Oil price effects on land use competition: An empirical analysis

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Abstract

The increasing use of food commodities for biofuel production may intensify the competition for arable land. To test this hypothesis we analyze the effects of crude oil prices on prices, areas and quantities of selected food commodities empirically. On the world level the crude oil price Granger causes an increasing area use for the production of maize, soybean oil, sugar and wheat. For the U.S., we find that the maize price is the key variable influencing the total area used for cereal production. In Indonesia and Malaysia the palm oil price has effects on the cultivated area for rice.

***Keywords**: food commodity prices, crude oil price, land use change, biofuel, Granger causality, cointegration*

1. Introduction

The production of biodiesel and ethanol increased markedly during recent decades and it is likely that this will continue or even accelerate in the future. Biofuel has become an energetic alternative of growing importance due to limited supply of fossil fuels in particular against the background of historically high crude oil prices. Rising demand from upcatching developing countries will further enhance the importance of alternative fuels. This has the potential to reduce greenhouse gas (GHG) emissions but the production of biofuel is still associated with high financial costs (Peters, Thielmann 2008). Moreover, rising demand for energy crops is likely to increase competition for arable land, implying the risk of further pressure on food commodity prices and deforestation.

The relations between crude oil prices, food commodity prices and land use competition have been analyzed in several studies, mainly empirically. The overall results indicate that there are effects from crude oil prices to food commodity prices but their strength varies between commodities and time periods. In addition, several studies argue that a causal link between biofuel production and land use change exists. Most of these studies are based on simulations with partial or general equilibrium models.[1]

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[1] See Hertel et al. (2009a) for a detailed overview of CGE models. CAPRI and GLOBIOM are eaxmples of PGE models recently used for policy evaluation (Britz and Hertel 2011; Havlík et al. 2011).

Within these models a direct land competition effect and an indirect displacement effect are distinguished. Indirect land use change (iLUC) [2] may lead to deforestation because oil crops replace cereals, which have to move to forested and other uncultivated grounds (Searchinger et al. 2008). However, the results from structural models depend heavily on assumptions on the causal structure e.g. for land supply or land allocation (Hertel, et al. 2009a) and the proper specification of coefficients (Searchinger et al. 2008).

In this paper, we analyze empirically the effects of commodity price movements on areas harvested. We use these changes in the areas under cultivation to draw conclusions on direct and indirect land use change even though it is not exactly the same. Similar to studies on the oil-food price co-movement, we perform Granger causality tests as well as cointegration tests. Our results reveal that controlling for global economic activity, crude oil prices Granger cause the prices of maize and wheat. Moreover, we find significant effects from crude oil prices to the area harvested of maize, soybean oil, sugar and wheat. The effect on the area of wheat can be regarded as evidence of indirect land use competition. However, for other important input factors for biofuel production such as palm oil we find no Granger causal effects. As indicated by impulse responses based on estimated VAR models most of these effects are positive. We thereby fail to find a direct displacement effect of land use competition.

In addition, we try to estimate the effects of input factors for biofuel production on prices, quantities and areas harvested of selected commodities, using a price index of vegetable fats and oils as a proxy. Our results suggest that an increase of the fats and oils prices generates an indirect effect on areas and quantities of the main alimentation crops. We conclude that on a world aggregated level there seems to be sufficient waste arable land so that there is no direct competition between oil crops and cereals. Nevertheless, the use of areas harvested for the production of biofuel seems to lead to indirect land use change (iLUC) because the acres of most of the analyzed crops increase.

To gain further insights in the direct and indirect effects of oil prices on land use change we analyze crude oil price effects as well as the effects of maize price changes in the US and palm oil price changes in Indonesia and Malaysia on areas harvested in more detail. Our results reveal that the oil price influences the area and quantity of cereals and maize in conjunction with an accelerating second round effect from maize prices on the prices of cereals and wheat. This substitution effect is caused by the use of a high percentage of U.S. maize in the ethanol production.[3] Additionally, for the two main palm oil[4] producers Indonesia and Malaysia – accounting for 85% of palm oil production (FAO 2012) – we reject a first round effect from oil to rice areas but we find an effect from the palm oil price on the area and quantity of rice.

The outline of the paper is as follows: Section 2 summarizes the main findings of the recent literature. Section 3 presents the data and the empirical methods used. The results are discussed in section 4. Section 5 concludes.

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[2] The iLuc concept describes the conversion of cultivated or uncultivated areas to cropland due to a displacement of cropland for the cultivation of oil crops (Kim and Dale 2011).

[3] The proportion of US-maize used for ethanol production is already above 25% (USDA 2012).

[4] Palm oil is the most important edible oil. A share of more than 20% is used for industrial production. The largest share is used for biodiesel production (USDA 2010).

2. Literature Review

Empirical findings on price linkages between the crude oil and food commodities are ambiguous. Rosegrant (2008) on the one hand, claims that food prices and fuel prices are highly correlated. He states that from the pre-crisis commodity price hike 2000-2007 as portion as high as 30% of the grain price increase was accounted for by biofuel demand. On the other hand, Campiche et al. (2007) reject a significant correlation between the prices of crude oil and corn using weekly data from 2003-2007. However, they do find a significant relation between crude oil and soybeans changing from negative to positive for the periods 2003-2006 and 2007, respectively. A cointegration test reveals a common trend with oil prices for both corn and soybeans in the period 2006-2007. Muhammad and Kebede (2009) also claim that maize and oil prices are highly connected and the price of maize has spillover effects to related agricultural products. Saghaian (2010), in contrast, finds a strong correlation between commodity and oil prices in his monthly dataset for 1996-2008. However, using pairwise Granger causality tests, he finds bidirectional links between ethanol and corn and unidirectional Granger causation from wheat and soybean prices to ethanol.

Focusing on edible oils, Yu et al. (2006) use Granger causality tests and impulse responses to analyze the link between the prices of these oils and the price of crude oil. They fail to find a significant effect of crude oil prices on the main vegetable oils used for biofuel production.

However, to answer the question whether there are direct effects from crude oil to commodity prices it is important to control for other factors. Harri et al. (2009) stress the importance of exchange rates. Using monthly data from 2000-2008, they find several cointegration relationships linking commodity prices, oil prices and the exchange rate. This finding fits into the discussion about excess co-movement triggered by Pindyck and Rotemberg (1990). With this term these authors underline the empirical finding that a co-movement exists between commodity prices that cannot be explained by underlying common macroeconomic factors.

This review illustrates that there is neither a consensus about the empirical significance nor about the likely direction of the effects between crude oil and food commodity prices. To analyze the impact of crude oil prices on land use it is therefore necessary to test the relation between crude oil and commodity prices in the dataset before proceeding with analyzing the effects on harvested areas. This empirical test of the effects on harvested areas is particularly important as most of these analyzes are performed in computable equilibrium models.[5] Agricultural computable partial equilibrium (CPE) models are specialized in the spatial dimension and achieve very robust supply responses (Britz and Hertel 2011). Price dynamics of land use are endogenously determined and available in great detail. Recently, specific policy measures concerning land-use change, GHG emissions and related topics were evaluated with help of CPE models like CAPRI or GLOBIOM (Britz and Hertel 2011; Havlík et al. 2011). Whereas CPE modes ignore the other parts of the economy, the entire economy is embedded in com-

[5] For a general discussion of different modeling approaches in agricultural displacement and deforestation see Angelsen (1999) and Hertel et al. (2009a). Sands and Kim (2009). Hertel el al.(2009b) and Reilley and Paltsev (2009) more specifically focus on modeling land use change in the context of climate policy and GHG emission

putable general equilibrium (CGE) models. However, the results from these studies depend to a large extent on the way land use is modeled as an input for production, on how new land available is introduced into the production process and finally on how the biofuel sector is modeled as a driving force of land use change and deforestation (Hertel et al. 2009a).

Several general equilibrium models are applied in the context of biofuel production and its impact on commodity prices: For example Gurgel et al. (2007) show that a substantial increase in land required for cellulosic biofuel production only causes a 5 to 10% increase in agriculture prices in the long run. Elobeid et al. (2007) investigate the effect of U.S. ethanol production and find that an expansion of the cultivation area for corn will be needed in order to satisfy the rising demand of the corn-ethanol industry. The computed 21% rise in corn acres mostly crowds out soybean production meanwhile it triggers the wheat price to rise about 20%.

Applying a general equilibrium trade model (MIRAGE) Al-Riffai et al. (2010) demonstrate that a positive biofuel demand shock from the U.S. and EU has diverse beneficial impacts: it reduces GHG emissions, increases food prices only modestly and it raises the export values of agricultural crops. A closer analysis reveals a displacement effect of cropland taking over pasture in Brazil.[6] Searchinger et al. (2008), in contrast, focus on the iLUC effect in a global model and find indirect effects on GHG emissions from the conversion of forest or grassland to oil crop acres. A recent study of Andrade et al. (2010) combines the analysis of both direct and indirect effects in a partial equilibrium model context. A direct land competition effect is modeled with ethanol crops replacing food production and forested areas. Increasing food prices, thereafter, lead to further deforestation and displacement of other crops, finally resulting in an equilibrium with higher food prices, less area harvested with food crops, and deforested areas. However, Murphy et al. (2010) argue that research and development activities may lead to higher productivity in biofuel production and reduce the speed of land use change.

The variety of model results underlines the necessity to investigate the direct and indirect effects of crude oil price and food commodity price changes on land use change empirically. In addition, Kim and Dale (2011) argue that these models rely on assumptions that have not always proven to hold in economic reality. These authors use a correlation test to investigate iLUC in the US. They attribute their neglect of causality between changes in cropland for corn and biofuel production to either the non existence of iLUC or to flaws in their methodology.

3. Methodology and data

To analyze the link between crude oil prices and land use change we exploit the Food and Agriculture Organization's (FAO 2012) production database using annual data from 1975-2009. Additionally, we obtained price data from the World Bank's (2011) Commodity Price Database (Pink sheet). From this database we use data of area harvested,

[6] Micro data seem to confirm that additional oilcrops in Brazil displace pasture and not forested area. However, there presumably is an indirect effect of pasture replacing former rainforest – deforestation (Barona et al. 2010; Walter et al. 2008; Rathman et al. 2010). Additionally, disaggregated satellite data can be obtained from the Brazilian space research institute (INPE).

quantity produced and the prices of maize, palm oil, rice, soybean oil, soybeans, sugar, sunflower oil, wheat, an aggregate of cereals and a price index of fats and oils. The price index "fats and oils" from the Pink Sheet is an index of vegetable fats and oils.[7] We use it as an indicator for the price of biodiesel which should be related to ethanol prices. In addition, to measure global economic activity we use real US GDP per capita.[8] All series are transformed in natural logs.

In order to establish the causal relationships between these variables under relatively weak assumptions we employ a vector autoregressive (VAR) model. We estimate this model with the level of the crude oil price index and the level of prices, quantities or areas of selected food commodities, respectively. In addition, we estimate a three variable VAR controlling for the level of real US GDP per capita. In total we get 122 estimated VAR models. In advance, we perform an Augmented Dickey Fuller (ADF) test to establish the order of integration of each time series. Depending on the time series properties of the variables we tested against a model with a stationary process or a deterministic trend. If the ADF confirms nonstationarity, the first difference of the variable is tested to find its order of integration. We take the median of the following Information criteria to determine the lag length of each VAR: sequential modified LR statistic (LR), Final Prediction Error (FPE), Aikaike information criterion (AIC), Schwarz-information criterion (SC), Hannan-Quinn information criterion (HQ). We limit the maximum lag length to four years.

After specifying the models we perform cointegration tests, Granger causality tests and calculate impulse response functions. While these tests are related each of them highlights a specific feature of the relation between the variables. Then, we start the empirical exercise by testing for cointegration between the crude oil price and the prices, quantities and areas of selected food commodities in order to analyze the long run co-movements. For this purpose we use the Johansen trace statistic. In addition, we test for Granger causality between the same variables. This test indicates the lead-lag-relationships between the variables. However, this test does not specify whether the effect is positive or negative. To get this information we compute impulse response functions for an oil price shock from the estimated VAR model. This approach allows us to include food commodity variables without a unit root. These results account for the interactions with world economic activity and offer information about the significance of the relationships throughout time.

4. Empirical Results

The results of the ADF tests are reported in Table 1. With regard to worldwide areas and prices we find that most series have a unit root. Exceptions are areas and prices of sunflower oil and sugar at the five percent level. For quantities the test rejects the unit root at least at the five percent level for cereals, maize, soybean oil and sugar. Regarding Indonesian and Malaysian areas and quantities of palm oil and rice we find that all se-

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[7] The Pink sheet fats and oils index contains prices of coconut oil, copra, groundnut oil, palm oil, palmkernel oil, soybean meal, soybean oil and soybeans.

[8] As a measure of economic activity we use U.S. GDP because world GDP is only available from 1980 on.

Table 1: *ADF test results*

	Price	Area	Quantity
World			
Crude oil	-1.35	--	--
Fats and Oils	-1.81	--	--
Cereal	-2.81	-2.39	-4.25**
Maize	-2.89	-2.74	-5.19***
Palm oil	-2.03	-2.97	-3.21*
Rice	-2.44	-3.29*	-2.13
Soybean oil	-2.63*	-2.22	-4.10**
Sunflower oil	-4.88***	-3.59**	-2.38
Sugar	-3.02**	-4.44***	-4.64***
Wheat	-3.01	-3.32*	-2.5
Indonesia & Malaysia			
Palm oil	--	-1.69	-2.77
Rice	--	-3.05	-1.94
United States			
Cereals	--	-4.63***	-5.99***
Maize	--	-4.52***	-6.12***
Rice	--	-3.04**	-4.89***
Wheat	--	-3.48*	-3.99***

*, **, *** indicate significance at the 10%, 5%, 1% level.

ries are non-stationary. In contrast, for the US the test rejects a unit root for all series under consideration. These results reduce the number of variables for the cointegration analysis but they impose no restrictions on the Granger causality tests and the calculation of impulse response functions.

The results of the cointegration tests (Table 2) allow us to draw conclusions about the link between crude oil prices, food commodity prices and cultivated areas. It is important to know whether the correlation is established by a long-run common trend or a short-term co-movement driven by the business cycle or other short-run developments. We find strong evidence for a common stochastic trend for soybean area and oilpalm area as well as for the prices of rice and wheat and the quantities of palm oil. In addition, we find evidence at the ten percent significance level for the maize price as well as the quantities of sunflower oil and rice. These results indicate a long-run co-movement between crude oil prices and some food commodities that are important for biofuel production. However, whether oil prices are related to prices, quantities or the area varies depending on the food commodity. Moreover, the common trend of oil price and the price and quantities of rice could indicate an indirect effect of oil price movements.

Table 2: *Johansen cointegration test results for food commodity variables with crude petroleum price*

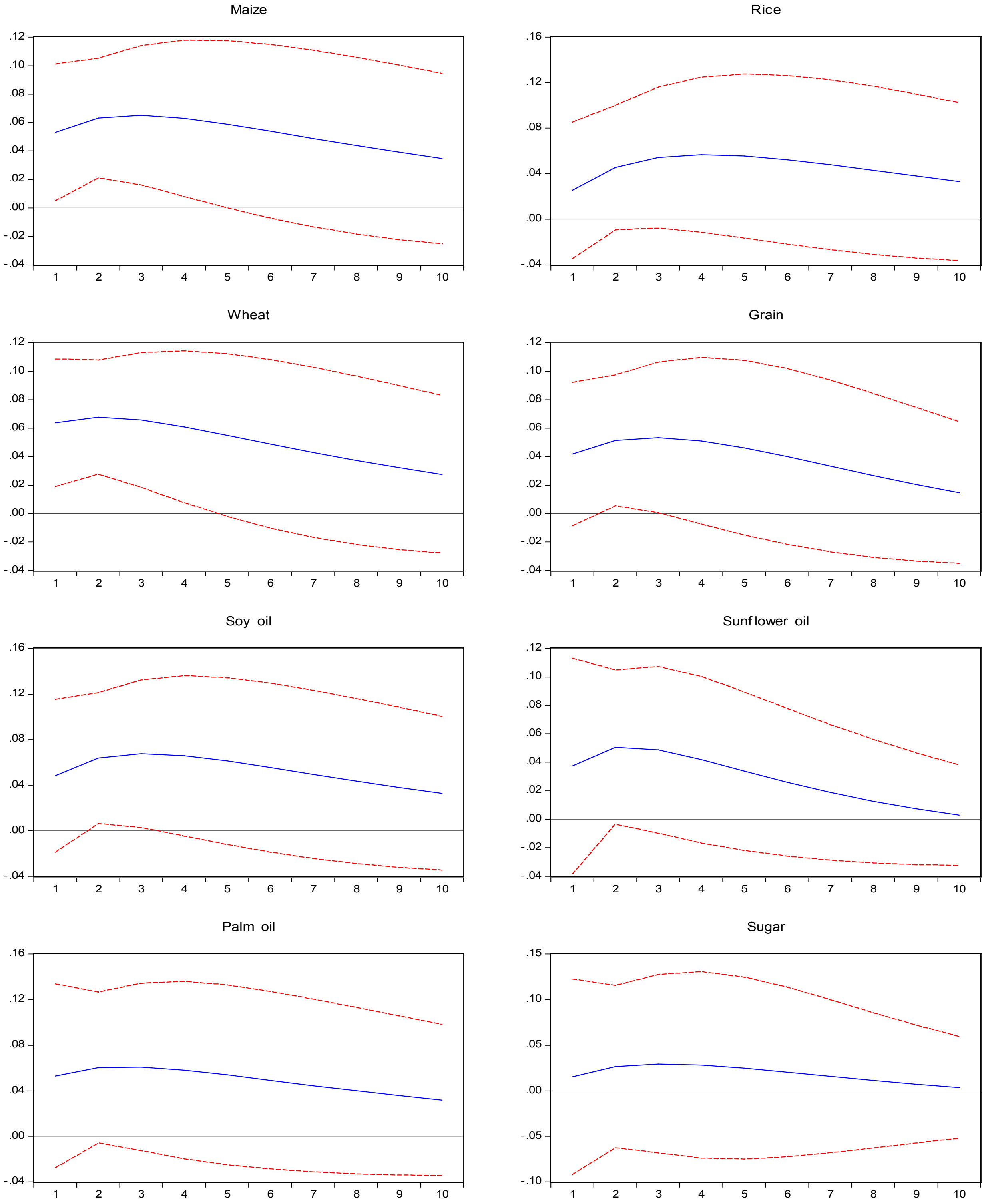
	None CI	At most 1 CI
Prices		
Fats and Oils	6.40	1.30
Cereals	15.47**	2.89*
Maize	14.18*	2.37
Palm oil	8.41	1.75
Rice	15.53**	1.16
Soybean oil	12.68	1.34
Wheat	16.86**	2.40
Area		
Cereals	9.29	2.79
Maize	6.92	2.49
Oil palm	25.07***	2.13
Rice	6.67	2.68
Soybean	22.12**	3.52
Wheat	6.38	1.58
Quantity		
Palm oil	28.58***	2.33
Rice	18.44*	2.32
Sunflower oil	20.07*	3.00
Wheat	13.51	2.27

*, **, *** indicate rejection at the 10%, 5%, 1% significance level.

The results of the Granger causality tests provide information about the dynamic relations between crude oil prices and food commodity variables (Table 3). The main findings of these tests are that crude oil prices Granger cause area, quantity and prices of the world aggregates of maize. Moreover, we find Granger causal effects for areas and quantities of soybean oil and sugar, for areas and prices of wheat and quantities of sunflower oil.[9]

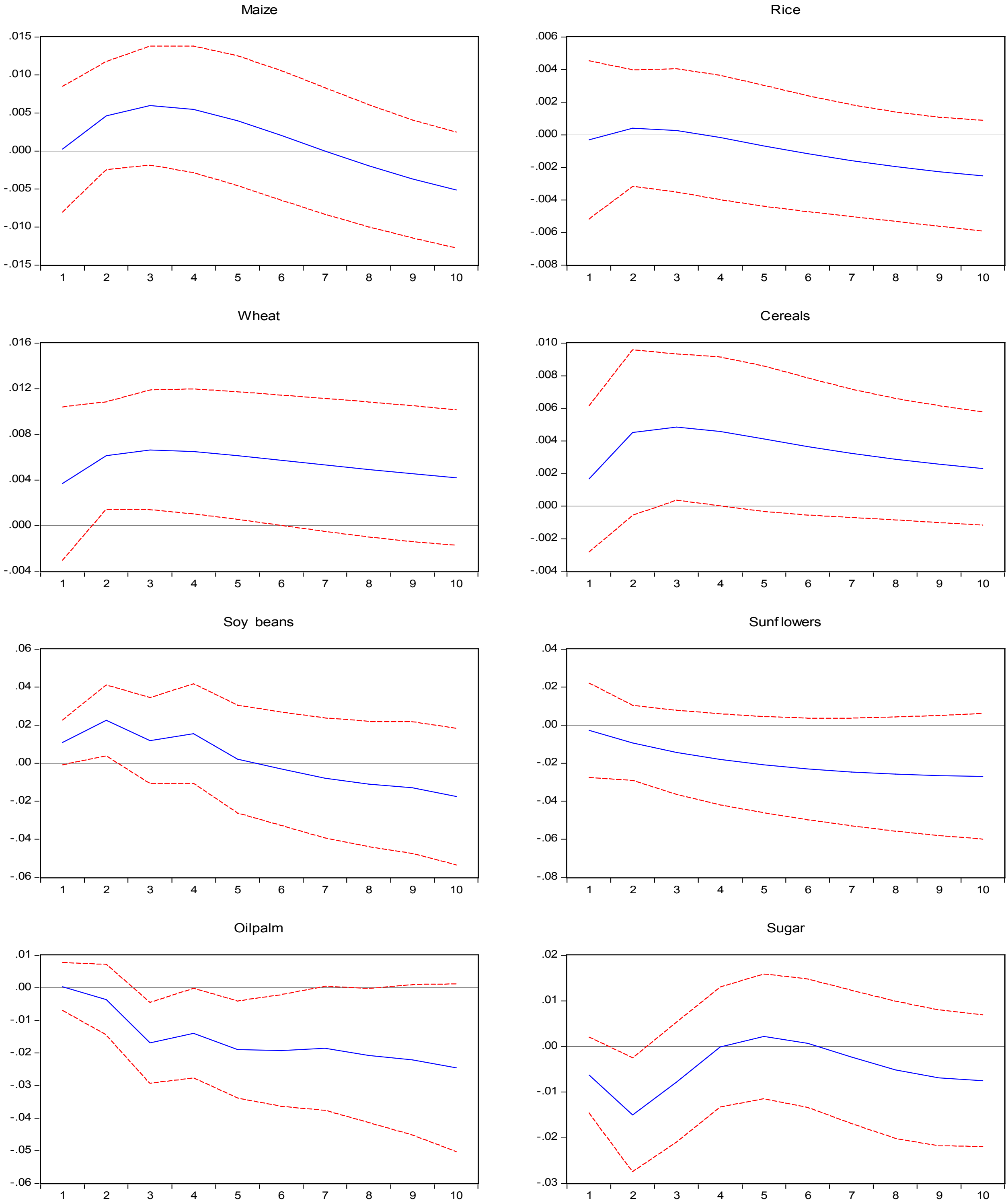
The impulse response functions calculated from the same VAR model specifications as for the Granger causality tests are presented in Figures 1 to 3. The overall picture is that an increase in the crude oil price leads to increases in areas, quantities and prices of food commodities. The significance of the impulse responses confirms in most cases the results of the Granger causality tests. However, there are also some differences: Most important, the impulse responses indicate significant price effects for cereals and soybean oil in addition to maize and wheat (Figure 1). With regard to areas the impulse re-

[9] We also tested for the reverse causation. We find Granger causal effects from area and quantity of soybean oil, sunflower oil quantity and area of sugar as well as area of maize in the US on crude petroleum prices.



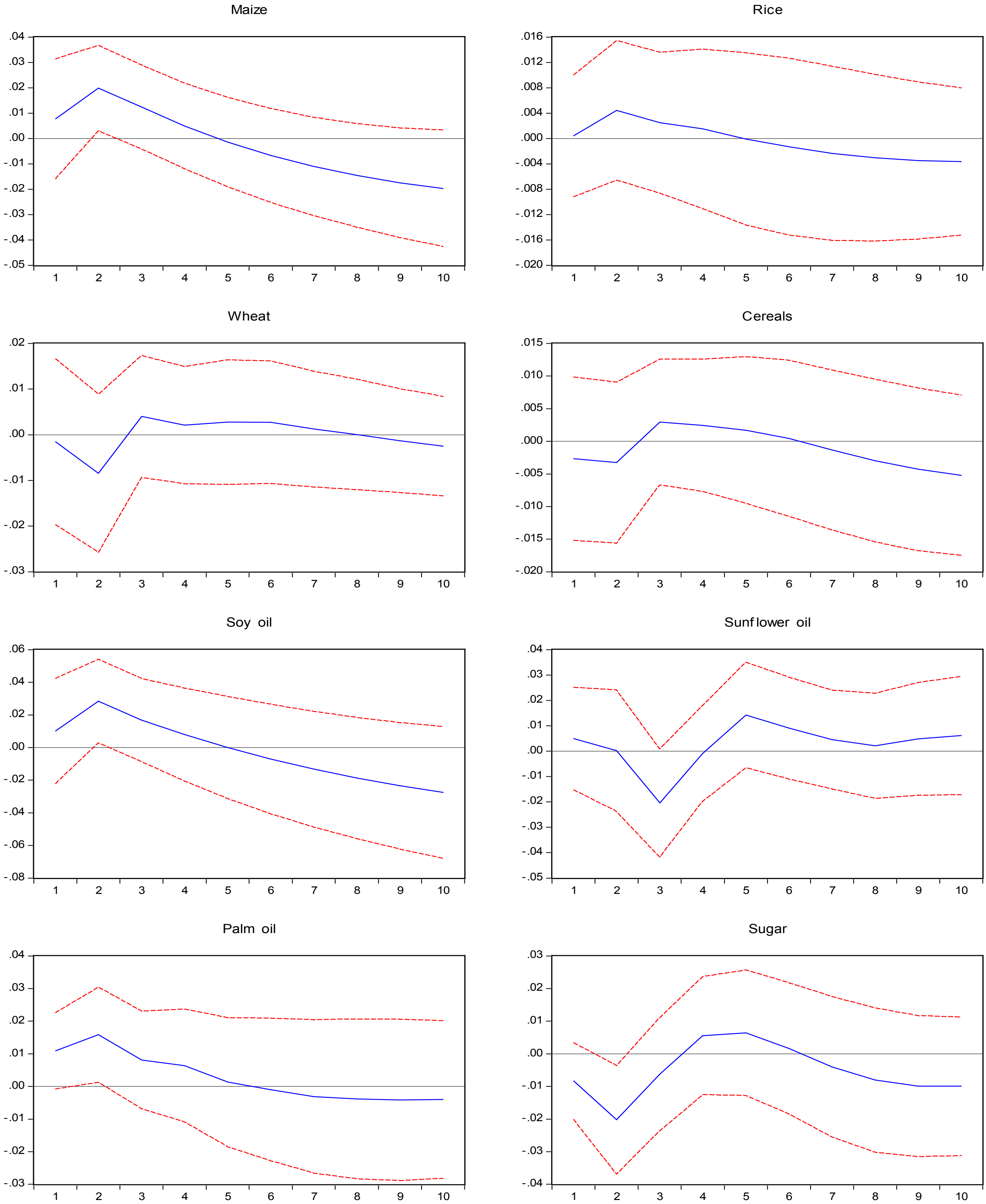
Responses of food commodity prices to a generalized one standard deviation innovation of the crude petroleum prices.

Figure 1 *Impulse responses of prices of selected food commodities to a crude petroleum price shock*



Responses of food commodity planted areas to a generalized one standard deviation innovation of the crude petroleum prices.

Figure 2: *Impulse responses of areas of selected food commodities to a crude petroleum price shock*



Responses of food commodity quantities to a generalized one standard deviation innovation of the crude petroleum prices.

Figure 3: *Impulse responses of quantities of selected food commodities to a crude petroleum price shock*

Table3: *Granger causality test results for world aggregates for food commodity variables with crude oil price*

	Price	Area	Quantity
Fats and oils	1.60	--	--
Cereals	1.90	3.88	4.57
Maize	3.66*	2.88*	5.49**
Palm oil	1.43	3.20[b]	2.84
Rice	2.25	0.06	1.00
Soybean oil	2.59	11.73***[a]	5.12**
Sugar	0.28	10.05***	13.60***
Sunflower oil	2.29	1.71	23.15***
Wheat	3.26*	6.08**	2.88

*, **, *** rejection at the 10, 5, 1% significance level respectively.

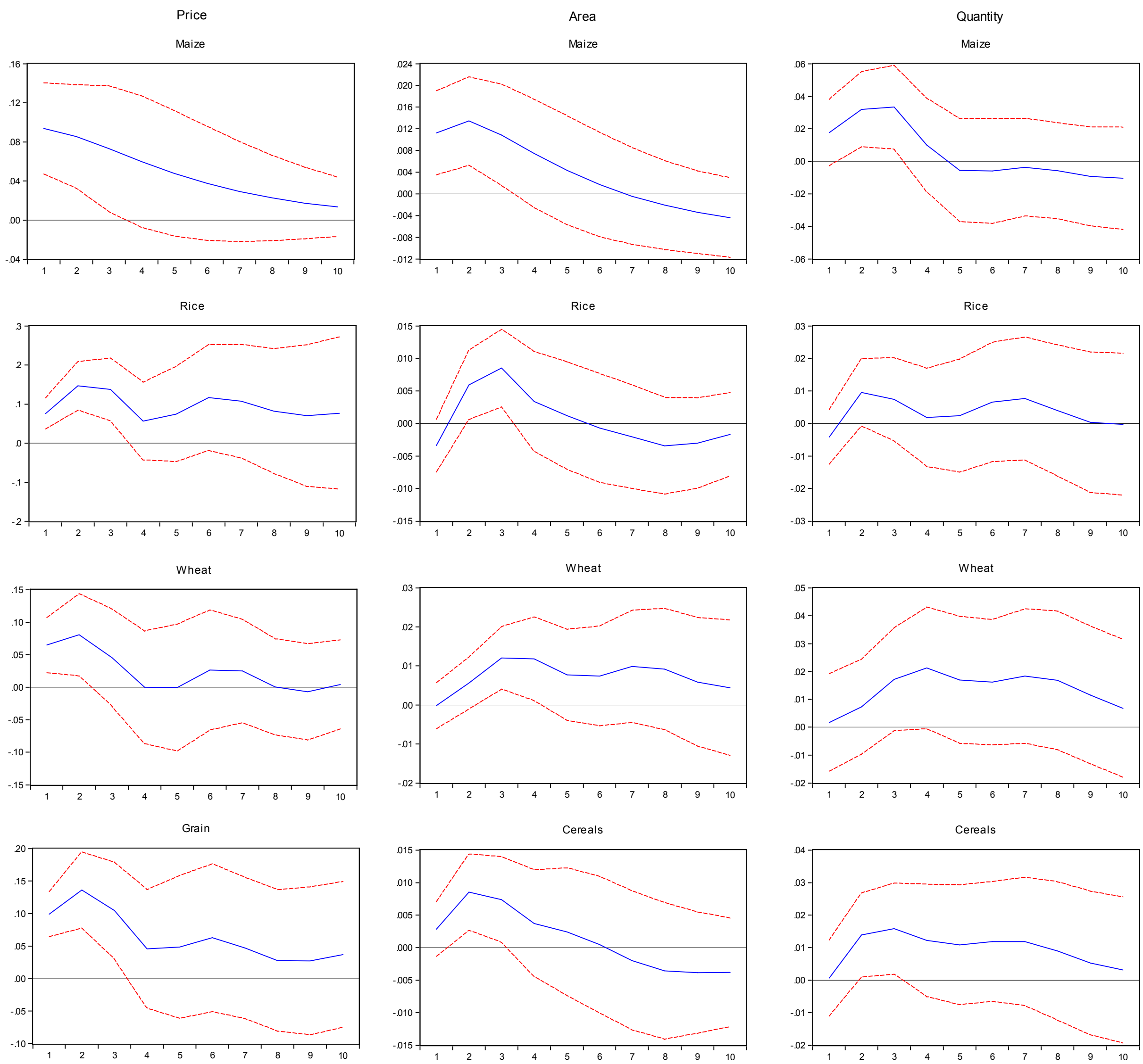
[a] area equal to soybean area

[b] area equal to oil palm area

sponse function is insignificant for maize but significant for cereals (Figure 2). For oil-palm and sugar areas we find negative effects of an oil price shock. The impulse responses for quantities indicate significant positive effects for maize, soybean oil and palm oil and a negative effect for sugar (Figure 3).

In summary, these results indicate that crude oil price movements directly Granger cause prices (maize and soybean oil) as well as harvested areas (maize, soybean oil, sugar) of some food commodities that are important for the biofuel production. However, the effect in particularly on wheat, though, cannot be explained accordingly. The influence on food commodities not used for biodiesel or ethanol production seems to be an indirect effect due to land use competition. However, as indicated by the impulse responses the effects of land use competition between the variables under consideration are still positive.

As our results suggest, crude oil price movements have an important impact on food commodities but they are clearly not the only source of recent developments. It is therefore interesting to analyze how changes in areas, quantities and prices of single food commodities are related to price movements of input factors for biofuel and biodiesel production. We use the price index for fats and oils as a proxy for the prices of these input factors and test the effects on maize, rice and wheat. The Granger causality test (Table 4) as well as the impulse response functions (Figure 4) reveal a much stronger impact of fats and oil price changes on areas, quantities and prices of these commodities than the impact from crude oil price changes. The results reveal an effect on prices but also on areas and quantities of wheat, maize and rice. However, this not an indication that oil crops replace wheat or rice. Instead, it is likely that rising prices of fats and oils trigger a rising production and land use of other food commodities such as rice, wheat, maize and cereals. One possible explanation is that food commodities not directly used for biofuel production are used as substitutes in other fields. These are the indirect effects of higher biofuel production on land use competition. However, if the areas for these crops are increased at least to some extent other areas have to be reduced. It is therefore likely that areas unused for agriculture so far – waste arable land, pasture or



Responses of a food commodity variable to a generalized one standard deviation innovation of the fats and oils price index.

Figure 4: *Impulse responses of area, quantity and prices of selected food commodities to a fats and oils price index shock*

Table 4: *Granger causality test results for food commodity variables and the fats and oils price index*

	Price	Area	Quantity
Cereals	15.21***	11.32**	9.05**
Maize	1.08	3.49*	18.31***
Rice	27.12***	13.67***	12.06***
Wheat	4.63	15.40***	6.12

*, **, *** rejection at the 10, 5, 1% significance level respectively.

forested areas – are cultured. A somehow puzzling result, however, is that we neither find Granger causality nor cointegration relations between the crude oil price and the fats and oils price index. A positive relation between both variables would have strengthened our conclusion above.

Furthermore, we verify our findings for the world data by examining land use competition in the U.S. as well as in Indonesia and Malaysia. A vast discussion relates to the use of maize for ethanol production in the U.S. (Searchinger et al. 2008; Elobeid et al. 2007; Gurgel et al. 2007; Muhammad and Kebede 2009). Applying the same procedure as for the world data, we look for first and second round effects. The results for the U.S. are reported in Table 5. We are able to reject the hypothesis of no Granger causality from the crude oil price to the area and quantity produced of maize and cereals but we find no effect for rice and wheat.

Table 5: *Granger causality test results for food commodity variables for the U.S.*

		Crude petroleum price	Maize price
Cereals	Area	2.82*	12.12***
	Quantity	4.61**	18.63***
Maize	Area	18.25***	20.50***
	Quantity	3.25*	18.33***
Rice	Area	0.16	0.13
	Quantity	0.1	0.19
Wheat	Area	0.04	14.77***
	Quantity	0.24	1.41

*, **, *** rejection at the 10, 5, 1% significance level respectively.

In addition, we analyze second round effects from biofuel production on land use change by testing for Granger causal effects from the maize price on area and quantity of cereals, maize, rice and wheat. The results indicate highly significant Granger causal effects for all variables except for the area and quantity of rice and the quantity of wheat. The Granger causal effect from the maize price on the area of wheat is evidence for the indirect land use competition (Harvey and Pilgrim 2010). Our results are also in line with Henderson and Gloy's (2007) conclusion that ethanol demand is not only driving commodity prices but also farmland values in the U.S.. One could even interpret the price increases of cereals outlined above as an explanation how biofuel demand has become a driver of farmland values in general.

Indonesia and Malaysia are important producers of palm oil which is used for biodiesel production.[10] Moreover, in both countries rice production is important, e.g. Indonesia is the third biggest rice producer of the world. Because both countries only produce negligibly small amounts of maize and wheat we focus on the rice production. Testing for first and second round effects of oil price changes in these countries we con-

[10] An overview of the development and influence of palm oil in the region of Malaysia and Indonesia is given by Lam et al. (2008).

centrate on palm oil and rice. To analyze first round effects we perform Granger causality tests from crude oil prices on prices, areas and quantities of palm oil and rice (Table 6). We only find a significant Granger causal effect from oil price on the quantity of rice. To account for additional effects we perform Granger causality tests with the palm oil price and area and quantity of palm oil as well as prices, areas and quantities of rice. Our results suggest significant Granger causal effects of the palm oil price changes on the quantity of palm oil as well as the area and quantity of rice. These effects of the palm oil price on rice variables indicate an indirect effect.

Table 6: *Granger causality test results for food commodity variables for Indonesia and Malaysia*

		Crude petroleum price	Palm oil price
Palm oil	Area	0.10	4.74
	Quantity	2.26	11.49***
Rice	Area	0.75	11.48***
	Quantity	8.79**	8.46**

*, **, *** rejection at the 10, 5, 1% significance level respectively.

5. Conclusion

This paper addresses the effects of crude oil prices and food commodity prices on land use change empirically. So far the majority of analysis of this topic uses general equilibrium models. These models are able to quantify the effects and indicate their economic relevance. However, it is still an open question whether the link between oil prices, food commodity prices and land use change is empirically significant. To fill this gap we estimate VAR models using annual data for crude oil prices as well as areas, prices and quantities for important food commodities at the world level, for the U.S., Indonesia and Malaysia. We perform cointegration and Granger causality tests as well as an impulse response analysis.

Our results reveal that crude oil prices only have statistically significant impact on some food commodities which is in line with the excess co-movement discussion. For world aggregates we find Granger causal effects on the prices of maize and wheat. More important for our analysis however, is the finding of Granger causal effects on the areas of maize, soybean oil, sugar and wheat. For the others commodities analyzed we find no significant effects. This indicates that oil prices over this long time horizon on average are not the dominant factor for the dynamics in food commodity markets. In line with this conclusion is the result that our tests fail to detect a significant link between crude oil prices and the price index for fats and oils.

Using the price index of fats and oils as a measure for prices of inputs for biofuel production we find a substantial impact of these prices on prices and areas of food commodities even if they are not directly used for ethanol production. Due to this positive effect and the fact that the impulse response functions of some cereals to the crude oil price were significantly positive we conclude that on a world aggregated level there seems to be sufficient waste arable land to prevent direct competition between oil crops and cereals.

There is also evidence that in the U.S. the price of maize is the source of price movements in other U.S. commodity markets, because maize is the main ingredient for the ethanol production. We find a first and a second round effect for the U.S. that might have been the driving factor for sharply increasing commodity prices and strong growth of the area under maize. In Indonesia and Malaysia the links between crude oil prices and the prices, quantities and areas of rice and palm oil are weaker. However, we find a significant effect from the palm oil price to the cultivated area and quantity of rice in Indonesian and Malaysian which we interpret to be iLUC. The iLUC bears the risk that it leads to even higher prices or the displacement of other areas such as pasture or forest in the future.

However, much more empirical work is needed for a better understanding of the relations between crude oil prices, food commodity markets and land use change. For example, an empirical analysis including a direct displacement effect of expanding crops to see how deforestation and the influence of a rising demand for meat are to be classified into the discussion.

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