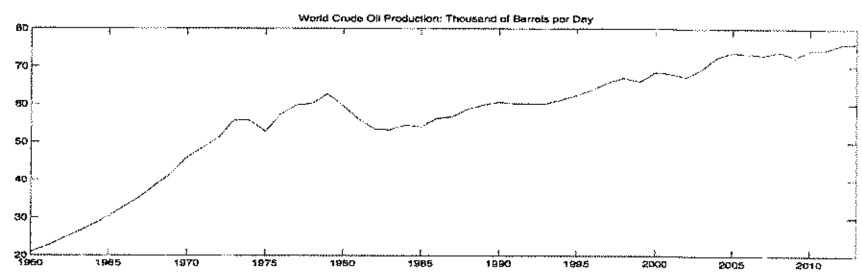
Appedix: Tables and Graphs

Table (1): **Average GDP Growth Rate: 1960 - 2013**

Country	**(%) Rate**	**Country**	**(%) Rate**
Benin	7.80	Malawi	7.80
Botswana	13.20	Mauritania	8.07
Burkina Faso	7.62	Niger	6.20
Burundi	5.81	Nigeria	12.70
Cameroon	8.19	Rwanda	10.04
Chad	8.36	Senegal	6.43
Democratic Republic Congo	10.08	Seychelles	9.76
Republic of Congo	10.44	Sierra Leone	7.04
Cote D'Ivoire	8.70	South Africa	8.38
Gabon	11.76	Sudan	9.41
Ghana	8.32	Swaziland	10.38
Kenya	8.45	Togo	7.84
Lesotho	9.22	Uganda	9.45
Liberia	6.27	Zambia	8.15
Madagascar	6.12	Zimbabwe	5.87

Figure (1)



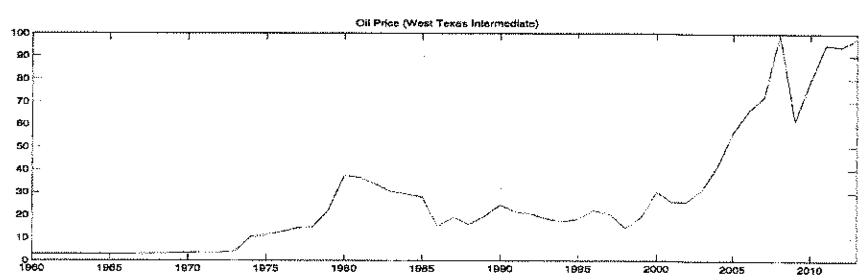


Figure 2: GDP in Selected SSA countries

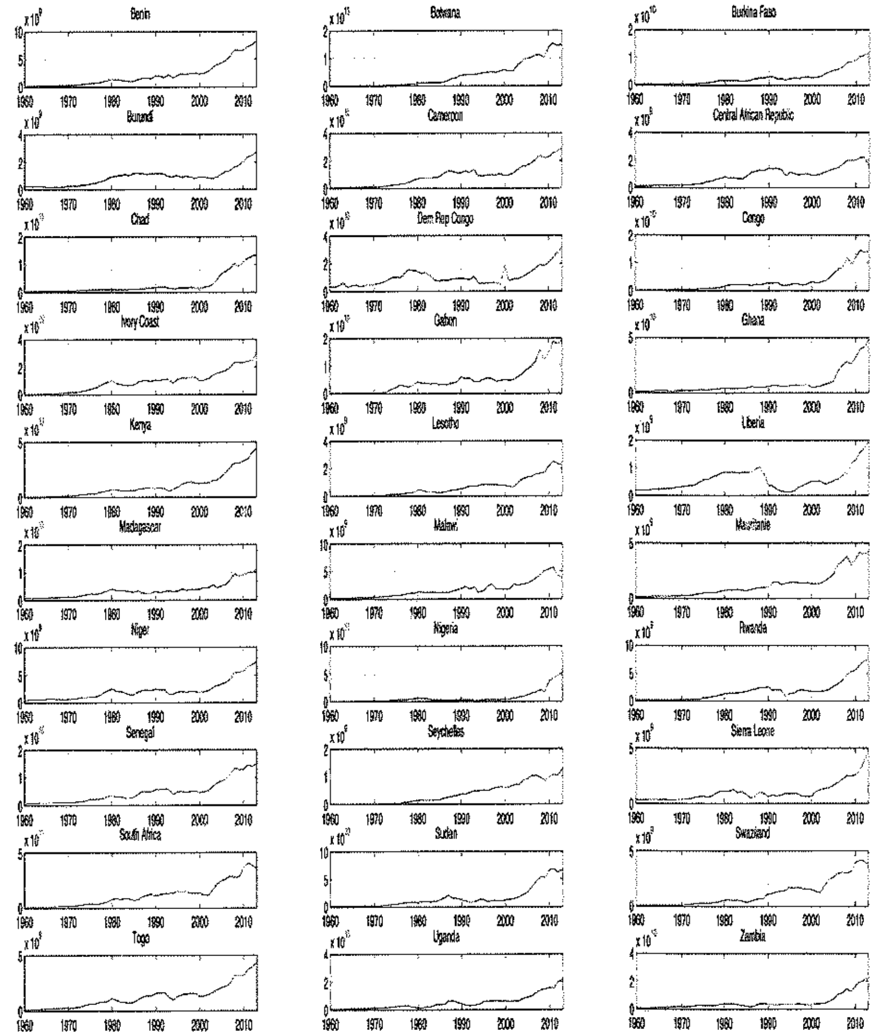
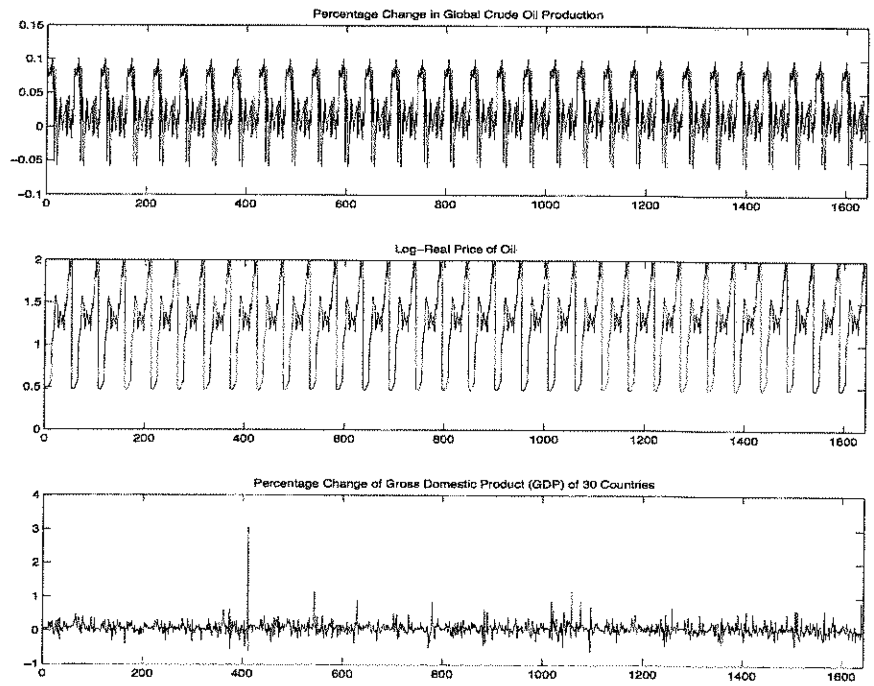
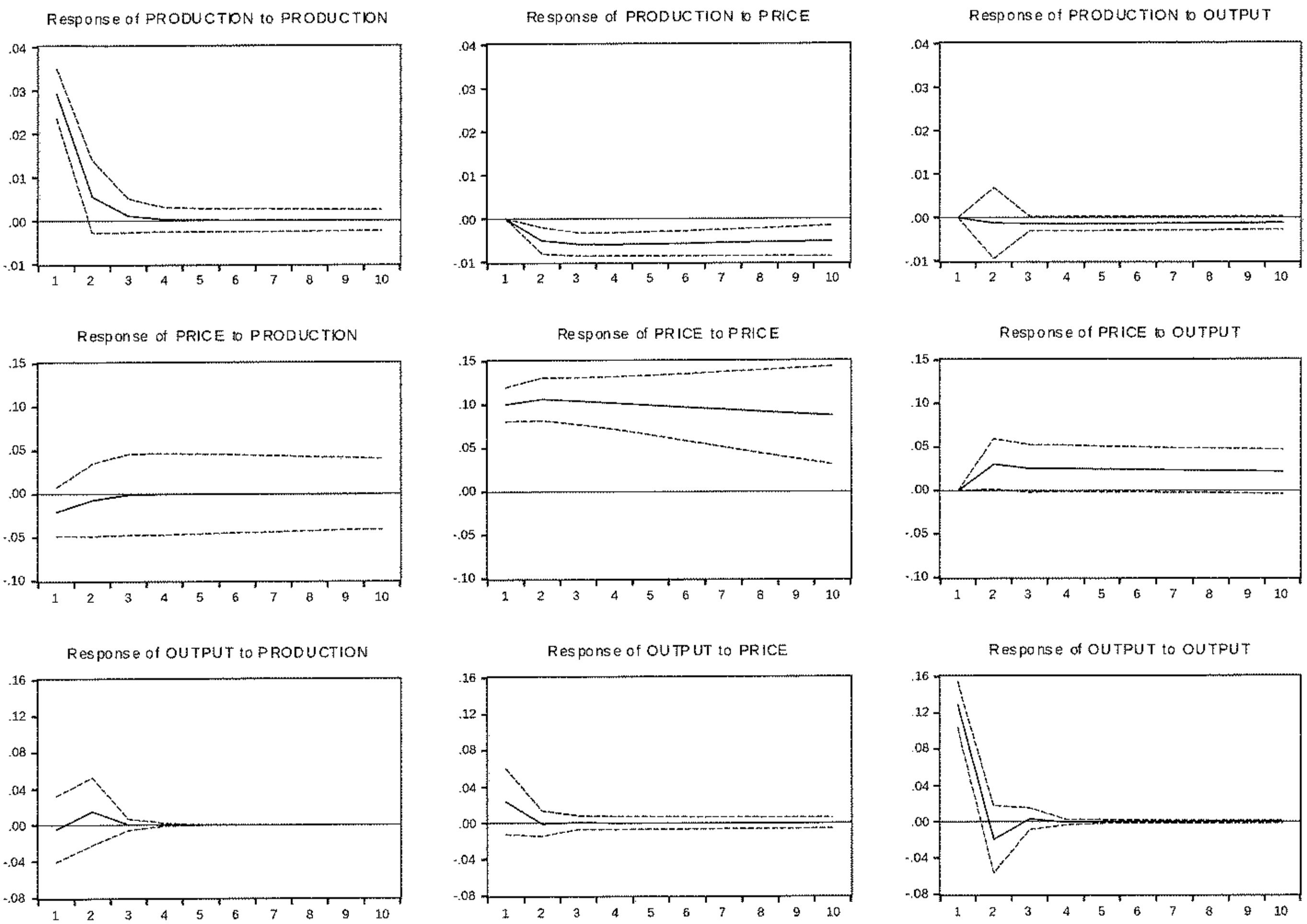


Figure 3: Panel Data

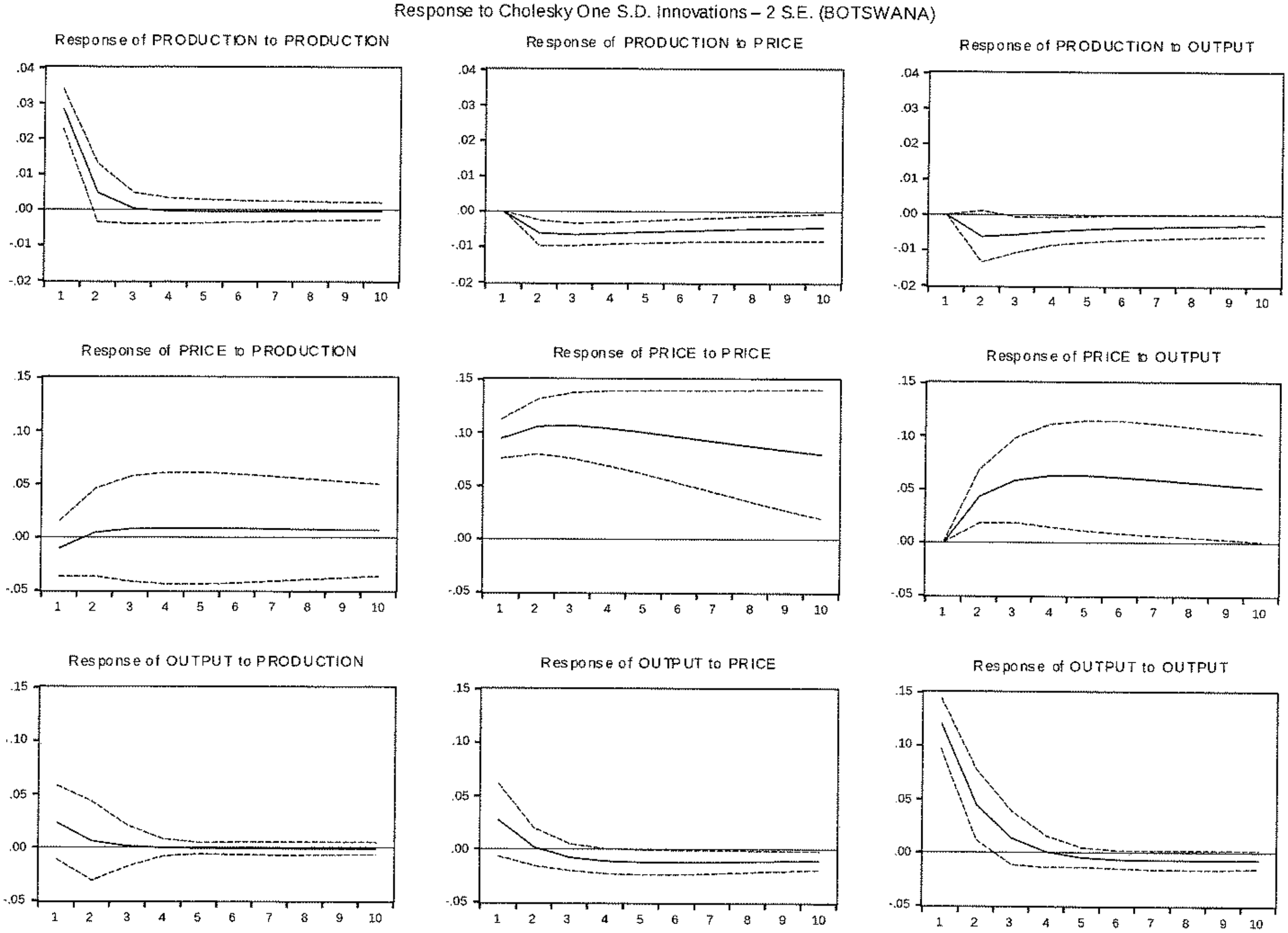


The cyclicality of the "Percentage Change in Global Crude Oil Production" and "Log Real Price of Oil" is due to them being exogenously determined. Hence they are the same for each SSA country used in the estimation of the PVAR.

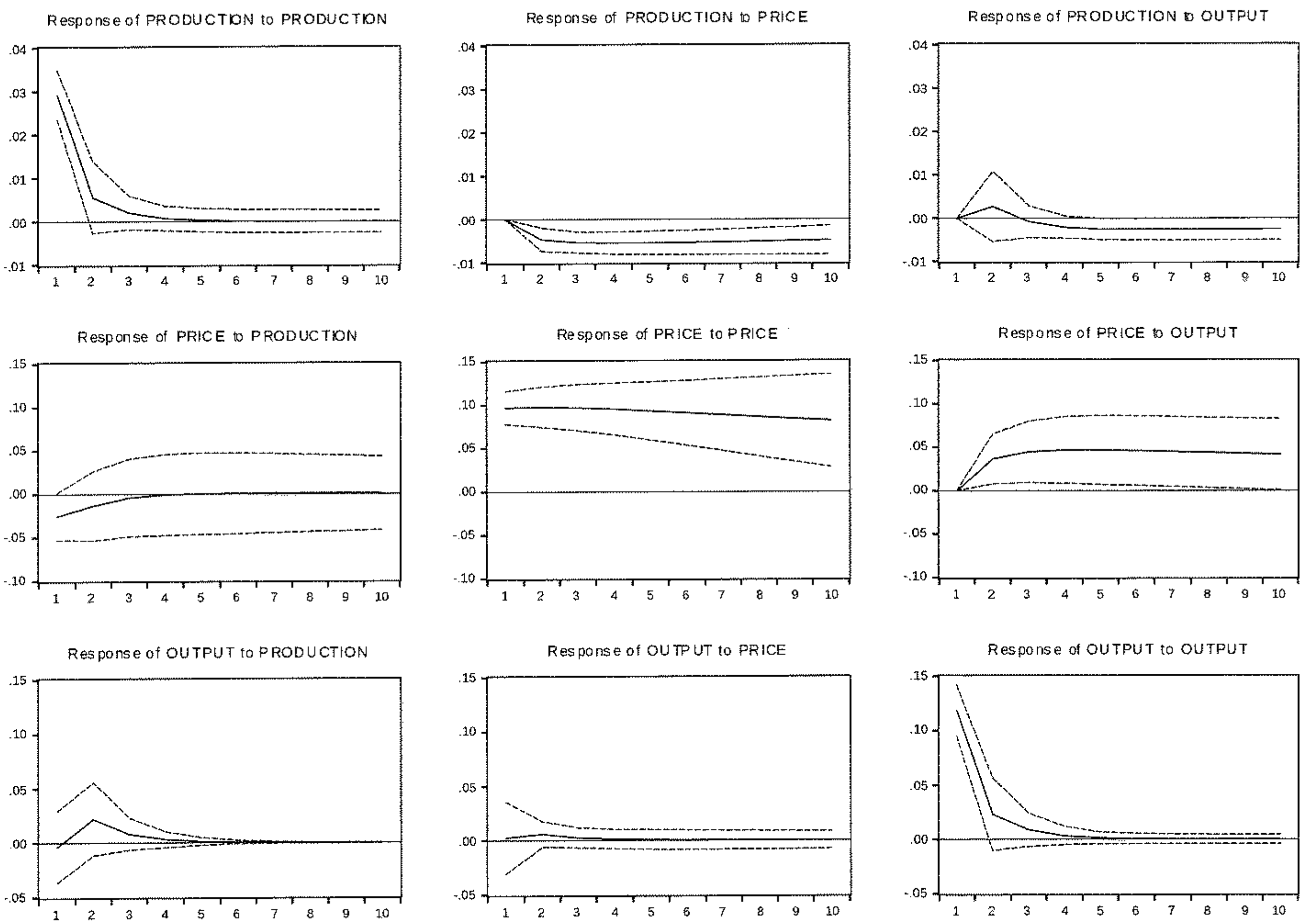
Response to Cholesky One S.D. Innovations – 2 S.E. (BENIN)



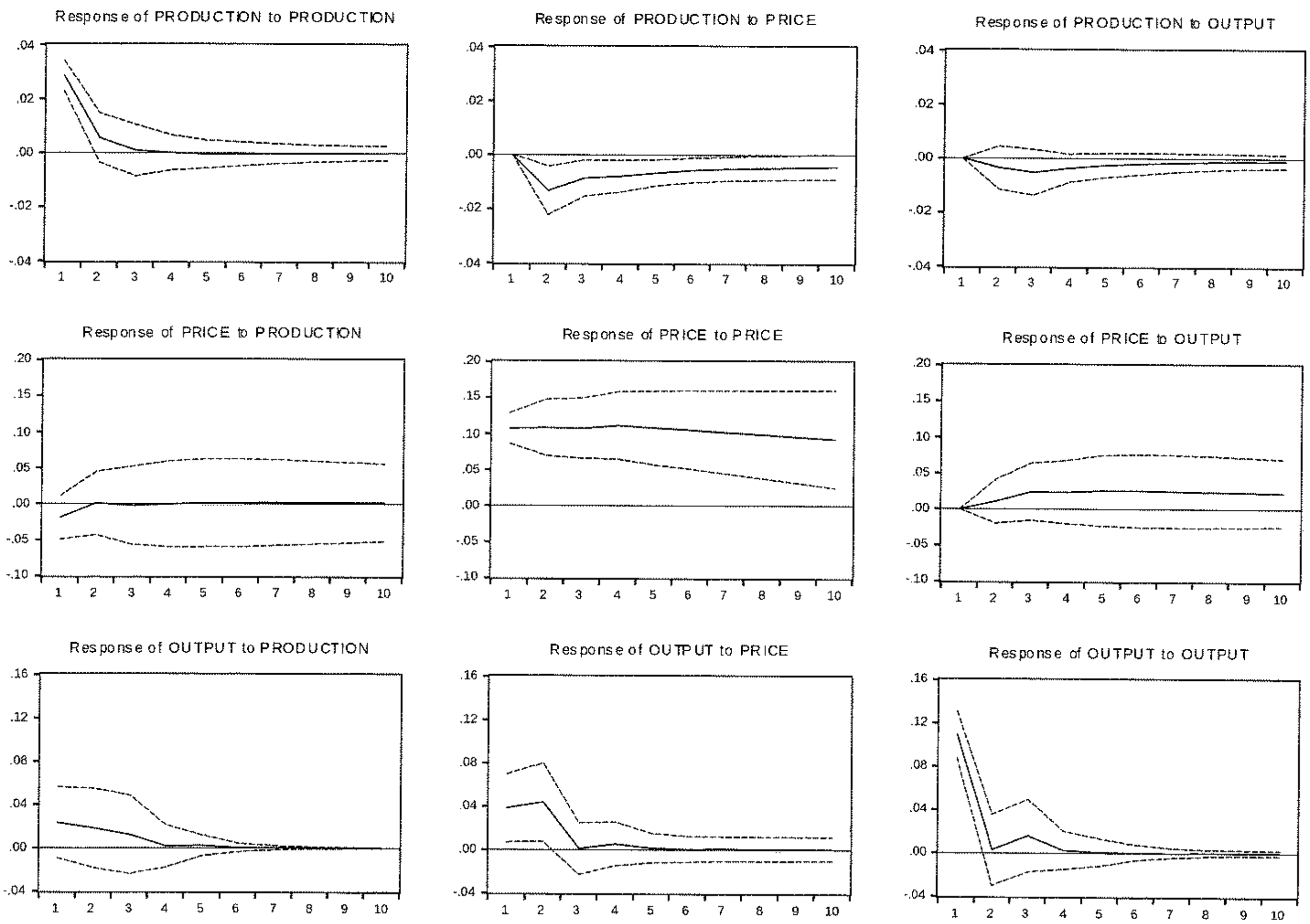
Response to Cholesky One S.D. Innovations – 2 S.E. (BOTSWANA)

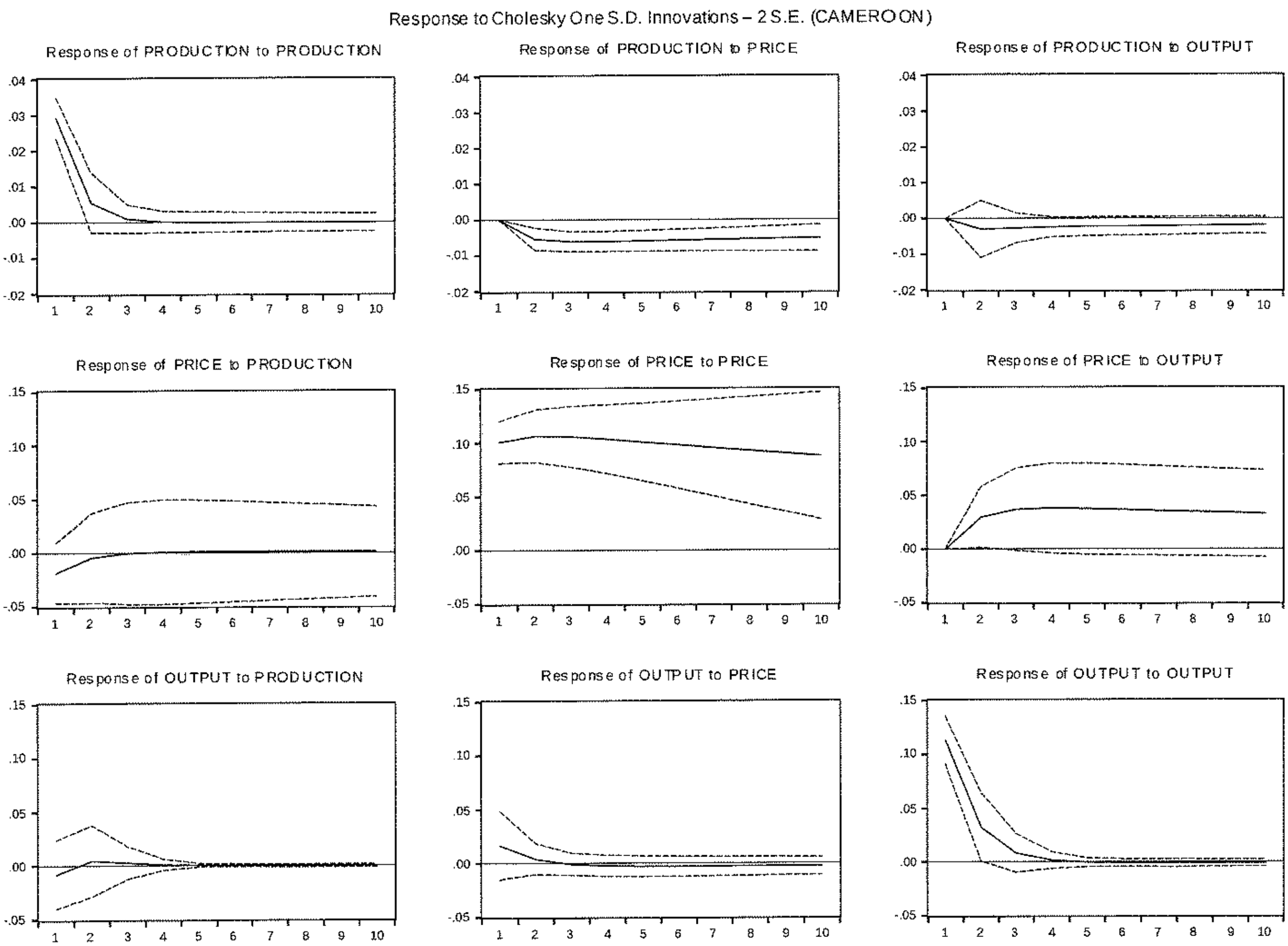


Response to Cholesky One S.D. Innovations – 2 S.E. (BURKINA FASO)



Response to Cholesky One S.D. Innovations – 2 S.E. (BURUNDI)




Response to Cholesky One S.D. Innovations – 2 S.E. (CAMEROON)
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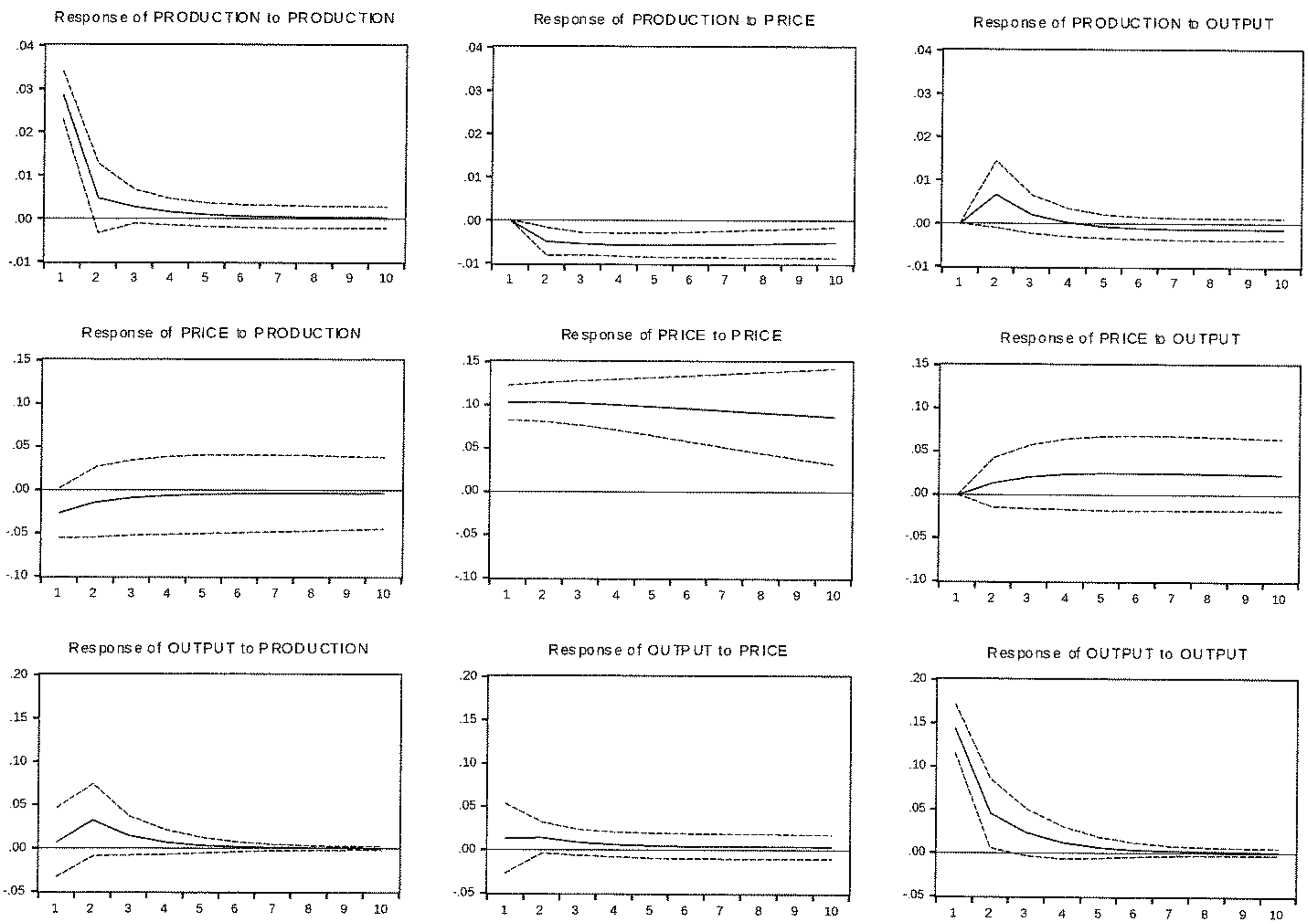
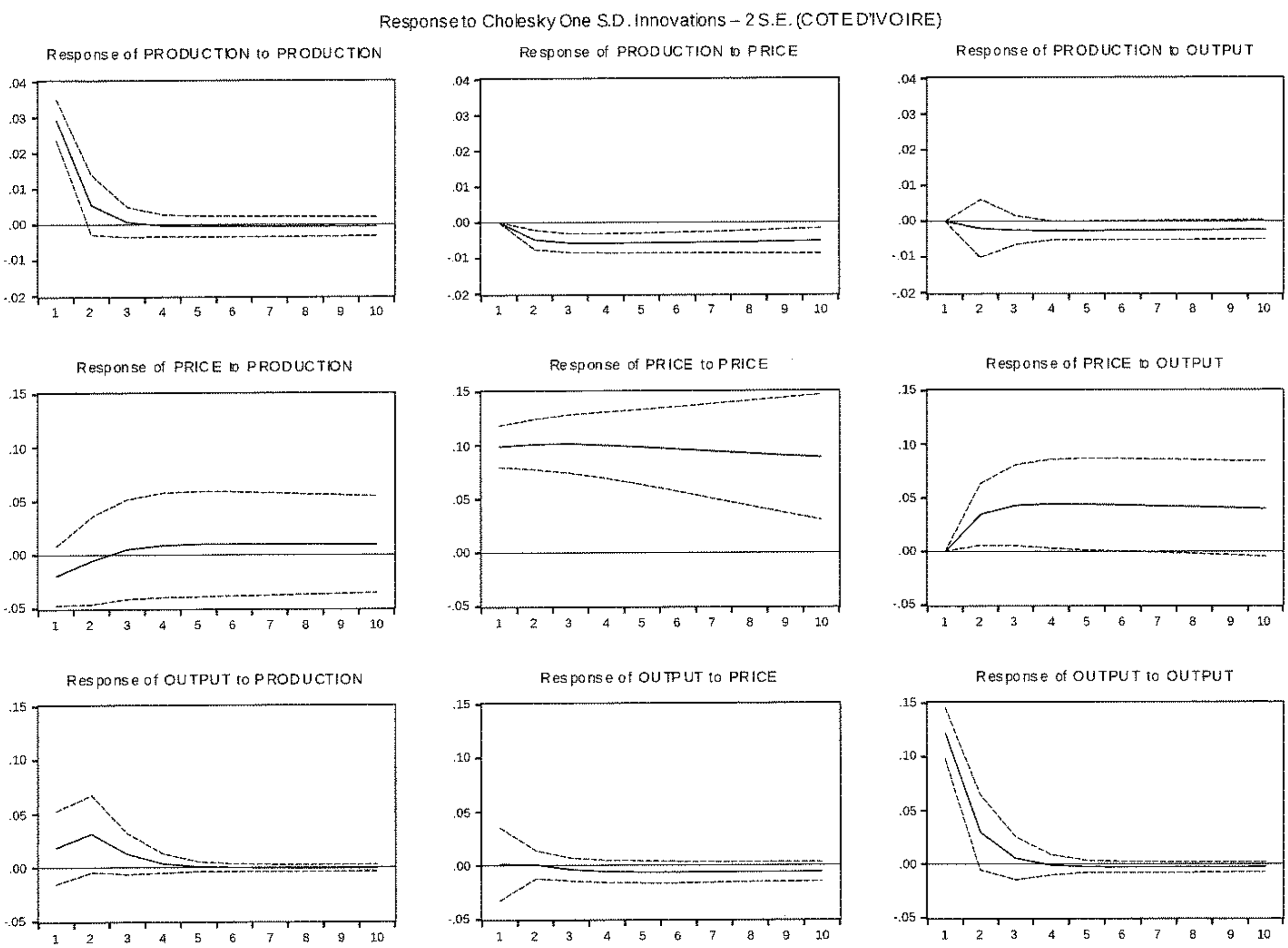
Response to Cholesky One S.D. Innovations – 2 S.E. (CHAD)




Response to Cholesky One S.D. Innovations – 2 S.E. (COTE D'IVOIRE)
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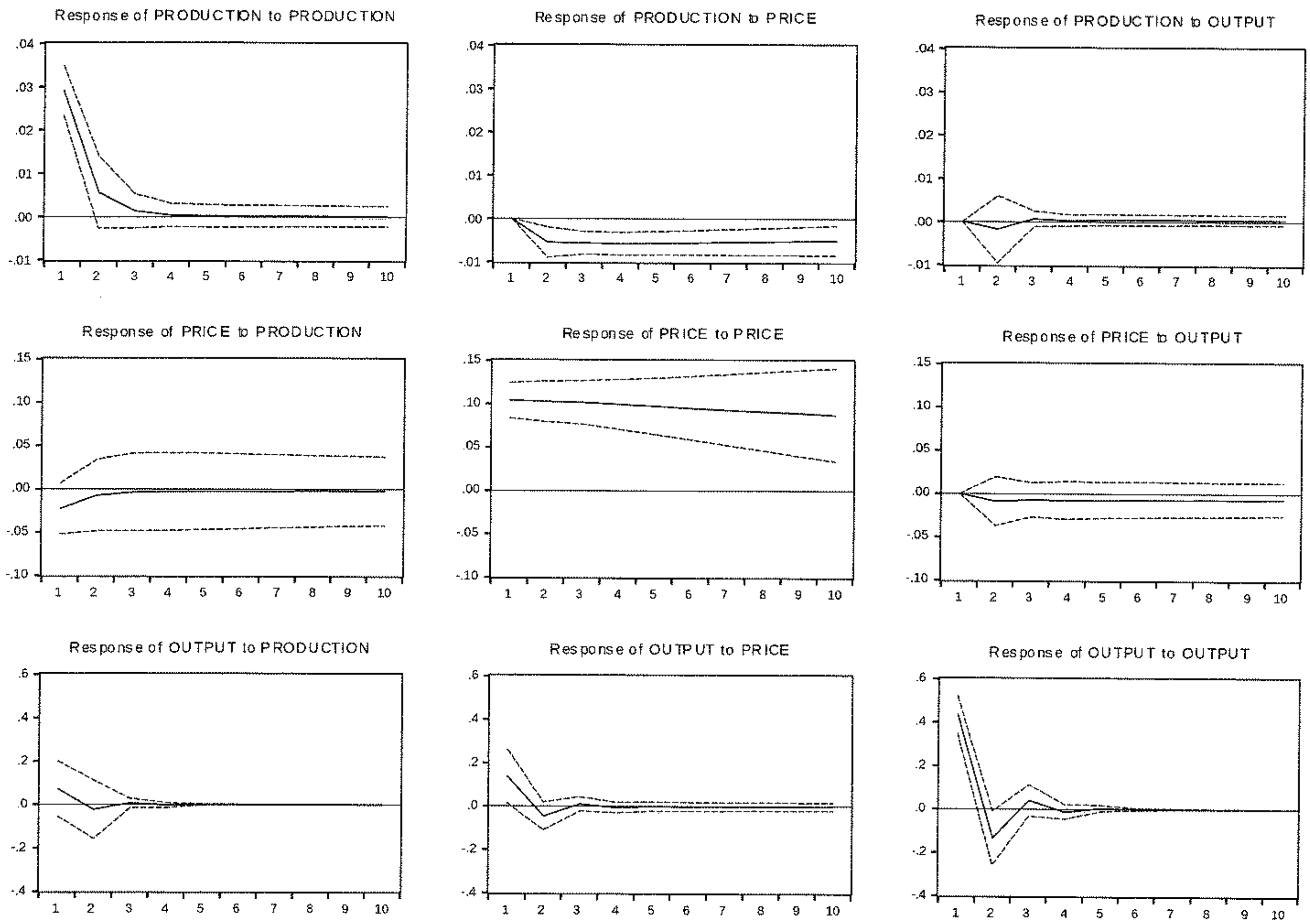
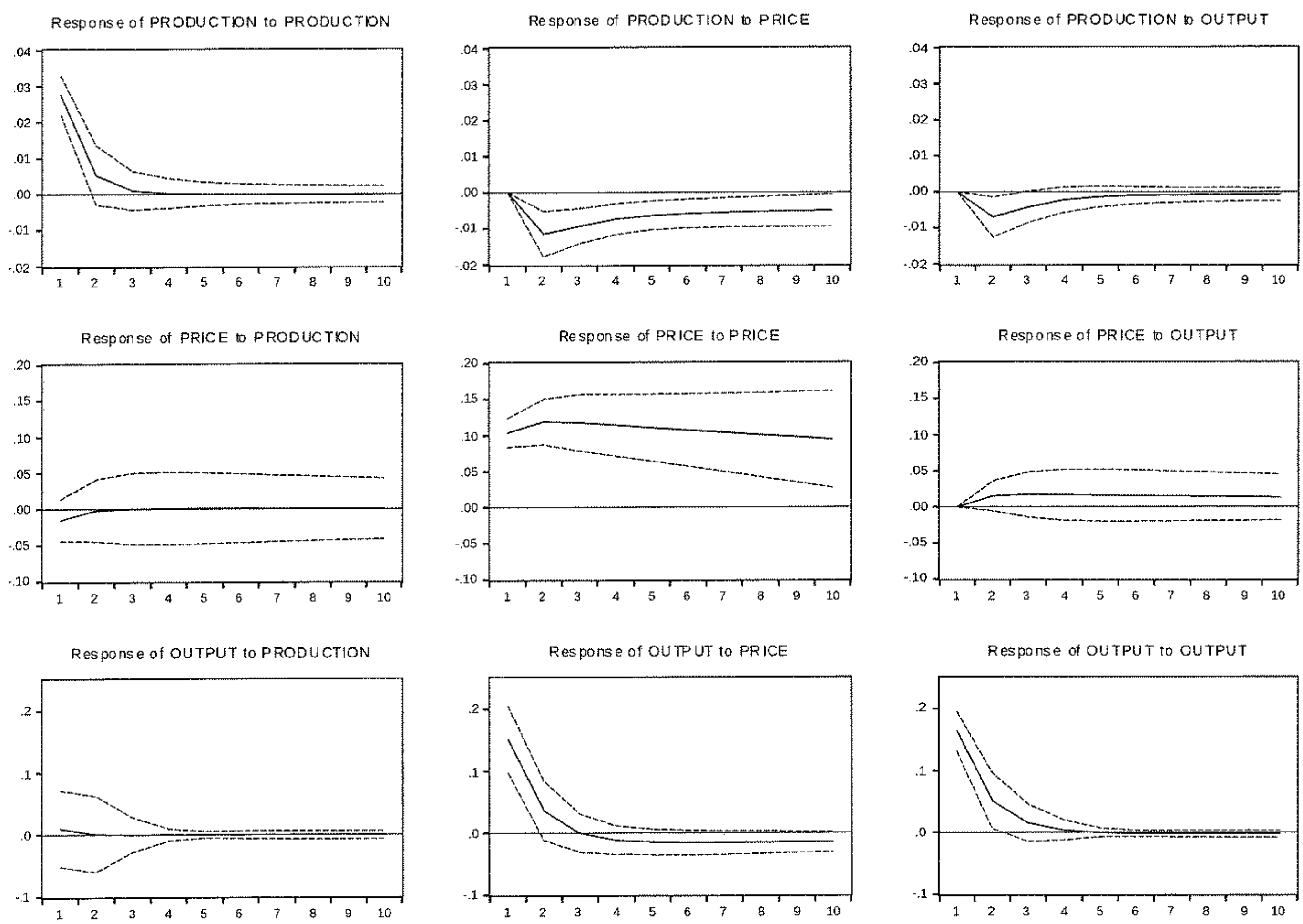
1 2 3 4 5 6 7 8 9 10

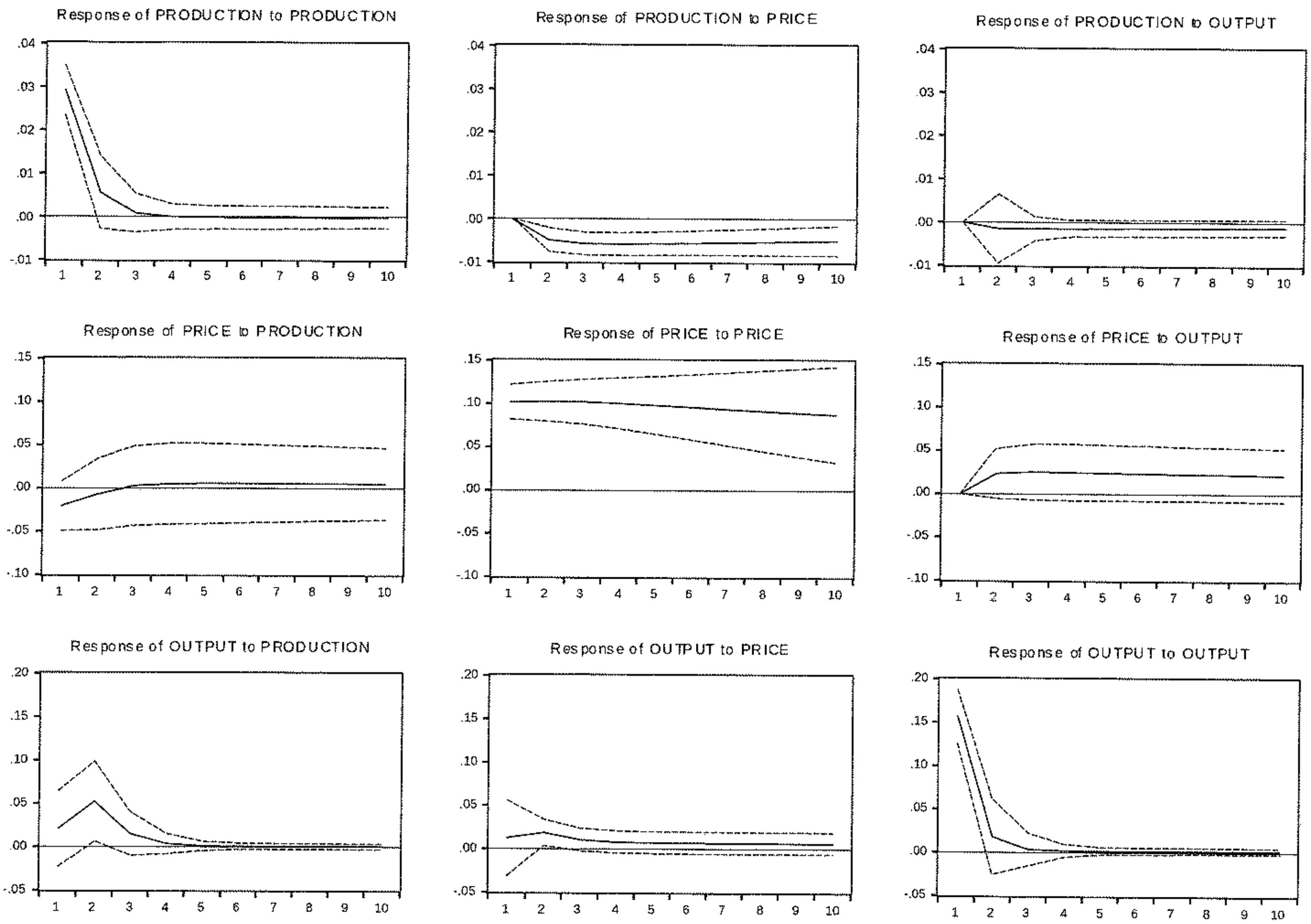
Response to Cholesky One S.D. Innovations – 2 S.E. (DEMOCRATIC REPUBLIC OF CONGO)



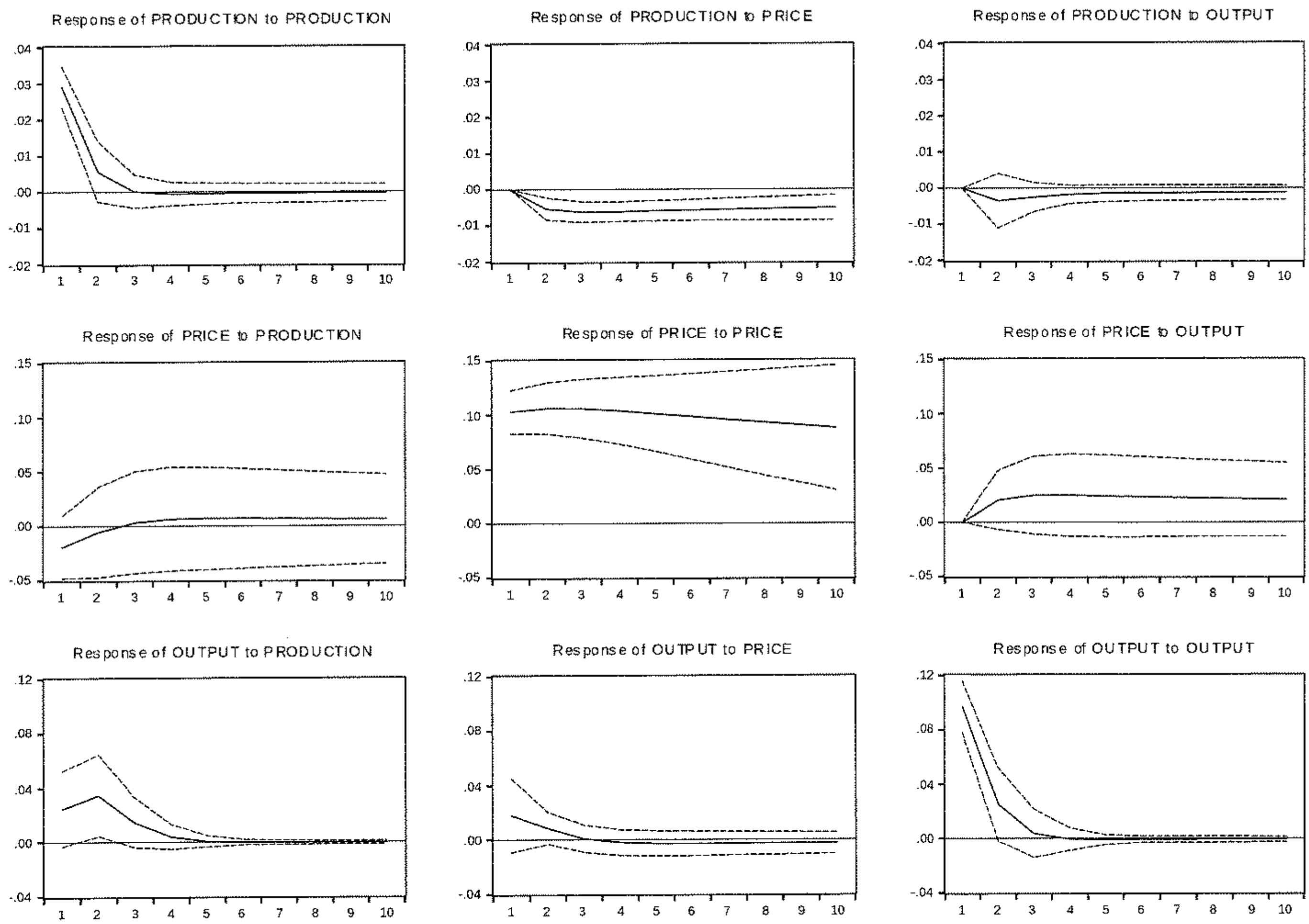
Response to Cholesky One S.D. Innovations – 2 S.E. (GABON)



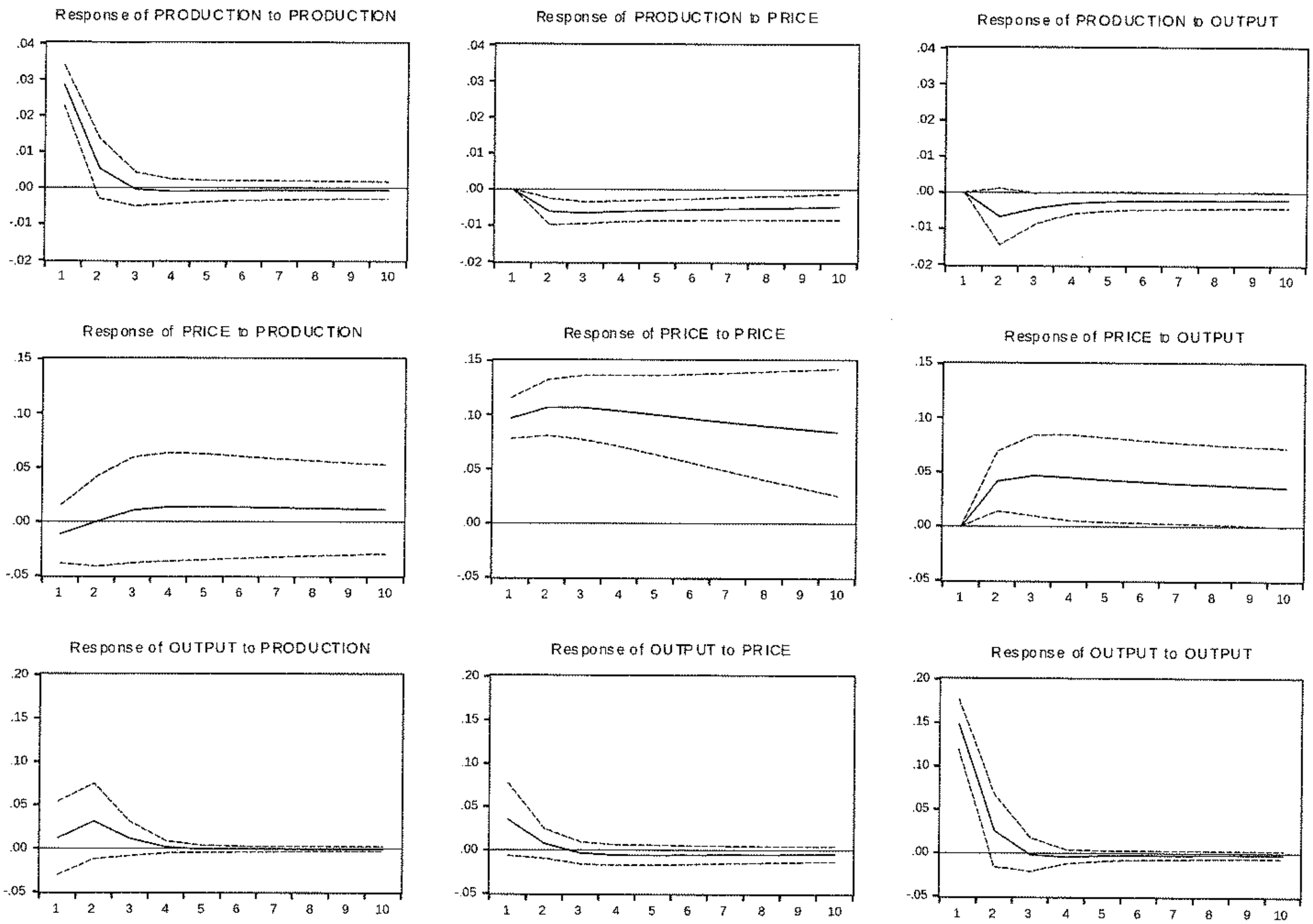
Response to Cholesky One S.D. Innovations – 2 S.E. (GHANA)



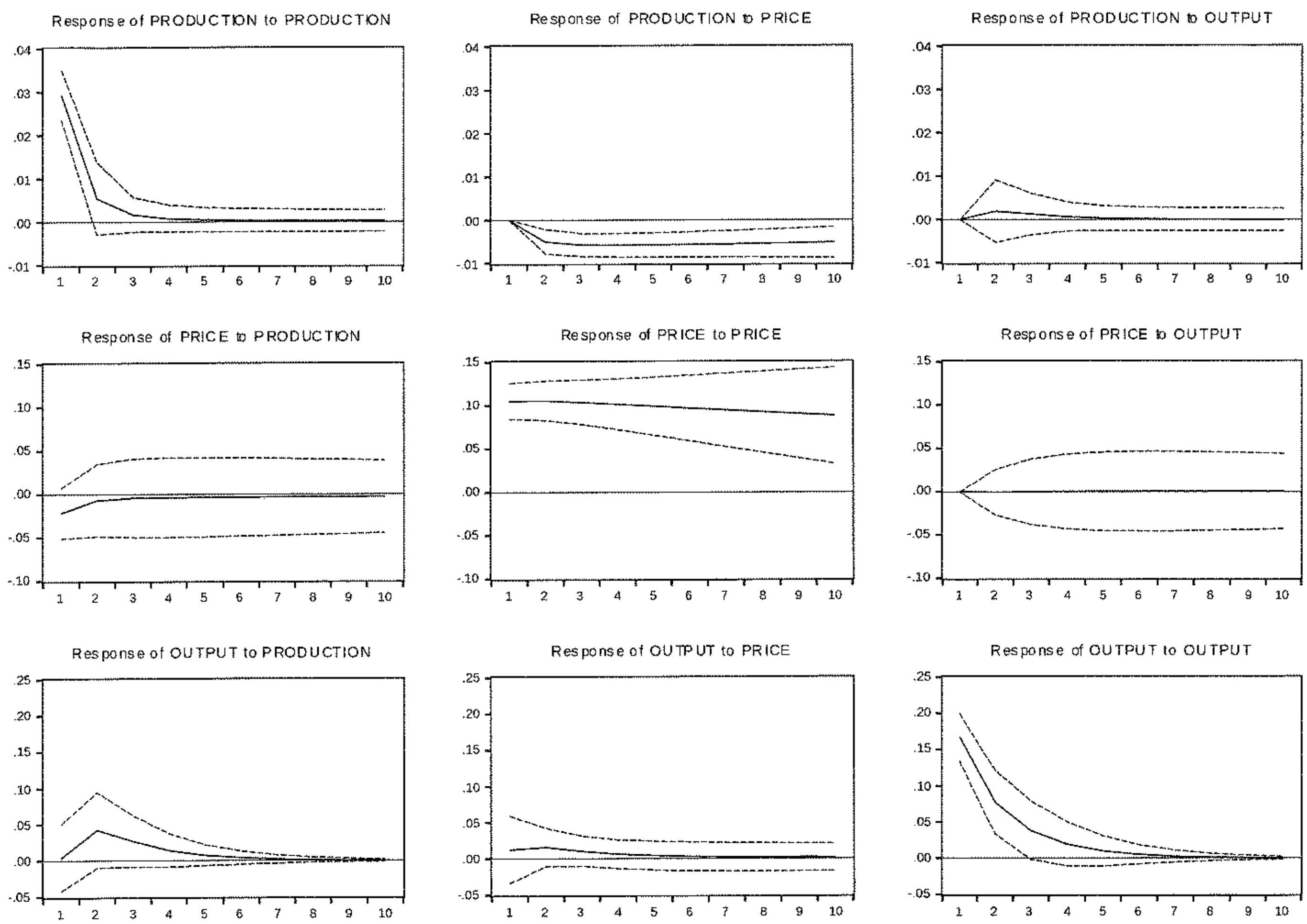
Response to Cholesky One S.D. Innovations – 2 S.E. (KENYA)



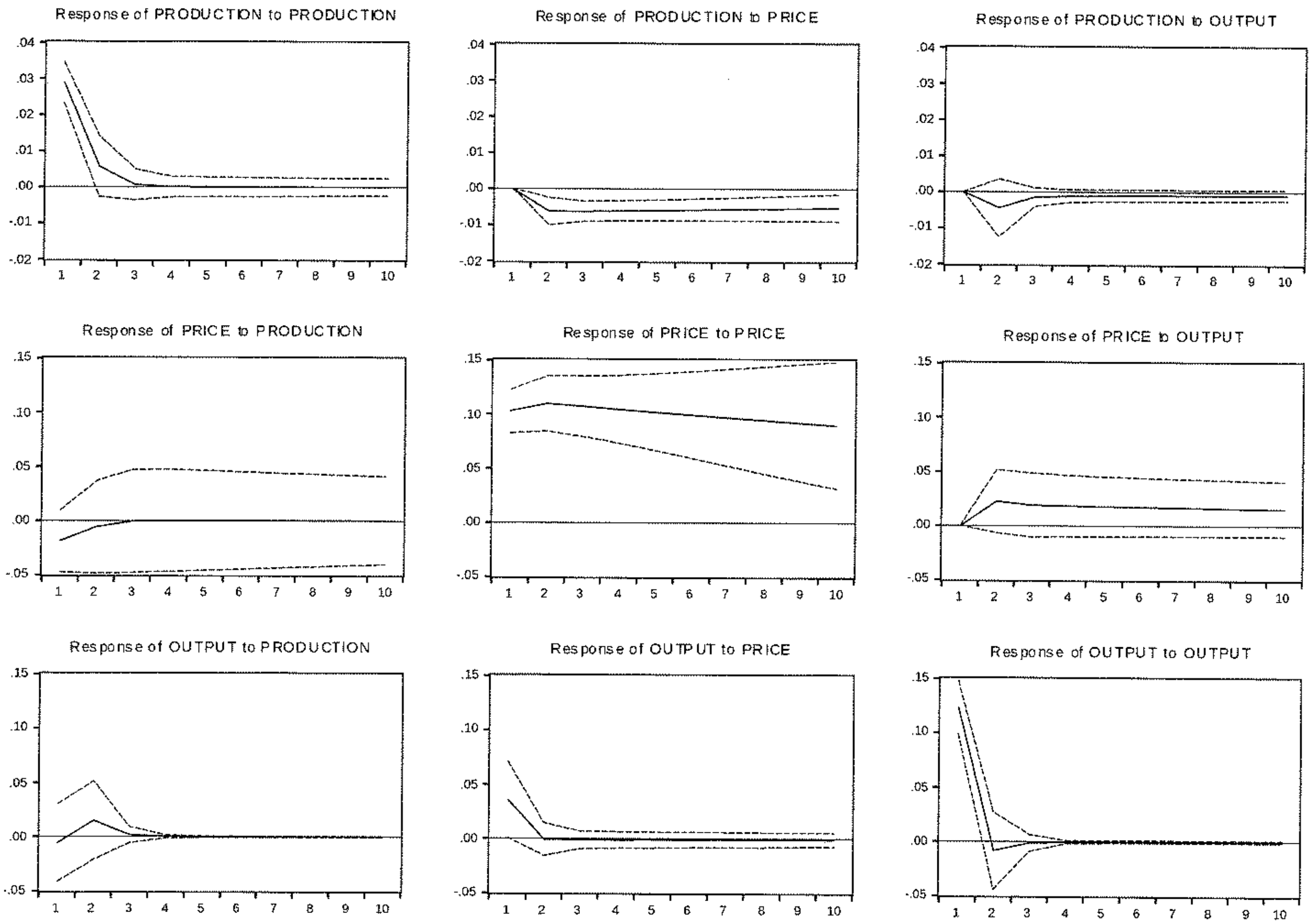
Response to Cholesky One S.D. Innovations – 2 S.E. (LESOTHO)



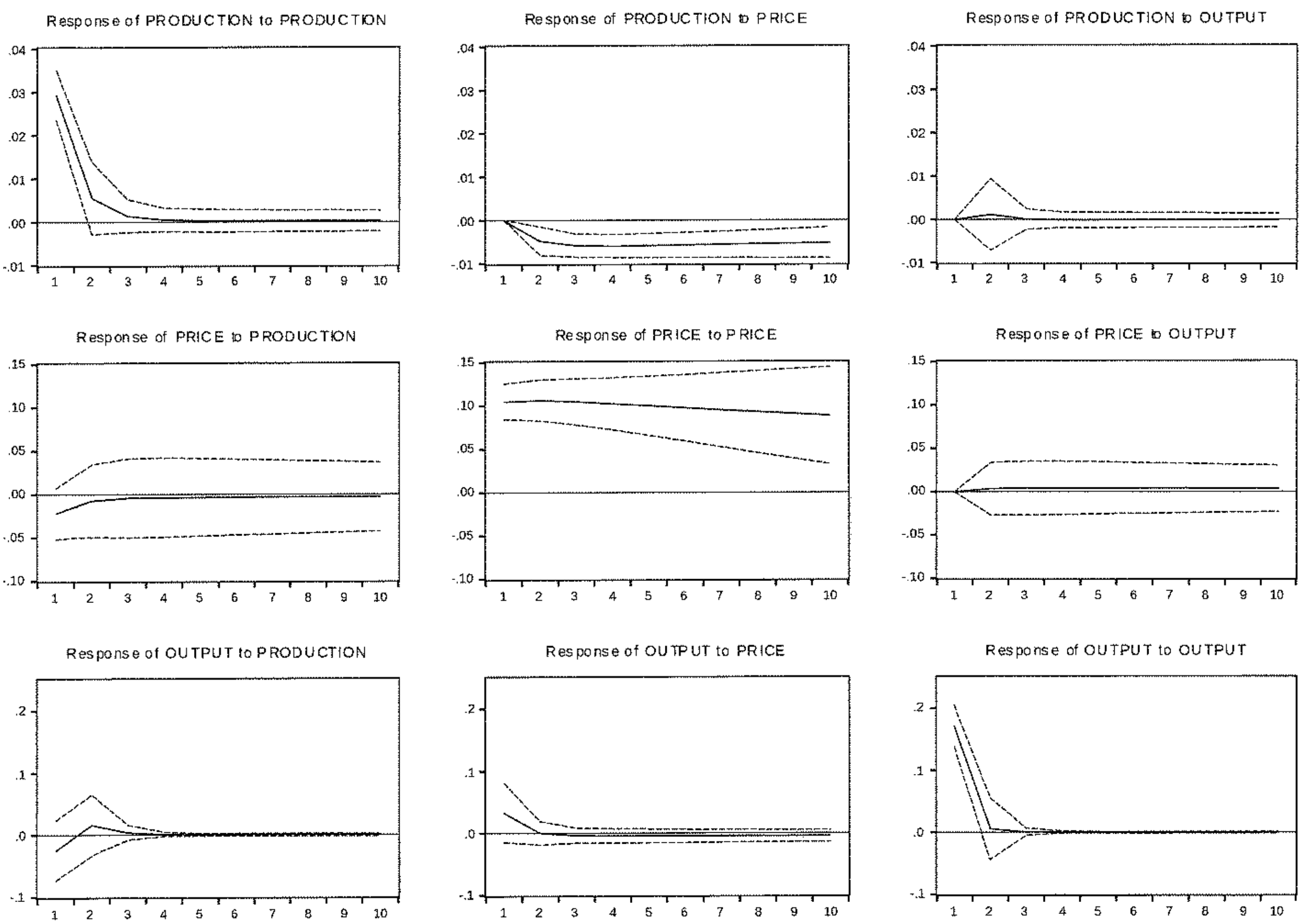
Response to Cholesky One S.D. Innovations – 2 S.E. (LIBERIA)



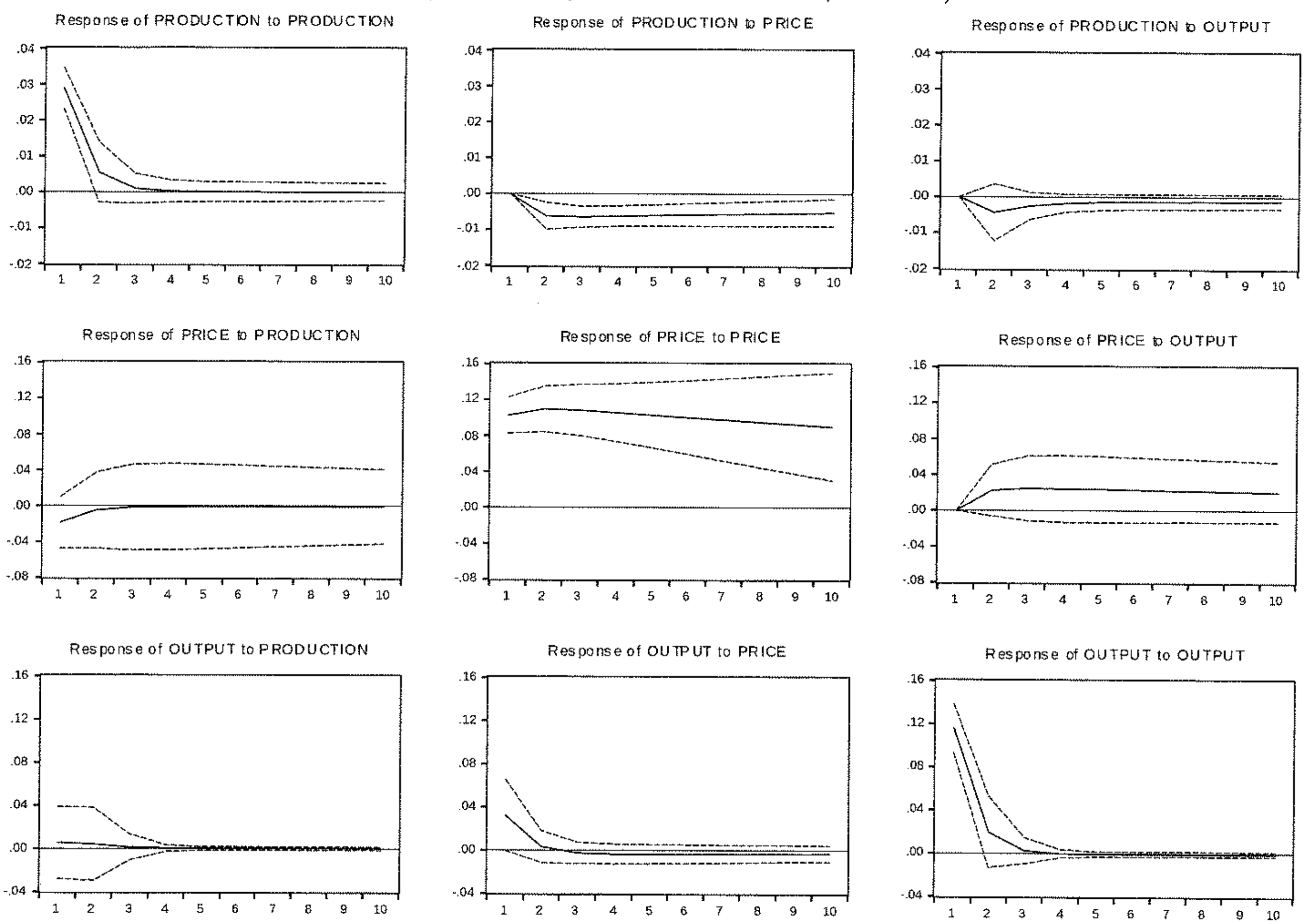
Response to Cholesky One S.D. Innovations – 2 S.E. (MADAGASCAR)



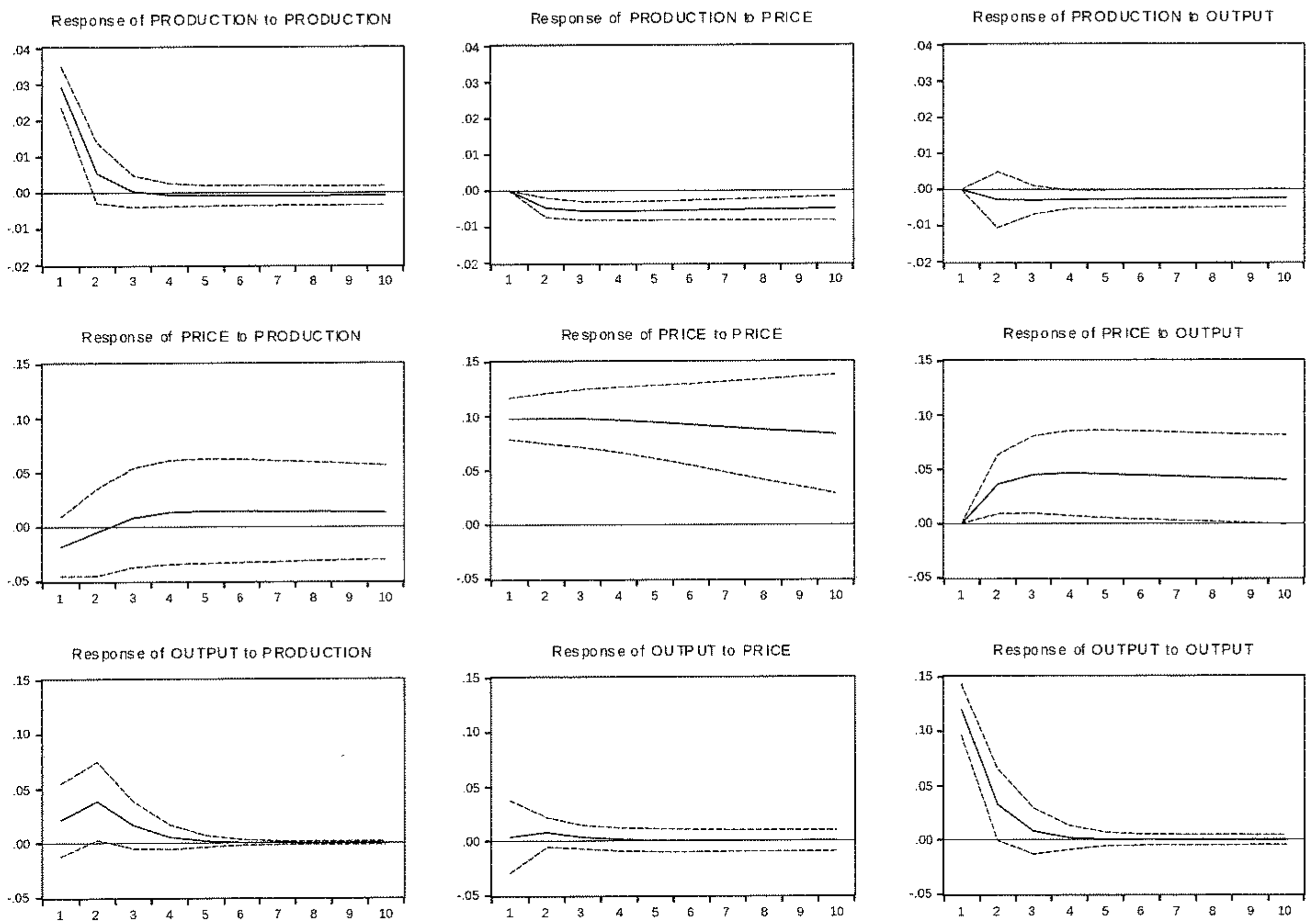
Response to Cholesky One S.D. Innovations – 2 S.E. (MALAWI)



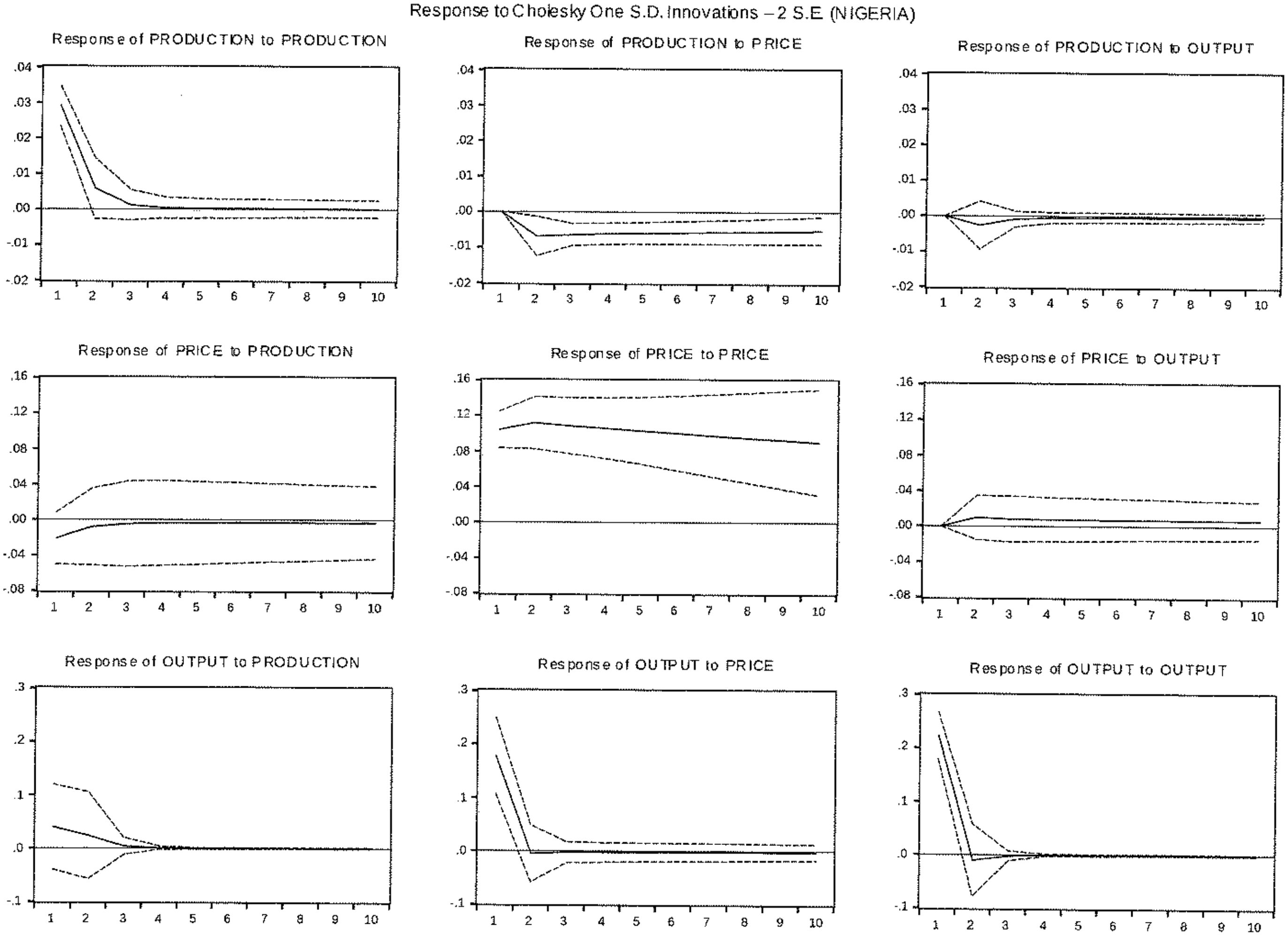
Response to Cholesky One S.D. Innovations – 2 S.E. (MAURITANIA)



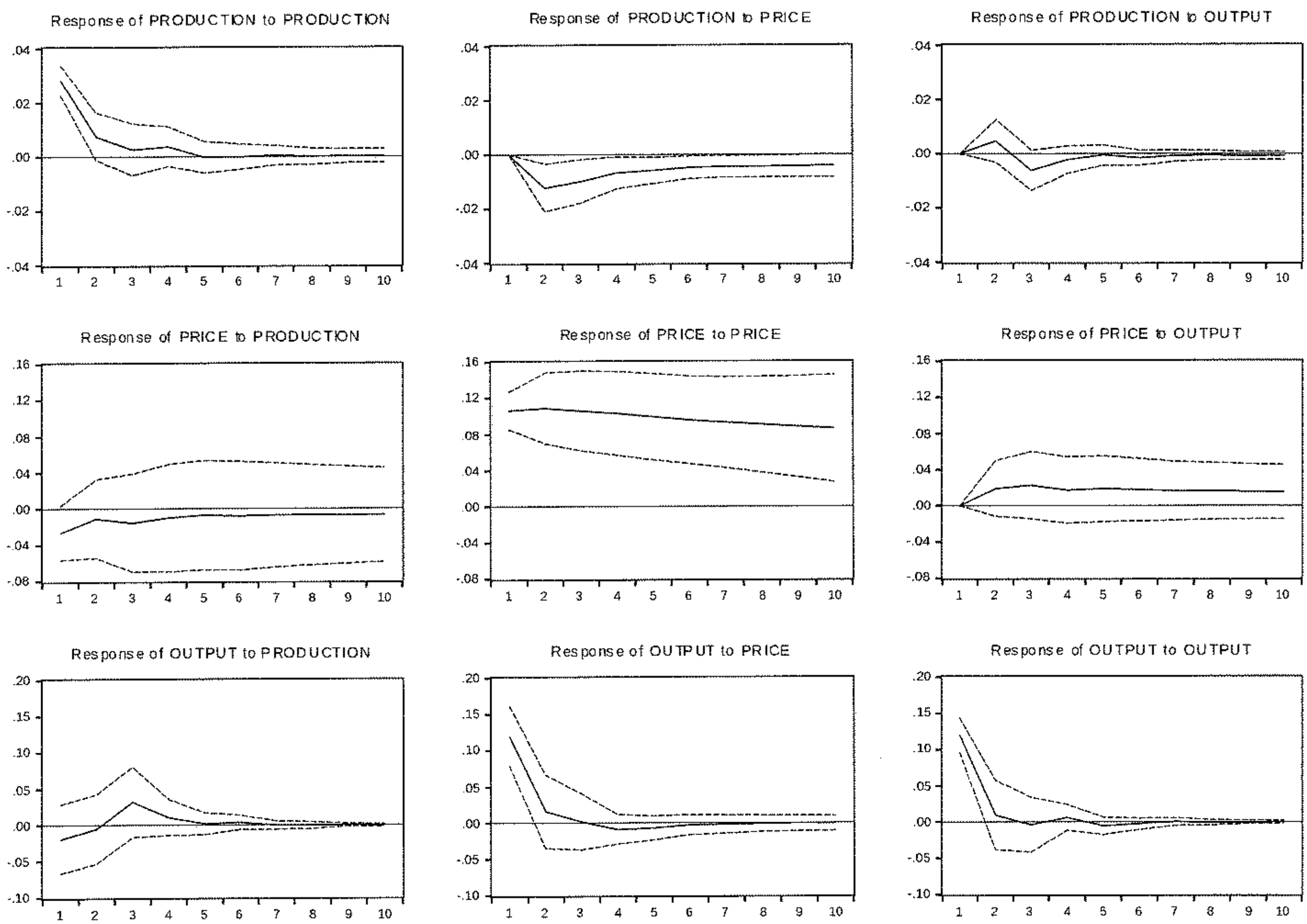
Response to Cholesky One S.D. Innovations – 2 S.E. (NIGER)



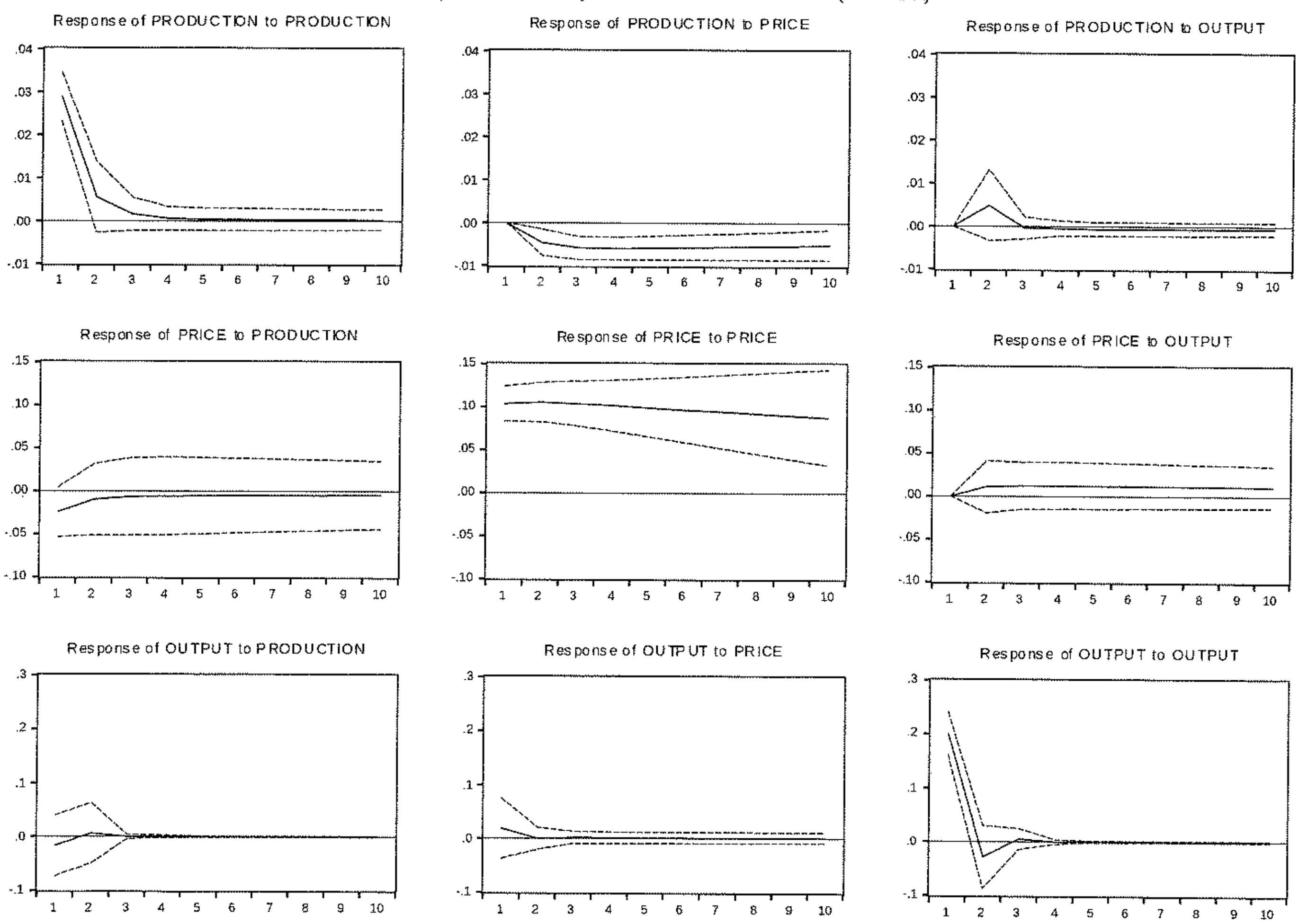
Response to Cholesky One S.D. Innovations – 2 S.E (NIGERIA)



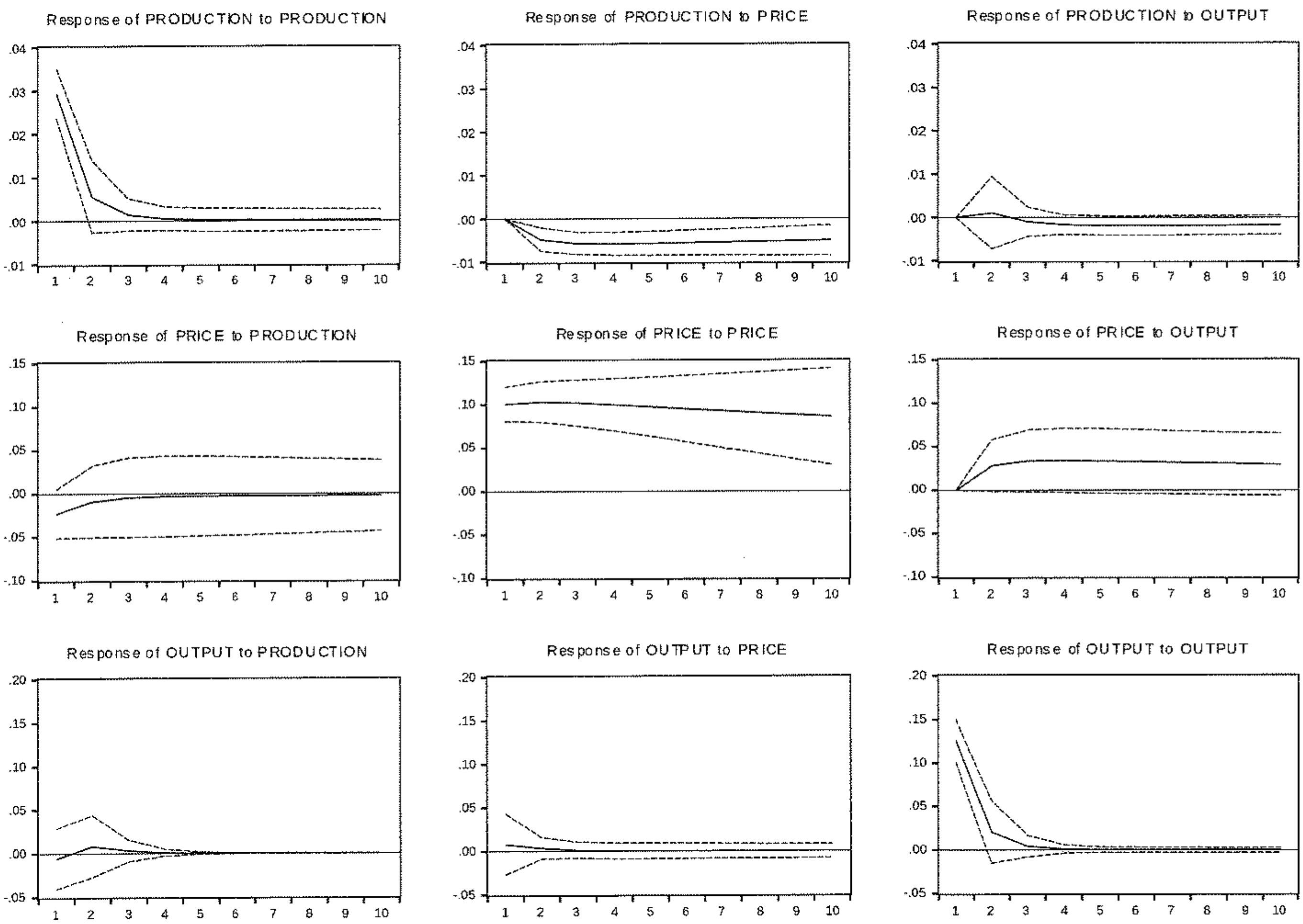
Response to Cholesky One S.D. Innovations ± 2 S.E. (REPUBLIC OF CONGO)



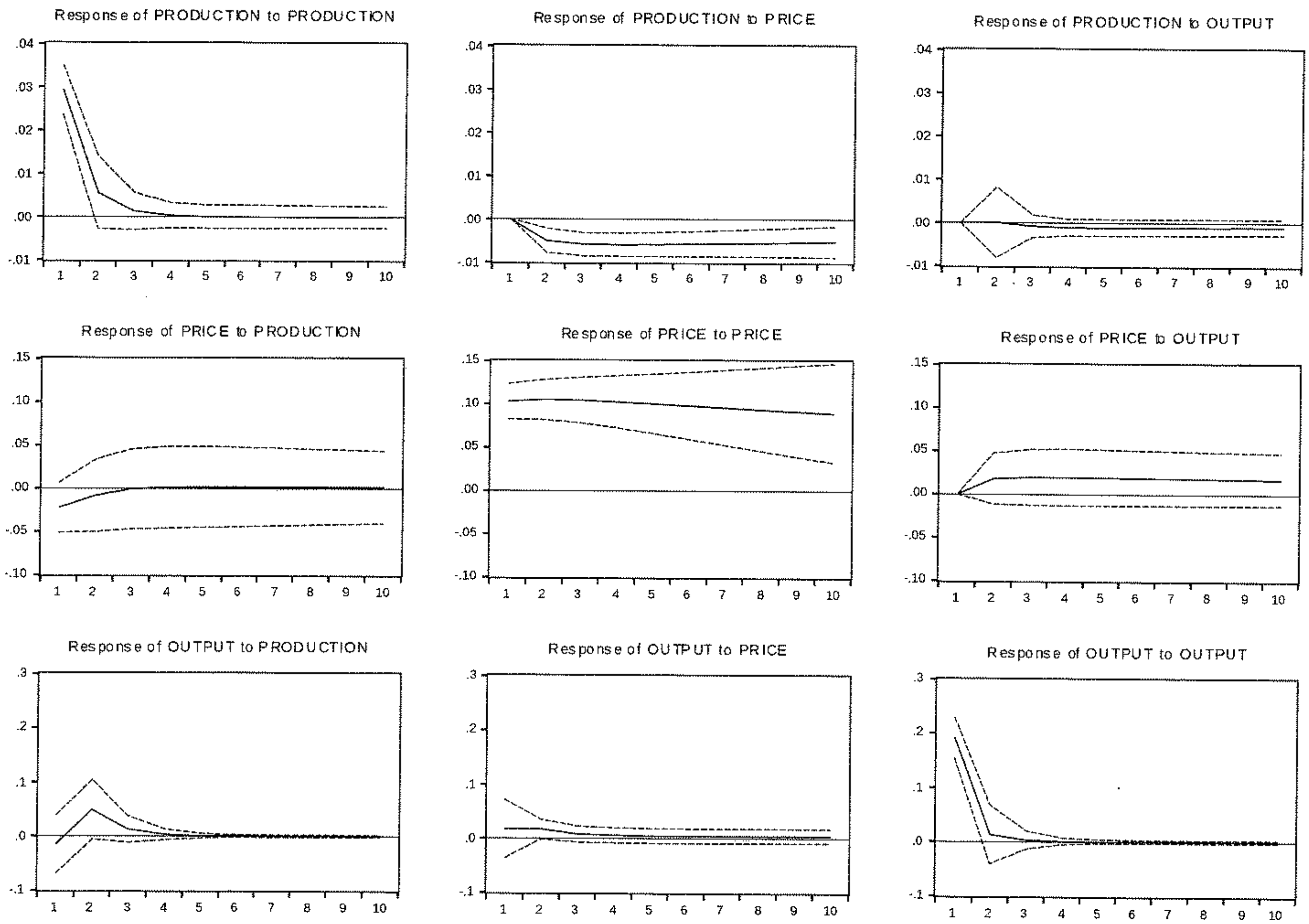
Response to Cholesky One S.D. Innovations – 2 S.E. (RWANDA)



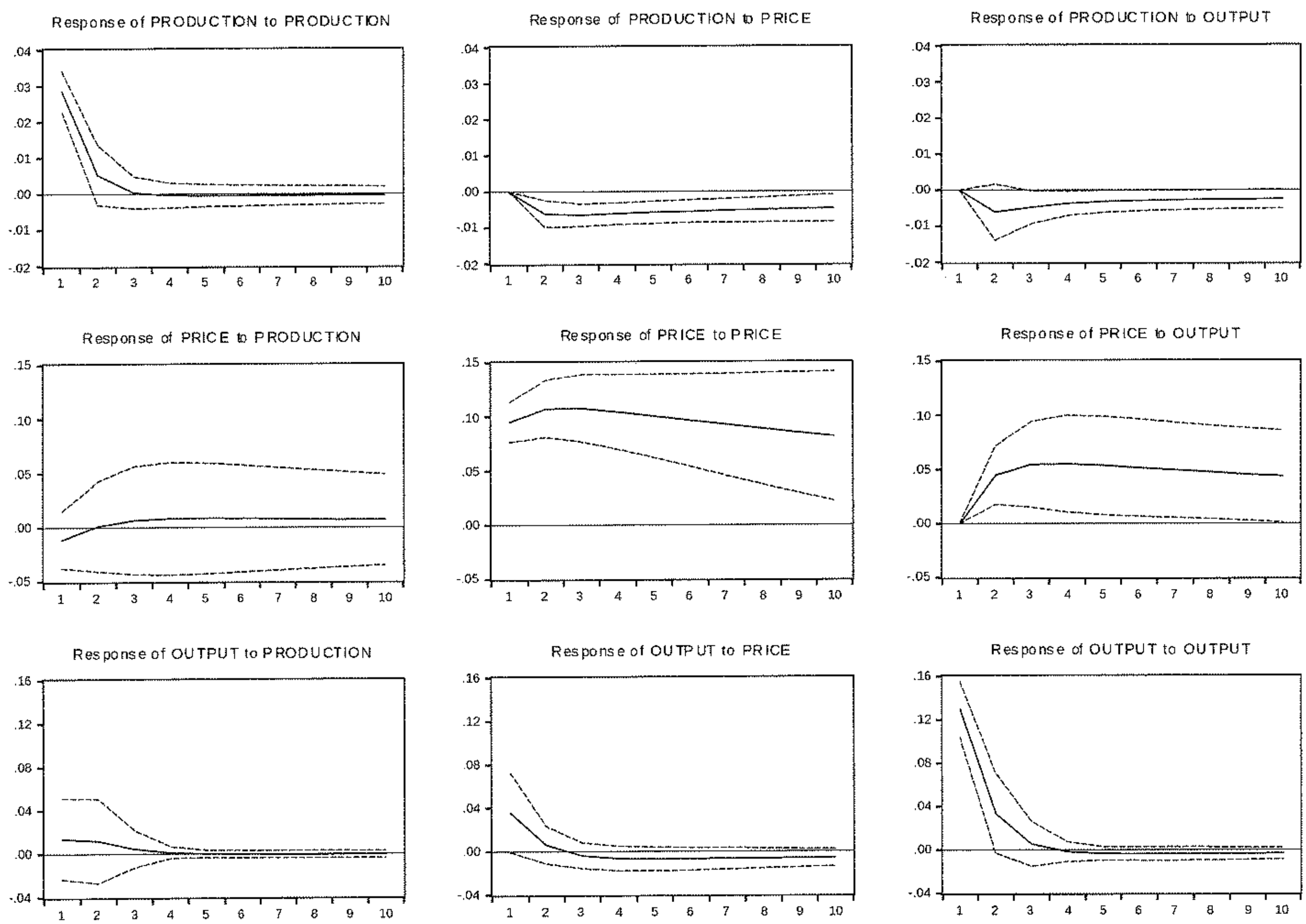
Response to Cholesky One S.D. Innovations – 2 S.E. (SENEGAL)

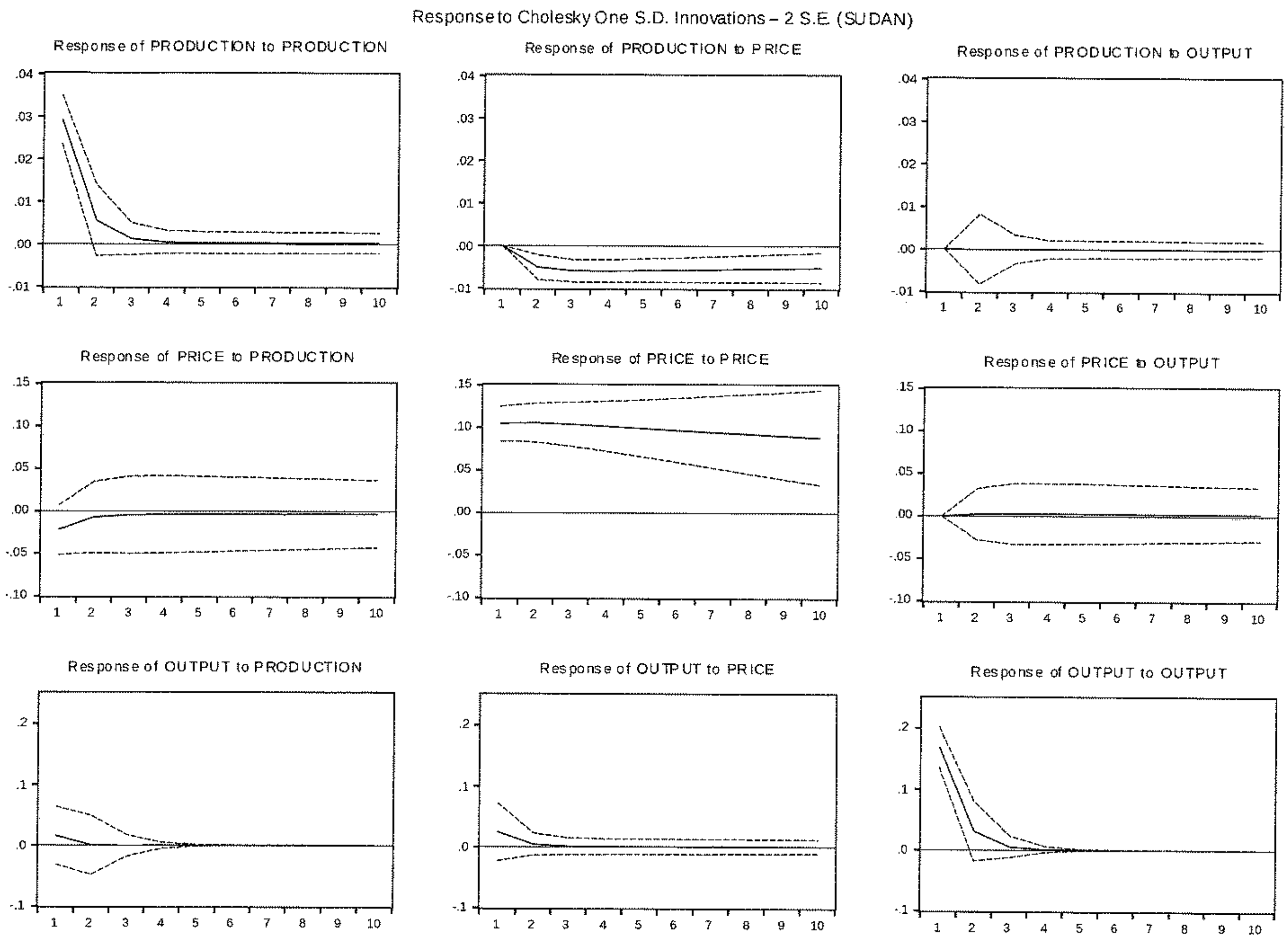


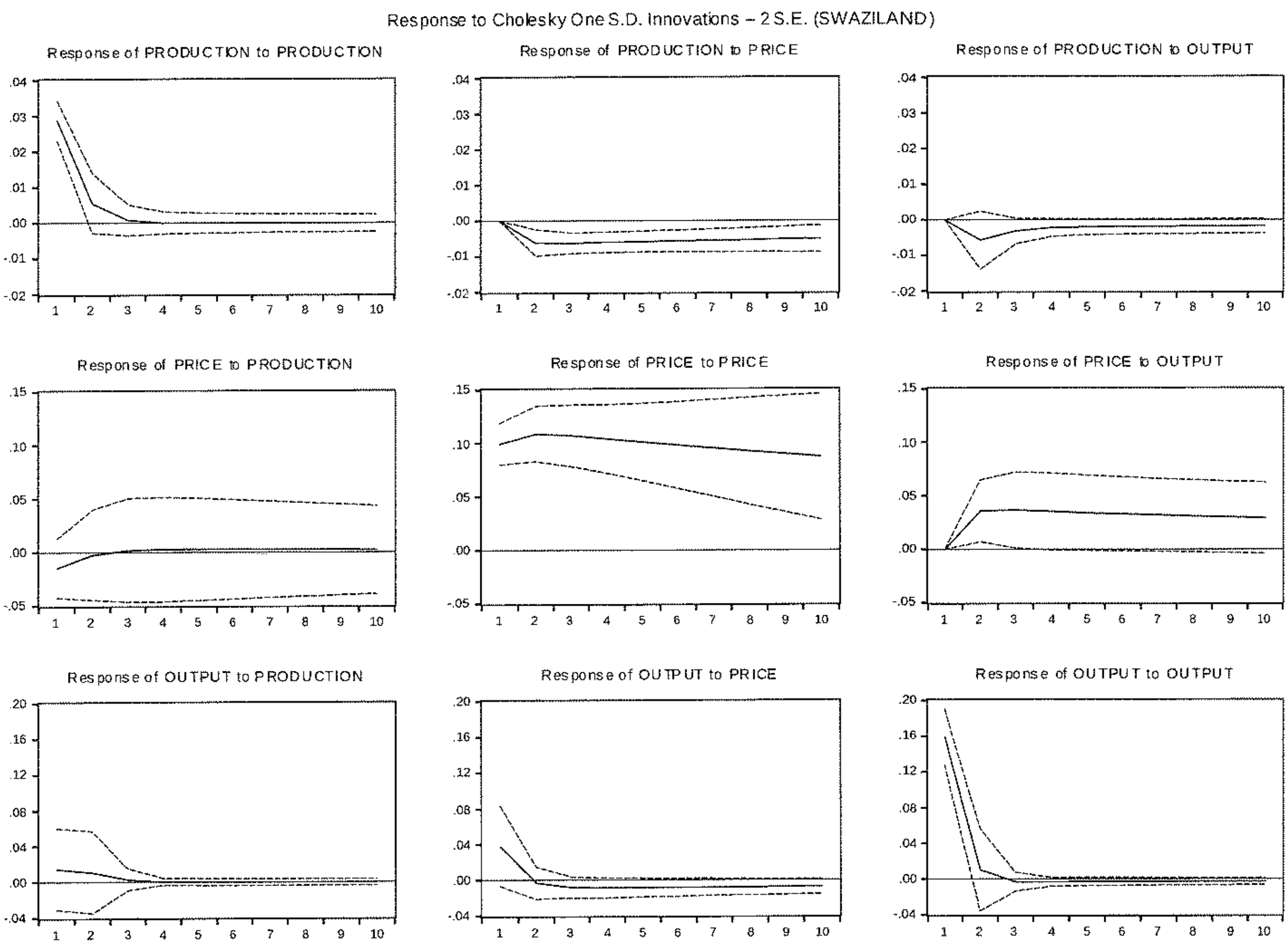
Response to Cholesky One S.D. Innovations – 2 S.E. (SIERRA LEONE)



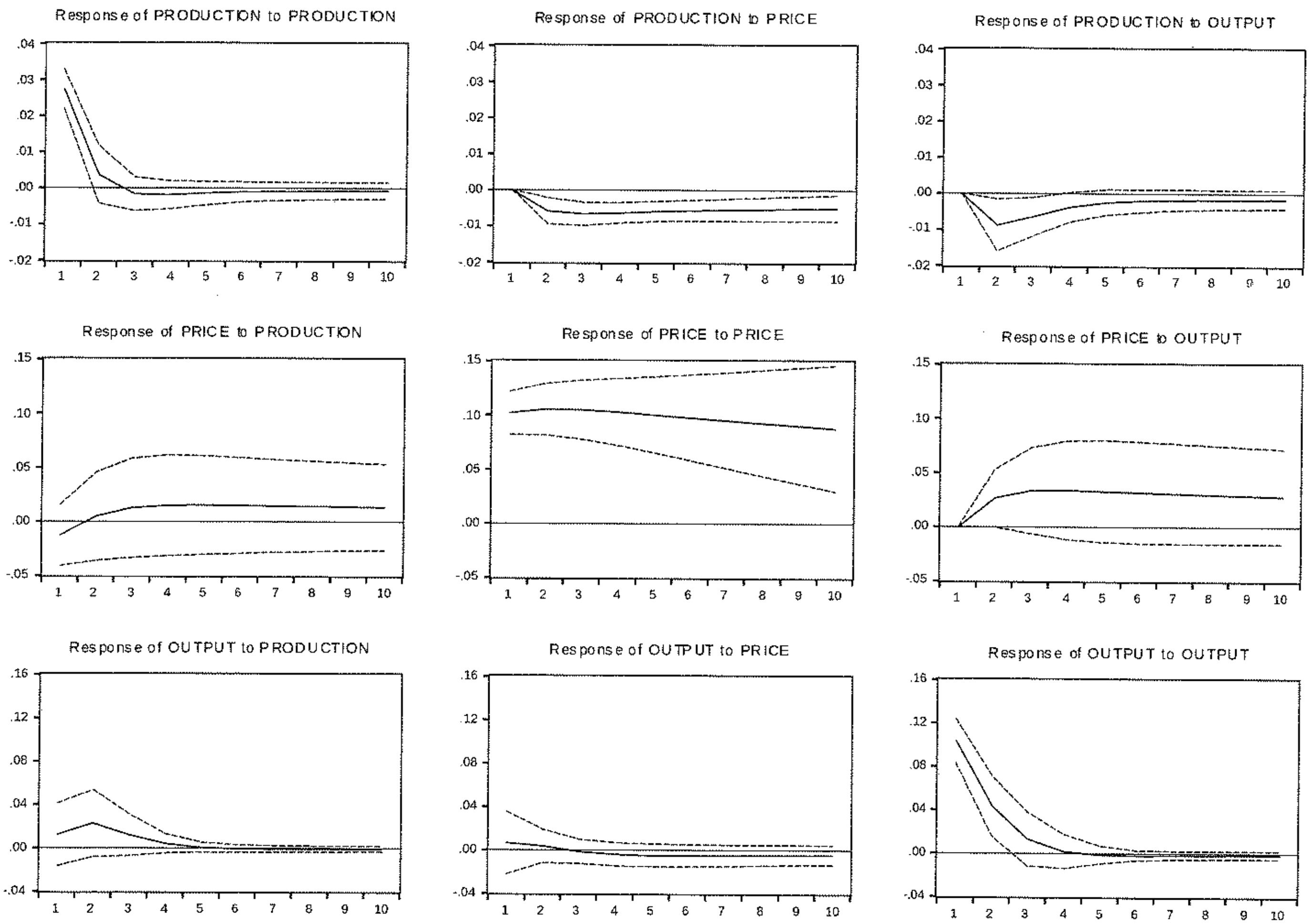
Response to Cholesky One S.D. Innovations – 2 S.E. (SOUTH AFRICA)



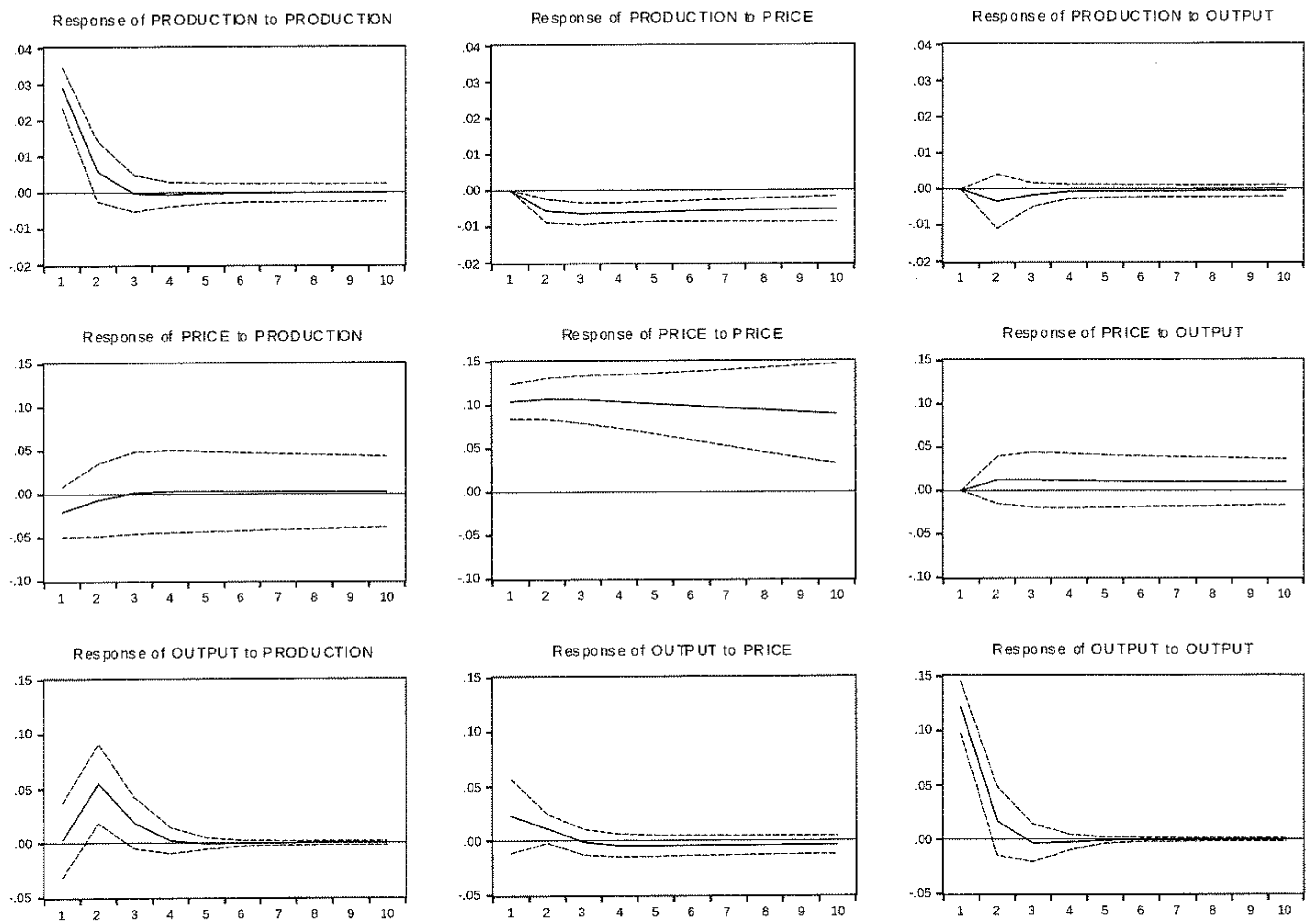

Response to Cholesky One S.D. Innovations – 2 S.E. (SUDAN)
Response of PRODUCTION to PRODUCTION
Response of PRODUCTION to PRICE
Response of PRODUCTION to OUTPUT
Response of PRICE to PRODUCTION
Response of PRICE to PRICE
Response of PRICE to OUTPUT
Response of OUTPUT to PRODUCTION
Response of OUTPUT to PRICE
Response of OUTPUT to OUTPUT


Response to Cholesky One S.D. Innovations – 2 S.E. (SWAZILAND)
Response of PRODUCTION to PRODUCTION
Response of PRODUCTION to PRICE
Response of PRODUCTION to OUTPUT
Response of PRICE to PRODUCTION
Response of PRICE to PRICE
Response of PRICE to OUTPUT
Response of OUTPUT to PRODUCTION
Response of OUTPUT to PRICE
Response of OUTPUT to OUTPUT

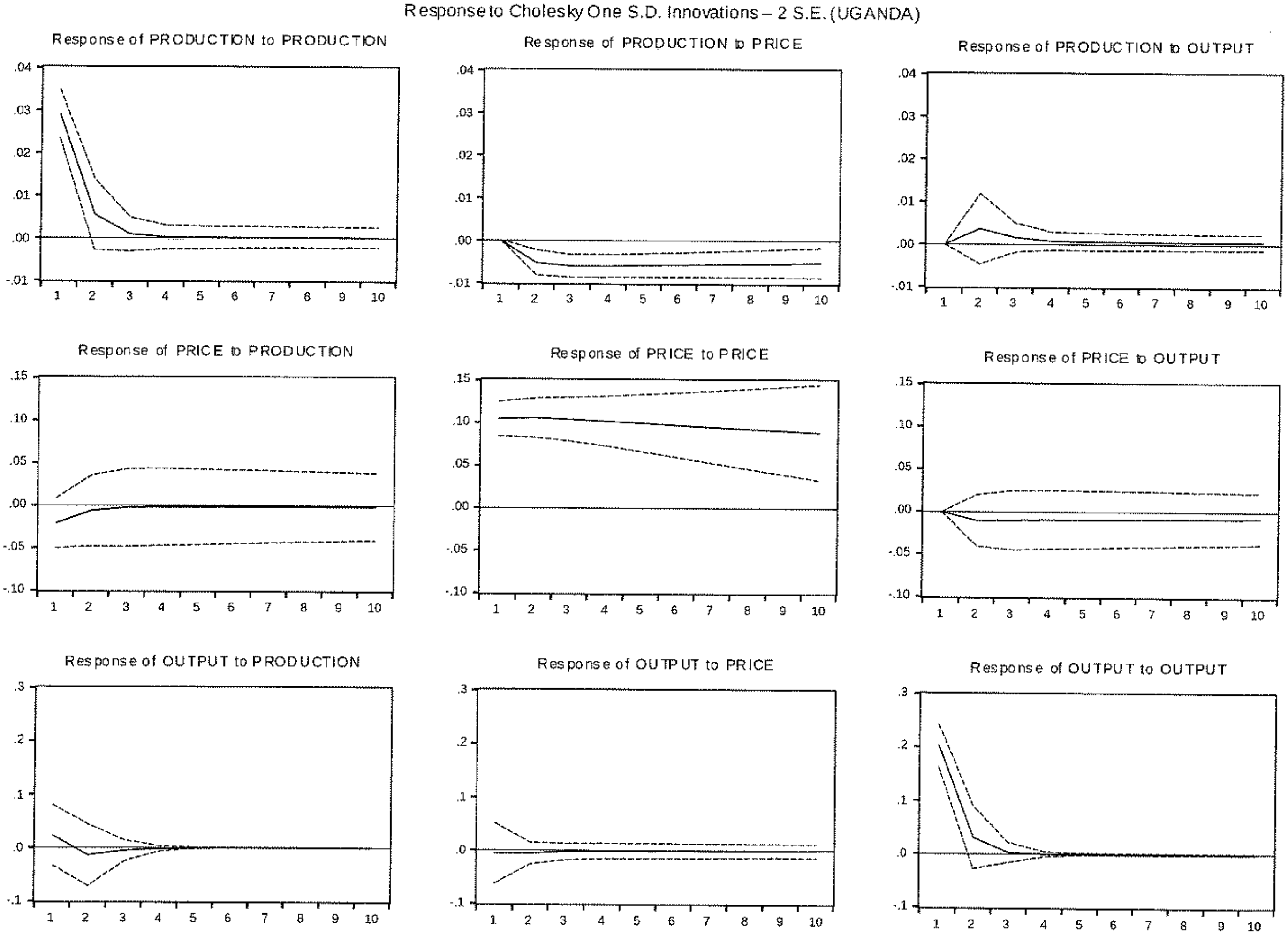
Response to Cholesky One S.D. Innovations – 2 S.E. (SYCHELLES)



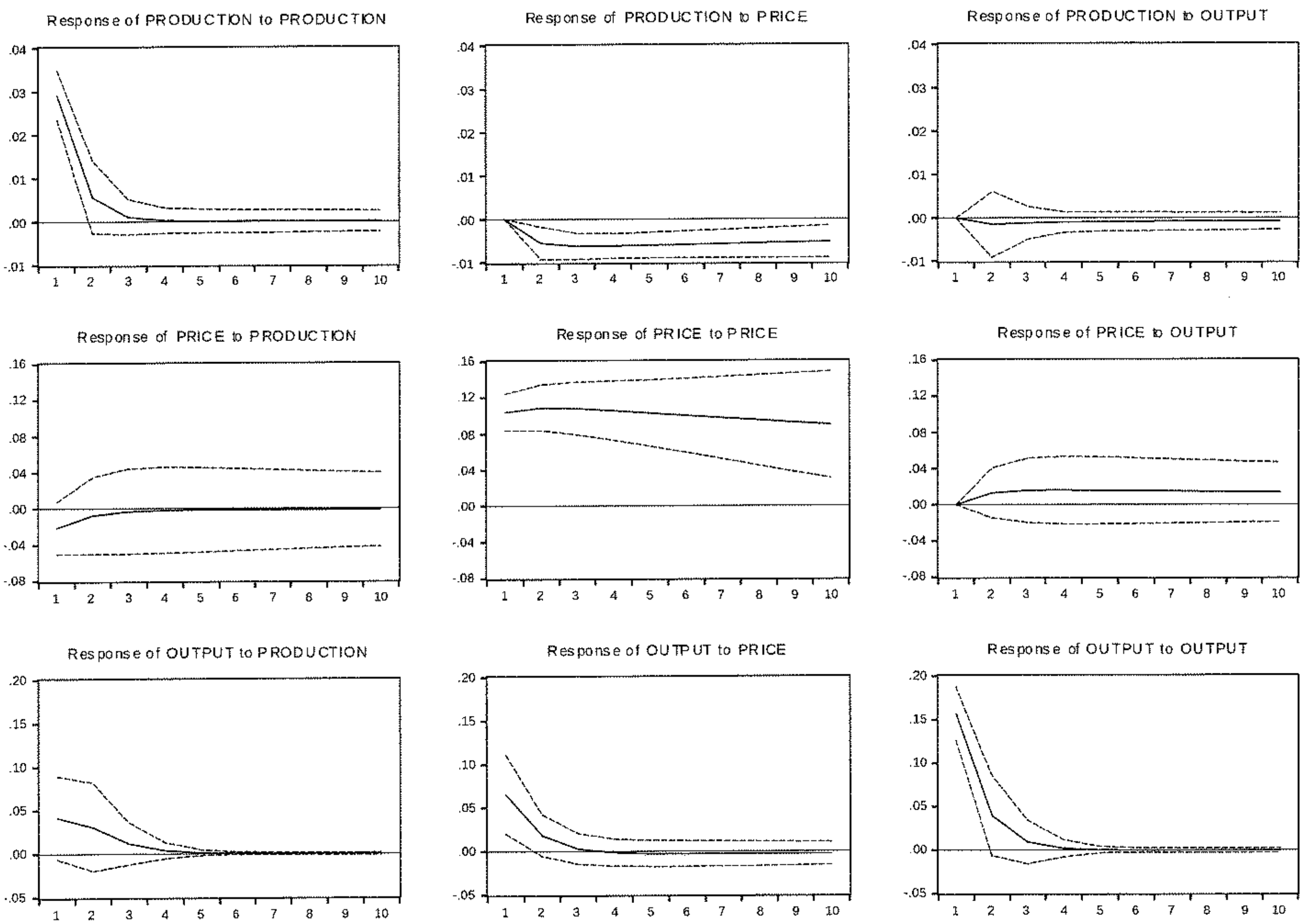
Response to Cholesky One S.D. Innovations – 2 S.E. (TOGO)



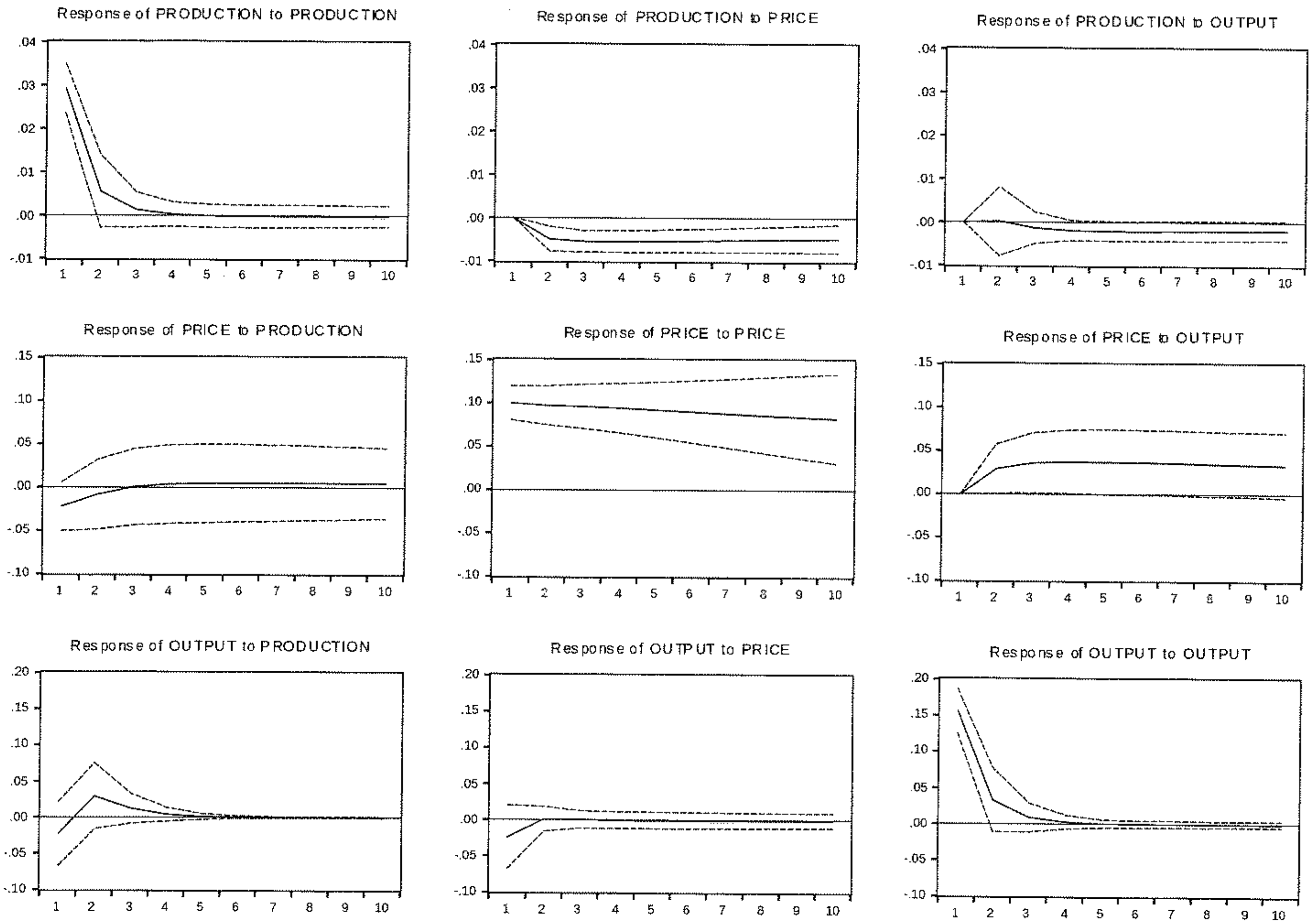
Response to Cholesky One S.D. Innovations – 2 S.E. (UGANDA)

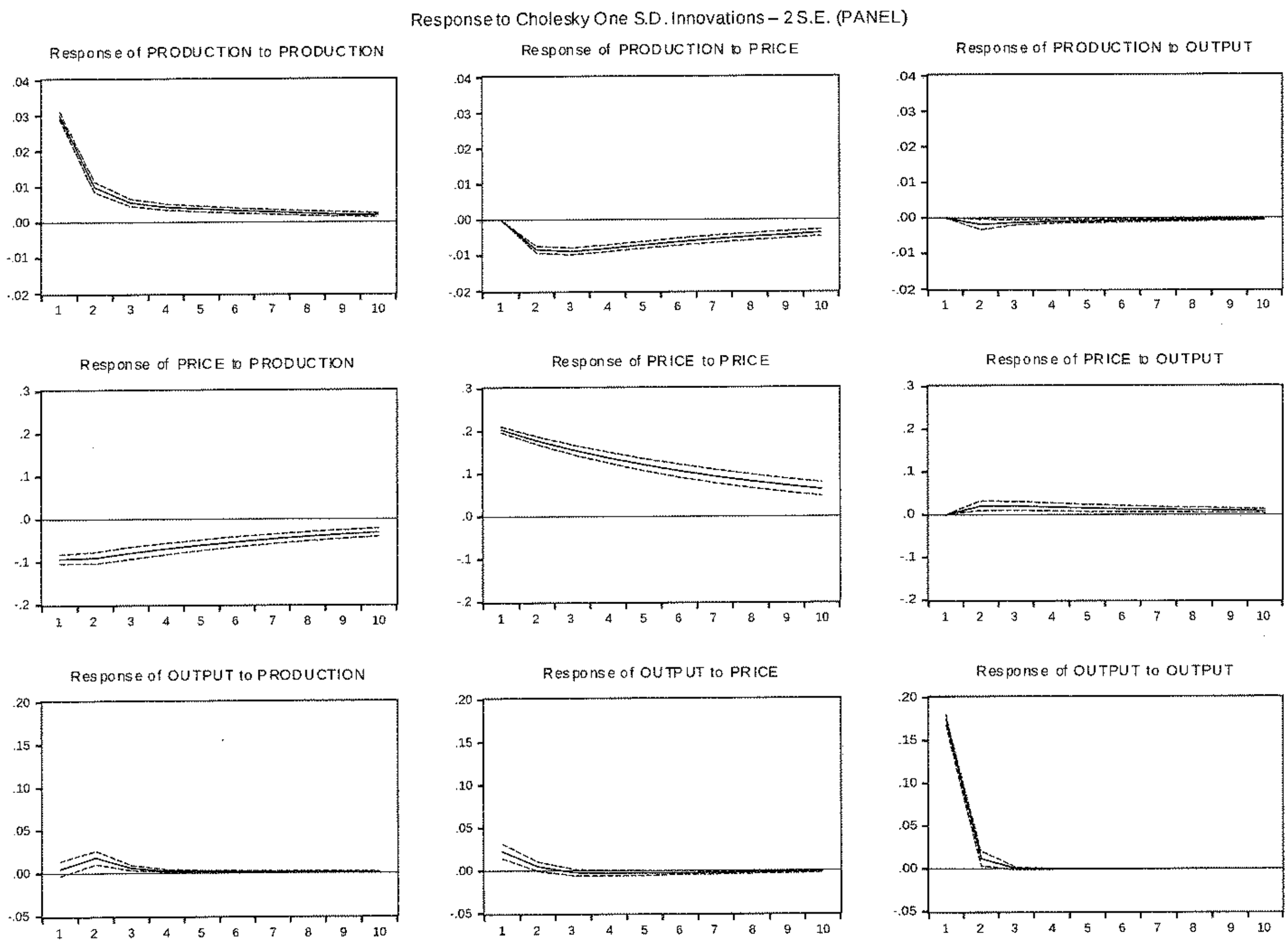


Response to Cholesky One S.D. Innovations – 2 S.E. (ZAMBIA)



Response to Cholesky One S.D. Innovations – 2 S.E. (ZIMBABWE)




Response to Cholesky One S.D. Innovations – 2 S.E. (PANEL)
Response of PRODUCTION to PRODUCTION
Response of PRODUCTION to PRICE
Response of PRODUCTION to OUTPUT
Response of PRICE to PRODUCTION
Response of PRICE to PRICE
Response of PRICE to OUTPUT
Response of OUTPUT to PRODUCTION
Response of OUTPUT to PRICE
Response of OUTPUT to OUTPUT

Variance Decomposition – 2 S.E. (PANEL)