EU agricultural production and trade:

Can more efficiency prevent increasing 'land-grabbing' outside of Europe?

Research Report*

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List of Abbreviations

BMELV	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz
CAP	Common Agricultural Policy
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization (of the United Nations)
FAPRI	Food and Agricultural Policy Research Institute
LEL	Landesanstalt für Entwicklung der Landwirtschaft und der Ländlichen Räume
LfL	Bayerische Landesanstalt für Landwirtschaft
OECD	Organization for Economic Co-operation and Development
SITC	Standard International Trade Classification
USDA	United States Department of Agriculture
WTO	World Trade Organization

1. PROBLEM SETTING AND OBJECTIVE OF THE ANALYSIS

The economic environment in which farmers in the European Union (EU) have to make their investment and production decisions has changed quite dramatically in past decades and especially in recent years. Key drivers of this change are numerous. Major drivers, however, are the following:

Key drivers of EU agriculture …

- The European Union has grown to 27 member states, representing more than 500 million consumers (LANZIERI, 2009) to be nourished by just 9 million people working full-time in agriculture (EUROSTAT, 2009).

- Beginning in the 1990s the European Union has embarked on a continuing reform process of its Common Agricultural Policy (CAP) which has resulted in more liberal agricultural markets and will continue to do so in the future.

- The reform process has been guided also by World Trade Organization (WTO) negotiations. As a result, in many key commodities farmers now produce for the market rather than for the government.

- Globalization of the world economy has not bypassed agriculture. To the contrary, international trade has grown rapidly and has led to an international interdependence of national agricultural and trade policies.

- The production of crops for bio-energy was virtually nonexistent in the European Union some 20 years ago. It has grown rapidly since then and constitutes a significant portion of farming activities (e.g. BANSE et al., 2008; SCARLAT et al., 2008 OECD and FAO, 2009).

- In addition, the long term trend of declining world market prices has come to an end. With the turn of the millennium, agricultural commodity prices have tended to increase - albeit with significant fluctuations as in the past, as global demand growth has outstripped the growth in supply (VON WITZKE et al. 2008; 2009).

- Public agricultural research investments have declined and acted to reduce productivity growth over the past 20 years (PARDEY et al, 2007; PARDEY, 2009).

… have resulted in an increasing trade

On balance, these changes resulted in the European Union becoming one of the largest agricultural commodity trading regions in terms of value and volume, a fact that is not too surprising since international agricultural trade has grown rapidly over the last few decades and trade expansion is expected to continue (e.g. AKSOY and BEGHIN, 2005; USDA, 2010). This includes agricultural trade by the European Union (e.g. WTO, 2009).

Another major change is the fact that the European Union has evolved into the single most important importer of agricultural commodities and food (EUROSTAT, 2010b).

Obviously, agricultural commodities do not fall from heaven like manna. Rather they are produced using a variety of inputs. When goods are traded internationally, it is as if the inputs which have been used in their

production are traded as well. That is, international trade in goods results in a 'virtual' trade of inputs as well. Natural resources including agricultural land and water represent essential inputs in the production of agricultural commodities and other goods. In recent years it has become obvious that natural resources play an ever more important role, accounting for about one fourth of the value of world merchandise trade (RUTA, 2010).

Analysing trade of inputs such as land

While the virtual trade in water has gained some attention both in research and the public debate of the consequences of globalization (see, e.g., HOEKSTRA, 2003; CHAPAGAIN et al., 2006), the virtual trade in agricultural land has not yet received much attention. Only few studies have looked at the 'land footprint' of agriculture (e.g., STEGER, 2005; WÜRTENBERGER et al., 2006; BURKE at al., 2008; VAN SLEEN, 2009). Usually, they have been limited to selected goods and regions.

As the European Union now has emerged as the world's largest importer of agricultural commodities (see chapter 3), it is reasonable to assume that the European Union now is a major importer of virtual agricultural land.

Objective of the study

The overall objective of this study is to quantify how much 'virtual' (ALLAN, 1993; 1994) land the European Union is using in third countries. More specifically, this study will provide answers to the following two questions:

- How much virtual land is used outside the European Union for agricultural purposes and how has the virtual land use of the European Union changed over time?

- How much virtual land would the European Union use under alternative scenarios focussing on changes in policies and technologies?

Structure of the report

This report is organised as follows:

- First, theoretical and methodological considerations regarding virtual land trade will be discussed (chapter 2).

- Second, agricultural trade flows of the European Union and their changes over time will be presented (chapter 3).

- Third, the virtual trade in agricultural land of the European Union is quantified under several alternative scenarios (chapter 4 and chapter 5).

- The paper concludes with some implications of the findings for virtual land trade as well as agricultural and research policy (chapter 6).

2. THEORETICAL FRAMEWORK AND METHODOLOGICAL CONSIDERATIONS

The concept of virtual inputs was initially developed by ALLAN (1993; 1994) for water. His basic idea is as follows: Essentially, any good being produced requires water. The water used in the production of a good is considered virtual water. When a good is traded internationally the virtual water is traded simultaneously (e.g. HOEKSTRA, 2003; HOEKSTRA and HUNG, 2003).

Concept of virtual land trade

Here we modify this concept so it can be applied to land in agricultural commodity production. By analogy, we define virtual land as the amount of land that is required to produce one unit of a given agricultural good. For instance, if it takes 'X' hectares of land to produce one metric ton of wheat, then 'X' is the number of hectares of virtual land contained in one metric ton of wheat, and exporting one metric ton of wheat from one country to another is equivalent to the export of 'X' hectares of virtual land. In essence, the import of agricultural goods adds land to the domestic resource base, while the export acts to reduce it.

The standard trade model

Much like other resources, land suitable for the production of agricultural commodities is unevenly distributed around the globe. As there is no strong correlation between the availability of land and other resources in a nation and its food needs, international agricultural trade is an important means by which food is moved from where it is abundant to where it is scarce.

The standard model of international trade theory stipulates that comparative cost and, thus, price advantage is the key determinant of international trade in goods. A country is an exporter of a good which it manages to produce at relatively lower cost than others and an importer of goods which it produces at higher cost than others.

The Heckscher-Ohlin model of international trade (e.g., LEAMER, 1995) is based entirely on relative differences in factor endowments, and thus differences in factor prices, as causes of differences in comparative cost advantage and disadvantage between countries. A country which is characterised by a relative abundance of a production factor is characterised by a relative low price for this input. Therefore, it has a comparative advantage in the production of goods which require relatively much of this production factor, all other things being equal. For instance, a country with a relative abundance of capital and scarcity of labour will be an exporter of capital intensive goods while importing labour intensive goods.

An application of the Heckscher-Ohlin model to agricultural commodity trade would suggest that a country with a relative abundance of farm land would be an exporter of land intensive crops such as wheat, corn or soybeans all other things being equal.

Violations and externalities

If the assumptions of the standard trade model of neoclassical economics are met, the concept of virtual trade in land, water or other resources would not contain information that goes beyond what is known from the Heckscher-Ohlin model. It would just be a different way of illustrating it.

However, things are different when one or more of the assumptions of the standard model of neoclassical trade theory are violated. In the real world, this is often the case, as government market intervention in agriculture continues to be pervasive around the globe leading to a multitude of distortions of economic incentives and international trade flows because countries do not specialise in the production of goods for which they have comparative advantage (e.g. TYERS and ANDERSON, 1992; ANDERSON, 2009; 2010; ANDERSON et al., 2010).

In addition, the existence of externalities acts to result in trade flows which do not reflect the true comparative advantages of countries. In essence, an economic externality is an unintended effect of an economic

activity on a bystander. Externalities can be positive or negative. They may occur in production as well as in consumption. In the case of a negative externality in production, there are costs caused by the production of a good which are not borne by the producer. This is the private marginal cost of production, which determines the supply, is below the social marginal cost. As the producer does not bear the full cost, factor input and production are higher than socially optimal.

Externalities and market distortions are of relevance for the purpose of this paper. To take an example: The rapidly growing world food needs could be met by expanding the acreage in the European Union or elsewhere or by increasing the productivity of the land being farmed already. The expansion of the acreage, however results in costs to society which the tiller of this land does not have to pay for. The reason for this is that deforestation or the conversion of grassland into cropland results in large emission of greenhouse gases which, in turn, result in large costs to society (e. g. STERN, 2006). In fact, these types of agricultural land use changes result in 18 percent of the man made part of global warming and contribute more to global warming than manufacturing or transportation (VON WITZKE et al., 2008).

Application of an indicator-based methodology

The conversion of agricultural trade into land trade is a rather complex issue. In principle, there are different approaches to quantifying virtual land use (e. g. WÜRTENBERGER et al., 2006). In this paper we use what we refer to as an indicator approach.

- Starting point of the analysis are international agricultural trade flows. Available trade statistics are based on internationally agreed upon classification of commodities. The Standard International Trade Classification (SITC) is the most widely used classification in trade analysis. The SITC is based on the degree of processing. Although goods produced from identical raw materials may end up in different classifications they can be attributed to their raw material, again. In addition, SITC is time proven in international trade analysis (XIMING and FUKAO, 2010). Therefore, it will be used here.

- In our analysis of international agricultural trade we include not only SITC0 (Food and live animals) and SITC1 (Beverages and tobacco) – as it is often the case (e.g. EUROSTAT, 2010b) – but additionally SITC22 (Oil-seeds and oleaginous fruits), SITC263 (Cotton), SITC268 (Wool), as well as SITC4 (Animal and vegetable oils, fats and waxes).

- For SITC0, SITC1, SITC22, SITC263, SITC268, and SITC4, export and import data in terms of value and volume were generated from EUROSTAT (2010a). Data for EU-27 are available for the years 1999-2008. Hence, this time period is covered here.

- The calculations of virtual land trade developments are based on average data for 1999/2000 and 2007/2008. Weighted averages are used in order to avoid distortions in results caused by annual fluctuations.

- Trade volumes were converted into tradable agricultural raw products; and the resulting volume was related to regional yields in order to compute land used for exports and imports. Excluded from this analysis were tradable products which cannot be associated (a) to the use of land, i.e. fish and water, and (b) to a specific agri-

cultural raw product, i.e. products summarised in SITC categories 'others', 'confidential' and 'miscellaneous'.

- Some very particular products such as spices were also excluded because of data and resource limitations. The products not included in this analysis have accounted for roughly 20 percent of EU-27's agricultural trade in 2007/2008.

240 categories of tradable products covered

- Finally, 240 categories of tradable products are included into our analysis. This represents 50 percent more of what has been included in other recent studies. STEGER (2005), e.g., has analysed 149 tradable products for the EU-15 and the year 2000 while VAN SLEEN (2009) has included 150 products for the EU-27 and the year 2005.

- The analysis of land use associated with agricultural trade is straightforward for unprocessed crops. In this case, only specific yields have to be known for proper conversion. Detailed information on yield can be found in EUROSTAT (2009), FAPRI (2010) and FAO (2010), e.g.

- The calculations are more complex for livestock based commodities, and for processed agricultural products, such as flour, macaroni or oilcakes.

- Meat and dairy products were converted into crops using feed ratios and feed mix percentages. Our calculations are mainly based on conversion rates provided by SULLIVAN et al. (1992). They have been updated in order to account for increased feeding efficiency and improved feeding technologies.

- Processed products have been converted into agricultural raw products using a rather broad spectrum of processing parameters. Numerous weights, measures and conversion factors had to be combined, based on FAO (2001) and USDA (1992). They have been updated using additional data sources such as STEGER (2005), BELIZT et al. (2008), SCHÖFFL (2008), and VAN SLEEN 2009).

- A particular issue arises because agricultural raw materials may be processed into goods which end up in different SITC. An example is oilseeds which usually are processed into oil cake and oil. Butter, cheese and dry milk have to be converted to liquid milk equivalents. Approaches on dealing with coupled products and information on crushing factors were used to avoid double counting of hectares (e.g., SULLIVAN et al., 1992; FAO, 2001; VAN DAM and ELBERSEN, 2004).

Finally, more than 40 crops covered

- Thus, it was possible to 'translate' traded goods into more than 40 crops such as wheat, corn, coarse grains (mainly consisting of barley, rye, oats, grain sorghum, and millet), rice, soybeans, palm fruits and nine other oilseeds, oleaginous fruits, sugar beet and sugar cane, coffee, cocoa, tea and tobacco, potatoes as well as additional 20 fruits and vegetables.

3. INTERNATIONAL AGRICULTURAL TRADE OF THE EU

The EU continues to be one of the world's largest agricultural commodity exporting and importing countries. This is depicted in figure 1.

Figure 1: Leading agricultural commodity exporters and importers by value, 2008 (in billion USD)

Exporters		Importers	
Country	Value	Country	Value
United States	134.0	Extra EU-27	173.1
Extra EU-27	127.6	United States	115.9
Brazil	61.4	China	86.8
Canada	54.1	Japan	80.6
China	42.3	Russia	34.3

Source: Own figure based on WTO (2009).

EU is a large world agricultural trader

As is evident, the EU is now the world's single largest agricultural importer even when intra-EU trade is excluded, while it is second only to the United States in exports. In total, net imports of the EU-27 amounted to 45.5 billion USD in 2008.
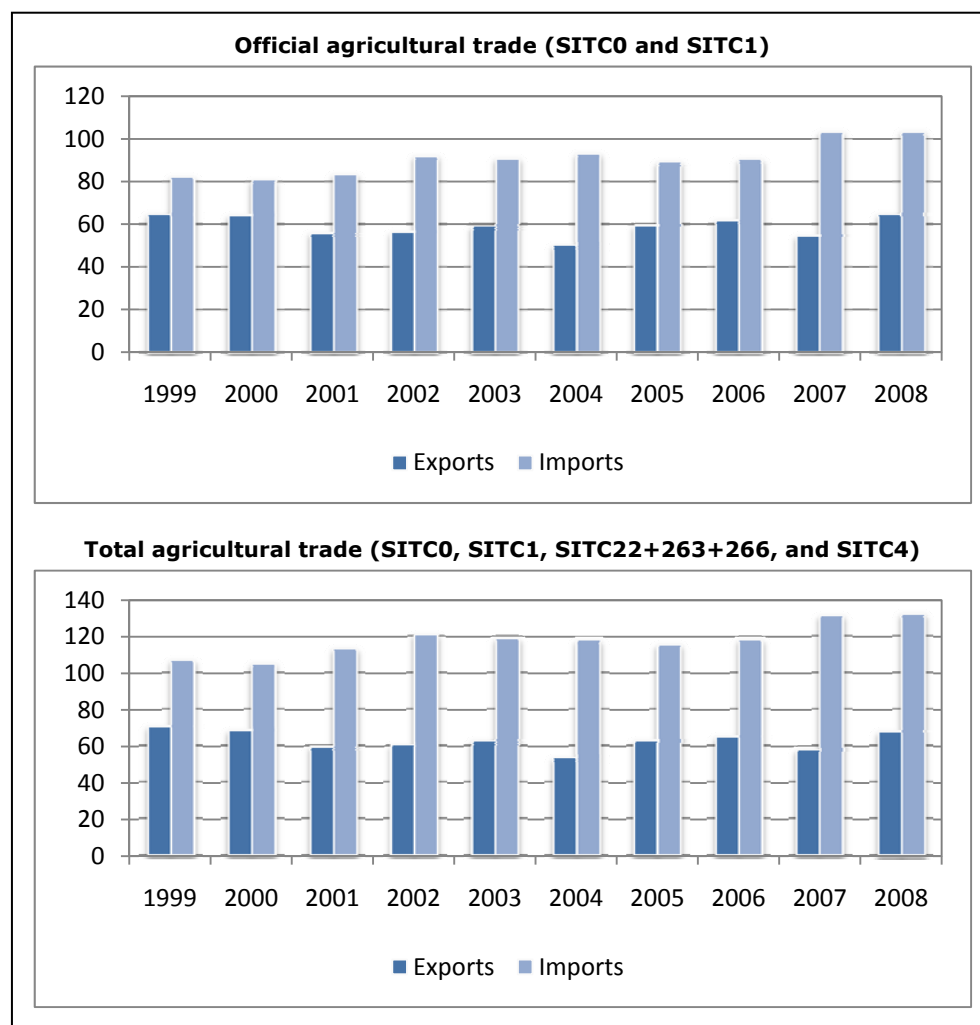
Amid the many changes the European Union has gone through during the last decade or so, it is not all too surprising to find that her international agricultural trade patterns have changed significantly as well. Figure 2 depicts the changes in EU-extra import and export quantities between 1999 and 2008:

- The volume of agricultural imports has always exceeded exports during the time period considered.

- Including SITC22, SITC263, SITC268 and SITC4 in addition to SITC0 and SITC1 does not increase the export volume by much. However, it acts to increase the volume of imports by about 30 million metric tons. To a large extent this reflects the fact that the European Union is the world's second most important importer of oilseeds.

- Total agricultural exports in terms of volume have slightly decreased over time.

- Total agricultural imports, however, have grown considerably from almost 107 million metric tons around the turn of the millennium to more than 132 million metric tons in 2008 which represents an increase of 24 percent

**EU is an impressive net importer of agricultural goods**

The resulting net trade position in terms of quantity is presented with figure 3. It combines the information of figure 2 in that it exhibits the agricultural net exports of the EU-27. As is obvious, the European Union continues to be a major net importer of agricultural commodities. In fact, the net import quantities can be considered impressive and almost doubled during the time period analysed here.

Figure 2: Agricultural export and import quantities, EU-27, 1999-2008 (in million tons)

Official agricultural trade (SITC0 and SITC1)

Total agricultural trade (SITC0, SITC1, SITC22+263+266, and SITC4)

Source: Own figure based on EUROSTAT (2010a, b).

Figure 3: Net trade quantities, EU-27, 1999-2008 (in million tons)
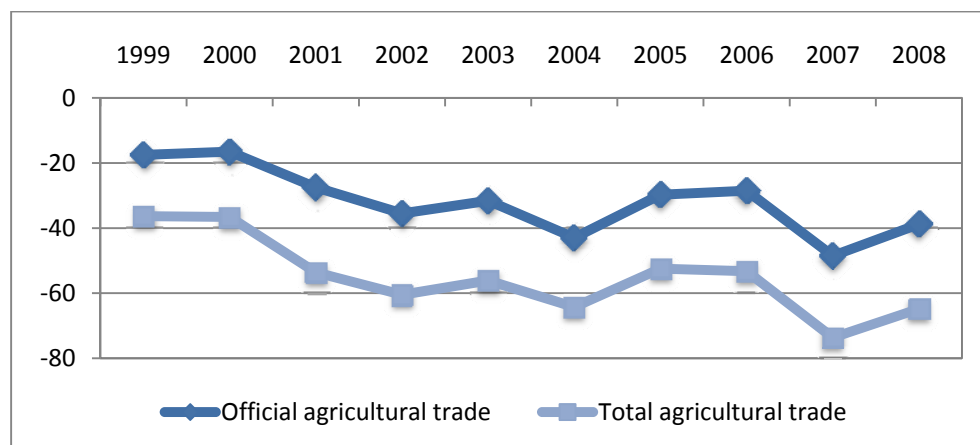
Source: Own figure based on EUROSTAT (2010a, b).

More details and additional information on international agricultural trade of the EU-27 is provided with Annex A. Agricultural exports and imports as well as the net trade position of the European Union are in terms of value. It becomes obvious that the net trade position of the EU-27 can be characterised similarly in terms of value with one exception: Contrary to volume, agricultural export values increased slightly during the past decade.

Recent market developments determine trade

The recent increase in agricultural export values of the European Union in part has been the result of international agricultural market developments since the turn of the millennium. The long-term trend in world market prices during which farmers around the world have produced ever more food for ever more humans at ever declining prices has come to an end. Since the turn of the millennium, agricultural commodity prices have tended to increase albeit with significant fluctuations as in the past.

The reason for the upward trend in international agricultural commodity prices is that global demand growth has outstripped the growth in supply:

- Demand growth is driven by a continued rapid population growth and increasing per capita food consumption in developing and newly industrialising countries.

- Food supply growth, however, cannot keep pace with the growth in demand for a variety of reasons including increasing global scarcities in resources for food production (including land, water and energy) as well as a general neglect of agriculture and its infrastructure in many parts of the world (VON WITZKE et al. 2008; 2009).

- The latter includes declining investment in public agricultural research (PARDEY, 2009) which is aggravated by a regulatory environment in many countries which discourages agricultural innovation.

Additional trade determinants

Besides those market developments additional driving factors determined agricultural trade of the European Union after the turn of the millennium:

- The reform process of the CAP certainly has had an impact on the agricultural net trade position of the European Union. Domestic price supports have been reduced significantly or they have been discontinued altogether. Export subsidies and import duties have been reduced as well.

- Direct payments have increasingly become decoupled from actual production. While the decoupled payments continue to show significant production effects (VON WITZKE et al., 2010) the incentives to produce have declined as a consequence of policy reform and modulation.

- The mandatory set aside requirement has been discontinued recently. While this will most likely increase production, its effects will not begin to show up until 2009/10, i.e. post the time period considered here.

- The 'Everything But Arms' agreement which permits unrestricted European Union market access for the least developed countries probably also contributed to the growth in net imports.

- In addition the European Union made further concessions in the WTO negotiation which have led to lower import barriers on many agricultural markets.

- The increasing value of the EUR against the USD during the time period considered here acted to make European Union exports more and foreign imports into the European Union less expensive.

- With increasing income consumers' demand in the European Union has shifted more towards 'food away from home' as well as more processed and prepared foods both of which are often considered to result in an increasing use of agricultural commodities for a given number of consumer calories.

Particular role of EU enlargement

During the time period covered here the European Union grew in members from 15 to 27 member states. Enlargement, however, should not be considered a key driving force with respect to recent agricultural trade developments. Figure 4 depicts agricultural EU-extra exports and imports of the EU-15 respectively EU-27 in 2004, the year when ten new member states joined the European Union. It becomes obvious that the numbers are similar indicating that self sufficiency was rather high in the new member states before accession.

Figure 4: Agricultural exports and imports of the EU-15 and EU-27 in 2004 (in million tons)
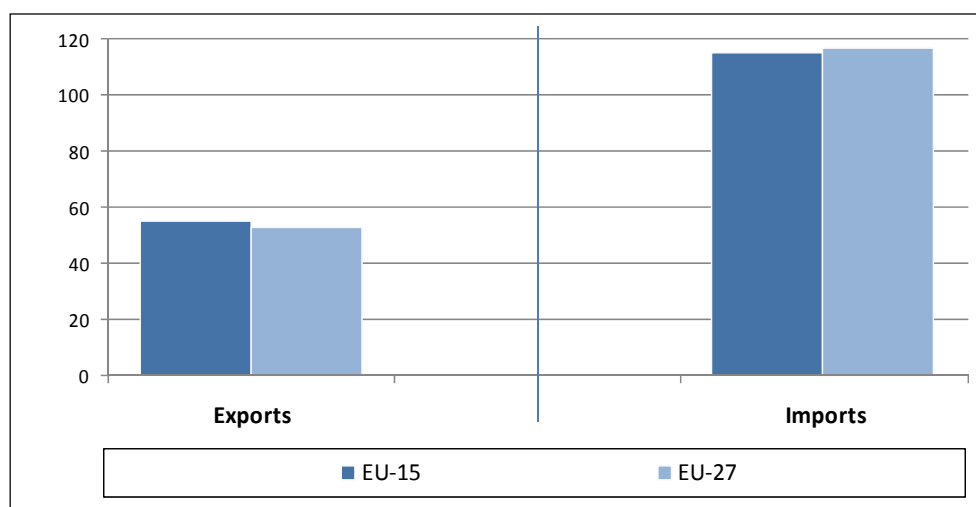
Source: Own figure based on EUROSTAT (2010a, b).

Selected markets in detail

Figure 5 summarises the change in trade patterns for selected but important agricultural commodities and commodity groups. More specific trade data and details on single agricultural commodities are exhibited in Annex B.

Grains

In total grains, the decline in export and the increase in imports are far above average. While the exports for wheat went up slightly and corn exports have declined by 7 percent, the export quantity of other grains (barley, rye, triticale, oats, etc) is down by more than half. Grain Imports rose significantly with more than 20 million metric tons in 2007/2008. This is three times more than less a decade ago. In wheat, net exports have declined by 2.5 million metric tons. In corn, the net

import quantity more than quadrupled. In other grains net exports have declined to near zero. Consequently, the European Union lost its position as a net exporter of grain and has become a net importer in recent years.

In addition to the variables discussed above this is likely to reflect substitution processes in the European Union, as feed corn acreage is now used to produce bioenergy. The same is true for grains other than corn. In Germany alone, 1.5 million metric tons of grains are used for bio-energy production (LₐFL and LEL, 2009; 2010). In addition, decline in animal production, mainly in beef and milk, has reduced the use of feed grains. Furthermore, the decoupled direct payments to farmers have increased the profitability of oilseeds relative to grains and have also contributed to the changing EU trade pattern in grains.

Oilseeds

The European Union is a large net importer of oilseeds and oilseeds products. Its net import position has become even more pronounced. European Union specific imports are second only to China.

Although soybeans imports have remained largely unchanged, there is a large increase in the import quantities in soybean oil, palm oil and other vegetable oils. In soybeans oil, the European Union has switched from a net export to a net import position. While feedstuff imports of soybeans have increased by about seven million metric tons, net imports of other feedstuffs have declined by roughly the same amount.

Despite increasing rapeseed production in the European Union – particularly caused by the reform of the sugar market regime which led to an increasing acreage planted to rapeseed – net imports of rapeseed oils have increased considerably partly reflecting a substantial increase of rapeseed oil consumption for food.

Meat

Bovine meat exports are down by more than 80 percent while other meat exports (mostly pig meat) have gone up by around 10 percent. The increase of imports in meats, both bovine and other meats, has been above average. In total meat, the European Union is still a net exporter, but exports went down from 2.2 to 1.4 million metric tons.

Several factors have contributed to the changing trade flows in meat. One of them results from the EU dairy quota regime. About two thirds of all cows in the European Union are dairy cows. With increasing productivity of cows a smaller herd size (and thus calves) is needed to meet the quota. Bovine meat production, hence, reflects the reduction in the number of beef cattle for fattening. Herd size has declined from 93 million animals in 2000 to 89 million in 2008. This likely is also the result of slaughter premiums, reduced EU import tariffs and export subsidies as well as the BSE-crisis.

The EU market regulations in pork and poultry traditionally have been fairly liberal. Production in the European Union had to struggle with increasing competition. A further issue are the limitations imposed by the European Union on the transportation of live animals. This has dramatically reduced, e.g., sales in the Middle and Near East.

Figure 5: Agricultural exports, imports and net trade for key commodities, EU-27 (in million tons)

		1999/2000	2007/2008	Change	
Wheat	Exports	12.82	13.29	%	3.7
	Imports	3.58	6.62	%	84.8
	Net trade	9.24	6.67		-2.56
Corn	Exports	1.06	0.99	%	-7.1
	Imports	2.70	10.28	%	280.8
	Net trade	-1.64	-9.29		-7.66
Cereals, other	Exports	11.23	4.73	%	-57.9
	Imports	0.68	3.84	%	460.7
	Net trade	10.55	0.90		-9.65
Soybeans	Exports	0.05	0.03	%	-40.0
	Imports	14.57	14.80	%	1.6
	Net trade	-14.51	-14.77		-0.25
Other oilseeds and oilfruits	Exports	1.77	0.87	%	-50.9
	Imports	3.51	3.39	%	-3.5
	Net trade	-1.74	-2.52		-0.78
Soybeans oils	Exports	0.97	0.29	%	-70.1
	Imports	0.03	1.05	%	3513.6
	Net trade	0.94	-0.76		-1.70
Vegetable oils, other	Exports	1.38	0.91	%	-34.1
	Imports	3.85	8.19	%	112.7
	Net trade	-2.48	-7.27		-4.79
Feeding stuff from soybeans	Exports	0.22	0.44	%	97.4
	Imports	16.12	23.39	%	45.1
	Net trade	-15.90	-22.95		-7.05
Feeds for animals, other	Exports	2.52	3.50	%	39.0
	Imports	14.56	9.01	%	-38.1
	Net trade	-12.04	-5.51		6.53
Meat, bovine	Exports	0.56	0.09	%	-83.8
	Imports	0.19	0.24	%	26.8
	Net trade	0.37	-0.15		-0.52
Meat, other	Exports	2.61	2.88	%	10.5
	Imports	0.76	1.33	%	76.3
	Net trade	1.85	1.55		-0.30
Dairy products	Exports	2.63	2.38	%	-9.6
	Imports	0.34	0.29	%	-14.3
	Net trade	2.30	2.09		-0.20
Vegetables	Exports	3.48	5.34	%	53.5
	Imports	7.72	6.56	%	-15.0
	Net trade	-4.24	-1.23		3.02
Fruit	Exports	2.14	3.48	%	62.4
	Imports	11.96	16.61	%	38.9
	Net trade	-9.82	-13.13		-3.31
Sugars	Exports	6.25	2.09	%	-66.6
	Imports	5.50	6.12	%	11.4
	Net trade	0.76	-4.04		-4.79
Coffee, Cocoa, Tea	Exports	0.70	1,05	%	49.1
	Imports	4.37	5.23	%	19.8
	Net trade	-3.66	-4.18		-0.52

Source: Own figure based on EUROSTAT (2010a, b).

Dairy

Dairy exports have declined by about 10 percent. This is mainly the result of the reform process of the CAP which has resulted in a significant reduction in the domestic minimum price (intervention price) and in export subsidies. In addition, an enlargement effect contributed to the decline in dairy exports: Quotas in the new member states were set below self sufficiency.

Fruit and vegetables

Fruit and vegetable exports have increased considerably. This reflects the enlargement of the European Union which included countries with a significant production potential. Fruit imports, in particular imports of tropical fruit, increased at the same time. Income growth in the new member states and, hence, changes in consumer preferences can be attributed to this particular development.

Sugar

The reform of the EU sugar policy in 2006 is beginning to have an impact on EU production and trade. Domestic minimum producer prices have been reduced by almost 40 percent. The sugar production quota has been reduced too. In addition sugar beets are used for the production of bioethanol. All this led to a substantial decrease of exports (almost 70 percent) and an increase of imports (10 percent). Consequently, the European Union lost its net export position and became a net importer of sugars.

4. CONVERSION OF AGRICULTURAL INTO LAND TRADE

The quantities of agricultural commodities and processed products which are traded have been translated into arable land requirements for exported and imported goods using the approach presented in chapter 2. The results of this procedure are displayed in figure 6.

EU land trade amounts to 35 million hectares …

As can be seen, virtual land exports have declined to 14 million hectares (minus 17 percent) during the time period considered here, while virtual land imports have gone up to almost 49 million hectares (plus 15 percent). In 2007/08 the virtual net import of land has amounted to almost 35 million hectares. This is an increase of almost 10 million hectares and nearly 40 percent relative to 1999/2000. Thus, the European Union is using approximately one third of her own utilized arable area outside its own territory.

… and is equivalent to the territory of Germany

The numbers are impressive: The currently occupied arable land in third countries (34.9 million hectares) is almost equivalent to the entire territory of Germany; and the increase of virtual land trade between 1999/2000 and 2007/2008 amounts to 9.6 million hectares which is larger than the land area of Hungary or Portugal.

A major cause of the substantial growth in virtual land import is the increased use of soybeans and related products. They accounted for an increase of about 3.7 million hectares. Additional substantial contributions have resulted from coarse grains (plus 2.7 million hectares), wheat (plus 1.6 million hectares) and corn (plus 1.5 million hectares). Palm

fruits have contributed an additional 1.0 million hectares to the increase in net imports of virtual land. Other oilseeds, oleaginous fruits and vegetables have acted to slightly reduce net imports.

Figure 6: EU arable land virtually traded (in million ha)
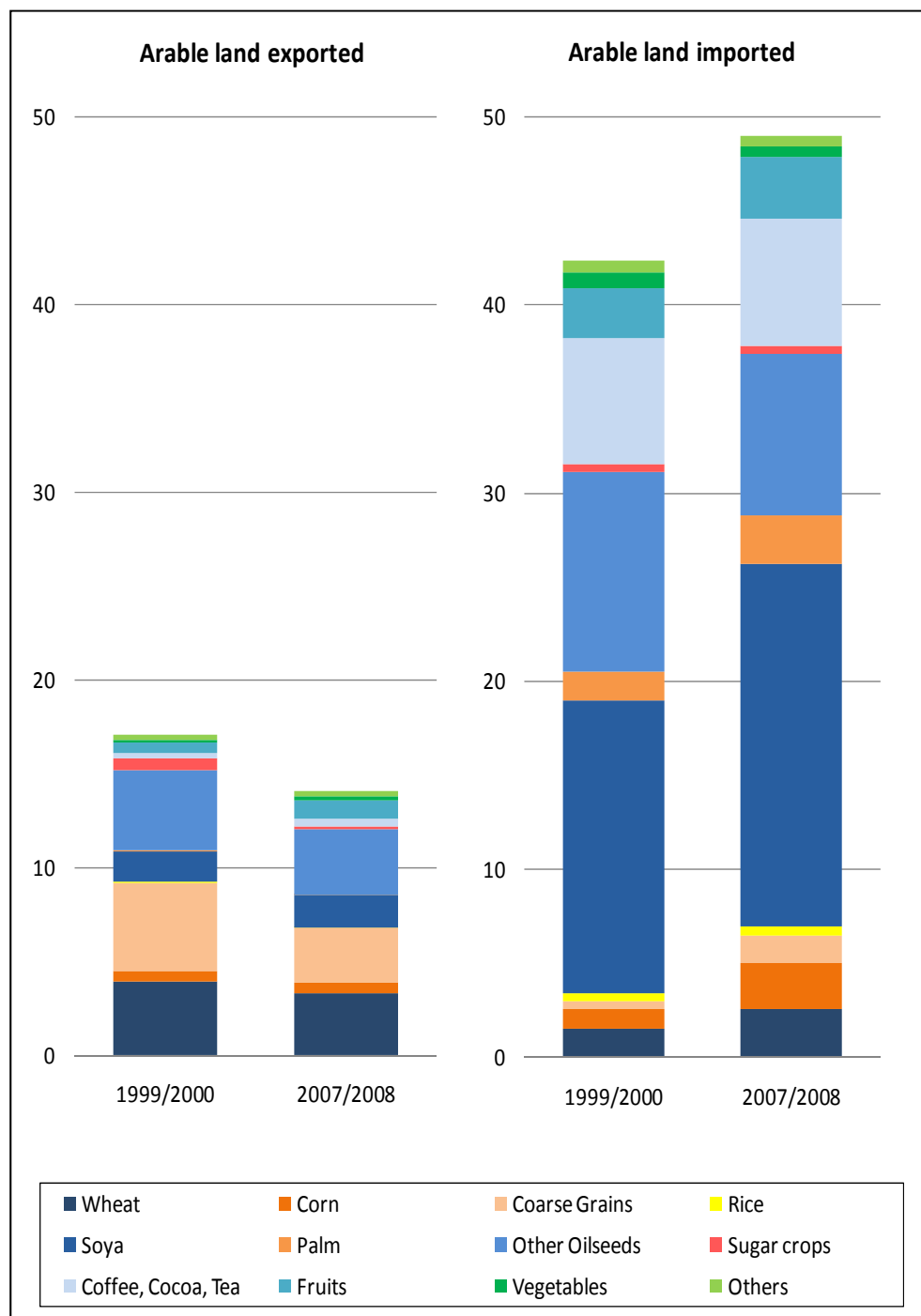
Source: Own calculations.

The resulting virtual land trade by commodity (group) for 2007/2008 is displayed in figure 7.

Figure 7: Composition of the land exports and imports and resulting net land trade of the EU, 2007/2008 (in million ha)

	Land exports	Land imports	Net land trade
Wheat	3.28	2.57	0.71
Corn	0.56	2.48	-1.92
Coarse grains	2.92	1.40	1.52
Rice	0.04	0.53	-0.49
Soybeans	1.71	19.24	-17.53
Palm fruits	0.05	2.61	-2.56
Other oilseeds	3.47	8.59	-5.12
Sugar crops	0.15	0.44	-0.29
Coffee, Cocoa, Tea	0.44	6.72	-6.28
Fruits	0.95	3.31	-2.36
Vegetables	0.22	0.56	-0.35
Others	0.31	0.54	-0.23
Total	**14.10**	**48.99**	**-34.90**

Source: Own calculations.

As is evident, the European Union is now a net exporter of virtual land in wheat and coarse grains only. All other commodities and commodity groups result in a net import of land. Soybean is the key commodity in this regard, as it accounts for more than 50 percent of the virtual land net import.

Grassland activities add additional land

The calculations above include arable land only. Grassland is adding additional hectares to net land imports of the European Union. However, suitable data are not available. A rough approximation of virtual grassland imports can be based on an analysis by SCHÖNLEBER (2009) which suggests that the traded quantities of red meat and dairy products would result in an additional land use of approximately 1 million hectares.

In sum, the European Union continues to be a major net importer of agricultural commodities. Net import quantities have increased significantly. Therefore, the European Union is not only a major importer of virtual agricultural land but is importing an increasing virtual agricultural acreage. The question is, now, how different technology and policy environments may alter the amount of virtual land grabbed by the EU outside its territory?

5. EU VIRTUAL LAND TRADE UNDER TECHNOLOGY AND POLICY CHANGE

Three scenarios

In the following we will analyse how alternative technologies and policies affect virtual land trade flows between the European Union and the rest of the world. Three scenarios for the European Union will be considered. They include increasing land productivity, i.e. yields, expansion of the acreage planted to organically produced crops, and growing bioenergy production.

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Scenario 'Yield increase'

Productivity growth in world agriculture has been on a decline since the Green Revolution of the 1960s and 1970s. From the 1960s through the 1980s productivity growth in world agriculture averaged around four percent. It is now down to about one percent with a continuing tendency towards further decline (FAO, 2008; VON WITZKE et al., 2008). There are two reasons for this:

- One of them has been the fact that the productive potential of crops has increasingly been captured by traditional breeding methods such that additional productivity growth can only be realised by ever increasing investment in agricultural research.

- And the second reason is that exactly this has not happened. To the contrary public agricultural research has experienced significant cut-backs, in particular when it comes to research aiming at productivity growth (PARDEY at al., 2007; PARDEY, 2009). Moreover, private agricultural research is faced with a regulatory environment in many countries that discourages innovation.

Yield growth in the European Union is an illustrative example for this. Since the 1990s wheat yields have increased by an annual rate of around 0.6 percent (EUROSTAT, 2009).

Yield increases 50 percent up

In the scenario 'Yield increase' we calculate the change in virtual agricultural land imports by the European Union under the assumption that the actual annual yield growth in the European Union was 50 percent higher than the actual growth during the time period between 1999/2000 and 2007/08. In wheat, to take an example, this would imply a yield increase of 7.7 percent rather than 5.1 percent.

Scenario 'Expanded organic farming'

The number of organic farming enterprises in the European Union has grown year by year. The number of consumers buying organic food products has increased as well. The European Union has policies in place which subsidize organic farming and encourage its expansion (EC, 2004).

Organic farming on 20 percent of land

Despite this, only about 3 percent of arable land and 4 percent of total agricultural land in the European Union are farmed organically (SCHAACK, 2010). Policy targets for organic farming are formulated by individual member states and not by the European Union. The German Government, e.g., in its sustainability strategy aims at a minimum of 20 percent of all agricultural land to be farmed organically (BUNDESREGIERUNG, 2008).

Yields in organic farming are lower than in conventional farming (see, e.g., NOMISMA, 2008). In the scenario 'Expanded organic farming' we calculate the change in agricultural land use which would have resulted if 20 percent of cropland in the European Union had been farmed organically in 2007/08.

Scenario 'EU's biofuels mandate'

Initially the European Union had formulated the objective of using 20 percent renewable energy in total energy consumption (EUROPEAN PARLIAMENT and EUROPEAN COUNCIL, 2007). The EU recently changed this objective and now aims at using 10 percent renewable energy respec-

tively 5.6 percent biofuels in road transportation (EUROPEAN PARLIAMENT and EUROPEAN COUNCIL, 2009; AL-RIFAI et al., 2010).

Biofuels mandate of the EU boosts consumption

According to AL-RIFFAI et al. (2010) this would imply the production of 10 percent more biodiesel and 157 percent more bioethanol than in 2008. In addition this would result in imports of biodiesel or biodiesel crops by 15 percent and of bioethanol by 500 percent (albeit from a rather low base). This in turn would lead to a growing sunflower, soy-beans, rapeseed and palm fruit demand for biodiesel production as well as an increased use of wheat, sugar (cane and or beets) and maize for bioethanol production. The production and import changes of these crops, being necessary to achieve the EU bioenergy objective, which have been generated by AL-RIFFAI et al. (2010) are used for the calcula-tion of the change in virtual agricultural land imports by the European Union.

Results for the three scenarios

Applying the selected parameters of the three defined scenarios to our indicator based approach results in acreages imported as depicted in figure 8.

Figure 8: Net land imports of the EU under changing technologies and policies (in million ha)
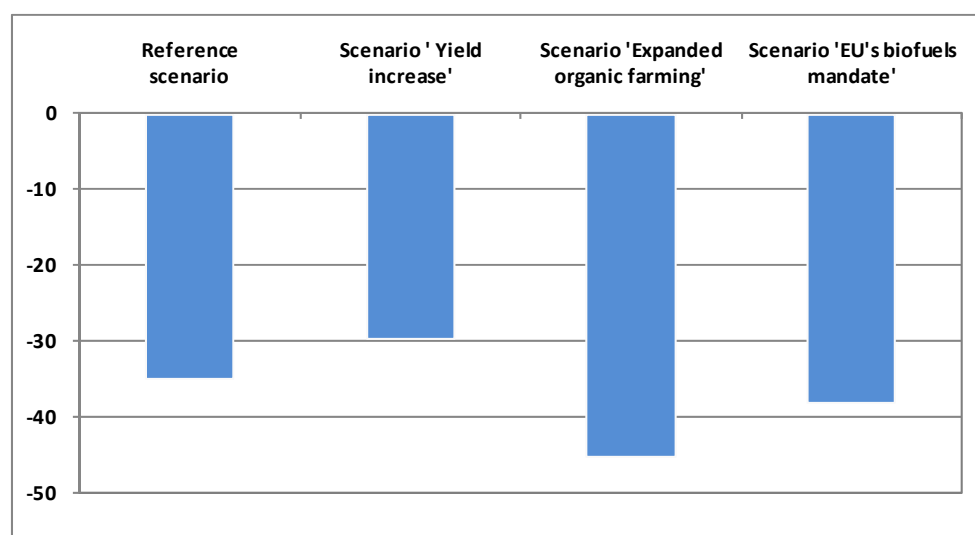
Source: Own calculations.

Higher yields decrease land imports

The 'Yield increase' acts to significantly reduce EU virtual land imports. It would save about 5.3 million hectares of cropland outside the Euro-pean Union. In fact, had productivity growth in the European Union been double of what it was in the 1999/2000 to 2007/08 period the virtual land import would have been about 10 million hectares lower and had remained roughly at the 1999/2000 level.

Organic farming and also biofuels increase land imports

Expanding acreage of organically farmed land would have the opposite effect. Under the assumption of this scenario the virtual agricultural land net import would increase by 10.2 million hectares to a total of 45.2 hectares. This is an increase in virtual land net import of almost 30 per-cent.

Achieving the EU biofuel objective would increase the amount of virtually imported land as well. However, the order of magnitude would be much smaller than in the scenario with expanded organic farming acreage. Net

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imports of virtual land would increase by slightly more than 3 million hectares.

6. CONCLUSIONS

Global food demand is likely to double in the first half of the 21st century (VON WITZKE et al., 2008). This rapidly growing demand can be satisfied by expanding the agricultural acreage or by producing more on the land being farmed already. From the 1960s to the 1980s about 80 percent of global food production growth was the result of productivity growth and only 20 percent was accounted for by expanding the acreage. As the land that is available for food production is limited on a global scale, the production growth necessary to meet the rapidly growing world food needs must be based even more on productivity growth (e.g. RUNGE et al, 2003; BRUINSMA, 2003; FAO, 2008).

The European Union is a net food importer. Her net imports have gone up significantly in the past decade. In fact the European Union is now tied with China as the world's largest net importer in terms of value. As a consequence, the European Union has become a large importer of virtual agricultural land. This would not be a major issue had the growth in net imports of virtual land not had negative economic externalities in the form of reductions in natural habitats such as tropical rain forests and increasing greenhouse gas emissions from converting forests and grasslands into cropland.

In this paper it has been demonstrated that increasing production of agricultural commodities in the European Union would significantly reduce net food imports. The analysis presented in this paper also suggests that it would also significantly reduce the import of virtual land from around the world. Moreover it has become clear that declining food production through expansion of organic production or bioenergy acreage would have the opposite effect.

Increasing agricultural productivity growth by just 0.3 percentage points per annum for major crops would reduce the European Union's net import of virtual land by 5.3 million hectares.

Productivity growth is a key in meeting global challenges

In sum, productivity growth in European Union agriculture (or in other regions of the world) is the key in dealing with at least three global challenges (see also figure 9):

• One of them is the fight against malnutrition around the globe. Economic analyses of agricultural commodity markets suggest significantly higher prices in the future. Most of these analyses arrive at price increases in the range of about 15 to 30 percent. However, when higher energy prices are accounted for, the commodity price increases will be much higher (VON WITZKE et al, 2009).

While it may be desirable that the poor countries of the world contribute more to meeting their food needs, it has become apparent that these countries will not – even under the best of all realistic scenarios – be close to become self sufficient in food in the decades ahead. In fact, the food import gap of developing countries is expected to quintuple between 2000 and 2030 (BRUINSMA, 2003). Therefore, the food needs of the world can only be met when the

rich countries produce and export more food and not less, as it is sometimes argued.

- Another challenge arises from the fact that significantly higher agricultural commodity prices also increase the incentives to expand the agricultural acreage. But already today deforestation and other forms of agricultural land use change contribute more to global warming than global manufacturing or transportation.

- Productivity increase is also instrumental for the preservation of natural habitats. It will enable farmers providing environmental public goods and services such as additional nature protection zones and more biodiversity along with maintaining adequate and secure food supply (DE L'ESCAILLE and CAPRI, 2010). This holds for the European Union and for the world at large.

Figure 9: The 'golden' triangle of productivity growth
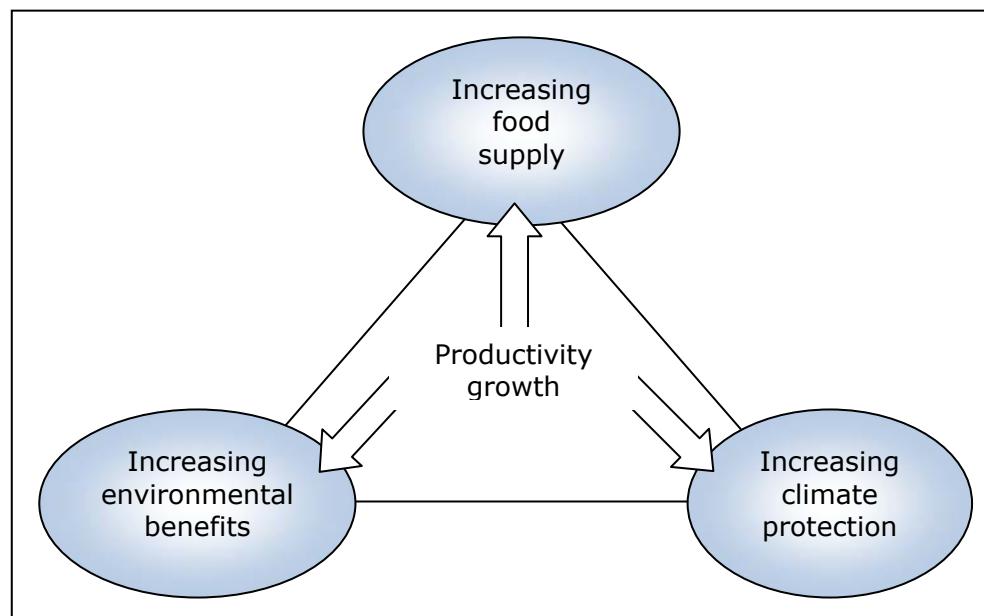
Source: Own figure.

Policy implications   Our findings have two major policy implications:

- To secure long-term productivity growth in agriculture around the world it is necessary to again increase public agricultural research and to create a policy environment which encourages private research investments rather than hindering it. Time and again economic analyses have demonstrated that the social rate of return to agricultural research is very high (e.g. PARDEY, et al., 2007; PARDEY, 2009; VON WITZKE et al., 2004). Typically it is far above the market interest rate, suggesting significant underinvestment in agricultural research from a societal perspective (RUTTAN, 1980; OEHMKE, 1986; ROSEBOOM, 2002).

- Investing in poor countries agricultural infrastructure and making available land saving technologies already in use in rich countries both have the potential to increase productivity in fairly short periods of time (e.g. VON WITZKE, 2010). At present the lacking availability of fertilizer leads to nutrient mining in many poor regions of the

world resulting in soil degradation which is costly to reverse. About 40 percent of the potential yield is lost to pests and diseases. Almost half of it could be avoided if farmers in poor countries had access to crop protection measures. Making of modern seed varieties available to farmers in poor countries can also increase food production there. A significant portion of crops is lost post harvest because of lacking infrastructure for storage, transportation and handling.

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ANNEX

List of Annexes

Annex A.1:   Agricultural export and import values, EU-27, 1999-2008 (in billion EUR)

Official agricultural trade (SITC0 and SITC1)

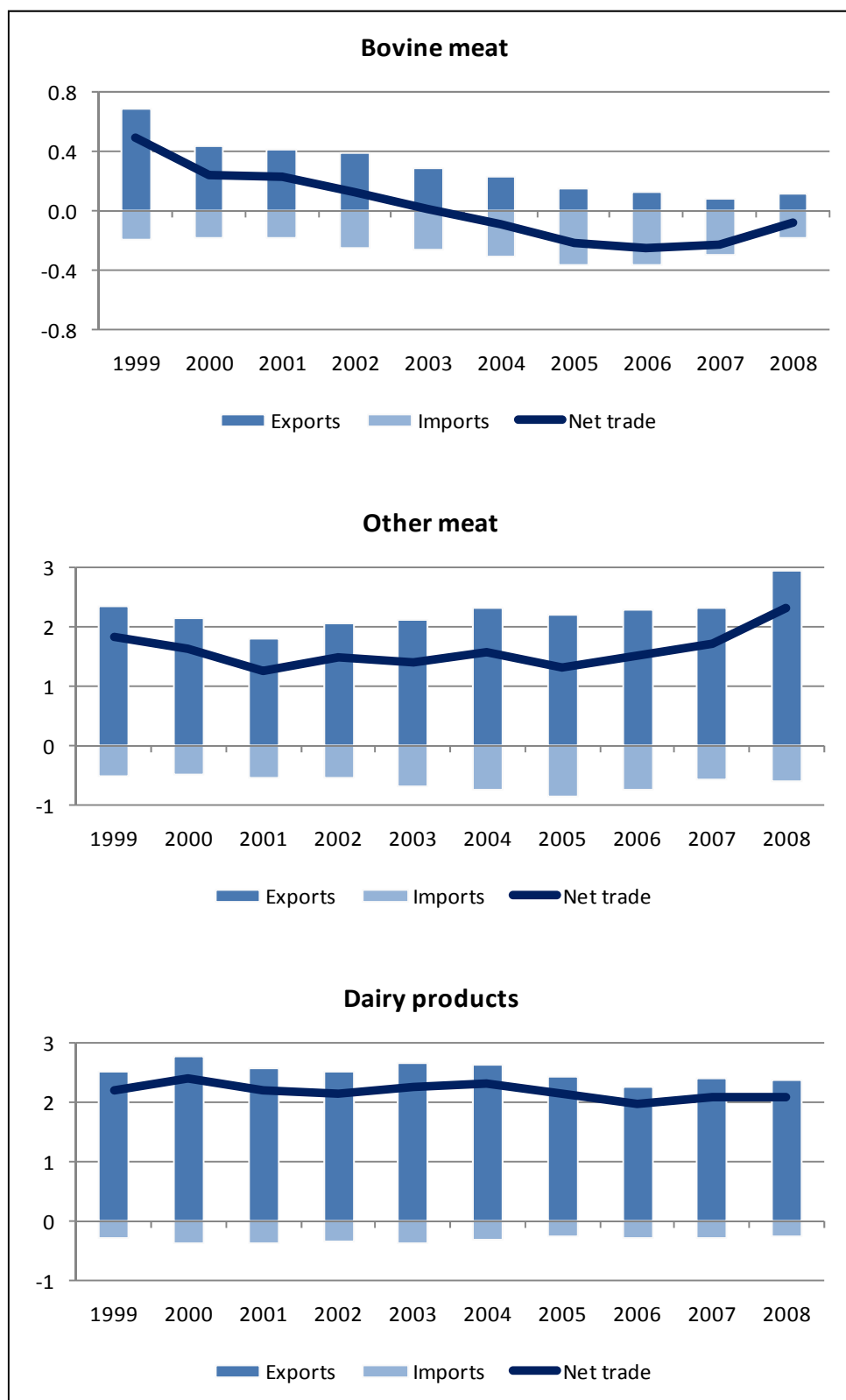**Total agricultural trade (SITC0, SITC1, SITC22+263+266, and SITC4)**

Source: Own figure based on EUROSTAT (2010a, b).

Annex A.2:   Net trade values, EU-27, 1999-2008 (in billion EUR)

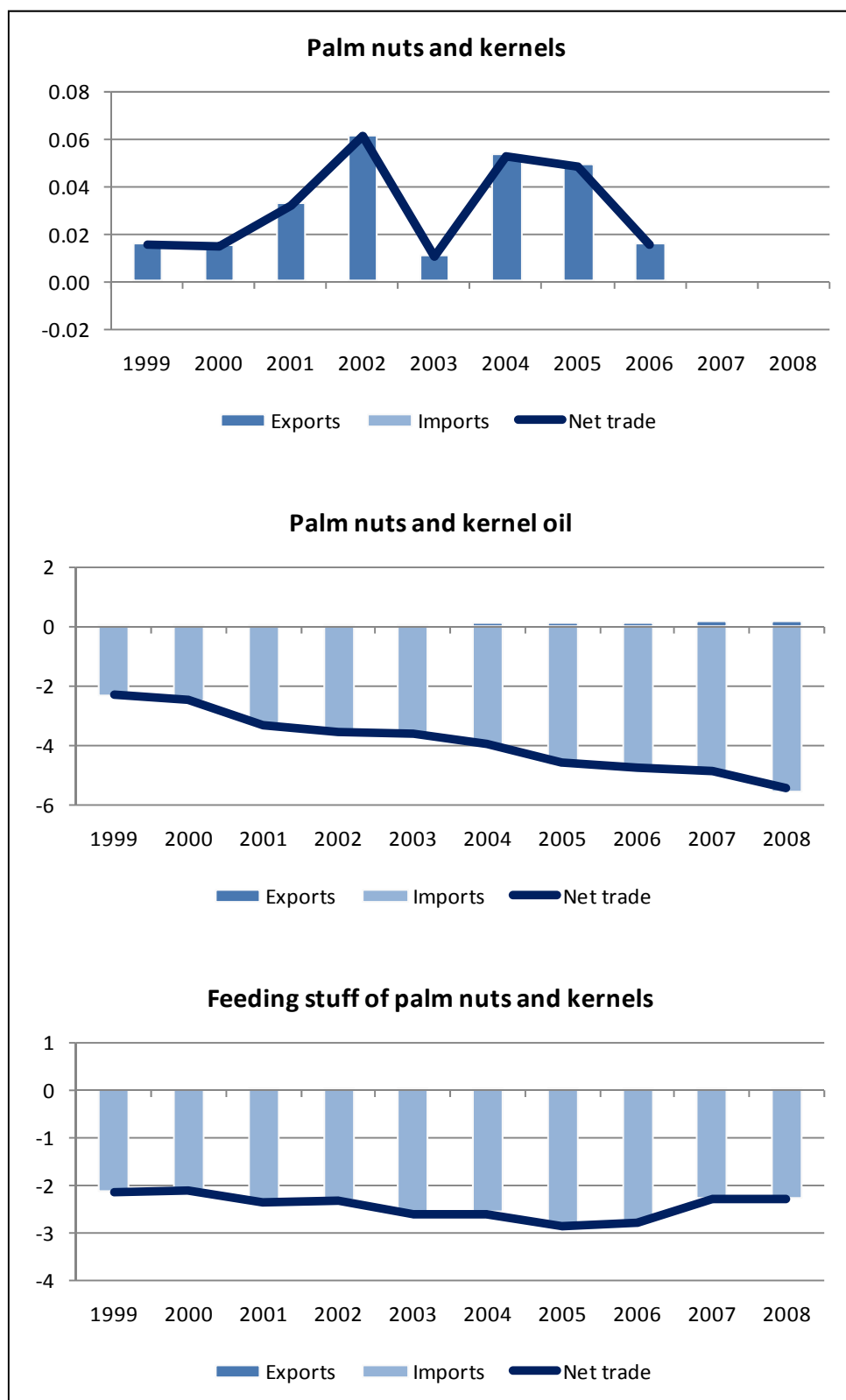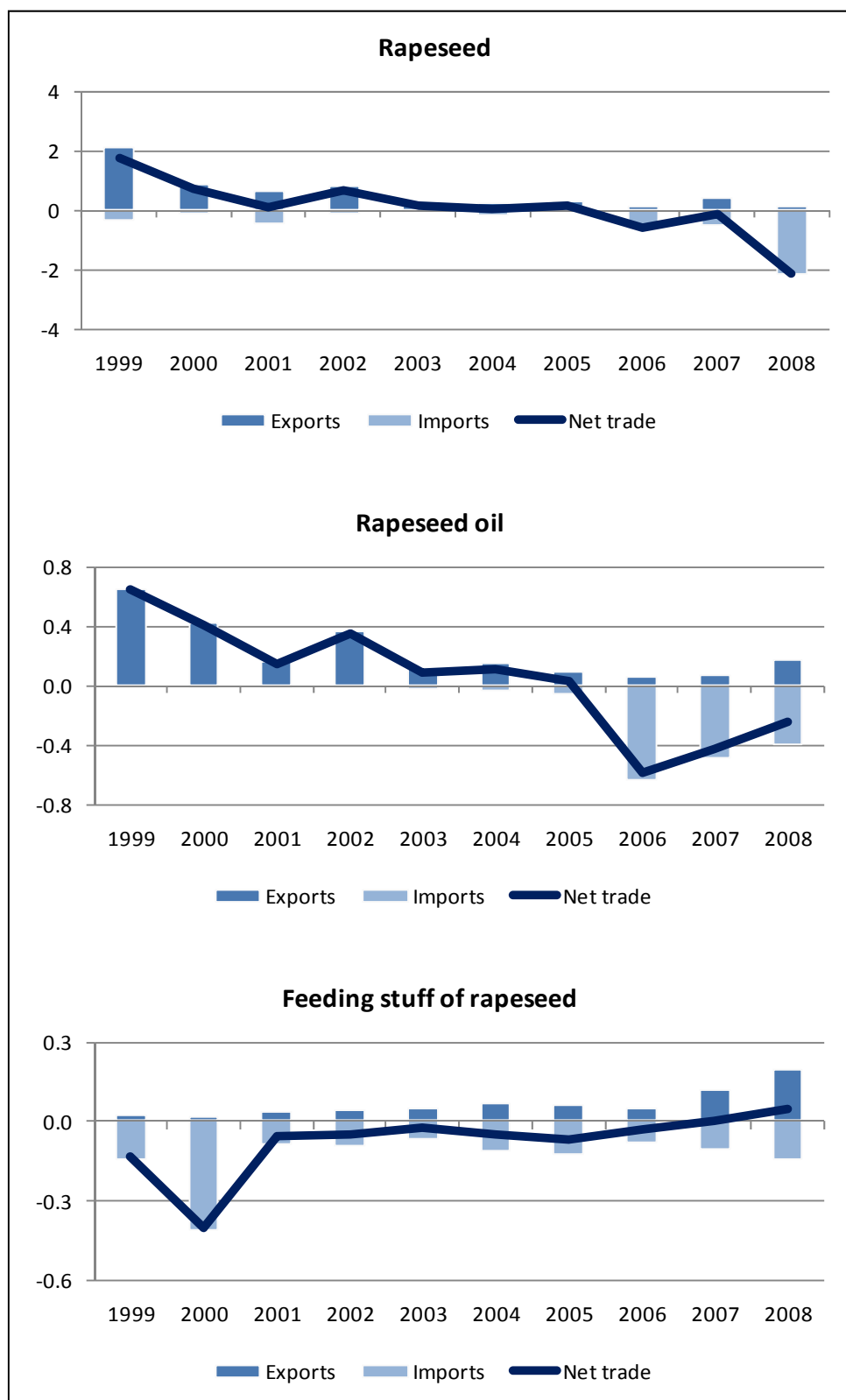Source: Own figure based on EUROSTAT (2010a, b).

Annex B.1: **Exports, imports and net trade of meat and dairy products, EU-27, 1999-2008 (in million tons)**

Bovine meat

Other meat

Dairy products

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.2:   Exports, imports and net trade of grains, EU-27, 1999-2008 (in million tons)
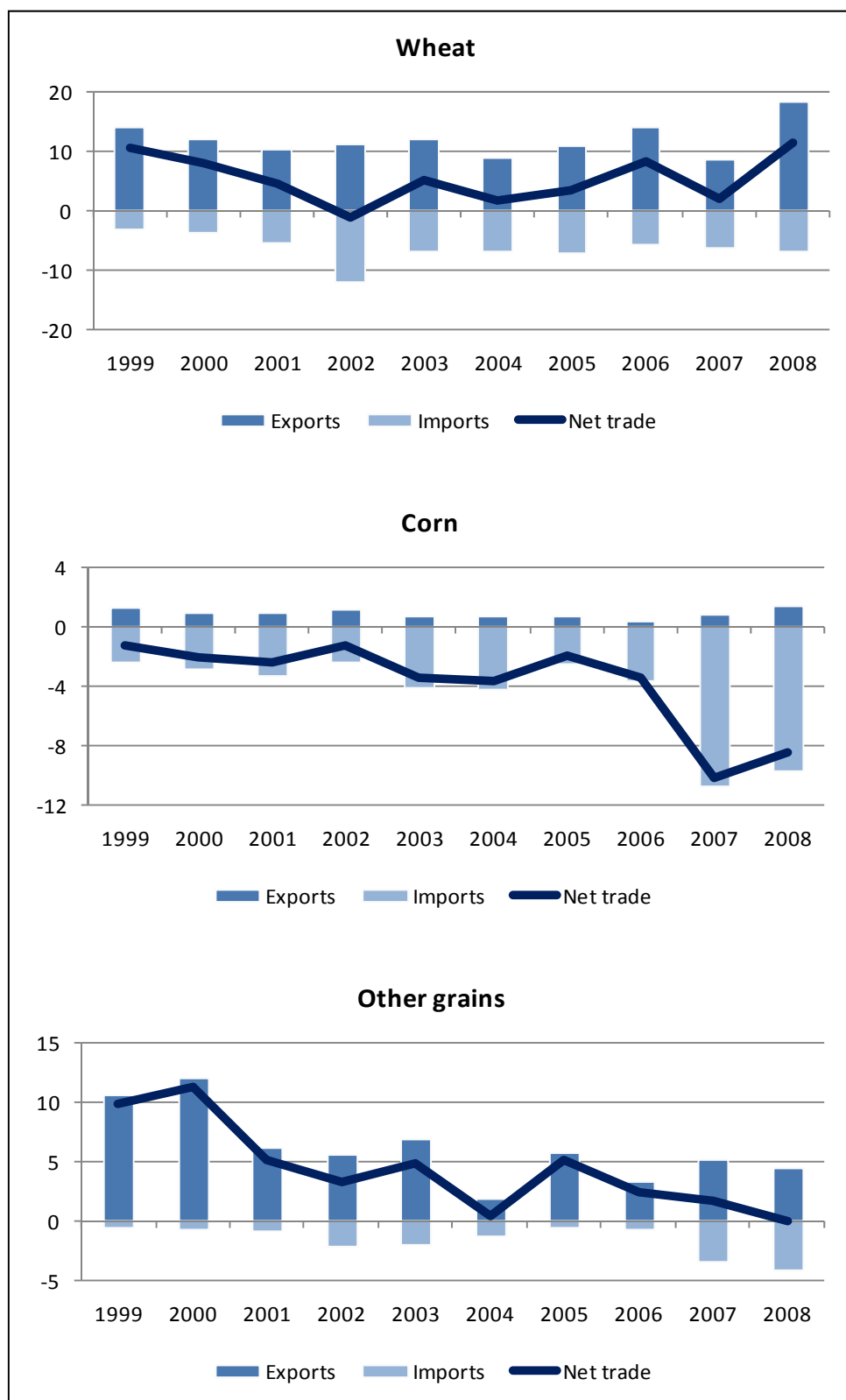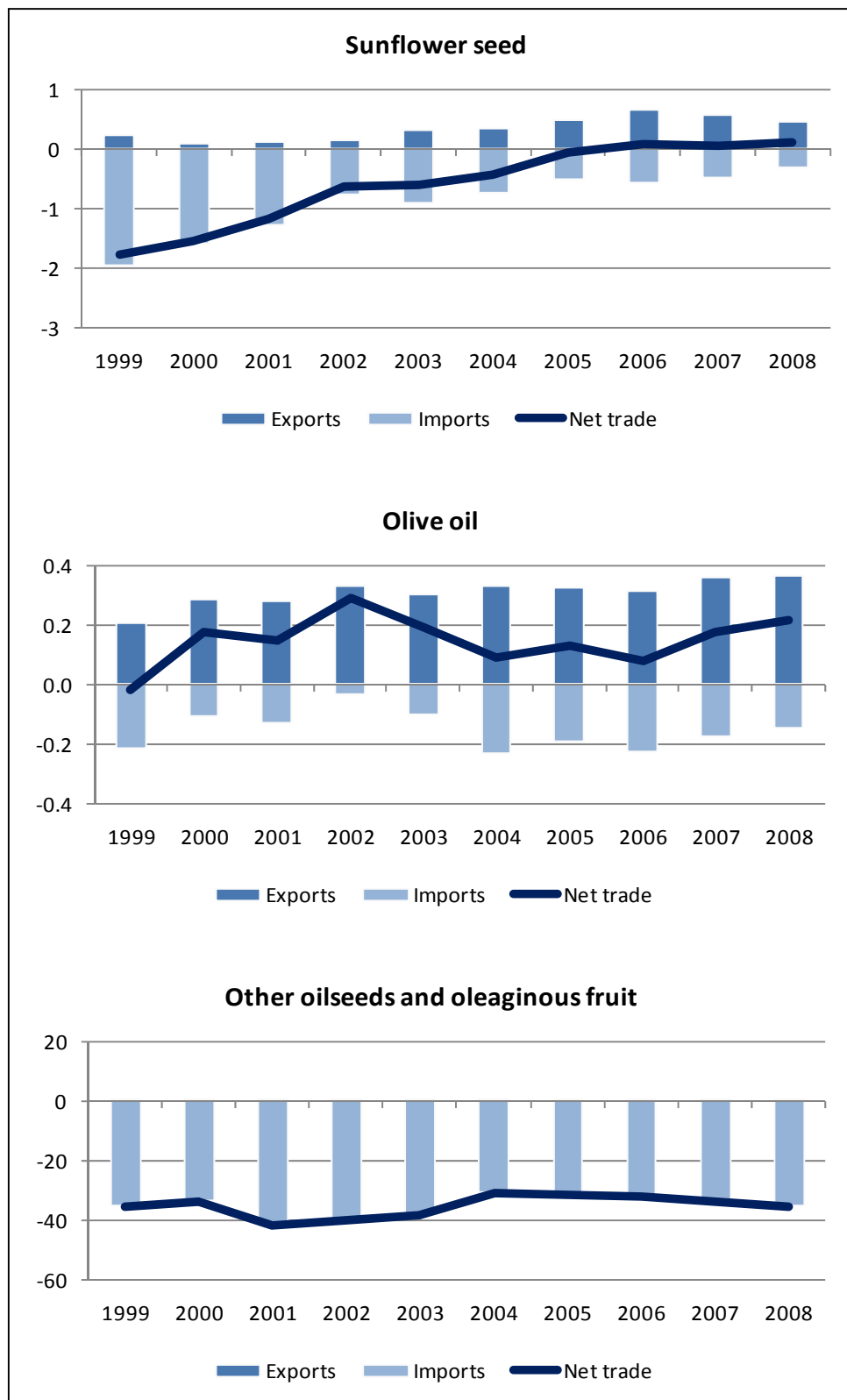

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.3:   Exports, imports and net trade of rice and cereal preparations, EU-27, 1999-2008 (in million tons)

Rice

Cereal meals and flours

Other cereal preparation
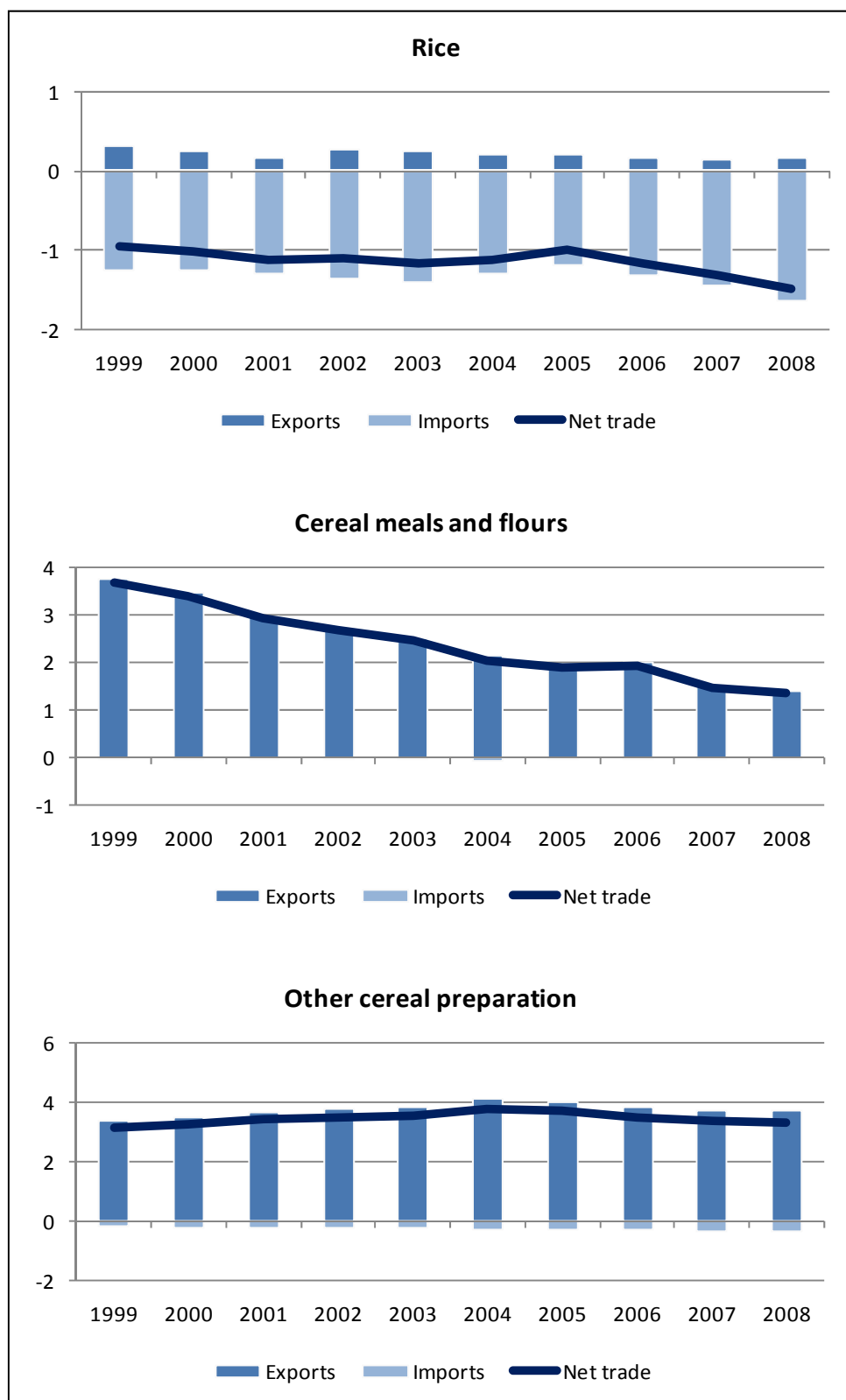
Source: Own figure based on EUROSTAT (2010a, b).

Annex B.4:   Exports, imports and net trade of soya beans and soya products, EU-27, 1999-2008 (in million tons)
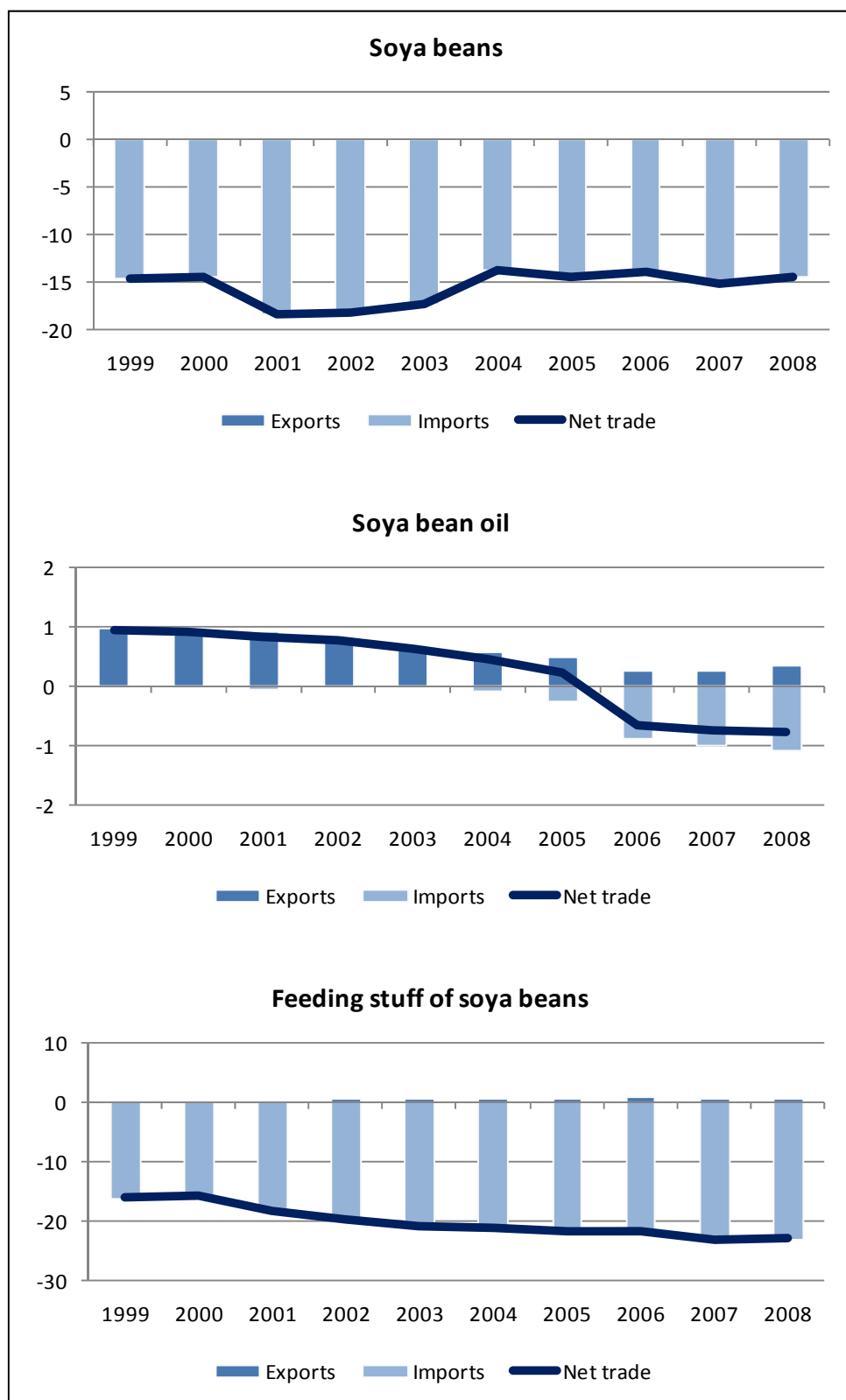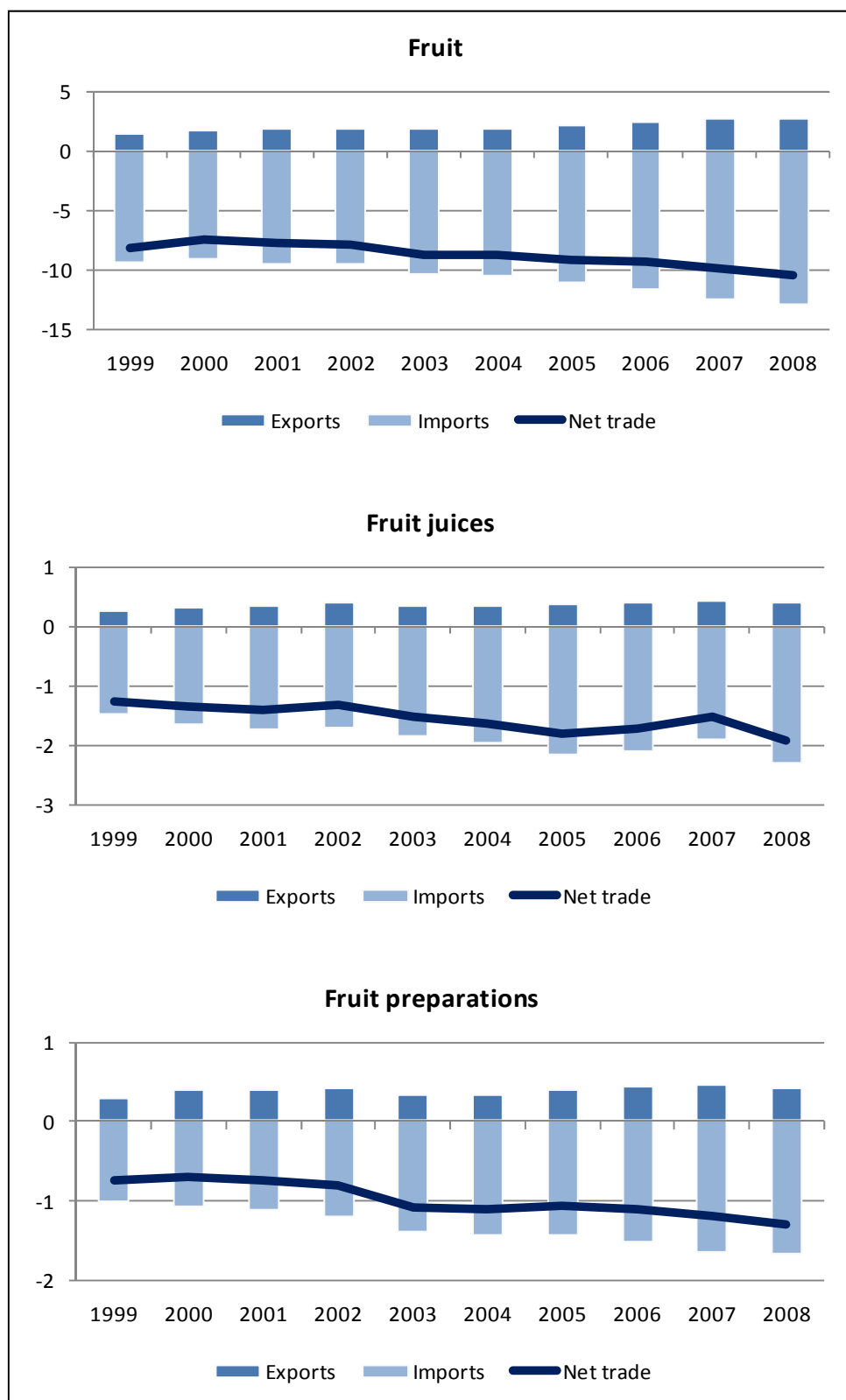

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.5: **Exports, imports and net trade of palm fruits and palm products, EU-27, 1999-2008 (in million tons)**

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.6:   Exports, imports and net trade of rapeseed and rapeseed products, EU-27, 1999-2008 (in million tons)

Rapeseed

Rapeseed oil

Feeding stuff of rapeseed

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.7: **Exports, imports and net trade of other oilseeds and oleaginous fruit products, EU-27, 1999-2008 (in million tons)**
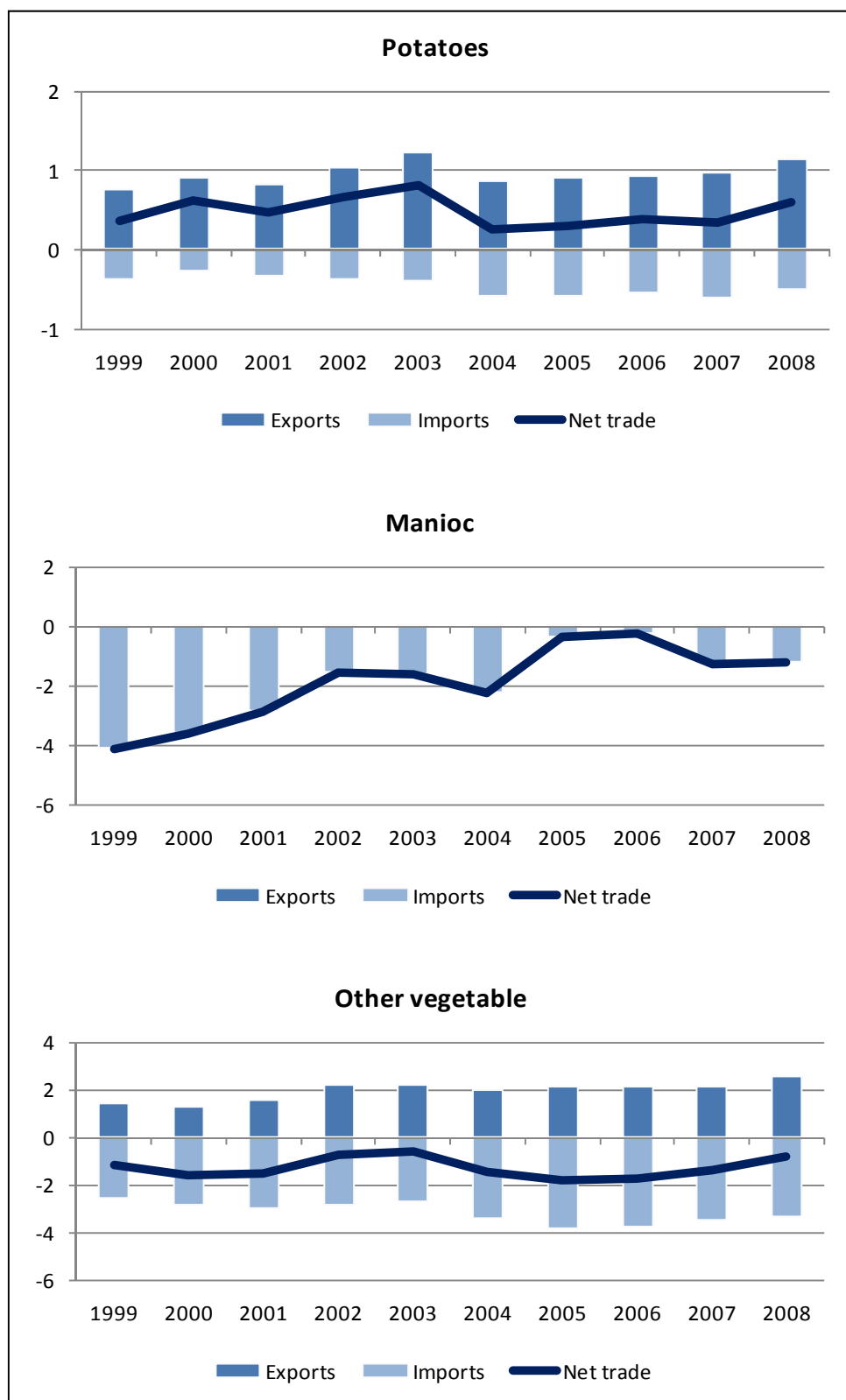

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.8:   Exports, imports and net trade of fruit and fruit products, EU-27, 1999-2008 (in million tons)
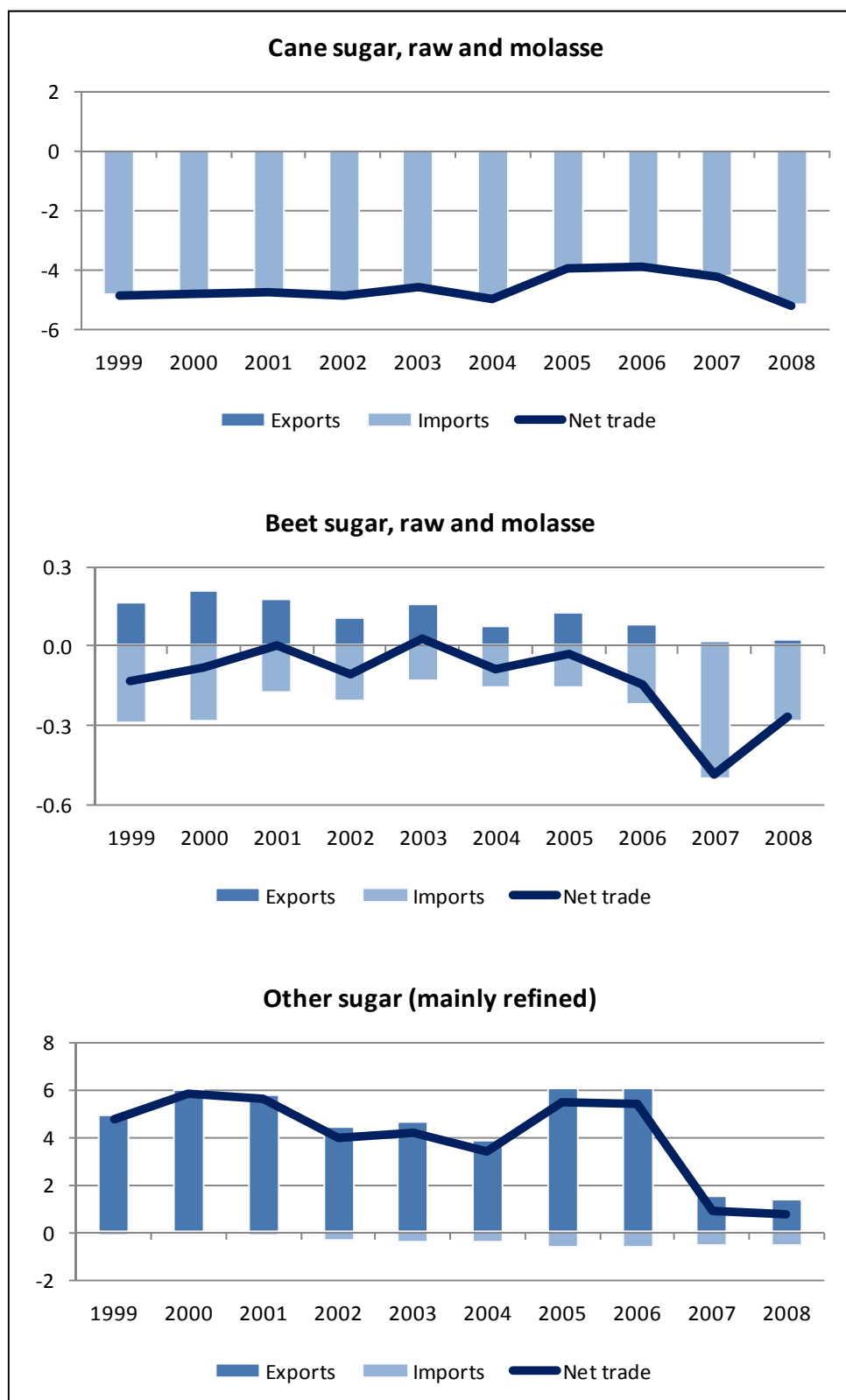

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.9:   Exports, imports and net trade of vegetables, EU-27, 1999-2008 (in million tons)

Potatoes

Manioc
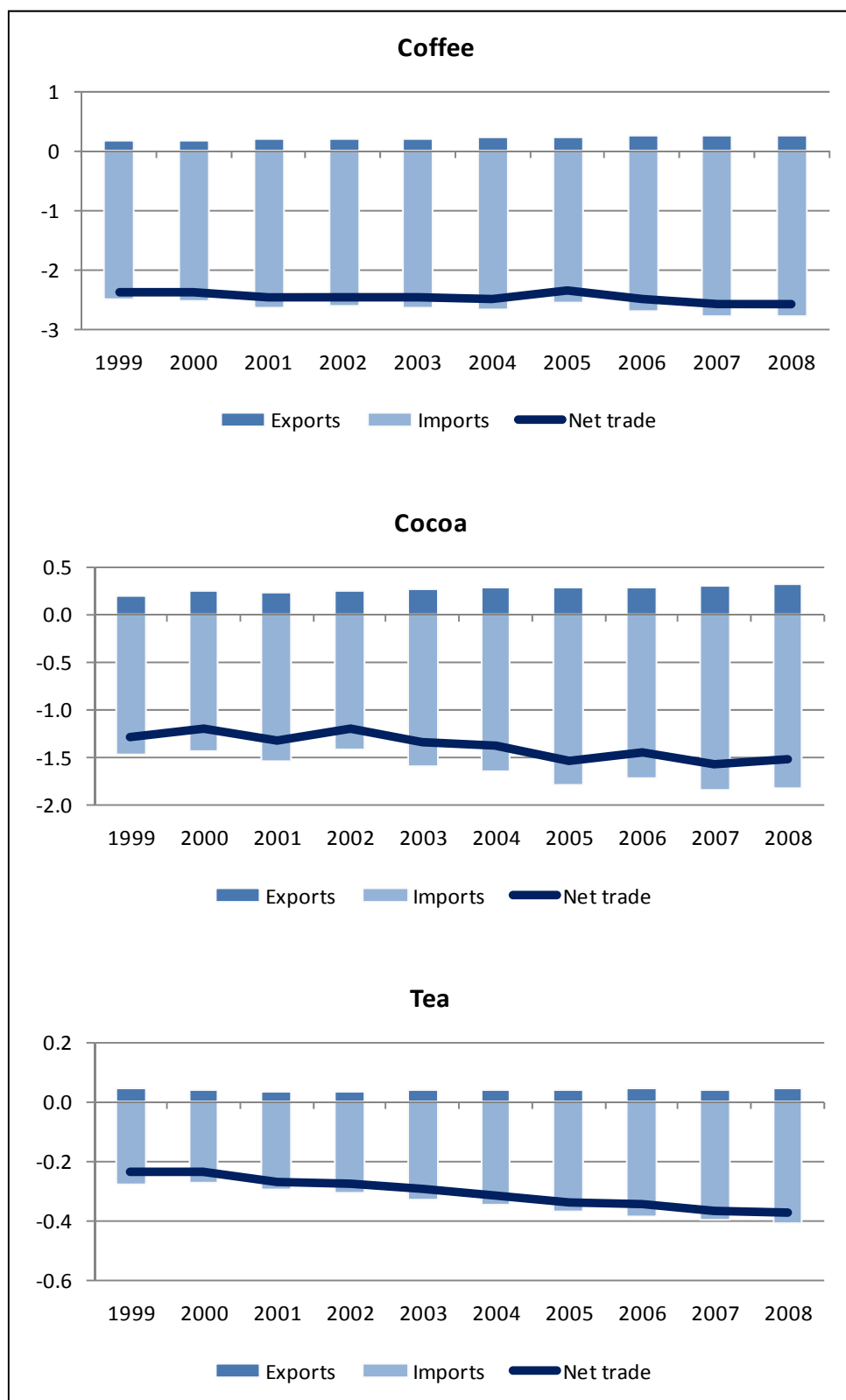

Other vegetable

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.10:   Exports, imports and net trade of sugar and sugar preparations, EU-27, 1999-2008 (in million tons)

Cane sugar, raw and molasse

Beet sugar, raw and molasse
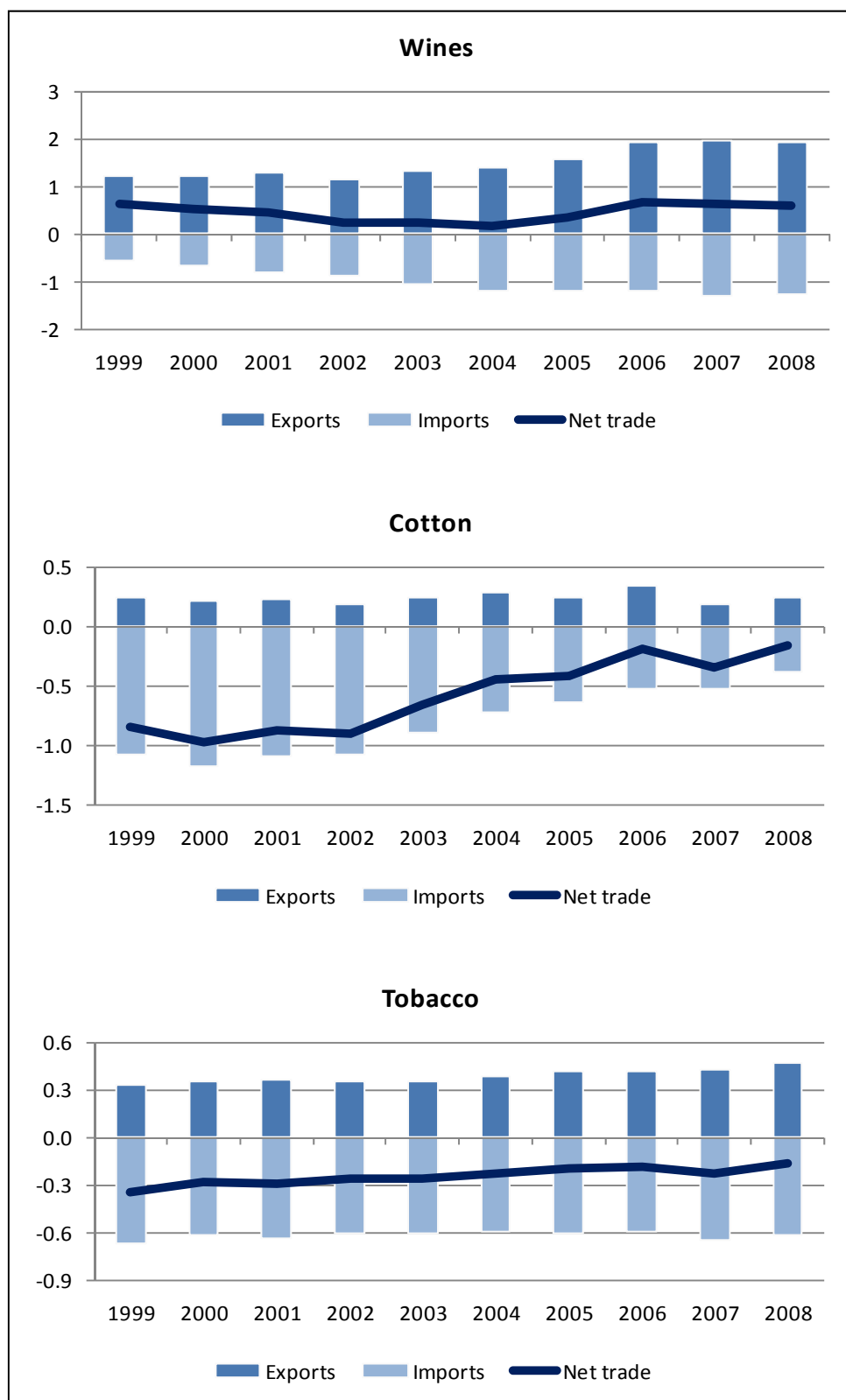

Other sugar (mainly refined)

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.11: Exports, imports and net trade of coffee, cocoa and tea, EU-27, 1999-2008 (in million tons)

Source: Own figure based on EUROSTAT (2010a, b).

Annex B.12:   Exports, imports and net trade of wines, cotton and tobacco, EU-27, 1999-2008 (in million tons)

Source: Own figure based on EUROSTAT (2010a, b).