Do Biofuel Policies and Meat Consumption Preferences Influence Food Security and Emissions in Developing Countries?

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Do Biofuel Policies and Meat Consumption Preferences Influence Food Security and Emissions in Developing Countries?

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In this paper, we examine the mutual and competitive relationship between climate security and food security in the context of expected macroeconomic growth till 2030. We analyze two approaches aimed at reducing Greenhouse Gas emissions: the European Biofuels Directive (EBD) and a reduction in meat consumption. The implications for developing country food security, as captured by the impact on food prices, food consumption and land demand are evaluated for both approaches, and the implications for climate security are evaluated by the impact on land use emissions and total emissions. The impacts of the two approaches are examined using data from the results of the EUruralis2 project (WUR, MNP, 2007) and regression techniques.

The analysis finds a small positive relationship between the EBD and food prices for some developing countries. The results of the food consumption analysis show that food consumption is lower under the biofuels scenarios suggesting that the income effect is insufficient to offset the increases in food prices. Land use emissions increase in some regions from the EBD but total global emissions appear unaffected. The shift in global consumer preferences away from meat appears to have negative effects on food security and positive effects on climate security. However lower food consumption in the developing countries is due to the method used to bring about shifts in consumer preferences; a tax on meat products.

KEYWORDS: Food security, climate security, biofuels, Computable General Equilibrium

1. Introduction

At the recent World Food Summit in Rome, UN Secretary-General Ban Ki-moon stated that “Food security and climate change are deeply interconnected” and “There can be no food security without climate security” (United Nations, 2009). With the world population projected to increase to 9.1 billion by 2050, mostly in developing countries (FAO, 2009a) and the production of some crops expected to fall by up to 49% in some developing countries (Nelson et al., 2009), the question of how to feed the world in a sustainable way is both pertinent and challenging.

This paper examines the mutual and competitive relationship between climate and food security for selected developing countries in the context of expected macroeconomic growth to 2030. Two approaches to managing the challenge of climate security are considered: the European Biofuels Directive (EBD) aimed at reducing carbon emissions from fossil fuel use and a shift in consumer preferences away from meat consumption which reduces methane emissions from agriculture as well as reducing the demand for grazing land and feed crops.

The paper begins with a brief background section followed by the objectives of the paper and the data and methodology. The results of the impacts of the EBD and changes in consumer meat preferences on food security and climate security are given in the results section followed by final remarks.

2. Background

Governments are faced with a dual policy objective of food security and climate security: erasing hunger by 2030 whilst reducing Greenhouse Gas (GHG) emissions across the board. Emissions from the agricultural sector accounted for approximately 14% of total Greenhouse Gas emissions in 2004 (IPCC, 2007). The challenge in meeting this dual objective is large given the context of rising food and energy demand and slower growth in agricultural yields in some regions due to climate change. The FAO projects that food production needs to increase by 70% by 2050 to meet the growing demand (FAO, 2009a). The FAO proposes that the expansion in food production necessary to meet the increased demand should come from a 20% expansion in land area and 80% improvements in yields concluding therefore that a significant increase in investment is needed to bring about the improvements in agricultural technology and yields. The increase in agricultural production implies changes in land use from non-agricultural land (e.g. forest) to agricultural land which releases CO_2 sequestered in the soil. Policies that secure the sustainable development of the agrifood sector are therefore needed. Any policy to reduce emissions and feed the world must offset the additional emissions that arise from the drivers of population and income growth and urbanisation (FAO, 2009a) as seventy percent of the world are projected to be living in an urban setting by 2050, compared with 49% currently (FAO, 2009a).

3. Objectives

The objective of this paper is to explore the mutual and competitive relationship between climate security and food security in the context of expected macroeconomic growth till 2030. The analysis presented in this paper gives an indication of the likely interactions between biofuels policy and consumer meat preferences and food and climate security. Both biofuels and reductions in meat consumption are considered as methods to reduce Greenhouse Gas emissions and ensure a sustainable future. However there are concerns that these efforts will have negative effects on food security in developing countries.

4. Data and Methodology

The impact of the European Biofuels Directive and changes in global meat preferences on food and climate security is examined using the results of the EUruralis2 project. EUruralis2 is a well known and well respected study that covers ex-ante projections for 36 regions from 2001 to 2030 for a range of scenarios. The results are generated using the linked LEITAP-IMAGE model where LEITAP is a socio-economic global Computable General Equilibrium model and IMAGE is a model of the global environment including emissions and land use change. The results are used as a dataset for an econometric analysis of the impact of the EBD and directly to examine the impact of a shift in consumer meat preferences. The focus of the EUruralis2 project is the European Union but it also includes several developing regions: Brazil, Rest of (South and Central) America, China, Rest of Asia (including India), North Africa, Sub-Saharan Africa and South Africa. As the majority of the world's poor live in these regions, these seven regions are the focus of the analysis presented in this paper.

The four key EUruralis2 scenarios were built around two uncertainties concerning the future world development (Westhoek et al., 2006): globalization and state regulation level of the world economy. These four scenarios vary along two dimensions; the level of globalization ranging from regional to global cooperation, and the degree of government intervention varying from low to high regulation. As options on future trade and agricultural policies are uncertain and because different policies might be relevant for each key scenario, we analyze various policy options within each of the four key scenarios. These policies differ by degree of trade and domestic support liberalization and biofuel policy options (Table 1). The combination of key scenarios and alternative policy assumptions leads to 34 EUruralis2 scenarios. [TABLE 1 HERE]

EBD impact identification

The impacts of the EBD on the dependent variables of food prices, food consumption, land demand, land use emissions and total emissions are identified by a series of linear regression models. The movements in the dependent variables are explained by the policy dummies and macroeconomic assumptions (GDP) specified for 34 EUruralis2 scenarios including two dummies associated with the EBD. Therefore, there are following explanatory policy variables in the equations: A1, B1, B2, C1, C2, C4, G1, G2, E2 and E3 (see Table 1). The estimated parameters associated with EBD dummies therefore shows the impact of EBD on analyzed variables.

The dependent variables and GDP in the food security regressions are expressed in percentage change from 2001 to 2030. The dependent variables in the emissions regressions are expressed as cumulative change between 2000 and 2030; however, the cumulative change in GDP is taken from 2001 as this is the base year of the LEITAP model. The regression equations are estimated using Ordinary Least Squares and general-to-specific approach in which all possible explanatory variables are included initially and the model is refined until all variables are significant and the model is a good fit of the data.

Meat preference impact identification

The econometric approach conducted for the EBD cannot be extended to the meat preference shift as changes in meat preferences are embedded within the scenario storylines (B1 and B2) in such a way that the individual effects cannot be distilled. Therefore, so called 'subtotals' calculated by the LEITAP model that show the effects of meat preferences shocks on B1 Scenario results are analyzed directly. In this way, the isolated impact of a shift in consumer preferences leading to reduction in meat consumption in 2010 to 2030 in all countries can be identified for eight scenarios within macroeconomic context covered by the B1 scenario storyline..

5. Results

The Impact of European Biofuels Policy

Explicit biofuels scenarios are included in EUruralis2 allowing the effect of the biofuels policy to be easily identified. Whilst the biofuels scenarios of 5.75% (E2) and 11.5% (E3) blending are considered as medium and high ambition in the context of the EUruralis2 scenarios, the scope of the policy is quite small on a global scale as it only applies to the EU and with relatively low blending levels. Finding impacts of biofuels on food prices and land use emissions for this size of biofuel policy would suggest that an expansion of the policy, either in terms of mandatory blending levels within the EU or the adoption of biofuels directives by other countries, would have greater effects. At this stage, the analysis of the impact of biofuels on food prices and emissions in developing countries is exploratory.

The Implications of the European Biofuel Directive for Food Security

The results of a series of cross-sectional regressions aimed at evaluating the impact of biofuels policy on a range of food security indicators are presented in this section. The implications for food security are evaluated by the impact on food prices, land demand and food consumption. The competing claim for land from food, feed and fuel use is evaluated by examining the impact of the biofuels policy on food consumption.

The results are reported for the key coefficients of interest: 5.75% biofuels blending (E2) and 11.5% biofuels blending (E3); other significant explanatory variables are included in each of the regressions but are not reported here. The R^2 value is reported for each regression as an indication of the goodness of fit of the model. Since the LEITAP model is approximately linear in percentage changes of the variables, the goodness of fit is very high for most of the equations

A series of cross-sectional regressions are specified to estimate the impact of biofuels policy on agricultural food prices in seven developing countries/regions. The results of the agricultural food price analysis are presented in Table 2. The fit of the models is good as shown by the high R^2 values in each case. An R^2 of 1 indicates that all of the observed variation in food prices is explained by the macroeconomic storylines and policy variables. This is in line with the deterministic nature of the dataset: the data are created from successive model runs where the difference between scenarios is due only to changes in policy and/or macro variables.

A priori, an expansion in the demand for biofuels is expected to lead to increases in food prices. As land is a relatively scarce resource, the extra land required to increase crop production for biofuels comes at a higher price. The higher crop price is transmitted to food prices either through direct input costs (e.g. grain) or through indirect input costs (e.g. feed grain costs that affect the price of meat). [TABLE 2 HERE]

The regression results shown in Table 2 suggest a small, positive relationship between mandatory biofuels blending in the EU and food prices in some developing countries. Whilst a positive relationship between EU biofuels policy and food prices is indicated in the results, not all the results are statistically significant: only the coefficients for Brazil and Rest of America are statistically significant in the case of a 5.75% blending level. The coefficients for these regions remain significant when the blending target is doubled and the relationship between the EU biofuels policy and food price increases also become significant for the Rest of Asia, North Africa and South Africa. The analysis suggests that the EU biofuels policy does increase food prices in some developing countries examined here and that the effect becomes stronger (and more statistically significant) with higher required biofuels blending shares in the EU. The analysis of values of estimated parameters shows that an impact of the (limited) biofuel policy is relatively small, i.e. economically not significant, for the majority of the analysed regions. The food price increase due to the implementation of the European Biofuels Directive (EBD) with an 11.5% mandatory blending is about 1% for Brazil and lower than 1% for other regions except North Africa where an 8% increase in food prices is predicted; although this result is only mildly significant. The observed increase in Brazilian food prices is in line with the role of Brazil as a key producer of biofuel crops.

The impact of biofuels policy on the demand for land is shown in Table 3. A priori, it is expected that increasing biofuel demand in the EU will increase demand for land in the developing countries covered here. [TABLE 3 HERE]

The fit of the models is good for all regions and in line with a priori expectations. The results show that increasing the blending share of biofuels in the EU increases the demand for land in Brazil at the 5.75% blending level by 2.4%. The results for the other developing countries at the lower blending level are statistically and economically insignificant. Therefore, it seems that to a large extent, 5.75% blending levels in the EU may be achieved by more intensive use of land (including land set aside) in the EU itself and does not affect the developing countries other than Brazil.

Increasing the mandatory blending share in the EU to 11.5%, expands the demand for land in all countries; with significant increases in land demand occurring in Brazil (5.2%), Rest of America (1.3%), Rest of Asia (3.9%) and South Africa (0.02%). The EBD has no impact on the agricultural land demand in China, South Africa and North Africa. Note however, that the use of biofuel by-products for animal feed (which are not included in the EUruralis2 analysis) is likely to reduce the effect on land expansion.

The above analysis shows that an EU biofuels policy is likely to put upwards pressure on land and food prices in some developing countries. The overall impact of the EU biofuels policy on food consumption (measured in changes in quantities, valued in constant prices) is shown in Table 4. With increasing land and food prices, the a priori expectation is that biofuels will lead to a small reduction in food consumption in developing countries. [TABLE 4 HERE]

The results of the food consumption regressions shown in Table 4 are broadly in line with a priori expectations; increased use of biofuels leads to small reductions in food consumption in some developing countries. A small significant decrease in food consumption is observed for Brazil at the 5.75% blending level. The introduction of 11.5% blending in the EU leads to statistically significant reductions in food consumption in most countries with the largest decreases observed in North Africa (8.1%), Rest of Asia (2.8%) and South Africa (1.7%). The negative relationship between biofuel use and food consumption is statistically significant for all regions except Sub-Saharan Africa which may be due to the amount of land available for expansion in this area.

The Implications of the EU Biofuels Directive for Climate Security

The implications for climate security of the EU biofuels policy are evaluated in this section by examining the impact on land use emissions and total worldwide emissions. The results of a series of cross-sectional regressions are presented for the key coefficients of interest: 5.75% biofuels blending (E2) and 11.5% biofuels blending (E3). The results of seven regression equations examining the impact of biofuels on land use emissions are shown in Table 5. The fit of the emissions regression models is less good than that of the previous regressions since data concerning emissions are only indirectly derived from the LEITAP assumptions via the IMAGE model. The regressions still explain between 78% and 100% of the observed variation in land use emissions (column R^2). A priori, the biofuels policy is expected to increase land use emissions in areas which produce biofuels. [TABLE 5 HERE]

The results of the emissions regressions show few significant coefficients for the EBD suggesting that the variation in macroeconomic storylines and other policies predominantly explain the observed changes in land use emissions. Low level EU blending requirements (5.75%) only lead to significantly large increases in land use emissions in Brazil (0.4%). Higher levels of mandatory blending (11.75%) further increase land use emissions in Brazil (3.1%) and also in Rest of America (1.4%). These results suggest that whilst the mandate is implemented in the EU, the effect is to increase land use emissions in regions that are the main producers of biofuel crops.

Land use emissions are however, only one part of the story. The overall impact on emissions of the EBD depends on the relative sizes of the reduction in energy emissions and any increases in land use emissions. Moreover, the overall impact on emissions cannot be evaluated at a country level as energy emissions reductions are likely to occur in developed countries with land use emissions occurring in developing countries. The results of two regressions examining the impact of EU biofuel policy on total emissions are shown in Table 6. Results are given for the world level to show the overall impact on global emissions and for Brazil as an example of the developing country level impact for a biofuel producing region.

The effect on global total emissions of the EBD are not statistically significantly at both blending shares levels suggesting that the policy has little impact. Furthermore, the specification of the regression is not sensitive to the omission of the biofuel dummies supporting the observation that the EU biofuels policy is not a key driver of total global emissions. The majority of the observed variation in total emissions can be ascribed to the different aspects of the macroeconomic storylines. At low levels of mandatory blending, the EBD does not appear to significantly decrease or increase total global greenhouse gas emissions. [TABLE 6 HERE]

The results for Brazil however show a positive and significant relationship between EU biofuel policy and Brazilian total emissions at both blending levels. This is in line with expectations as Brazil is a key producer of biofuel crops. The introduction of 5.75% blending shares in the EU is associated with a 0.3% increase in total emissions in Brazil whereas a higher 11.5% blending requirement in the EU increases Brazilian total emissions by 3.1%.

The Impact of Shifts in Meat Preferences on Food & Climate Security

The implications of a global shift in consumer preferences away from meat consumption for food and climate security are examined in this section. The results presented are averages over eight B1 scenarios thus the global context in which the preference shift takes place is one of global co-operation in which there is free-trade and environmental and social goals exist alongside profit-driven economic growth. The impact of changes in meat preferences on land-use and total emissions cannot be evaluated using the results of the IMAGE model as the individual effect of the meat preference shift cannot be isolated. An attempt to evaluate the likely impact on emissions is made at the end of the section.

The shift in consumer preferences is implemented in the LEITAP model using a tax on meat consumption. The effect of the tax is to reduce meat consumption and shift consumption towards other goods. The use of a tax in this context is instrumental rather than policy based; it is a mechanism to induce consumers to shift their consumption away from meat. A tax on meat products of 18% is introduced from 2010 to 2020 and a further 18% is levied from 2020 to 2030 in all countries. The size of the tax increase is chosen to bring about a 5% reduction in meat consumption by households in each period. The increase in the price of meat from the introduction of the tax is clear from Figure 1. [FIGURE 1 HERE]

The price of the All Food composite rises for all developing countries when the meat tax is introduced but by less than the increase in the price of meat due to the lower share of meat in total food consumption. The share of meat in total food consumption varies between 11% in Rest of Asia and 29% in China in the LEITAP model. Overall, the smaller increases in the prices of all foods suggests that the prices of Other Food (non-meat food) fall when the price of meat increases. The increase in the price of all commodities is less than that of the food price increase as developing countries spend between 15% (Brazil) and 47% (Sub-Saharan Africa) of total expenditure on food products. The share of food expenditure in total expenditure in these regions compares with a global average of 12%.

As with the analysis of the biofuels policy, the impact on prices is only one side of the story as there may also be income effects. Indeed, the shift in consumer meat preferences leads to small increases in income of between 0.3% for Brazil and 1.2% for North Africa (as calculated from the results of the LEITAP model) but they are insufficient to offset the increase in the prices of all commodities and total consumption falls. The impact of changes in consumer meat preferences on the consumption of meat, all food and all commodities is shown in Figure 2. (measured in changes in quantities, valued in constant prices). The introduction of the tax has the desired effect and reduces the demand for meat by between 8% (North Africa) and 10% (Sub-Saharan Africa). [FIGURE 2 HERE]

Inducing a shift in meat preferences by introducing a tax on meat products increases the price of food and reduces consumption. The extent to which this increases the number of malnourished people in developing countries is difficult to assess without an assessment on the impact on calorific intake, however increasing the economic barrier to food consumption through increased food prices is likely to increase the malnourished population. Note that the negative impact of shifting meat preferences on food consumption are driven by the means of achieving the shift: the meat tax. The impact of changing consumer meat preferences on food security should be evaluated using other means such as advertising to achieve the shift in order to gain a full understanding of the likely effects on food security.

A priori, a reduction in the global consumption of meat is likely to reduce the demand for land for cattle rearing and grazing and for growing animal feed, although this may be offset to some extent by increased demand for cropland. The implications of a shift in meat preference on the demand for land are shown in

Figure 3. [FIGURE 3 HERE]

As expected, the demand for land for meat production falls for all regions as result of changes in consumer preferences towards lower meat consumption, except South Africa which experience a small increase of 0.2%. The largest reductions in land demand by the meat sector are experienced by the meat producing regions of Brazil (3.1%) and the Rest of America (2.7%).The demand for land for other food production also falls in most regions as the reduction in land for producing animal feed offsets any increase in land demand for non-meat foods. The reduction in the demand for land in Brazil and Rest of America is partly due to a fall in meat exports from these regions of 5% and 6% respectively. The increase in the demand for land for meat production in South Africa is due to an anomalous increase in meat exports from this region. This results should be viewed with caution and warrants further investigation.

The overall picture from a global reduction in meat consumption is one of reduced pressure on land. Unlike biofuels where the overall impact on emissions is uncertain because it depends on the relative magnitude of two countervailing effects, the direct and indirect effects of reducing meat consumption on emissions work in the same direction. Firstly, the number of animals being reared is reduced which reduces methane emissions and the need for land conversion. Secondly, the reduction in the demand for animal feed reduces the pressure on land and land-use emissions. The increased demand for non-meat products may offset some of the reduction in land demand to some extent but the overall pattern is likely to be one of lower emissions with lower meat consumption.

6. Final remarks

An evaluation of the impact of biofuels on food prices in seven developing countries/regions suggests that an EU biofuels policy may lead to increases in food prices in some regions. The demand for land increases as the demand for biofuels increases, notably in Brazil as a key supplier of biofuel crops. An EU biofuels policy is associated with increased land use emissions in some regions but at the global scale preliminary analysis indicates that the EU biofuels policy does not have a significant impact on total emissions either positively or negatively.

The finding of a positive relationship between EU biofuel policy and food prices is balanced by an awareness of the link between agricultural prices and farm income in developing countries such that increasing prices cannot be viewed as conclusively increasing malnutrition. Changes in agricultural prices have an opposite effects on producers and consumers and further analysis of the impacts on these two groups is required in addition to an evaluation of the changes in prices relative to changes in income. It is likely that trends in urbanisation will lead to the impact on consumer prices being an important part of future research alongside the impact on farm incomes. The results of the food consumption analysis are however more concerning as food consumption is lower under the biofuels scenario suggesting that any income effect is insufficient to offset the increases in food prices and that there is competition for land use between food, feed and fuel.

The shift in global consumer preferences away from meat brought about by a tax on meat is likely to have negative effects on food security and positive effects on climate security. Food consumption of non-meat products is likely to be higher in some regions when global preferences move away from meat consumption but overall consumption is lower due to the higher prices faced by consumers. The demand for land is lower in almost all regions when consumers switch away from consuming meat. The fall in the demand for land is less than the reduction in meat demand suggesting land use extensification. A reduction in meat consumption could be an important tool in achieving lower emissions as it is likely to reduce both methane and land use emissions. Achieving the preference shift may however be challenging. The increase in food prices associated with the reduction in meat consumption is attributable to the tax mechanism that is introduced to generate the changes in consumer preferences. Although a direct tax on meat consumption may be politically unrealistic, the increase in the price of meat from the tax can be viewed as the cost of bringing about the shift in preferences, perhaps through education and awareness. Other policy tools for bringing about a change in consumer preferences for meat should be considered as an alternative to the increase in meat prices examined here.

The results presented in this paper are based on the scenario analysis conducted for the EUruralis2 project. The modelling approach at the time of the project did not incorporate by-products of biofuel production in livestock production. The use of by-products reduces the direct competition between food, feed and fuel and introduces a more complementary relationship between biofuels and food crops. The use of by-products is likely to reduce the impact of biofuels on food prices by reducing the direct demand for crops for animal feed and the impact on emissions through reducing land expansion. In contrast, the widespread adoption of mandatory biofuels blending in countries outside the EU together with higher blending shares is likely to put further pressure on agricultural prices and reduce food consumption even with by-products. The biofuels policies considered here are conservative and apply only to the EU but show that increasing the biofuels share from 5.75% to 11.5% already lead to small increases in food prices. Further research on global biofuels policies and higher blending shares, together with 'second generation' biofuel technology will further inform research into the competing claim between food, feed and fuel.

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Table 1. Specific policy assumptions

Key scenario assumptions	
A1	high economic growth, increasing population, high agro technology, border and market phased out, no bio-energy policy
B1	medium economic growth, increasing population, high agro technology, border support phased out, market support stable, 5.75% blending
A2	medium economic growth, decreasing population, high agro technology, border and market stable, no bio-energy policy
B2	low economic growth, decreasing population, high agro technology, border and market stable, 5.75% blending
Alternative policy options	
Border support	
G1	full liberalization: in 2010 still market price support, after 2020 all market price support abolished; price difference with world market = 0%
G2	decreasing market price support: in 2010 still market price support, after 2020 all price support reduced by 50%
G3	constant price support: until 2030 unchanged market price support
Income support	
C1	abolishment of all income support; abolished after 2010
C2	decreasing income support; budget reduced by 50% in 2030
C3	stable income support; no change in the budget until 2030

C4	increasing income support; budget increased with 50% in 2030
Biofuel	
E1	low or no ambition on bio-energy - 0% blending, no taxes, no subsidies
E2	medium ambition on bio-energy - 2010 onwards: 5.75% blending
E3	high ambition on bio-energy - 2010 onwards: 11.5% blending

Table 2 Impact of Biofuels on Food Prices

	5.75% Blending		11.5% Blending		
	Coefficient	T-Ratio	Coefficient	T-Ratio	R^2
Brazil	0.444***	9.966	1.109***	10.760	0.999
Rest of America	0.101**	2.516	0.357***	3.840	0.999
China	0.044	1.168	0.481	1.522	0.999
Rest of Asia	0.084	0.935	0.635***	3.045	0.998
North Africa	-0.075	-0.244	8.001*	1.751	0.941
Sub-Saharan Africa	0.184	1.522	0.351	1.260	0.994
South Africa	0.063	0.653	0.737***	3.324	0.998

*** significant at 1%, ** significant at 5%, *significant at 10%

Table 3 Impact of Biofuels on the Demand for Land

	5.75% Blending		11.5% Blending		
	Coefficient	T-Ratio	Coefficient	T-Ratio	R^2
Brazil	2.392***	5.811	5.167***	14.050	0.999
Rest of America	0.271	1.476	1.299***	3.058	0.995
China	0.006	0.250	0.577	1.581	0.951
Rest of Asia	0.207	1.680	3.901**	2.162	0.883
North Africa	0.001	1.201	0.004	1.651	0.999
Sub-Saharan Africa	0.190	0.980	3.033	1.405	0.994
South Africa	0.000	0.000	0.016***	5.007	0.996

*** significant at 1%, ** significant at 5%, *significant at 10%

Table 4 Impact of Biofuels on Food Consumption

	5.75% Blending		11.5% Blending		
	Coefficient	T-Ratio	Coefficient	T-Ratio	R^2
Brazil	-0.230***	-3.220	-0.616***	-3.756	0.999
Rest of America	-0.039	-0.587	-0.283*	-1.832	0.999
China	-0.017	-0.239	-0.545***	-3.405	0.998
Rest of Asia	0.179	0.455	-2.824***	-3.202	0.998
North Africa	-0.574	-0.860	-8.129***	-5.484	0.995
Sub-Saharan Africa	0.436	0.510	-0.701	-0.369	0.999
South Africa	0.221	0.554	-1.649*	-1.855	0.999

*** significant at 1%, ** significant at 5%, *significant at 10%

Table 5 Impact of Biofuels on Land Use Emissions

	5.75% Blending		11.5% Blending		
	Coefficient	T-Ratio	Coefficient	T-Ratio	R^2
Brazil	0.373***	4.850	3.108***	12.130	0.999
Rest of America	-0.035	-0.270	1.443***	3.325	0.983
China	0.001	0.103	-0.053	-1.353	0.948
Rest of Asia	-0.346	-1.447	-0.644	-0.841	0.776

North Africa	0.002*	1.786	0.003	0.778	0.818
Sub-Saharan Africa	-0.328	-1.146	-0.033	-0.036	0.991
South Africa	-0.317	-1.549	-0.247	-0.376	0.965

*** significant at 1%, ** significant at 5%, *significant at 10%

Table 6 Impact of Biofuels on Total Emissions

	5.75% Blending		11.5% Blending		
	Coefficient	T-Ratio	Coefficient	T-Ratio	R^2
World	-0.364	-1.199	-0.059	-0.061	0.991
Brazil	0.325***	3.217	3.086***	9.168	0.998

*** significant at 1%, ** significant at 5%, *significant at 10%

Figure 1 Impact of Shift in Meat Preferences on Food Prices (% Change, 2010-2030)

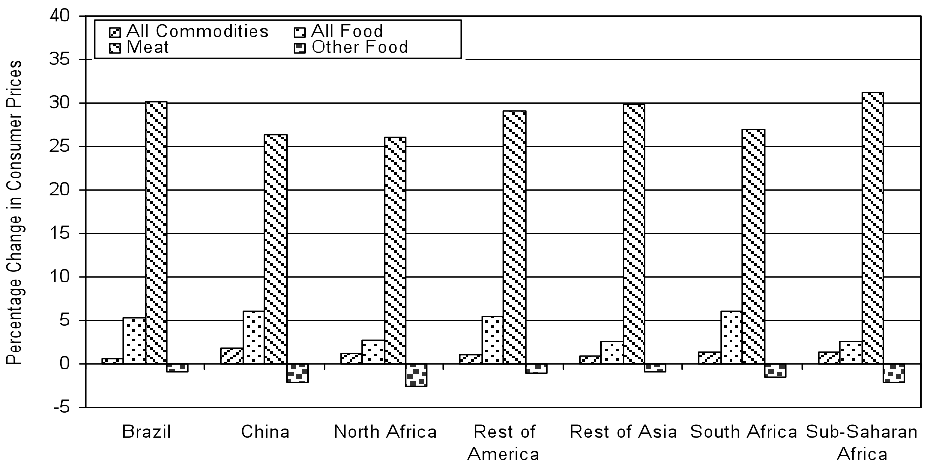


Figure 2 Impact of Shift in Meat Preferences on Consumption (% Change, 2010-2030)

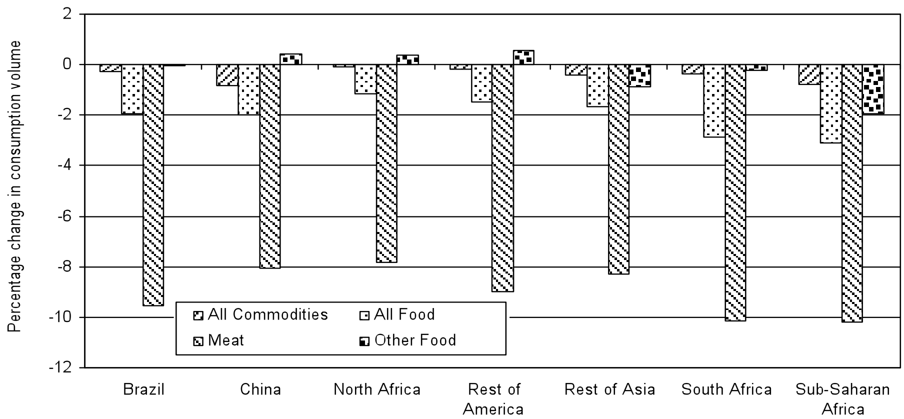
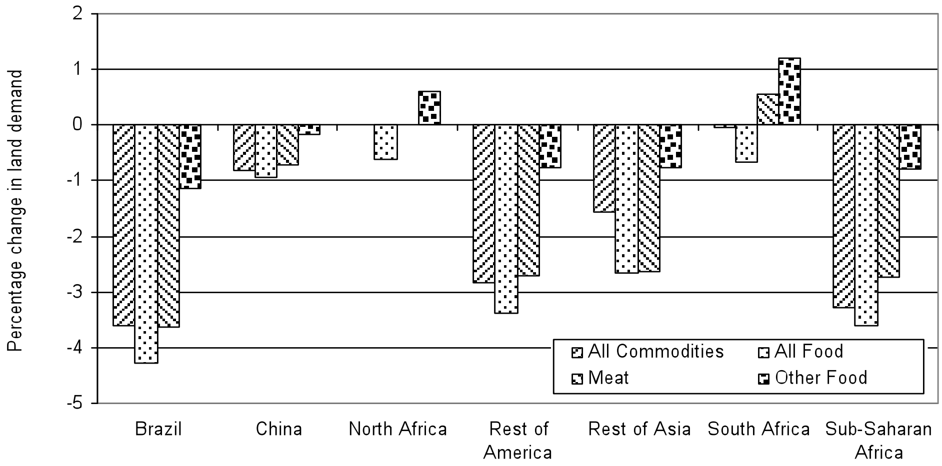


Figure 3 Impact of Shift in Meat Preferences on Land Demand (% Change, 2010-2030)



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