Dynamic bioethanol price pass-through : implication for food security

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Highlights

- A positive bioethanol world price shock leads to increasing maize price until two years after the shock before decreasing.
- On average, high magnitude shocks correspond to an impact greater than low magnitude shocks .
- The asymmetry result with respect to shocks direction indicates a nil net effect, suggesting bioethanol does not penalize food security through food access.
- The impact of bioethanol price shocks on maize is greater in countries with low export barriers.

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Abstract

In a context of food insecurity and energy deficiency, this paper analyzes the dynamic pass-through of world bioethanol price shocks to food prices, particularly maize price, on a sample of developing and developed countries, over the period 2000-2014. In order to estimate the dynamic responses at each period of interest, we use the local projections, a robust method to misspecification and that allows generating multi-step predictions. Our results show that there is a positive response of maize prices to bioethanol price shocks. On the whole sample, the impulse response function displays that a one-cent increase in bioethanol prices per liter contributes to around 50 cents rise in maize price two years after the shock. In addition, on average, the asymmetry in shocks magnitude indicates that high magnitude shocks impact is more important than low magnitude shocks; while asymmetry with respect to shocks direction reveals a nil net effect, suggesting that bioethanol is not harmful to food security. However, the intensity of these impacts differ among countries, depending on income level, trade openness, exchange rate regime, maize production, net maize trade or the role of public policies.

Keywords: Maize price · Bioethanol price · Pass-through · Food security · Local projections

JEL Codes: Q11 · Q16 · Q41 · Q01

1 Introduction

High commodity prices assign consumers of both developing and developed countries by transmitting disruptions in the business cycle and creating inflationary pressures (Hochman et al., 2010). People from developing countries are more affected by food price shocks because many people live on the margins of an adequate nutrition. Thereby, high food prices lead to the reduction of food access and consumption. Moreover, changes in food prices impair farmers' incomes and future production, especially in the case of downward variations. They also contribute to raise their incomes, when there are positive price shocks. Based on these findings, food price shocks could result in broader social risks in terms of food security but also human development and political stability.

Food price variations can be explained by some factors such as energy production, primarily biofuels. As they use agricultural crops as feedstocks, the increase in the maize global price since 2004 was explained by the tripling of ethanol production from 15 to 50 billion liters over the period 2004–2010 (Chen and Khanna, 2012). This significant growth is caused by the raise in biofuel demand and price, as well as high oil prices. Indeed, ethanol policies (subsidies and restrictions on imports) in the U.S, combined with high oil prices, led to use around 5 percent of the world's caloric production of maize, soybeans, wheat, and rice (Roberts and Schlenker, 2013).

The assumption that high world prices translate into high domestic prices is ultimately an empirical question. The central objective of this paper is to empirically examine the extent of bioethanol world prices pass-through to domestic consumer prices, which is a good measure of food access. In developing countries, the government often subsidizes the price of basic necessities; that means consumers are not always confronted with the market price of these products. Given that public subsidies distort food prices, consumer prices may therefore not be fully adjusted to higher world prices. In addition, data on consumers prices are hardly available. They are however linked to producer prices, allowing to use these latter as a proxy for food access.

We focus on maize, one of the main feedstocks for bioethanol production in many countries[1] and because of data availability; thereby, the change in bioethanol prices could enhance some variations in maize producer price. We analyze the static and dynamic responses of maize prices to bioethanol price shocks by using the local projection. This method is robust to misspecifications and allows generating multi-step predictions through the re-estimation of the direct forecasting models for each forecast horizon. Moreover, local projections take into account asymmetric effects and non-linearities which are mainly relevant in this study.

While most of the studies are country-specific and in particular focus on the US market (Zhang et al., 2009) and other advanced economies in Europe (Busse et al., 2012; Abdelradi and Serra, 2015), this paper adds to literature on biofuels and food security, by assessing the dynamic response in a large sample of advanced, emerging, and low-income countries over the period 2000-2014. Moreover, it evaluates the asymmetry in the effects with respect to bioethanol world price shocks direction, as well as shocks magnitude and analyses the impact according to some heterogeneities.

The remainder of this paper is structured as follows. Section 2 reviews the main ideas behind the link between energy and food prices. Then, section 3 presents data sources and the empirical method. Section 4 analyses in the whole sample how maize prices have answered to change in world bioethanol prices and section 5 focuses on the robustness check. Finally, in section 6 we analyse some heterogeneities before concluding in section 7.

2 Background

Despite the efforts of governments and international organizations, the number of food insecure people remains high. Indeed, around 780 million people are undernourished and two billion are malnourished (McGuire, 2015). There is a list of causal determinants of food insecurity which matter for individuals well-being and health. These determinants could be

[1]According to the Department for Environment, Food and Rural Affairs (DEFRA), the share of world bioethanol production by maize was 49% in 2008 that of sugarcane was 33% .

the lack of food supply and food access at household and country level. The lack of food supply is often linked to the decrease in food production, due to climatic extreme events or crisis that reduce a government' ability to import food. However, nowadays, the lack of food supply is also attributed to renewable energy production specifically biofuels. The lack of food access, primarily due to high food prices could also be attributed to various factors such as rapid population growth in developing countries, low inventory levels, loose monetary and expansionary fiscal policies, depreciation in the U.S. dollar and diversion of food crops into biofuel production (Baffes, 2011).

There is a negative correlation between food supply and food prices. Low food availability could involve high prices, which could severely affect food security in the short-run. Therefore, the decrease in food supply related to biofuel production leads to the increase in food prices. Focusing on bioethanol real world price, and some main crops used as feedstocks such as maize, we can see in the figure 1 that bioethanol price raise is attended by an increase in maize producer price. Indeed, from 2002 to 2008, the growth rate of ethanol price was approximately 74% and that of maize price 98%. Likewise, a decrease in bioethanol price is followed by a decline in maize price.

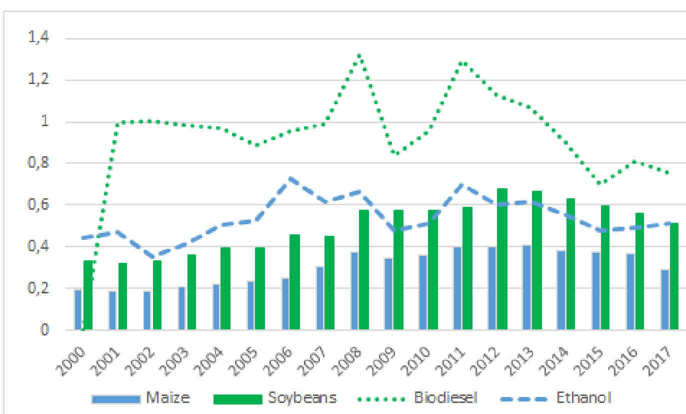


Figure 1: Trends in biofuels and some agricultural feedstocks prices

Bioethanol price variations can be attributed to some factors. Zilberman et al. (2013)

find two possible reasons for changes in bioethanol prices. Firstly, it could be attributed to a change in bioethanol demand due to a rise in gasoline price. The second reason is a change in bioethanol supply resulting from a variation in the refining capacity. Moreover, when bioethanol is considered as a substitute to energy, its price would reflect the difference in energy content. However, if it is used as an additive for the improvement of gasoline chemistry, bioethanol price can be above the energy equivalent price. Hence, the effect of a variation in biofuel prices on food prices can be predicted when the cause of the change in biofuel prices is specified. The reduction in the price of bioethanol could reduce its production and raises food availability for human consumption, so that the price of food goes down and vice versa. Second, if the change in biofuel price is created by a fluctuation in the price of gasoline, the direction of the change in food prices and that of biofuels will be the same. Finally, if the fluctuation in biofuel price is caused by an increase in refining capacity, the sense of the change in food prices will go in the opposite direction to the price of biofuels.

The amplitude of the relation between biofuels and food prices can differ according to geographic areas. Figure 2 shows us that maize prices are higher in countries of the Middle East and North Africa, Latin America and the Caribbean, and South Saharan Africa than that of other regions, meaning that they could be more affected by the rise in bioethanol price.

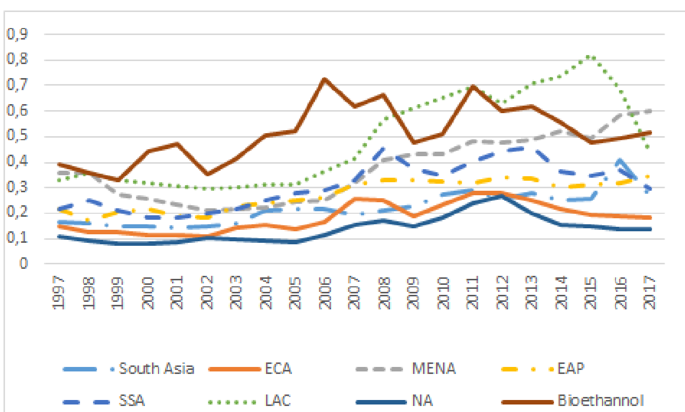


Figure 2: Trends in ethanol and maize prices by region

As previously said, one of the determinants of food price volatility is biofuel price shocks because they are produced with food crops. Recent energy policies which favor biofuel production, help to creating a large and persistent demand for maize. According to Robles et al. (2010), the raise in food prices from 2007 to 2008 reveals important reductions in calorie intake in several Latin American countries primarily for children. Likewise, higher food prices enhanced the number of underweight children in many African countries such as Mozambique, Zambia and Zimbabwe (Arndt et al., 2016; De Brauw, 2011; Hoddinott and Kinsey, 2001). However, the role of biofuels on high agricultural commodity prices in both 2007-2008 and 2011 is controversial. Since the 2007-08 food crisis, some authors have imputed the level and volatility of commodity prices to the increase in biofuel demand. While, for others the common factors across commodities are more important than biofuel shocks because biofuel would mostly affect maize (Abbott et al., 2008; Gilbert, 2010). In addition, some studies on the link between food and energy provided evidence that price transmission mechanisms are generally non-linear. For example, Busse et al. (2012) use a Markov-switching Vector Error Correction Model (VECM) to see the link between biodiesel, diesel, rapeseed oil and soybean oil price levels in Germany. They show that there is a co-integration between biofuels and agricultural commodities. Another study has been made in Brazil and indicates a positive and non-linear link between ethanol prices, sugar and oil prices (Balcombe and Rapsomanikis, 2008).

3 Empirical method

3.1 Model specification

In this subsection, we explain the method used to analyze the role of bioethanol world price shocks in clarifying trends in some food prices. Firstly, we do a static analysis by computing the pass-through coefficients as follows:

$$PT^i = 100 * \frac{P^i_t - P^i_{t-1}}{P'_t - P'_{t-1}} \quad (1)$$

Where the pass-through (PT) is considered as the ratio between the absolute change in food prices (P^i_t) and the absolute change in bioethanol prices (P'_t), both expressed in US dollars. i is an index for the food product or agricultural commodity considered. In our study, we just have maize as agricultural product; so, P^i_t represents maize producer price.

As maize is used to bioethanol production, the link between these two commodities price goes through exports channel. Therefore, pass-through coefficient could be considered as a proxy of export policies. We assume transportation costs and margins that determine the price structure are stable; hence, any variation in supply cost is likely to be driven by some modifications in export barriers. If for a positive change in the world bioethanol prices, the pass-through coefficient is lower than 100 percent, this could mean there is strong export barriers or low export subsidies. Inversely, a coefficient of more than 100 percent would imply a low export barriers or high export subsidies.

On the one hand, a high pass-through could indicate that low export barriers which favor maize exports, contribute to reducing its availability in the local market and lead to high maize producer prices. In this case, countries are competitive and there is a greater impact of world prices on local prices. On the other hand, a country with low pass-through could mean it is less competitive than other countries with high pass-through level. Maize will be more available because its exports will be less important than that of other countries. Hence, even if there is an increase in maize price, its magnitude will be lower than the case of high pass-through. Furthermore, pass-through coefficient can be negative when prices registered opposite direction. This effect can be explained by the role of monetary authorities in inflation targeting policies, exchange rate movement, trade openness or the decline in the share of bioethanol consumption in economy.

Secondly, we analyze the dynamic response of food prices to world biofuel price shocks.

In the literature, many authors used Vector Autoregressive models (VAR) (Steinsson, 2008; Benati and Surico, 2009; Kristoufek et al., 2012; McPhail, 2011) which suppose that data are generated by a VAR model that coincides with the data generating process. However, this model can introduce misspecifications in the impulse response functions when data are not generated by a VAR model (Jordá, 2005). Another method widely used is the Vector Error Correction Model (VECM) (Kurmann and Mertens, 2014; Mallory et al., 2012), but this method can suffer from low power of cointegration tests. For these reasons we choose the local projection approach developed by Jordá (2005) because contrary to VAR models, the main idea of this method is to estimate local projections at each period of interest. Moreover, impulse responses are considered as predictive functions with ever-larger horizons. Therefore, a VAR model whose forecast errors are repeated and correlated, cannot give a good approximation, unlike the local projection that minimizes forecast errors at each horizon. In addition, we can estimate local projection by simple regression techniques and there are no misspecification problems because they are more robust. Likewise, they allow easy experimentation with highly non-linear and flexible specifications that could be impractical in a multivariate context.

The impulse response is usually estimated by the Wold decomposition of a linear multivariate Markov model and could be considered as the difference between two forecasts (Hamilton, 1994; Koop et al., 1996).

$$IR(t,h,d_i) = E(y_{t+h}|v_t = d_i; Y_t) - E(y_{t+h}|v_t = \lambda; Y_t) \qquad h = 0,1,2,3 \tag{2}$$

Where y_t is a random vector; $E(.|.)$ is the best mean squared error predictor; λ dimension is $n \times 1$; v_t is the reduced-form disturbances vector; columns d_i of $n \times n$ matrix D give the relevant experimental shocks; and Y_t which is equivalent to $(y_{t-1}, y_{t-2}, ...)$.

Local projection leads to computing the decomposition of the forecast-error variance. The following expression determines the error in forecasting y_{t+h}:

$$y_{t+h} - E(y_{t+h}|X_t) = \mu^h_{t+h} \tag{3}$$

Where the residual μ^h_{t+h} is the forecast errors average moving from time t to $t+h$ and therefore uncorrelated with the dependent variable that is explained by its lagged values $(y_{t-1}, y_{t-2}, ...)$. h represents the number of horizon considered. Here we analyze the dynamic response until three years after the shocks because after these years the effect returns to its initial value and becomes subsequently insignificant.

As well as being robust to misspecification, this method allows generating multi-step predictions by re-estimating the direct forecast models for each forecast horizon (Koop et al., 1996; Jordá, 2005). Moreover, local projection takes into account net effects and non-linearities which are mainly relevant in this study. We implement this method, in our case, through the following equation:

$$\Delta FP_{i,t+h} = \alpha_\rho \sum_{\rho=0}^{\varrho}(\Delta FP_{i,t-\rho}) + \beta_1 \Delta Biofuel_t + \gamma_\rho \sum_{\rho=1}^{\varrho}(\Delta Biofuel_{t-\rho}) + \lambda_\rho X_{it} + \tau + \zeta_i + \epsilon_{it} \qquad h = 0, .., 3. \tag{4}$$

Where $\Delta FP_{i,t+h} = FP_{i,t+h} - FP_{i,t-1}$[2] , with FP the annual price of agricultural feedstocks considered, here maize; $Biofuel$ is the annual bioethanol prices; τ defines a time trend; ζ gives country specific effects; error term is ϵ_{it}; h refers to the number of horizons; X_{it} predictor variables and ρ indicates the number of lags[3]

This baseline model assumes that a positive shock leads to raising maize price; while a negative shock contribute to decreasing maize price. However, we have to consider the two shocks in order to determine what effect is the most important. To take into account the possibility of getting asymmetry in the effects, we add to equation 4 the variable $Biofuel$

[2]Variables have been taken in first-difference, hence, even if they were I(1), they become stationary in first-difference. These results have also been verified by Fisher-Augmented Dickey-fuller unit root test.

[3]Here the optimal number of lags is two. Moreover, standard errors have been clustered by country because treatment is repeated in all countries.

divided into two censored variables specified as follows:

$$Biofuel_t^- = \begin{cases} \Delta Biofuel_t & \text{if } \Delta Biofuel_t < 0 \\ 0 & \text{if } \Delta Biofuel_t \geq 0 \end{cases} \tag{5}$$

$$Biofuel_t^+ = \begin{cases} \Delta Biofuel_t & \text{if } \Delta Biofuel_t > 0 \\ 0 & \text{if } \Delta Biofuel_t \leq 0 \end{cases} \tag{6}$$

With $Biofuel_t^+$ and $Biofuel_t^-$, respectively the positive and negative biofuel price shocks.

$$\Delta FP_{i,t+h} = \alpha_\rho \sum_{\rho=0}^{\varrho}(\Delta FP_{i,t-\rho}) + \theta_1 Biofuel_t^+ + \theta_2 Biofuel_t^- + \gamma_\rho \sum_{\rho=1}^{\varrho}(Biofuel_{t-\rho}^+) + \omega_\rho \sum_{\rho=1}^{\varrho}(Biofuel_{t-\rho}^-) + \lambda_\rho X_{it} + \tau + \zeta_i + \epsilon_{it} \qquad h = 0, ..., 3. \tag{7}$$

As it is presented by equation 7, the net effect will be the sum of these two coefficients ($\theta_1 + \theta_2$). If it is positive, it will mean that the impact of positive shocks is greater than that of negative shocks. In this context, we could conclude that bioethanol is on average harmful for consumers but favourable for producers. While, if the net effect is negative, it will indicate that negative shocks impact is higher than that of positive shocks. This finding might suggest that bioethanol is on average disadvantageous for maize producers, but advantageous for consumers. A nil net effect will show that positive shocks impact is as high as that of negative shocks. In this case, we could deduce that there is a compensation between these two effects; thereby, bioethanol would not be a threat to food security.

Another type of asymmetry will consist in testing price shocks effect according to their magnitude. Therefore, as shown in the Equations 8 and 9, we consider the absolute value of bioethanol price variation and then define two variables that contain low and high shocks, as follows:

$$Biofuel_t^L = \begin{cases} |\Delta Biofuel_t| & \text{if } |\Delta Biofuel_t| < M \\ 0 & \text{if } |\Delta Biofuel_t| \geq M \end{cases} \tag{8}$$

$$Biofuel_t^H = \begin{cases} |\Delta Biofuel_t| & \text{if } |\Delta Biofuel_t| > M \\ 0 & \text{if } |\Delta Biofuel_t| \leq M \end{cases} \tag{9}$$

With $Biofuel_t^H$ and $Biofuel_t^L$, respectively high and low bioethanol price shocks; M represents the median value.

$$\Delta FP_{i,t+h} = \alpha_\rho \sum_{\rho=0}^{\varrho}(\Delta FP_{i,t-\rho}) + \theta_1 Biofuel_t^H + \theta_2 Biofuel_t^L + \gamma_\rho \sum_{\rho=1}^{\varrho}(Biofuel_{t-\rho}^H) + \omega_\rho \sum_{\rho=1}^{\varrho}(Biofuel_{t-\rho}^L) + \lambda_\rho X_{it} + \tau + \zeta_i + \epsilon_{it} \qquad h = 0, ..., 3. \tag{10}$$

We also consider the value of parameters θ_1 and θ_2, however, the net effect between high and low shocks magnitude will be obtained by $(\theta_1 - \theta_2)$. If this difference is positive, it will mean that on average, the impact of high magnitude shock on maize price is more important than that of low magnitude shock. Conversely, if the net effect is negative, it will indicate that high shocks effects are not entirely transmitted to maize price that could be due to public interventions. No net effect will signal a compensation between these two impacts.

3.2 Data

Our sample is constituted by 77 developed and developing countries from 2000 to 2014. Most of the data come from the World Development Indicators (WDI), Food and Agriculture Organization (FAO), International Energy Agency (IEA), International Monetary fund (IMF) and the Organisation for Economic Co-operation and Development (OECD) statistics. As dependent variable, we use maize price to assess bioethanol world price shocks effects. This choice is due to the availability of data, but also because it is one of the main bioethanol feedstocks[4].

Our variable of interest is bioethanol real price, which has been taken to assess biofuel price shocks. This variable is expected to create positive dynamic responses of maize price. Then, biofuel and maize production have been chosen as predictor variables because they affect the level of prices through the mechanism of demand. Moreover, exchange rate variation can affect bioethanol price and its pass-through into maize producer price. The US dollar weakness reduces the domestic-currency price of bioethanol and maize, and inversely because they are denominated in dollar. In addition, we insert trade openness and inflation rate. These variables impact both bioethanol and maize price because they influence biofuel trade, production and prices. They are supposed to have a positive impact on maize price. Furthermore, some studies focus on the link between oil price and biofuel, find that oil price also affect biofuel production and its price. Finally, following these studies, we add the crude oil world price among predictors in the robustness check but also the world price of other cereals because there is a correlation among them. Table 1 gives a summary and descriptive statistics of all data used.

[4] In addition, Zhang et al. (2009) find a relationship between the volatility of world prices of maize and ethanol, as well as gasoline and oil.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std.	Min	Max
Maize price	1,149	267.69	289.84	34.80	3206.10
Maize production	1,155	9375603	3.83e+07	39	3.61e+08
Ethanol real price	1,155	.55	.10	.35	.73
Inflation rate	1,114	6.69	9.69	-8.24	168.62
Exchange rate	660	96.61	16.69	54.06	296.33
Trade openness	1,129	79.75	42.86	20.96	382.29
Biofuel production	1,147	14.94	84.42	0	1056.69
High shocks	1,078	0.07	0.08	0	0.20
Low shocks	1,078	0.02	0.02	0	0.06
Negative shocks	1,078	-0.40	0.06	-0,19	0
Positive shocks	1,078	0.05	0.07	0	0.20
Crude oil price	1,155	0.48	0.19	0.21	0.75
Rice price	1,155	149.77	58.25	72.92	266.58
Barley price	1,155	185.37	67.94	100.99	289.58
Wheat price	1,155	192.07	65.98	100.74	292.97

4 Results

4.1 Static analysis

Figure 3 shows bioethanol world price fluctuations between 2000 and 2014 which allowed us to identify 5 sub-periods. Indeed, between 2000 and 2002, there was a slight rise and then a significant drop in the world price of about 0.45 to around 0.35 USD per litre. From 2002 to 2006, the world price experienced a strong growth until reaching its peak in 2006 with an estimated price of around 0.7 USD per litre. The strong growth observed from 2002 to 2006 preceded an incremental decline in prices until 2009 before growing again between 2009 and 2011. Finally, in the last sub-period identified from 2011 to 2014, there was a slight decrease in prices.

Table 2 presents the median pass-through for different country groups in all sub-periods considered. We can remark that there is a great heterogeneity of coefficients, but also some symmetries between them and bioethanol price changes described in figure 3. Positive variations in bioethanol world prices are followed by an increase in coefficients, and negative

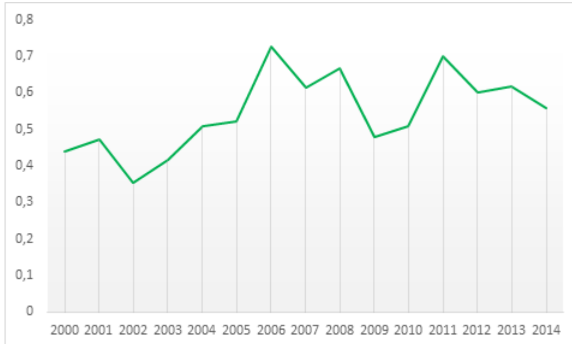


Figure 3: Trends in ethanol real prices (US dollars per liter)

Table 2: Median pass-through coefficients by country groups

	Median pass-through coefficients				
	[2000-2002]	]2002-2006]	]2006-2009]	]2009-2011]	]2011-2014]
All countries	-26,60	105,65	14,98	337,87	-4,97
Developing Asia	-88,08	84,31	-27,3	269,85	-59,26
Sub_saharan Africa	-157,05	199,51	177,45	157,17	-62,96
MENA	103,46	196,63	14,72	151,87	-255,67
Emerging Europe	44,04	87,75	-151,95	447,68	45,28
Latin America	7.89	42,31	189,5	476,03	226,97
Advanced Economies	-47,15	92,2	-164,87	512,77	-24,85
commonwealth	74,79	213,88	-24,51	163,52	29,07

variation in world prices, by a decline in coefficients. In addition, in all the study period, pass-through coefficients are on average positive and high in Latin America, which could display that bioethanol price changes are significant determinants of maize price inflation level in this region. Inversely, Developing Asia countries scored relatively low pass-through coefficients due to their high dependence on imported food (Jongwanich and Park, 2011).

In Sub-Saharan Africa countries, we note a decline in pass-through coefficient from 2009 to 2011, although bioethanol world prices have increased. The same result applies to Latin America and the Caribbean countries between 2006-2009; pass-through coefficient was significantly higher than the previous period although bioethanol world prices have fallen on average.

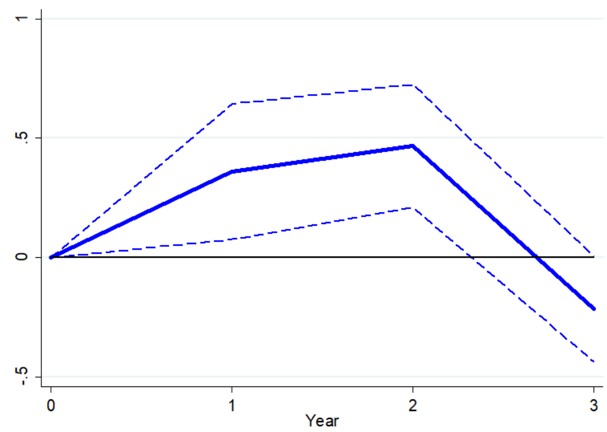
4.2 Dynamic Responses

As previously mentioned in the methodology, after presenting static analysis result, we examine the dynamic response of maize through local projection. Thereby, Figure 4 indicates how a transitory shock in bioethanol prices reverberates to maize producer prices for all countries in our sample. Finding allows us to conclude that in the short run, there is a significant and positive effect of ethanol price shocks. The magnitude implies that 1 cent per litre raise in bioethanol price favors the increase in maize price of 40 cents at the peak level which appears 2 years after the shock. After this peak, the effect drops, becomes negative and not significant. This result is in line with Zhang et al. (2009, 2010) who find that the enhance in bioethanol prices have short-run, but not long-run effects on agricultural commodity prices. The increase in maize price effect during the first two years could be due to the increase in bioethanol demand or consumption (figure C.4) and production, which have helped to rise maize demand and therefore its price. Otherwise, the decline after two years could be attributed to farmers adaptation. Indeed, as we can see in many countries when the price of a product steps up in the market, people seek opportunities to profit by increasing production, which in turn could lead prices down (Isik, 2002). Hence, the decrease in price might be due to an increase in maize production after the second year, which can, therefore, correspond to the farmers' response to this shock.

4.2.1 Asymmetry

We decide to study the asymmetric effects of pass through due to some results of the static analysis and the fact that biofuels is an oligopolistic market. Therefore, the lack of competition, production and research costs could cause oligopolistic seller to maintain a prior price in response to a negative price shock until biofuel demand change. In addition, according to Borenstein et al. (1997), price asymmetry can be expensive for final consumers, highlighting the importance of appreciating, identifying sources and taking appropriate actions.

- **Asymmetry with respect to shocks direction**.

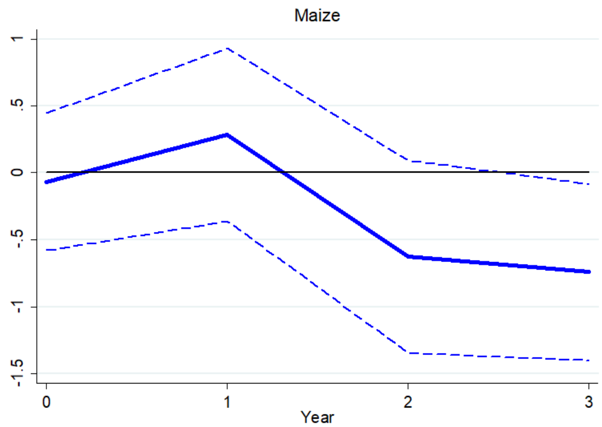


Dashed lines represent the 95 percent confidence intervals.

Figure 4: Dynamic responses of Maize

The net effect shows, in general, there is a compensation between positive and negative price shocks. As indicated by the previous results, a positive shock to the world price of bioethanol would have the effect of contributing to the raise in maize producer price. Furthermore, negative shocks contribute to the decline in maize price. Thereby, this net effect could suggest that producing bioethanol would not have a negative effect on maize consumer and producer and therefore on food security.

Asymmetric results presented suggest that on average bioethanol is not harmful to food security. Indeed, since 2000, there have been positive and negative change in bioethanol world price. But we note that these shocks, on average did not penalise maize producers income and consumers food access in the short-run. According to the conventional wisdom, when there is no public intervention producer prices lead consumer prices (Tiwari et al., 2014). Hence, we can say that the effect observe in producer prices is imputed to consumer prices, because a variation in producer prices create a change in consumer prices.

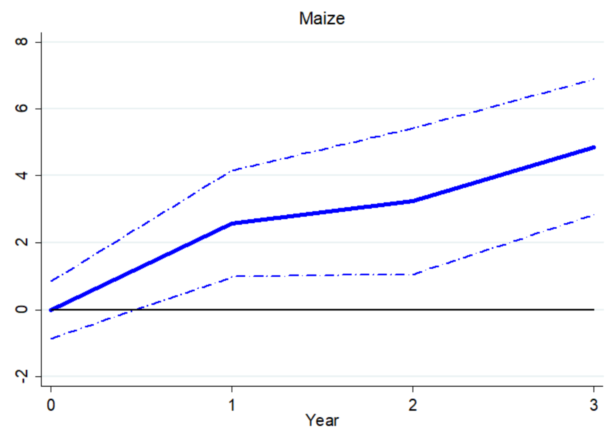


Dashed lines represent the 95 percent confidence intervals.

Figure 5: Asymmetry in shocks direction

- **Asymmetry with respect to shocks magnitude**

After displaying the asymmetry with respect to shocks direction, we test the shock magnitude effects. Using the absolute value of bioethanol variations, we have categorized shocks to low and high, according to whether they are lower or higher than the median value. Figure 6 allows concluding that the impact of high shocks is more important than that of low shocks. Indeed, the net effect between high and low magnitude shocks is positive, suggesting that the impact of high shocks on maize price is larger than low shocks.



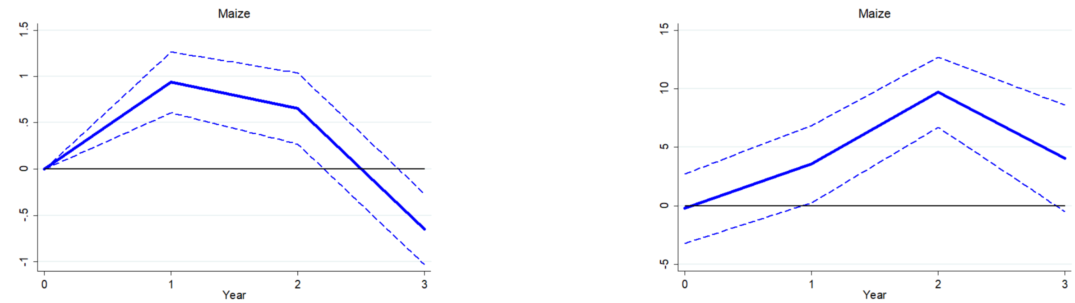
Dashed lines represent the 95 percent confidence intervals.

Figure 6: Asymmetry in shocks magnitude

5 Robustness check

5.1 Effect before financial crisis

Financial crisis contributes to increasing international food prices that have reached between 2007-2008 their highest levels in 30 years, threatening food security for the world's poor (FAO, 2009; Lee et al., 2017). Hence, in order to see if the observed effect is not only due to the financial crisis, we test the dynamic response of maize during the period prior to 2007. Figure 7 indicates that the impact is not due to the financial crisis effect. As in the whole sample, during the period prior to the financial crisis, a positive shock in the world bioethanol price contributes to increasing the maize producer price until attaining its peak one year after the shock before declining. In addition, we can notice that on average the impact of high magnitude shocks is higher than low magnitude shocks; this is in line with Figure 6 and shows that ours findings are robust. Furthermore, we do not make a representation of the asymmetry with respect to shocks direction because there was only one negative bioethanol price shock during the period prior to the financial crisis.



Assuming symmetric response   Asymmetry in shocks magnitude

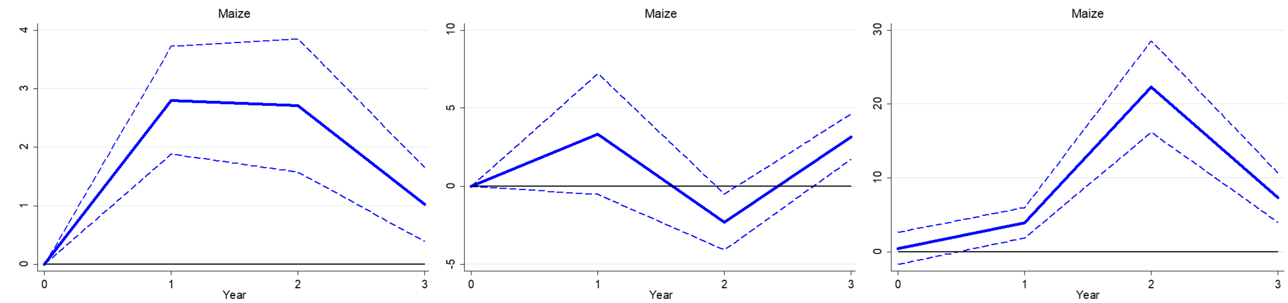
Dashed lines represent the 95 percent confidence intervals.

Figure 7: Maize price response before financial crisis

5.2 Additional predictors

Bioethanol world price can also be correlated to the world crude oil that could influence bioethanol production cost and price; as a result, it could affect maize price through transport costs (Zhang et al., 2009; Vacha et al., 2013). Moreover, there is a correlation between cereal prices and some of them are also used for bioethanol production such as wheat. Hence, we assume that other cereals world prices could assign bioethanol price and maize price. For this reason, and according to the availability of data, we add among predictors the world price of crude oil other cereals such as wheat, rice and barley. We remark in Figure 8 that the impact of bioethanol does not change. As in Figure 4 there is an increase in maize producer price until reaching its peak two years after the shock before decreasing. A positive shock of bioethanol world price leads to raising maize price.

Similarly to findings obtained in the asymmetry subsection, by adding these additional predictors there is on average a nil effect according to the asymmetry with respect to shocks direction. Moreover, in the short-run, the asymmetry with respect to shocks magnitude is positive, meaning that high shocks result exceeds low shocks.



Assuming symmetric response

Asymmetry in shocks direction

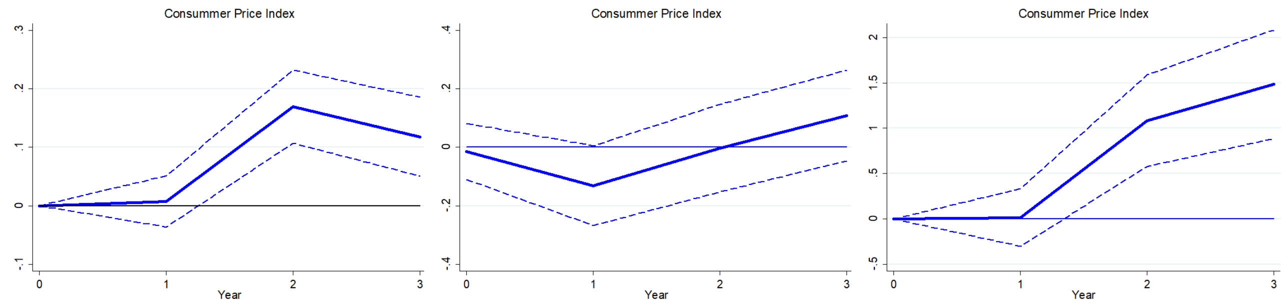
Asymmetry in shocks magnitude

Dashed lines represent the 95 percent confidence intervals.

Figure 8: Maize price response with additional predictor variables

5.3 Consumer Price Index (CPI) as dependent variable

Consumer price index can be defined as a measure that assess the weighted average of a basket of consumer goods and services prices (Burns et al., 2008). Hence, due to the lack of data on maize consumer price, we choose the CPI as dependent variable, in order to see what will be its impulse response to a bioethanol world price shock. Figure 9 displays that a positive bioethanol price shock has no effect on CPI one year after the shock, but leads to raising CPI after the first year until attaining its peak two years after the shock before decreasing. In addition, there is also a compensation between positive and negative shocks impact and we can remark that the effect of high magnitude shocks is more important than low magnitude.



Assuming symmetric response | Asymmetry in shocks direction | Asymmetry in shocks magnitude

Dashed lines represent the 95 percent confidence intervals.

Figure 9: Dynamic response of consumer price index

6 Some heterogeneities

Previous findings were observed in the whole sample. However, static analysis allows us to think that these results could differ according to country groups. Hence, we will see in the following subsection what could be the impulse response of maize price to bioethanol price shocks according to country groups, as well as a country level of income, maize production, exchange rate regime, trade openness, public policies and net trade of maize.

6.1 Income group

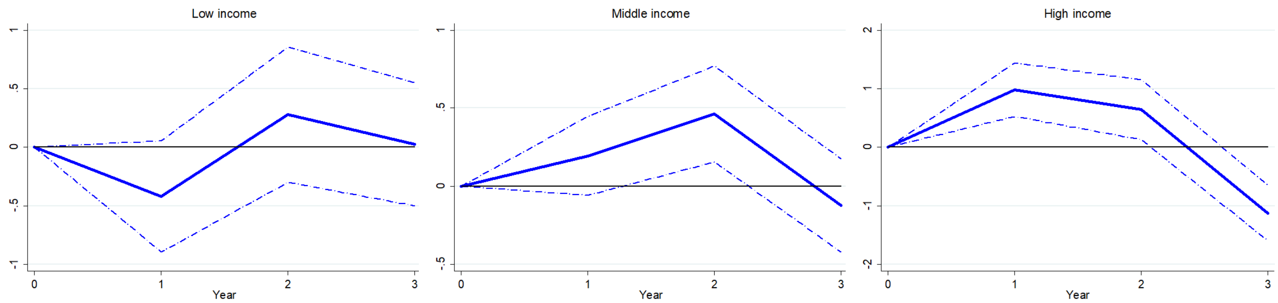
Income level is one of the main determinants of the level of poverty and food insecurity in a country (Smith et al., 2016). People from low-income countries are more exposed to hunger and undernourishment. Thereby, policy makers and international organizations adopt some measures to allow people to be less sensitive to price shocks, precisely positive shocks. Thus, we assume that bioethanol price shocks impacts on maize price can differ according to the level of income.

6.1.1 Symmetric effects

Assuming a symmetric response, Figure 10 shows that the effect of bioethanol price shocks on food prices differs under income level. Indeed, there is no significant effect for low-income countries over the period, however, it is positive and significant for high-income countries. For middle-income countries, the impact of bioethanol price shocks is significant only 2 years after the shock, causing the enhance in maize price by around 50 cents when the world price rises by 1 cent. In addition, the effect quickly fades because we notice a rapid decline in the effect after the second year.

The effect obtained for low- and middle-income countries could be explained for a variety of reasons. One is that many of these countries are African countries facing food insecurity. As a result, governments are putting in place grants and subsidies to farmers to reduce production costs and their impacts on producer and consumer prices. In many of these countries, such as Ethiopia, South Africa and Kenya, farmers have joined together in cooperatives to gain technical and financial support. Moreover, in other countries such as Malawi, the government takes some measures to restrict exports when international food prices are high (Chalmin et al., 2019). As mentioned in the empirical method, the amplitude of pass-through tends to be low in the presence of strong export barriers. Another cause would be trade openness; these low-income and middle-income countries are less open because they are often less competitive in the international market. Thus, they are less affected by a global price shock.

Contrary to the effect observed for low-income countries, a 1-cent increase in the world price of biofuels would enhance corn prices by about 100 cents a year after the shock. This finding is the same as Chiou-Wei et al. (2019); they display there is a positive feedback effect of maize price to bioethanol price shocks. Then, the effect gradually declines until becoming not significant and negative at the end of the third year. This effect can be explained by the fact that in most of these countries, product prices are liberalized (Kpodar and Abdallah, 2017). Thus, fluctuation intensity of bioethanol price, will have more consequences than low-income countries; in addition, these countries have also a high level of trade openness.



Dashed lines represent the 95 percent confidence intervals.

Figure 10: Dynamic responses of Maize according to the level of income

6.1.2 Asymmetric effects

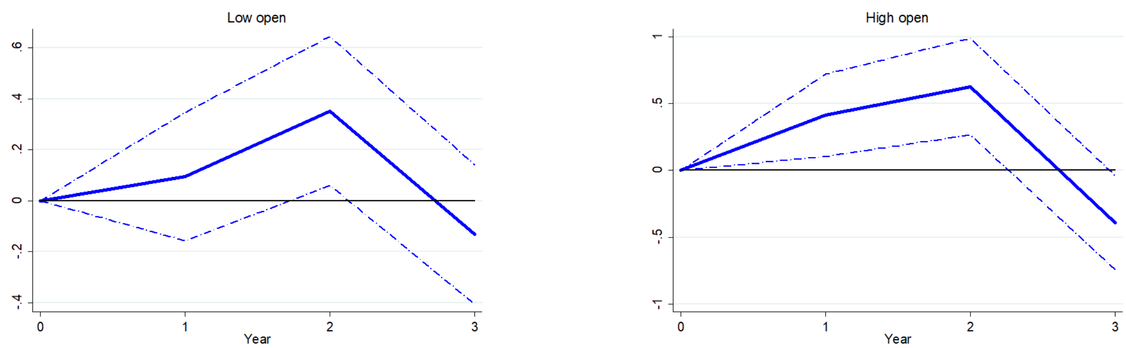
As for the whole sample, we note a compensation between negative and positive shocks impact mainly for low-income countries (Figure A.1). However, for middle-income countries, there is a peak after two years which shows that positive shocks effect is lower than negative shocks. The same impact applies for high income countries, on average the net effect between positive and negative shocks is nil until the middle of the second year where the effect of negative shock becomes higher than that of positive shock. Thus, we could say bioethanol production is not harmful to food security mainly in low- and middle-income. Moreover, we can notice an increase in maize access for consumers after two years.

Figure B.1 indicates the asymmetry in shocks magnitude according to the level of income. We can observe on average a nil effect for high income countries; for low- and middle-income countries, the impact is also nil until becoming positive after two years.

6.2 Trade openness

6.2.1 Symmetric effects

Opening countries to international trade can be beneficial for both the producer and consumer (Javorcik et al., 2006). From this statement, and as mentioned above, we note that positive bioethanol price shock effect on maize production price is significant and larger in countries with a high degree of trade openness. This is because trade openness facilitates the increase in market size (Brülhart, 2011). However, the raise in bioethanol price is particularly related to the enhance in its demand. As a result, trade openness provides a significant market and demand for already competitive countries and raises maize producer prices. This effect starts immediately after the shock and up to 2 years when it reaches its peak, causing maize prices to rise by about 60 cents before falling and becoming insignificant by the end of the third year.



Dashed lines represent the 95 percent confidence intervals.

Figure 11: Dynamic responses of Maize according to the level trade openness

6.2.2 Asymmetric effects

Figure A.2 states the asymmetry in shocks direction and allow concluding that on average, the response effect of domestic maize price during negative world price shocks is higher than those of positive price shocks. However, as for the full sample, the asymmetry with respect to shocks magnitude (Figure B.2) displays a positive net effect, indicating that high magnitude impact is the most important.

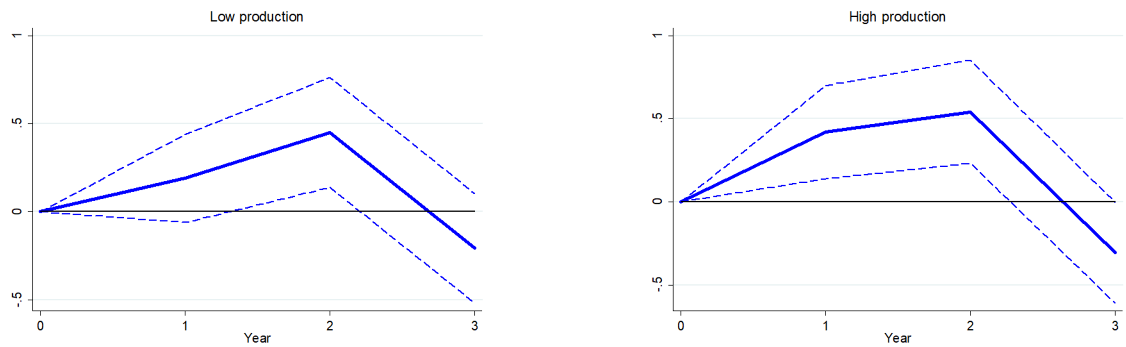
6.3 Maize production

Commodities prices vary among countries according to the level of their production. Indeed a country specialised in the production of a commodity can apply low prices, due to economies of scale or, conversely, apply high price mainly in a monopoly situation (Joskow, 2007). Hence, we assume that the impact can also differ according to the level of maize production. In order to analyze this heterogeneity, we categorize countries in our sample into high and low producer according to the median value of maize production.

6.3.1 Symmetric effects

Figure 12 presents the impact that a global positive shock of bioethanol prices would have on maize price in the large or small producing countries of this cereal. We note that price response is higher in the major maize producing countries. Indeed, an increase in world prices of 1 cent would cause a raise in the producer price of about 50 cents two years after the shock before fading.

Because the curves look similar to those obtained in Figure 11, we tested the dynamic of maize price response according to the level of trade openness and maize production. We find that the impact is greater in the major maize producing countries which have a high degree of trade openness. These results allow us to confirm those obtained in Figure 11 and especially to explain our new results, by the fact that the major maize producing countries are for the most of them, countries with a significant degree of trade openness. As a result, in a situation of positive shocks linked to an increase in demand, the only ones able to meet this demand are the leaders in maize production, that favors the rise in producer price. This is why we notice an increase in price from the beginning of the shock up to 2 years after it for countries with high level of maize production and trade openness (Figure C.2).



Dashed lines represent the 95 percent confidence intervals.

Figure 12: Dynamic responses of Maize according to the level maize production

6.3.2 Asymmetric effects

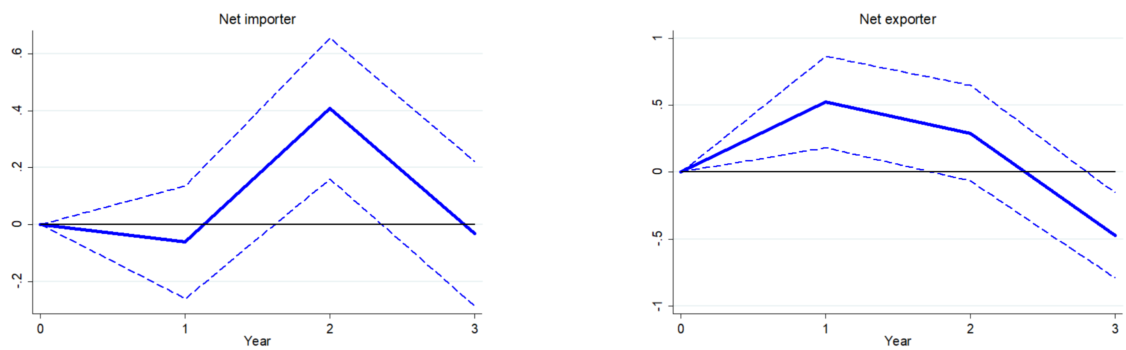
According to the level of maize production, the net effect reveals that the response to a positive shock is lower than that of the negative shocks for low maize producer's countries, while for high maize producer countries, the same effect is observed but after one year (Figure A.3).

Similarly to the whole sample, the asymmetry in shocks magnitude (Figure B.4 shows on average a positive net effect for high maize producer countries; while, for countries with a low level of maize production, this net effect is nil until becoming positive from the second year.

6.4 Net maize trade

6.4.1 Symmetric effects

We can have different effects in maize price according to the net trade of maize. Figure 13 allows us to show that the dynamic response of maize is more important in net maize exporting countries rather than net importers. Indeed, we remark that the effect is significant after the shock until reaching its peak one year after it, before declining. While it is only significant two years after the shock for net importers before decreasing. This result in line with pass-through coefficient and static analysis interpretation. We assume that net maize exporting countries are the most competitive in maize market. Hence, a positive shock in bioethanol price could lead to a rise in its feedstocks demand such as maize. As a result, net maize exporter countries would take advantage of this increase by raising maize price. Moreover, the impact is similar to that obtained according to the level of maize production, suggesting that these findings are robust as on average, net importers have a low level of maize production than net exporters.



Dashed lines represent the 95 percent confidence intervals.

Figure 13: Dynamic response based on net maize trade

6.4.2 Asymmetric effects

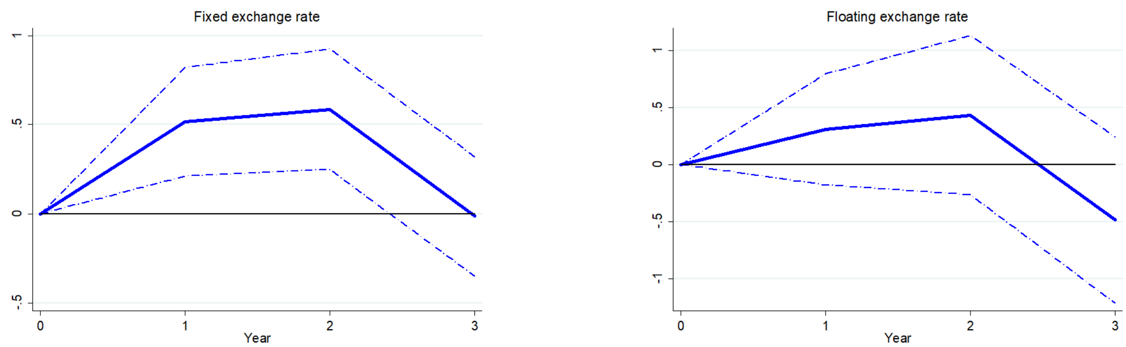
Figure A.4 presents the asymmetry in shocks direction according to the net maize trade. We remark a nil net effect for net importer countries, while the effect is positive before becoming negative after two years for net exporter countries. After shocks direction, the analysis of asymmetry with respect to shocks magnitude (Figure B.6 reveals a compensation between the impact of high and low magnitude shocks for net exporter countries. However, the result obtained for net importers allows concluding that high shocks magnitude impact are on average more important than low magnitude.

6.5 Exchange rate regime

Traded commodities price is influenced by exchange rates that have strong repercussions on their exports and imports (Harri et al., 2009; Kwon and Koo, 2009). There are different effects of bioethanol price shocks depending on the type of exchange rate regime.

6.5.1 Symmetric effects

A positive price shock has a positive and significant impact on the price of maize for countries with a fixed exchange rate regime. While it has no effect in countries with floating exchange rate. One of the advantages of a floating regime is that the exchange rate can vary according to the terms-of-trade shocks: the currency depreciates automatically when the world prices of the imported product increase, and it also automatically depreciates when the world prices of the exported product fall (Broda, 2001). Since bioethanol price is global and expressed in dollars per litre, the result obtained for countries with a fixed exchange rate can be explained by the fact that the currency of these countries is backed by the dollar or the euro, contrary to floating exchange rate. So, if the dollar price of a good raises, the same good local currency price will be multiplied by the dollar price value growth; While when the dollar goes down, commodity prices will be cheaper (McCalla, 2009). In a floating exchange rate regime, the price of a country's currency is set by the foreign exchange market on the basis of supply and demand relative to other currencies. This is contrary to the fixed exchange rate regime concept (Reinhart and Rogoff, 2004), in which the government wholly determines the rate. As a result, an increase in the price of bioethanol will seem more expensive in countries with a fixed exchange rate regime than those with a floating rate. Likewise, this result is in line with those obtained in Figure C.1. Their is a positive and significant impact for countries which are net maize importer with fixed exchange rate regime.



Dashed lines represent the 95 percent confidence intervals.

Figure 14: Dynamic responses of Maize according to the exchange rate regime

6.5.2 Asymmetric effects

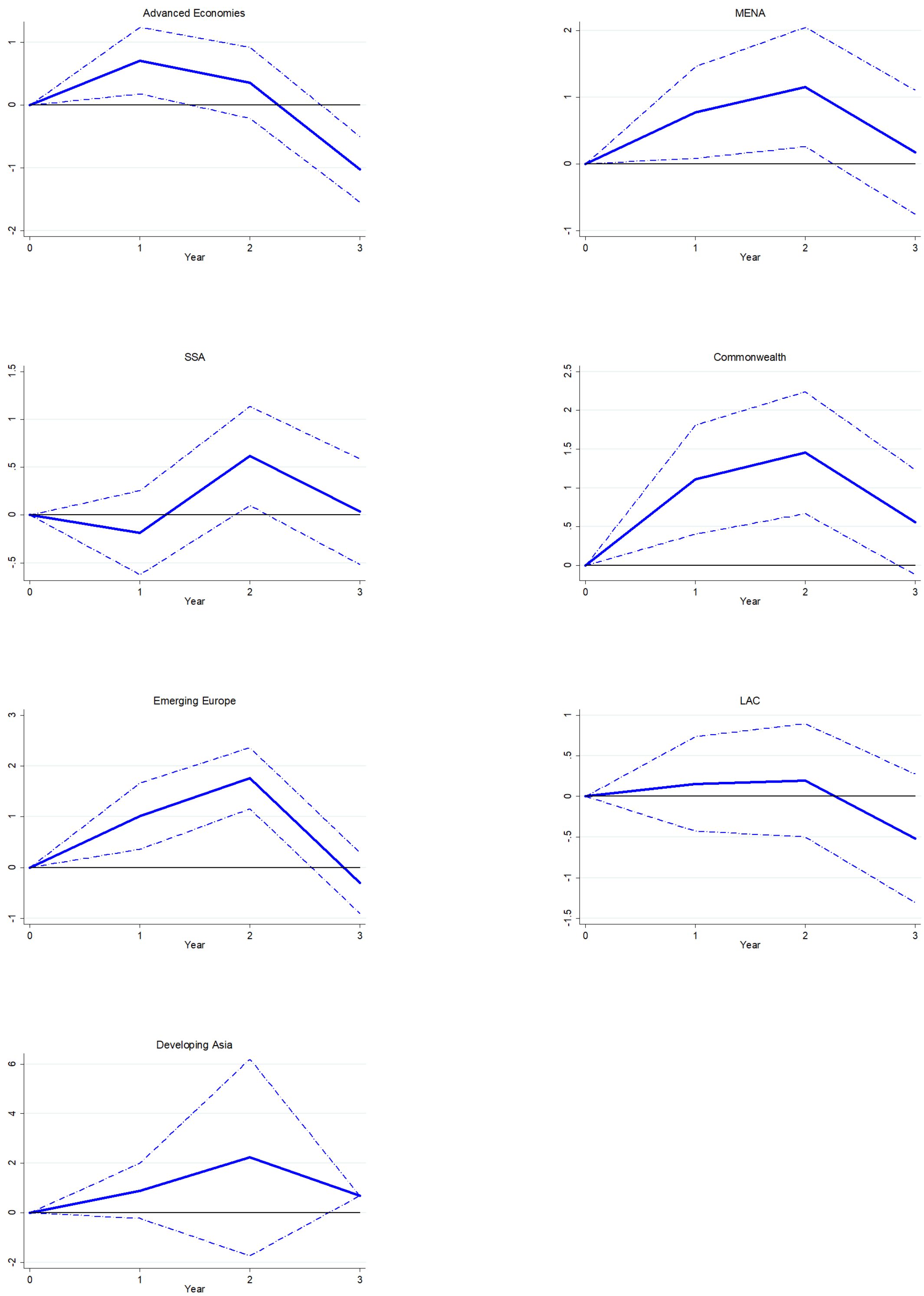
As we can see in Figure A.5, on average and according to exchange rate regime, there is no significant effect suggesting a compensation between positive and negative shocks impacts. Results are similar to the asymmetry with respect to shocks magnitude (Figure B.5). We also notice that low magnitude shocks effects are as important as high magnitude. Furthermore, due to symmetric result, we can note that floating exchange rate regime will be more advantageous because it does not lead to the reduction in maize producers incomes or consumers power purchase.

6.6 Country groups

6.6.1 Symmetric effects

In order to verify our results, we also test the dynamic response of maize producer price to a positive bioethanol price shocks according to country group. As previously assumed, the results indicate a non-significant effect in Sub-Saharan Africa and Middle East North Africa. We note that these results are consistent with those observed in low- and middle-income countries, as most of these countries are clustered in these two groups of income.

Furthermore, responses in Emerging Europe and Advanced Economies are similar to



Dashed lines represent the 95 percent confidence intervals.

Figure 15: Dynamic responses of Maize according to country group

those in high-income countries. These results are therefore fair because most of them are high-income countries whose prices are liberalized relative to those in sub-Saharan Africa or Middle East North Africa.

On the other hand, we have no effect for countries belonging to the group of Latin America and the Caribbean and Developing Asia. As mentioned in the static analysis, the effect observed in Developing Asia is linked to food export barriers implemented by the governments of these countries as most of them depend on imported food. As a result, an increase in the world price of bioethanol does not have the same magnitude in these countries compared to the Emerging countries of Europe or Advanced Economies.

6.6.2 Asymmetric effects

For most of the countries groups (Figure A.6) the asymmetry results in shock direction are not significant. This finding precisely concerns the Sub-Saharan Africa, Latin America and the Caribbean and Middle East and North Africa, and are comparable to asymmetry in shocks direction obtained for low- and middle-countries (Figure A.1). The same result applies for Emerging Europe, while in Advanced Economies the effect becomes negative and significant from the third year. For Developing Asia and Commonwealth, the impact is negative and significant until two years before becoming not significant.

The asymmetry in shock magnitude (Figure B.3) shows a compensation between high and low magnitude shocks impacts for Advance economies, Sub-Saharan Africa, Latin America and the Caribbean and Middle East and North Africa. However, for Emerging Europe and Developing Asia, the impact becomes positive and significant respectively after one and two years. Otherwise, in the Commonwealth, there is on average positive and significant effect until the third year where it is not significant.

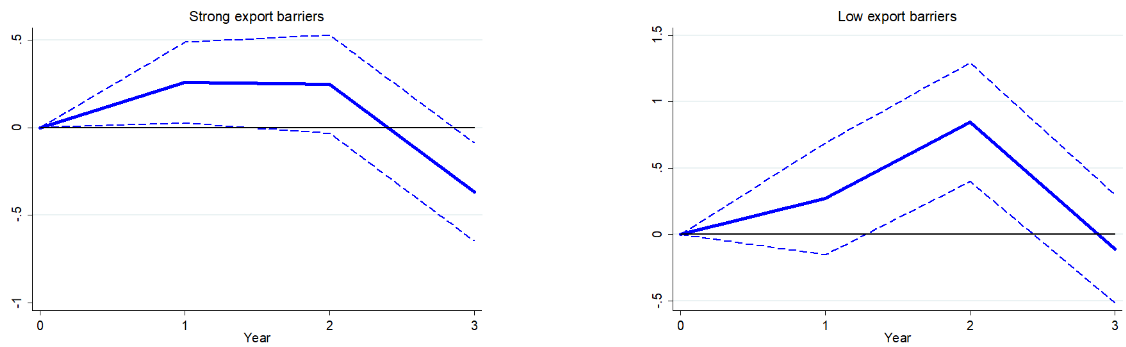
6.7 The role of public policies

Depending on public policy, bioethanol world price shocks may have different impacts on maize producer price; it may be totally, partially or not at all reflected on price. Thereby, the impulse response of maize can differ according to the kind of policies implemented in a country that could influence the dynamic bioethanol price pass-through on maize producer price (Zhang et al., 2010; Ivanic et al., 2012).

6.7.1 Symmetric effects

As mentioned in the empirical method, we could consider pass-through coefficients as a proxy of public policies precisely export policies. Hence, we categorize countries according to the level of pass-through computed at the beginning of our study period[5]. Countries are, then, classified into high and low level of pass-through, by comparing the coefficient obtained in 2001 to the median value obtained by considering the full study period. Figure 16 shows that for countries with a low level of pass-through, which means that export barriers are strong, there is no significant effect; while we observe the reverse effect for countries with a high level of pass-through. Due to strong export barriers, the effect of bioethanol price shocks is not entirely transmitted to maize price as it is the case when export barriers are low.

[5]We consider the beginning of our study period rather than the average of pass-through coefficients computed during the full study period because government can take some measures to adapt to the shocks. Therefore, by focusing on 2001, we can rest assured that even if a measure had been taken as a result of the change observed between 2000-2001, it would be less important than which could have been taken over the entire study period.



Dashed lines represent the 95 percent confidence intervals.

Figure 16: Dynamic responses of Maize according to public policies

6.7.2 Asymmetric effects

Figure A.7 represents the asymmetry in shocks direction according to the role of public policies. Thus, results display that for countries with low export barriers, the effect is not significant the first year, but from the second year it becomes negative and significant. However, in countries with strong export barriers, the net effect is nil, meaning that these countries are more resilient to shocks effect. Hence, we could conclude that on average there is no impact on food security due to the compensation between positive and negative shocks effects.

Furthermore, the analysis of asymmetry with respect to shocks magnitude (Figure B.7) shows on average a positive and significant impact from the first year in countries with low export barriers, as well as countries with strong barriers. However, the effect intensity is more important in countries with low barriers than that with strong barriers.

According to symmetry and asymmetry results, export barriers seem to be more advantageous for consumers through the increase in maize access. As this measure can not succeed in the long-run, to reach food security goal, we need to find the optimal level of export barriers in order to increase consumers power purchase without reducing producers income.

7 Concluding remarks

In a context of food energy deficiency, it is important to find some alternative sources of energies. Among these alternative sources we can use biofuels. However, they are produced with agricultural crops, which according to some studies could lead to high food prices and high food insecurity.

Following these studies, this paper aims at assessing the dynamic responses of food prices mainly maize price to the world bioethanol price shocks, through local projection. Before proceeding to the dynamic analysis, the static analysis displays that the episodes of increase in bioethanol world price were accompanied by a raise in the pass-through coefficients. These results have been corroborated by those of the dynamic analysis, showing us, in general, an increase in the world price of bioethanol also leads to a raise in maize producer price. However, this impact disappears three years after the shock and its intensity varies according to the level of income, trade openness, maize production, country groups, exchange rate regime net trade of maize, or public policies. Thus, due to some government policies, the effect is higher in high-income countries or those with high levels of trade openness compared to those with low levels of trade openness or low-income.

Due to some results found during the static analysis and the fact that biofuel market is oligopolistic, we analyze the asymmetry with respect to shocks direction and shocks magnitude. Findings indicate a compensation between positive and negative shocks effects, suggesting that there is no negative effect on food security, more precisely on food access. However, the impact of high shocks magnitude tends to be greater than that of low shocks magnitude.

As robustness checks, we add additional predictors variable such as the world crude oil price and other world cereal prices, we also only consider the period prior to 2007-2008 crisis and the consumer price index as dependent variable. We find similar results are those obtained in the result section, displaying that findings are robust.

We can conclude that bioethanol could be promoted in both developing and developed countries in order to reach the goal of energy security, because in the short-run, bioethanol does not assign food access to consumers and does not penalize producer income. Otherwise, this paper can be extended by using a set of commodities entering in bioethanol production and by using consumer prices when data will become easily available.

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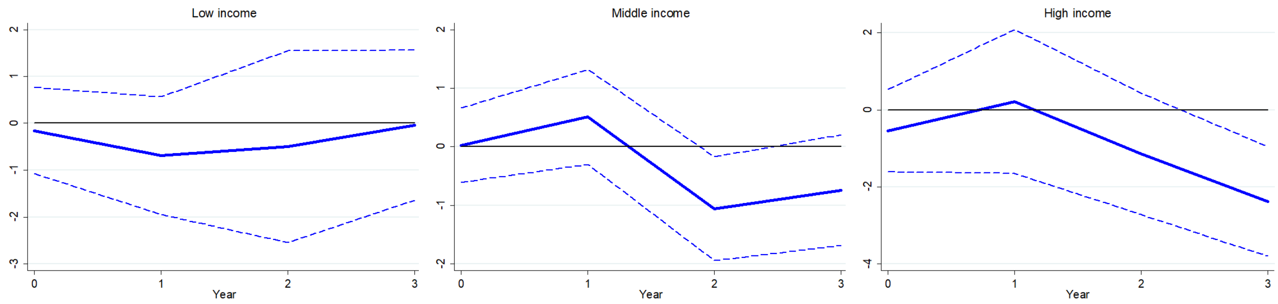
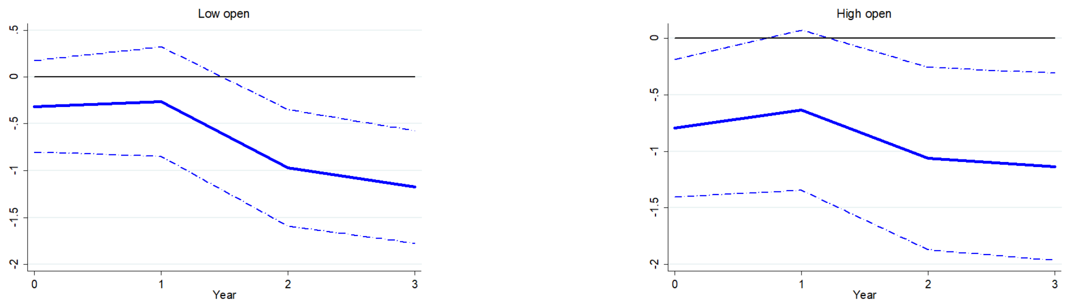
SUPPLEMENTARY MATERIAL

Appendix A. Asymmetry with respect to shocks direction: some heterogeneities



Dashed lines represent the 95 percent confidence intervals.

Figure A.1: Asymmetry in shocks direction according to the level of income

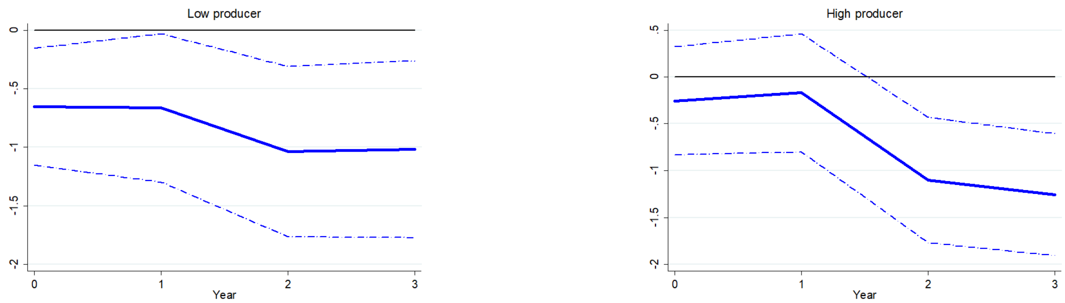


Dashed lines represent the 95 percent confidence intervals.

Figure A.2: Asymmetry in shocks direction according to the level of trade openness

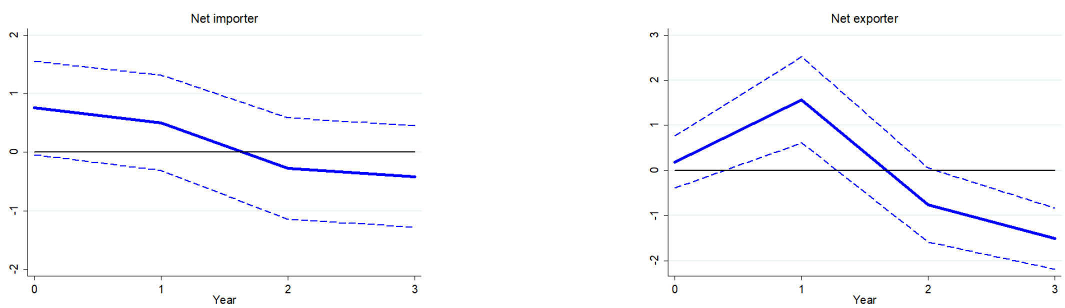
Appendix B. Asymmetry with respect to shocks magnitude: some heterogeneities

Appendix C. Supplementary graphs and tables



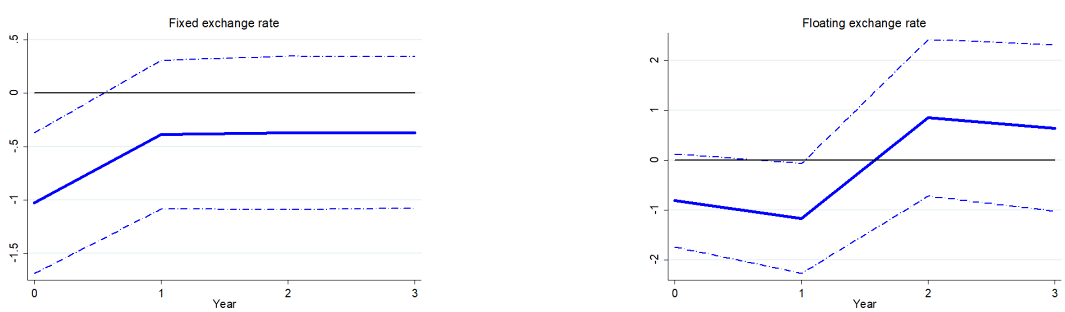
Dashed lines represent the 95 percent confidence intervals.

Figure A.3: Asymmetry in shocks direction according to the level of maize production



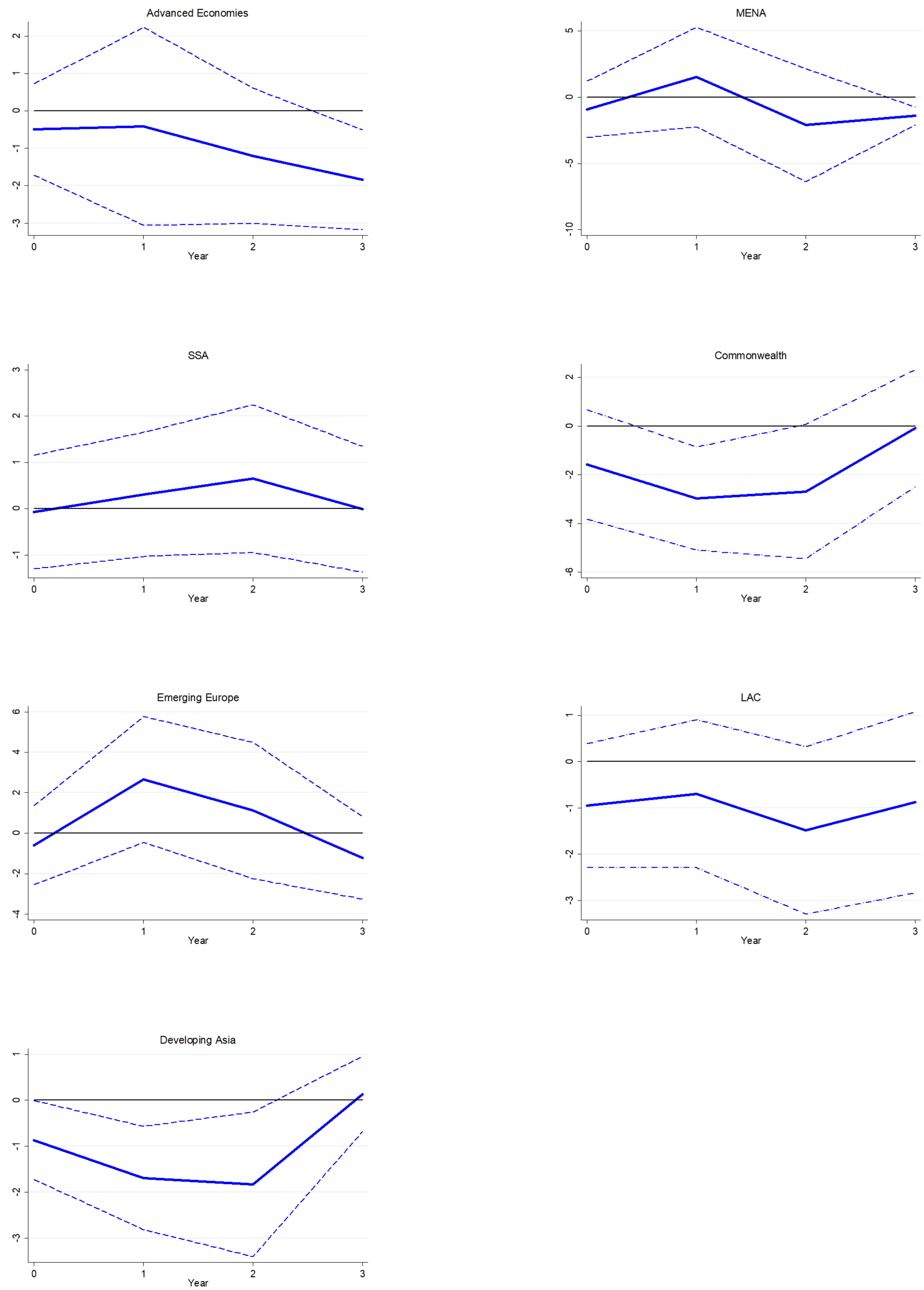
Dashed lines represent the 95 percent confidence intervals.

Figure A.4: Asymmetry in shocks direction based on net maize trade



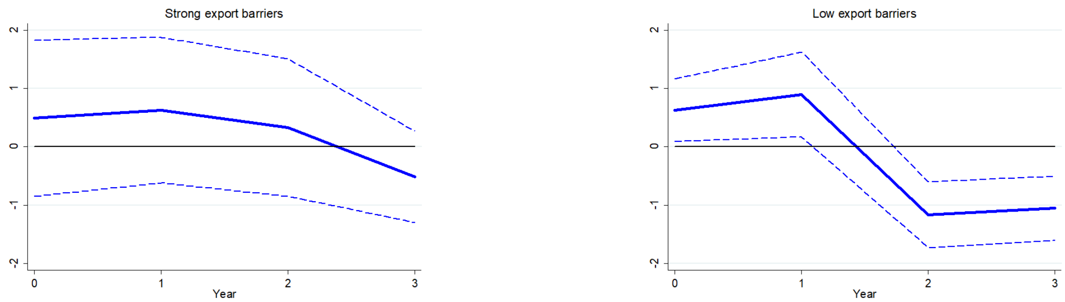
Dashed lines represent the 95 percent confidence intervals.

Figure A.5: Asymmetry in shocks direction according to the level of exchange rate regime



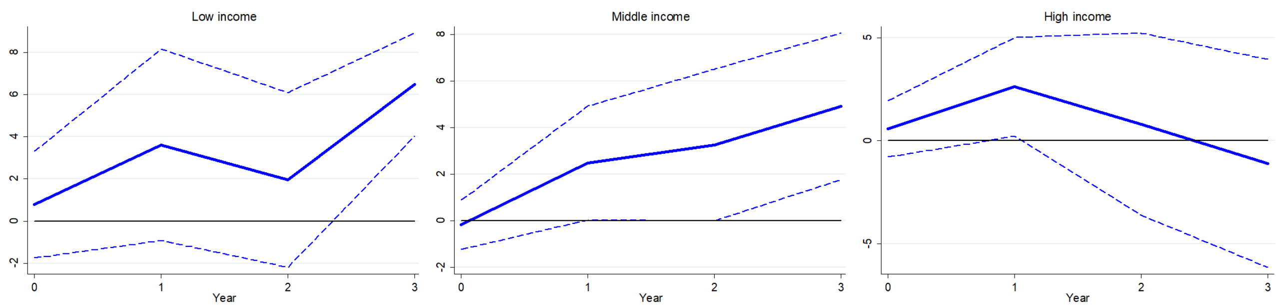
Dashed lines represent the 95 percent confidence intervals.

Figure A.6: Asymmetry in shocks direction according to country groups



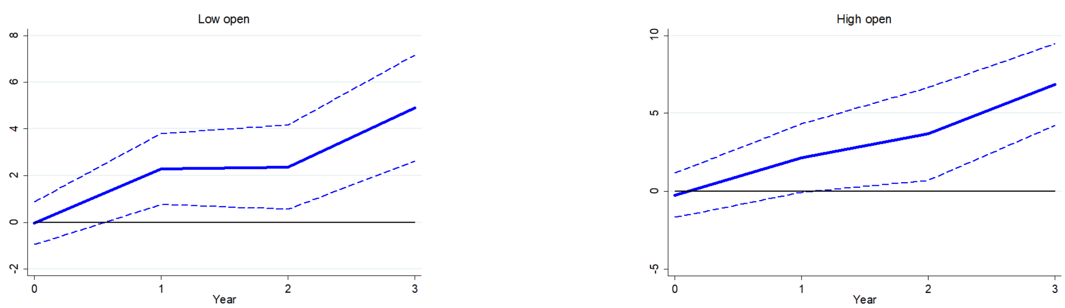
Dashed lines represent the 95 percent confidence intervals.

Figure A.7: Asymmetry in shocks direction according to public policies



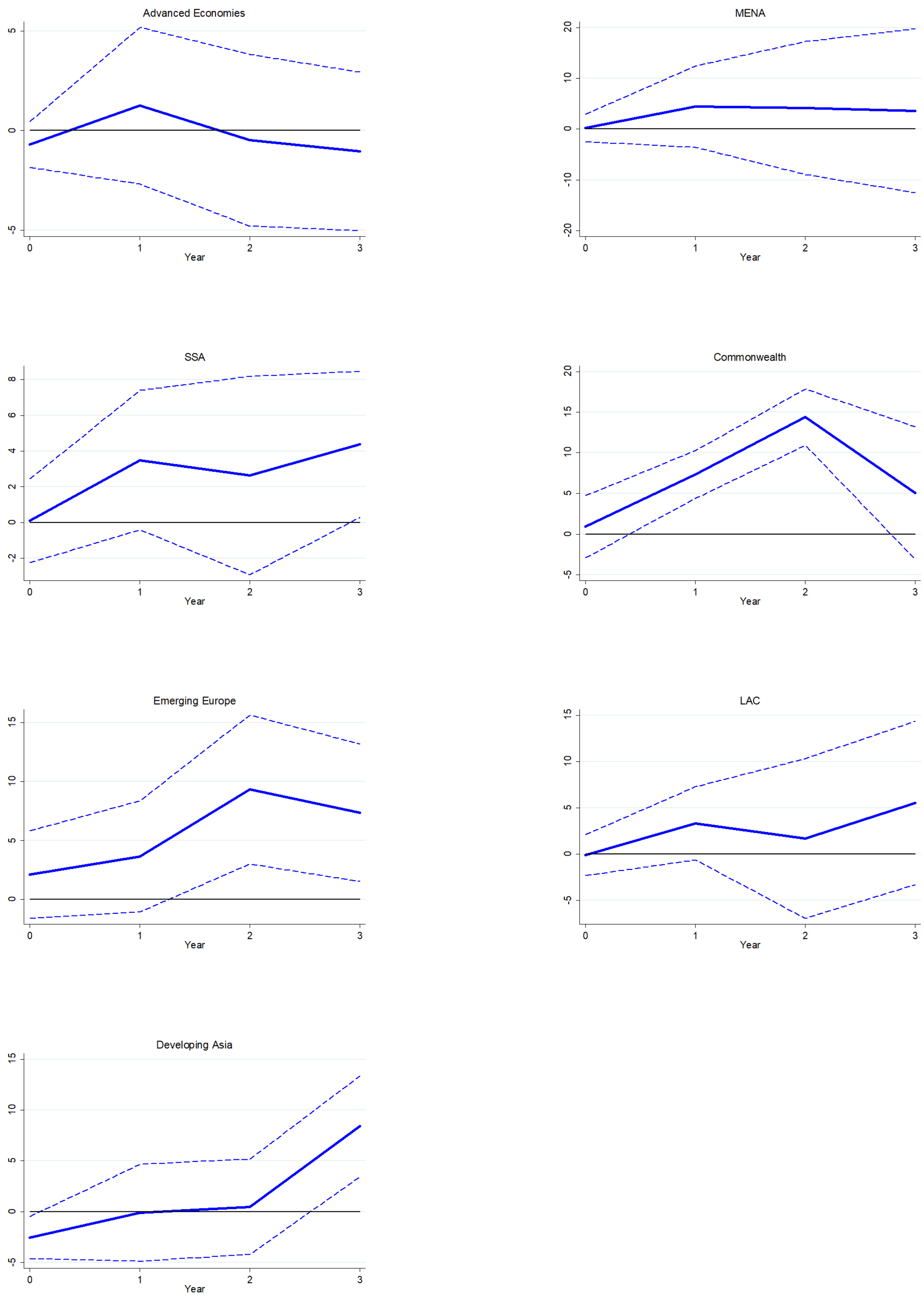
Dashed lines represent the 95 percent confidence intervals.

Figure B.1: Asymmetry in shocks magnitude according to the level of income



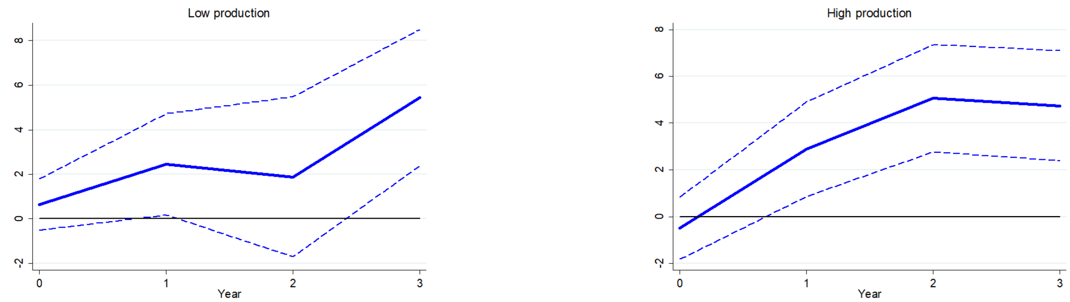
Dashed lines represent the 95 percent confidence intervals.

Figure B.2: Asymmetry in shocks magnitude according to the level of trade openness



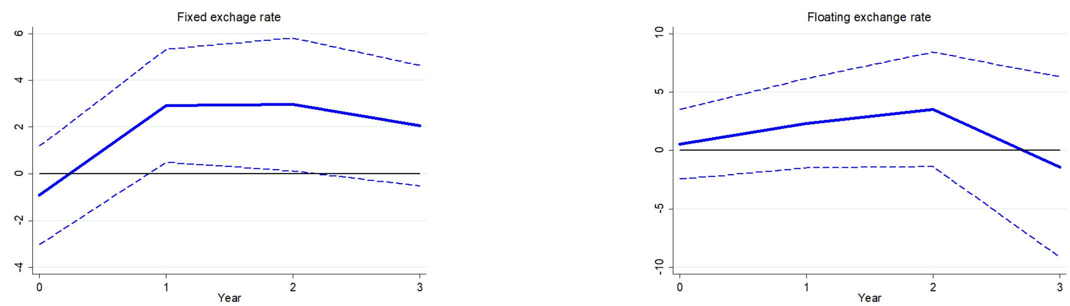
Dashed lines represent the 95 percent confidence intervals.

Figure B.3: Asymmetry in shocks magnitude according to country groups



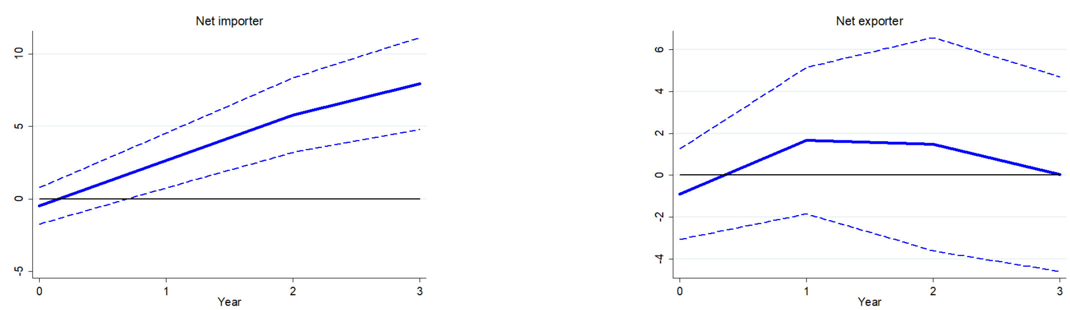
Dashed lines represent the 95 percent confidence intervals.

Figure B.4: Asymmetry in shocks magnitude according to the level of maize production



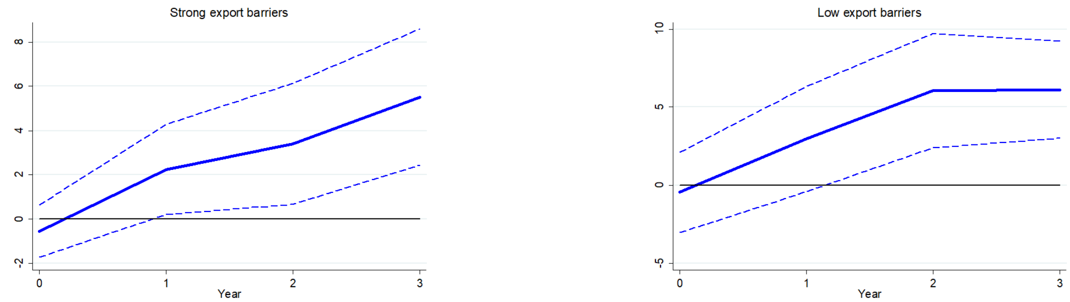
Dashed lines represent the 95 percent confidence intervals.

Figure B.5: Asymmetry in shocks magnitude according to the level of exchange rate regime



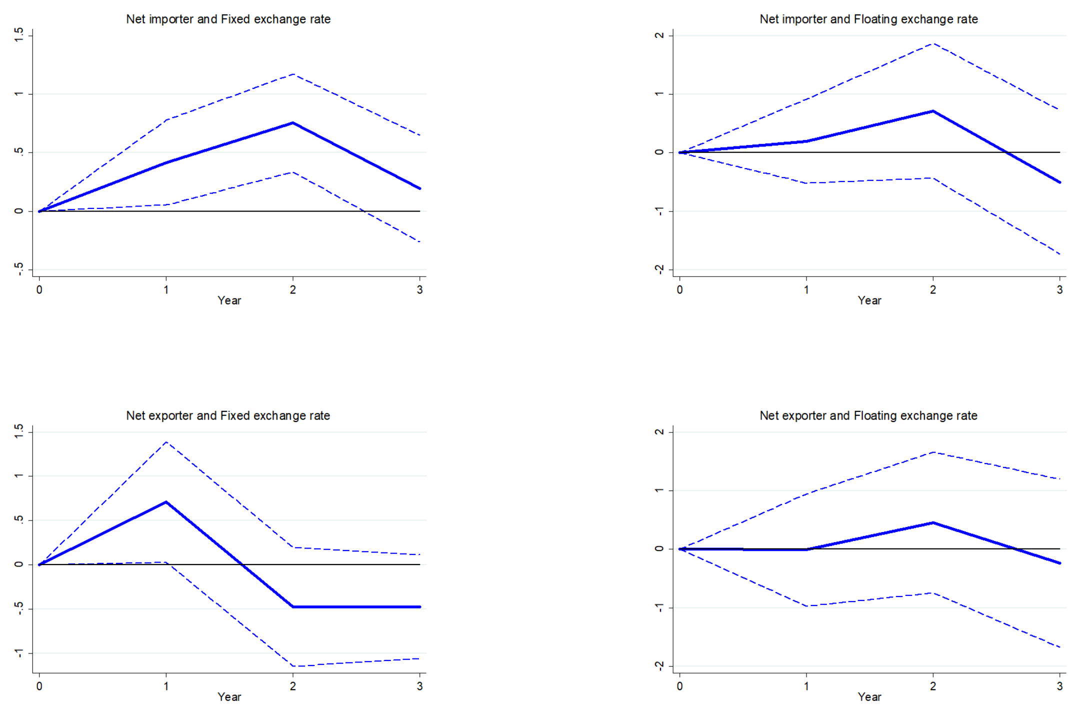
Dashed lines represent the 95 percent confidence intervals.

Figure B.6: Asymmetry in shocks magnitude based on net maize trade



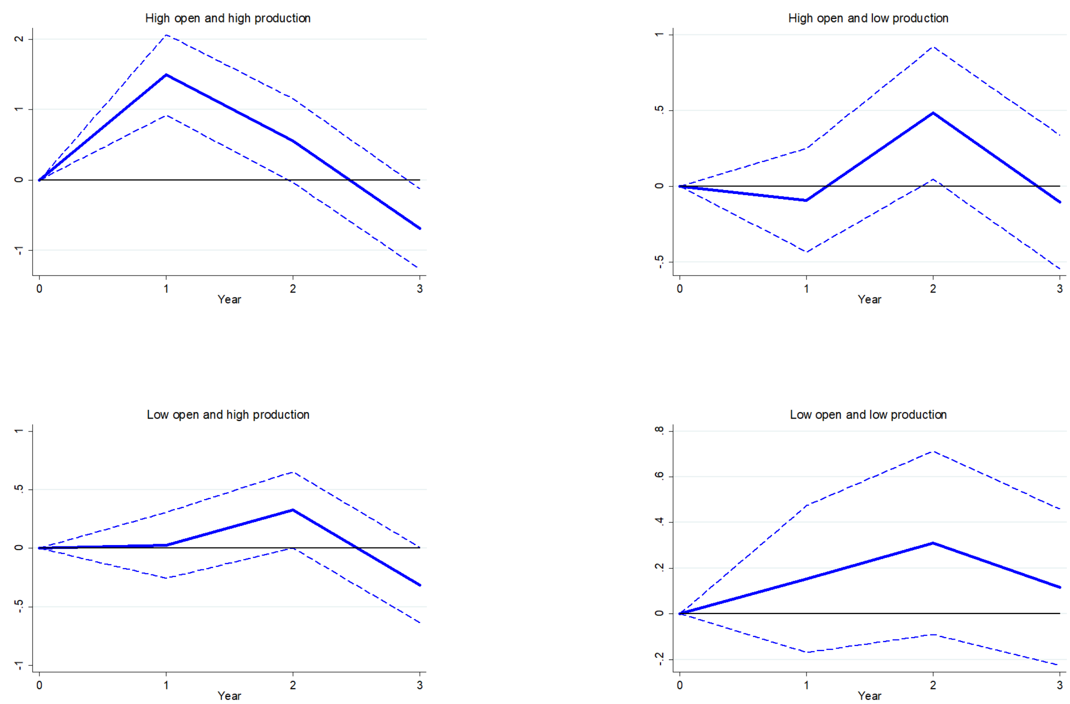
Dashed lines represent the 95 percent confidence intervals.

Figure B.7: Asymmetry in shocks magnitude according to public policies



Dashed lines represent the 95 percent confidence intervals.

Figure C.1: Dynamic response of maize price by the level of net maize trade and exchange rate regime



Dashed lines represent the 95 percent confidence intervals.

Figure C.2: Dynamic response of maize price according to the level of maize production and trade openness

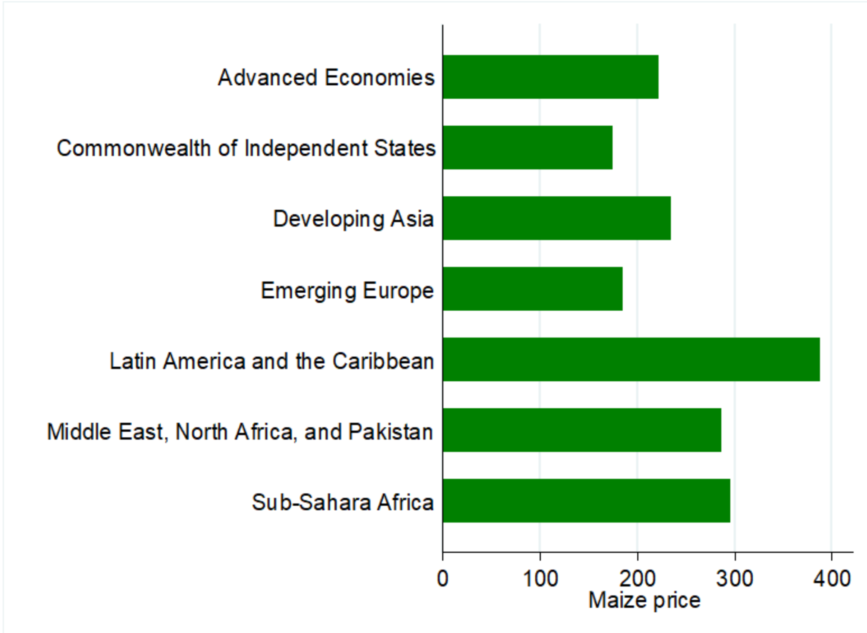


Figure C.3: Average maize price (US dollars per tonne)

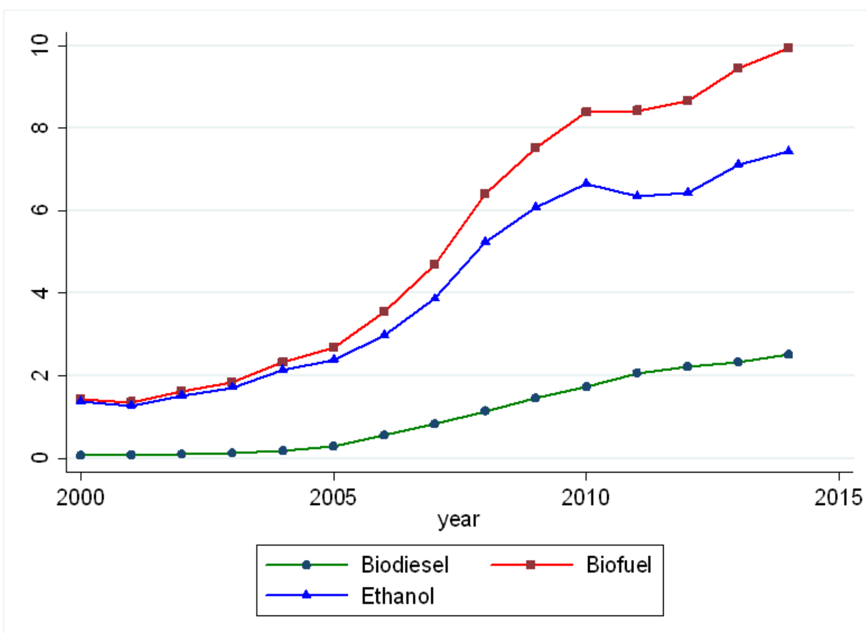


Figure C.4: Biofuel consumption

Table 3: Countries

Argentina	Ecuador	Lithuania	Senegal
Australia	Egypt, Arab Rep.	Luxembourg	Serbia
Austria	Ethiopia	Malawi	Slovak Republic
Azerbaijan	Fiji	Mali	Slovenia
Belarus	France	Mexico	South Africa
Bolivia	Gambia, The	Moldova	Spain
Botswana	Germany	Morocco	Sri Lanka
Brazil	Greece	Mozambique	Switzerland
Bulgaria	Hungary	Nepal	Tanzania
Burundi	Indonesia	New Zealand	Thailand
Canada	Iran, Islamic Rep.	Nigeria	Togo
Cape Verde	Israel	Panama	Turkey
Chile	Italy	Paraguay	United States
China	Jamaica	Peru	Uruguay
Colombia	Jordan	Philippines	Venezuela, RB
Congo, Rep.	Kazakhstan	Poland	Vietnam
Costa Rica	Kenya	Portugal	Yemen, Rep.
Croatia	Kyrgyz Republic	Romania	
Czech Republic	Lao PDR	Russian Federation	
Dominican Republic	Lebanon	Rwanda	