The economic impact of invasive alien species. Bridging ecosystem services accounts to general equilibrium models: the case of crop pollination in Europe.

Authors:

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1. Introduction

Changes in the natural environment can have an impact on the economy. In some case these changes are direct, and their linear consequence that can be easily tracked, e.g. tree plantations provide timber to be cut and sold; droughts reduce the availability of water supply to households and economic activities living that area. In other cases, the linkage is not that direct and is not at all linear. There are in fact services provided by nature that remains hidden from non-experts, especially regulating and maintenance services that only indirectly affect economic sectors and households, such as the dilution of pollutants in soil and water bodies, the presence of forests upstream to control the risk of events such as avalanches and flooding, the presence of urban green to prevent psychophysical diseases. There is a vast range of environmental issues that have economic impacts that are not systematically tracked and measured.

Among these issues, if we consider the case of invasive alien species, could we ever address questions such as: "does a hornet embarked in a cargo from China to France affect the exports of the primary sector in Germany?" Although we may be aware that alien species could affect economy and in turn society, it is difficult to clearly track where, how, and how much. This might be possible if pieces of information (and tools) from each field involved are bridged and can thus interact without the claim of one discipline to model the others.

A direct linkage between ecological and economic systems would be facilitated if data structure and compilation principles were coherent and compatible. Thanks to the System of integrated Environmental and Economic Accounts (SEEA), environmental information is reported as satellite account to the core economic account. Ecosystem services accounts can thus facilitate the assessment of economic impacts (economic modelling) generated by changes in ecosystems and their services (ecological complexity).

The illustration we propose in this paper concerns a case of an Asian hornet which affect the crop pollination ecosystem service that in turns affect pollinator-dependent crops. The exercise is structured as follows: first we proceed by explaining the presence of the invasive species as the exogenous shock; second we estimate the impact of the exogenous shock on the ES pollination; third, we assess how changes in pollination generate impacts on crops that are SNA (System of National Accounts) product; finally, we use variations in the SNA product to assess changes in trading and welfare.

2. Materials and method

Two major components underpin the whole exercise:

- the ecosystem accounting framework, which uses the accounting tables generated by the INCA project as input data for this example;
- the general equilibrium model, which uses the GTAP social accounting matrix.

Before targeting specifically INCA and GTAP processing, we briefly introduce the invasive alien species we consider for this application and its geographical distribution throughout Europe.

2.1 The context: the invasion of *Vespa velutina nigrithorax*

Pollinators provide a wide range of benefits to nature and society (Potts et al., 2016): from the food security to the maintenance of environments' biodiversity, safeguarding their spiritual and cultural heritage value. However, international focus on pollination services has been mostly driven by the benefits in terms of food products. In this context, understanding the relationships between pollination services and crop yield is crucial to quantify how changes in pollinators' populations will affect food provision. Considering global crop markets, pollinated crops often record higher prices than other crops "with the greatest benefits in southern and eastern Asia and Mediterranean Europe, owing to greater production of highly pollinator-dependent crops and higher market prices" (Potts et al., 2016).

Since the decline of pollinators can cause economic losses in the agriculture sector, many studies have attempted to assess the economic value of pollination services, e.g. by (Nicola Gallai, Salles, Settele, & Vaissière, 2009), (Melathopoulos, Cutler, & Tyedmers, 2015), (Hanley, Breeze, Ellis, & Goulson, 2015), (Breeze, Gallai, Garibaldi, & Li, 2016). Pollinators are in fact exposed to numerous threats, such as climate change, plant protection products and invasive alien species (IAS). The latter is acknowledged not only as a major threat to biodiversity, but also to economy, e.g. through the impact on agriculture.

Alien Species are living organisms transported outside their natural range across ecological barriers due to direct or indirect human action (e.g. related to worldwide trade and human mobility). In their new environment some species (IAS) can become established, spread rapidly, and cause a significant negative impact on the ecology of their new location as well as serious economic and social consequences (Frankham, Ballou, & Briscoe, 2010; Jeschke et al., 2014; Ricciardi, Hoopes, Marchetti, & Lockwood, 2013).

Social insects (such as *Hymenoptera*) are amongst the species most invasive, because of their high dispersal abilities and reproductive rates, their adaptability to a broad range of diets and habitats, their effective predator defenses and competitive abilities. *Vespa velutina nigrithorax* (de Buysson, 1905), known as the yellow-legged hornet or Asian hornet (*Hymenoptera: Vespidae*) is the first *Vespidae* predator accidentally introduced in Europe from Asia. It was first observed in south-west France (Villemant et al., 2006) in 2004, to then rapidly spread in Spain (Castro and Pagola-Carte, 2010; López et al. 2011), Portugal (Grosso-Silva and Maia 2012), Italy (CABI 2013), Belgium (Rome et al. 2013), the Netherlands (EASIN-NOTSYS, first official notification September 2017), Germany (Orlov 2014, Witt 2015), the UK and Switzerland in 2017 (Budge et al. 2017; Keeling et al. 2017). Studies on the potential invasion of *V. velutina nigrithorax* showed that almost all European countries could be colonized, with a reduced risk only in the drier southern regions (Beggs et al. 2011). Based on current experience, the

Asian hornet would not face any barrier to introduction and dispersion in countries bordering the ones already colonized, and thus its spreading is likely along the Atlantic, Mediterranean and the Southern coasts of Black and Caspian Seas (Rome et al. 2011; Villemant et al. 2011; Barbet-Massin et al. 2013).

The Asian hornet is listed as an IAS of Union concern in the frame of the EU Regulation 1143/2014 (Regulation on IAS), due to the risk it presents to the European biodiversity and ecosystem services. The Regulation on IAS fosters cooperation and coordination across EU Member States borders, and requires the establishment of national surveillance systems. Among the many initiatives supported to study and contrast the invasion of *V.velutina nigrithorax*, we refer to a Life project called Stop Vespa Asiatica[1] that specifically targets and monitors this IAS and its impact on pollinators. Additional and complementary information can be retrieved from the European Alien Species Information Network EASIN: https://easin.jrc.ec.europa.eu/easin/).

Figure 1 reports the distribution in Europe of *V.velutina nigrithorax* and can be used to identify which countries and relevant regions are affected. The knowledge of the geographic distribution is the pre-condition to assess the impact of *V. velutina nigrithorax*. Another important information concerns the predation rate: due to the lack of studies about the impact of *V.velutina nigrithorax* on wild bees and bumble bees (the two groups of species modelled for crop pollination), we have to assume that the predation rate estimated for honey bees is the same for wild bees and bumble bees. Specifically we refer to the rate estimated by Villemant et al. (2011) in rural areas.

Based on the assessment undertaken within the Life project Stop Vespa Asiatica, the regions or areas affected by *V.velutina nigrithorax* (monitored from 2014) are the following:

- France: *Ile de France, Champagne-Ardenne, Haute-Normandie, Centre, Nord-Pas-De-Calais, Lorraine, Alsace, Franche-Comte, Pays de la Loire, Bretagne, Poitou-Charentes, Aquitaine, Midi-Pyrenees, Limousin, Rhone-Alpes, Auvergne, Languedoc-Roussillon, Provence-Alpes-Cote d'Azur*
- Spain: *Galicia, Asturias, Cantabria, Pais vasco, Navarra, Rioja, Castilla-Leon, Cataluna, Comunidad Valenciana, Baleares*
- Portugal: *Norte, Centro*
- Italy: *Piemonte, Liguria, Veneto, Lombardia, Toscana*
- United Kingdom: *Yorkshire and The Humber, South West*
- Netherlands: *Zeeland*
- Germany: *Karlsruhe, Rheinhessen-Pfalz*
- Belgium: *Hainaut*

[1] Ref. https://www.vespavelutina.eu/en-us/

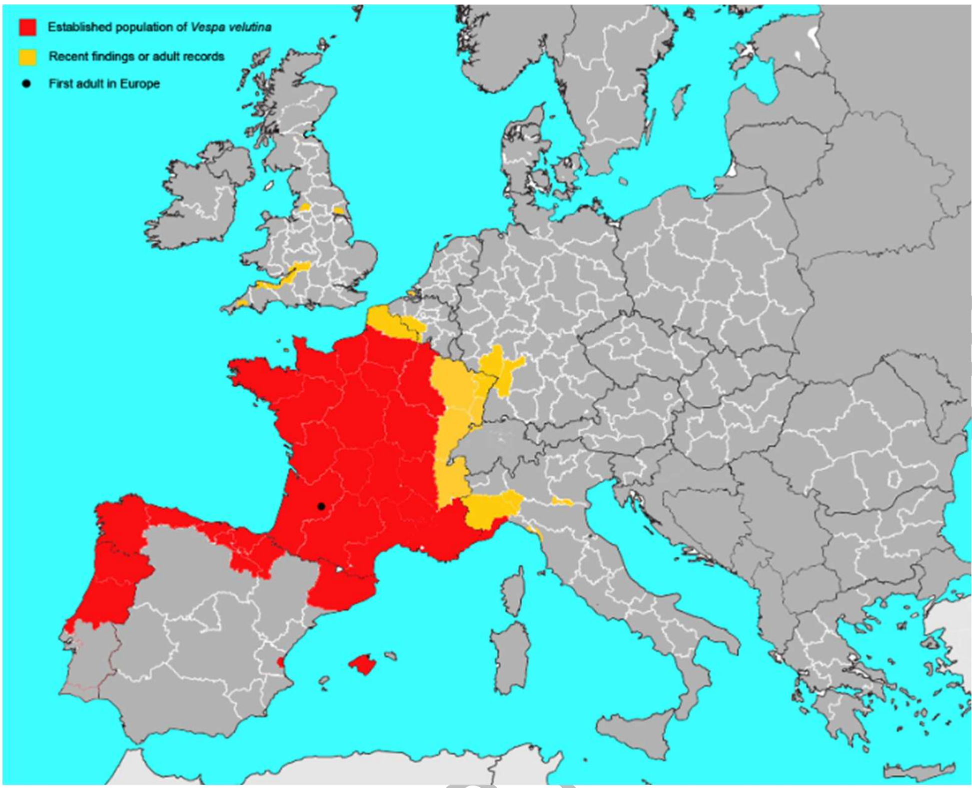

Figure 1 – *V.velutina nigrithorax* distribution in Europe (source: http://www.stopvelutina.it/wp-content/uploads/2018/09/VV_EU.png)

2.2 The crop pollination supply and use tables

The System of National Accounts (SNA) is an international standard for the systematic compilation and presentation of economic data. It represents the economy in a structured, integrated and consistent way. The role of natural capital is completely absent from the standard SNA. The way to integrate the natural capital domain of information in the SNA is through satellite accounts. With satellite accounts, the core SNA remains the same while its statistical framework is applied to adapted outputs. The System of Environmental-Economic Accounting (SEEA) proposed and supported by the United Nations since 1993 provides methodological guidelines for setting up satellite accounts concerning natural capital ((United Nations, 1993; United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, & Bank, 2003; United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, et al., 2014)). Specifically, the UN SEEA EEA (Experimental Ecosystem Accounting) target accounts reflecting the role of ecosystems and their services ((United Nations, 2017; United Nations, European Union, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development, & Group, 2014).

The Knowledge and Innovation Project on an Integrated system for Natural Capital and ecosystem services Accounting (KIP INCA) was set up by the European Commission with the objective to design and implement an integrated accounting system for ecosystems and their services in the EU by testing and further developing the technical recommendations provided by the UN SEEA EEA (European

Commission & European Environment Agency, 2016; La Notte, Vallecillo, Polce, Zulian, & Maes, 2017). The different components of the UN SEEA EEA include accounts of ecosystem extent, ecosystem condition, ecosystem services, and thematic accounts as well as monetary accounts, which would help to integrate the results of ecosystem accounting with other economic indicators derived from SNA.

The accounting module that specifically targets ES accounts are the supply and use tables in physical and monetary terms. Supply and use in accounting terms refer both to the amount of ecosystem service effectively used (Figure 2). In supply table the “sectors” that generate the service flow are Ecosystem Types (satellite entries to the SNA). In the use table the sectors that receive the flow are the conventional Institutional Units according to the main standard classification systems ISIC[2], NACE[3], NAICS[4], etc. (already in the core SNA). The ES flow is a satellite entry and represents what is actually used, not to be confused with what ecosystem could provide. Specifically, the ecosystem’s ability to generate ES is the ecosystem service potential (ES potential) and is irrespective of the demand. ES actual flow is generated when the ecosystem services demand interacts with the ES potential (La Notte, Vallecillo, Marques, & Maes, 2019). No interaction determines no actual flow, even if ES potential is high. ES actual flow represents the transaction that takes place between ecosystem types and Institutional Units.

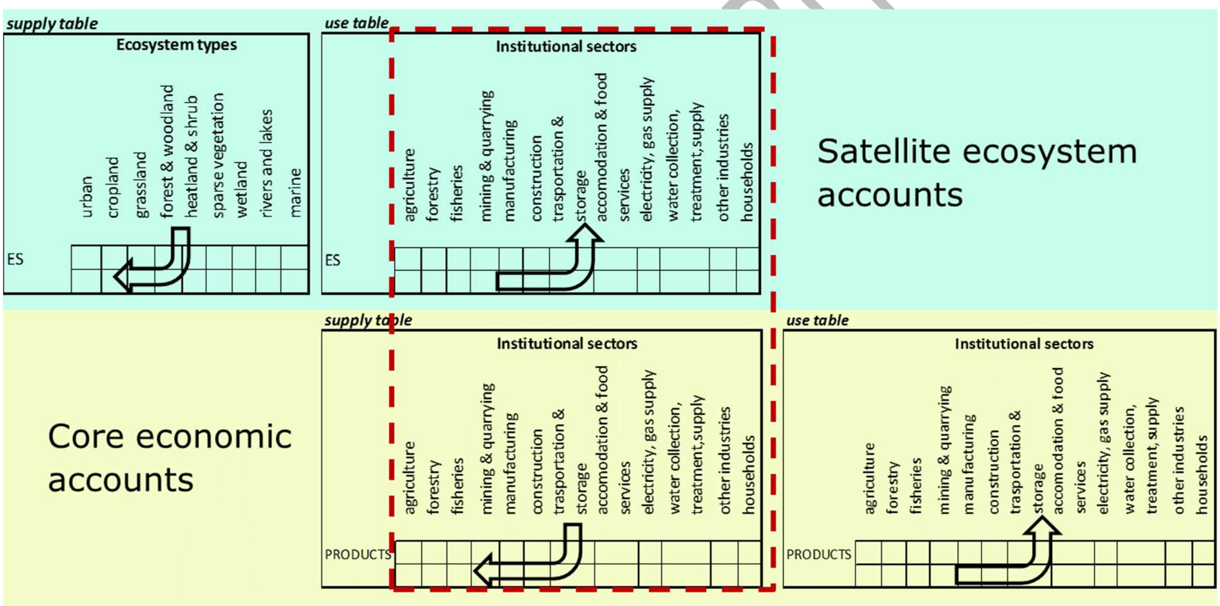

Figure 2 – The integration between ecosystem and economic accounts

KIP INCA has developed supply and use tables for a number of ecosystem services, among which we specifically recall “crop pollination” (Vallecillo et al., 2018). Crop pollination potential is based on an indicator of the environmental suitability to support wild insect pollinators. This indicator integrates two different models: an Expert-Based Model for solitary bees (computed with ESTIMAP toolbox, (Zulian, Maes, & Paracchini, 2013)) and a Species Distribution Model for bumblebees, predicted with observed species records following Polce et al. (2013). Both models are based on land cover, climate

[2] International Standard Industrial Classification
[3] Statistical Classification of Economic Activities in the European Community
[4] North American Industry Classification System

data, and on the distance to semi-natural areas. The environmental suitability is used to delineate service providing areas (for further details ref. Appendix III in (Vallecillo et al., 2018)).

Crop pollination demand is based on the extent of pollinator-dependent crops, following the methodology described in Zulian et al. (Zulian et al., 2013). For the modelling, spatial data derived from the CAPRI model (Britz & Witzke, 2014; Leip et al., 2008) quantified the demand as the number of hectares per square kilometer. The overlap between crop pollination potential and demand defines the area generating the actual flow of service. Within the areas of potential presence of pollinators, the service flow is calculated by multiplying the production of each pollinator-dependent crop by the degree of dependency on pollinators (Klein et al., 2007).

Although based on the application of the pollinators dependency ratio, the ES accounts clearly show that part of the demand is not met because the ES potential does not cover all the production in need of crop pollination (Table 1). The application undertaken for the EU (Vallecillo et al., 2018) shows that the actual flow is only processed for the 66% of production rather than the 100% of production. Other approaches (including the FAO tool, ref. (N; Gallai & Vaissière, 2009), when applying the pollinators dependency ratio, assume that the whole extent of crops is covered by the pollinators potential

For this exercise, we consider production data extracted from CAPRI (Britz & Witzke, 2014; Leip et al., 2008) which report a NUTS2 specification, and only considered those pollinator-dependent crops present in the provinces affected by *V.velutina nigrithorax*. The list of affected regions reported in 2.1 should not be passively taken: based on the spatial assessment of the actual flow, it is possible to check whether pollinator dependent crops are really affected. Some regions should not be considered because of the lack of pollinator-dependent crops: the region is affected by the invasion but not in terms of reduction for some specific crops (Table 1). This confirms how important is to use datasets that are geographically and statistically detailed to avoid over and under-estimations.

Table 1 – Pollinator-dependent crops that were not considered in the affected regions

Countries	***Regions***	***Pollinator-dependent crops***
France	Picardie	Apples, pears and peaches, Citrus Fruits,Other Fruits
	Basse-Normandie	Apples, pears and peaches, Citrus Fruits, Other Fruits
	Bourgogne	Apples, pears and peaches, Citrus Fruits, Other Fruits
	Nord-Pas-De-Calais	Soya
	Rhone-Alpes	Flax and hemp
Spain	Galicia	Rapeseed, Soya, Sunflower, Flax and hemp
	Asturias	Other Oilseeds, Rapeseed, Soya, Sunflower, Flax and hemp
	Cantabria	Other Oilseeds, Soya, Flax and hemp
	Pais vasco	Soya, Flax and hemp
	Rioja	Soya
	Comunidad Valenciana	Rapeseed
	Baleares	Rapeseed, Soya, Flax and hemp
Italy	Liguria	Other Oilseeds, Rapeseed, Soya, Sunflower, Flax and hemp
Germany	Karlsruhe	Sunflower, Flax and hemp
	Rheinhessen-Pfalz	Sunflower

To calculate crop pollination actual flow (Actual $Flow_{CP}$) we apply the ES ratio obtained in Vallecillo et al. (Vallecillo et al., 2018), named ecosystem contribution (EconCon) which represents the pollinator dependency, and multiply it by the production data extracted from CAPRI, as follows:

$$Actual\ Flow_{CP} = EcoCon * Production \qquad \text{Equation 1}$$

The rate of predation by *V.velutina nigrithorax* of 0.35 (Villemant *et al.*, 2011, ref. section 2.1) is applied to Actual Flow$_{CP}$, as follows:

$$Predation = 0.35 * Actual\ Flow_{CP} \qquad \text{Equation 2}$$

The affected service flow (Predation) could be used to address two different questions. The first question is: how much income was missed due to the presence of *V.velutina nigrithorax*? To respond, we need to compare the total production of pollinator-dependent crops in the country and the Predation in affected countries.
The following formula expresses the missed gain percentage caused by the *Vespa velutina*:

$$Missed\ gain = \frac{\sum Predation_{affected\ regions}}{\sum Production_{tot}} \qquad \text{Equation 3}$$

The second question is: what happens if *V.velutina nigrithorax* extends its invasion to other regions within each country? In this case, we need to calculate the value of Predation in all the other regions that are not currently affected, and then compare it to the total production. The following formula expresses the percentage of hypothetical loss caused if the *V.velutina nigrithorax* continues to expand:

$$Hypothetical\ loss = 1 - \frac{\sum Production_{tot} - \sum Predation_{not\ affected\ regions}}{\sum Production_{to}} \qquad \text{Equation 4}$$

2.3 The linkage with economic modelling

General Equilibrium (GE) models are an important tool for analyzing economic issues since they can represent the economy throughout the linkages between agents, sectors and other economies. To do this GE models need to include a massive number of variables, parameters and equations. The Global Trade Analysis Project (GTAP[5]) was established in 1992 to facilitate quantitative analyses of economic issues in an economy wide framework by providing (i) a standard modeling framework, (ii) global data base and (iii) software for implementing the model and working with the data (Hertel et al., 1997). The standard GTAP Model is a multi-region, multi-sector, computable GE model, with perfect competition and constant returns to scale. The underlying equation system of the GTAP Model includes two different sets of equations: (i) one set covers the accounting relationships which ensure that receipts and expenditures of every agent in the economy are balanced (i.e. SNA macro perspective); (ii) the other set specifies the behavior of optimizing agents in the economy (e.g. demand functions) and are based upon microeconomic theory (Brockmeier, 2001). The GTAP consortium produces periodically consistent global economic database, widely used in the research. For this application in fact we used the GTAP 9 Data Base (Aguiar, Narayanan, & McDougall, 2016) which captures world economic activity in 57 sectors of 140 regions.

The following exercise demonstrates how to bridge ES accounts with GTAP variables to assess economic impacts driven by changes in ES flows. In the case of pollination, an external shock affects the ES use which in turns affect the SNA benefit which enter into the production system (Figure 3). This is possible because, thank to ES accounts it is possible to spatially quantify ES flows for crops and regions

[5] https://www.gtap.agecon.purdue.edu/about/project.asp

and the changes occurring in these flows. These changes will be used to “shock” the production for the sectors supplying those crops in the GTAP system.

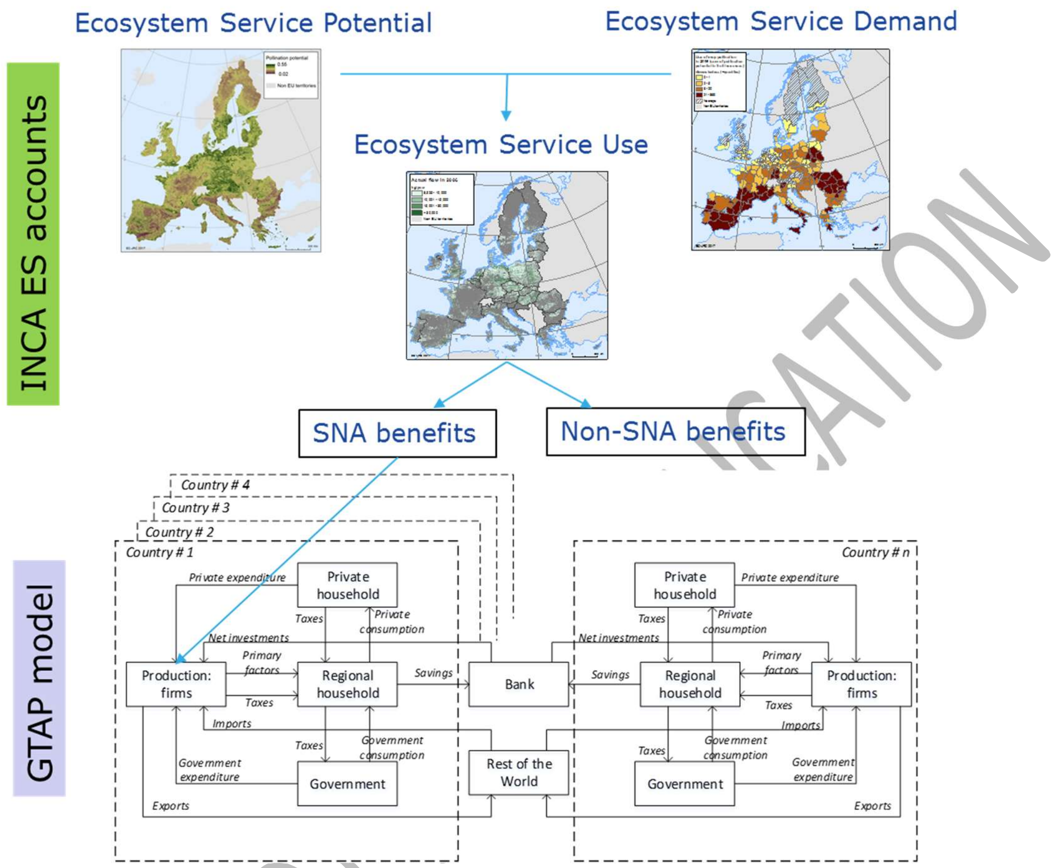

Figure 3 – Visual summary of INCA-GTAP sequential approach

Before using GTAP model and database, it is necessary to harmonize classifications and aggregations. First, we need to aggregate (i) the database in GTAP according to the specifications if this exercise, and (ii) the pollination accounts according to the GTAP classification. In the first case, we proceed with the aggregation of sectors and countries. About the aggregation of sectors:

- we keep disaggregated the following sectors which have a direct linkage with the pollinator-dependent crops we are considering: vegetables [4], oil seeds [5], plant-based fibers [7], vegetable oils and fats [21], textile [27] and wearing apparel [28];
- we partially disaggregate the following sectors which are indirectly linked to the previous sectors because they could be substitute or intermediate consumer: “other agri” [1-3, 6, 8-20] and “other food & beverage” [22-26];
- we aggregate all the remaining sectors that do not have any evident linkage with the previous sectors: “other sectors” [29-57]

For the aggregation of countries, we used as reference the “UN Geoscheme”[6] and aggregate the countries according to their proximity to the areas affected by *Vespa velutina nigrithorax*. Specifically:

[6] Ref. https://en.wikipedia.org/wiki/United_Nations_geoscheme

1. Belgium
2. France
3. Germany
4. Italy
5. Netherlands
6. Portugal
7. Spain
8. UK
9. Eastern Europe
10. Northern Europe
11. Southern Europe
12. Western Europe
13. Africa
14. Northern America
15. Latin America
16. Central America
17. Asia
18. Rest of the World

Table 4 reports the pollination accounts aggregation according to GTAP codes.

Among the identified sectors, one is particularly sensitive to the impact of *V.velutina nigrithorax*: "Vegetables, fruits, nuts" (v_f [4]). For the purpose of this exercise, the drawback of GTAP database lies in the high level sector data aggregation, that requires more processing to avoid overestimates. In fact, not all products reported in "Vegetables, fruits, nuts" are affected by the *V.velutina nigrithorax*, but only those reported in Table 2. We thus need to shock not the whole sector, but only part of it. To obtain an estimate of the extent of "Vegetables, fruits, nuts" under consideration, we use the ESTAT dataset (specifically [apro_cpsh1][7]) and calculate for each country affected by the *V.velutina nigrithorax* the proportion of pollinator-dependent crops with respect to all crops reported in "Vegetables, fruits, nuts" (v_f [4]). These estimates should take place for each of the GTAP sectors, but unfortunately not have enough data are currently available. This is a major limitation which needs to be addressed.

Table 2 – Pollination accounts aggregated according to GTAP codes

GTAP aggregation	Codes	Correspondence with ES accounts
Vegetables, fruits and pulses	v_f [4]	Apples, pears, peaches; citrus fruits, other fruits, tomatoes, pulses
Plant based fibers	pfb [5]	Flax and hemp
Oil seeds	osd [7]	Oil seeds
Other agricultural products	other agri [1-3,6,8-20]	[linked sectors]
Vegetables oils & fats	vol [21]	Soya, sunflower, rapes
Food and beverage	other food & beverage [22-26]	[linked sectors]
Textile	tex [27]	[linked sectors]
Wearing apparel	wap [28]	[linked sectors]
Rest of sectors	other sectors [29-57]	[not linked sectors]

Once we have calculated the percentage of "missed gains" and "hypothetical loss" and we have appropriately set the database (previous paragraphs this section), we have to identify the variable in

[7] Available at https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=apro_cpsh1&lang=en

the GTAP model be shocked by those percentages. We need to consider changes in output (yield) at unchanged utilization of all factors. "AO" represents the output augmenting technical change in sector j of region r. Within GTAP, "AO" is part of technical change variables.

3. Results

This exercise addresses two questions:

- How much would be produced if *Vespa velutina nigrithorax* were not present? (missed gain)
- How much would be lost if the *Vespa velutina nigrithorax* expanded its occupation range to other regions? (hypothetical loss)

Before applying the assessment an additional step is undertaken: from the GTAP sector "v_f" only the crops assessed in the ES accounts are extracted, based on official statistics obtained from other sources (in our case ESTAT).

The GTAP model provides a considerable number of variables to be analyzed. Once the applications are computed we looked at the following variables, that we thought instrumental to the quantify the production and trade affected by the invasion of *Vespa velutina nigrithorax*. Specifically:

- Production (q_0);
- Import prices (pms);
- Export quantity (qxs);

3.1 Computation of the ecosystem service accounting side

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The results are reported in Table 3. The service flow is here expressed as amount of yearly production that depends on the action of pollinators.

Table 3 - Crop pollination actual flow in physical terms (year 2012, 1,000 tons)

	France	Italy	Spain	Portugal	Germany	Belgium	Netherlands
Apples, pear and peaches	502.86	562.79	486.59	185.97	681.01	298.35	324.54
Citrus fruits	1.34	52.46	114.45	8.26	-	-	-
Other fruits	155.21	349.93	612.64	42.26	153.42	121.87	117.88
Other oilseeds	2.56	0.01	1.11	0.15	0.71	0.35	0.07
Pulses	12.71	1.27	1.63	0.25	11.77	0.23	0.25
Rapeseeds	209.13	2.02	1.74	-	1,037.68	14.59	2.05
Soya	3.12	4.87	0.10	-	0.40	-	-
Sunflower	57.41	13.49	12.47	0.39	12.39	-	0.63
Flax and hemp	13.24	0.04	0.37		0.60	2.38	0.68
Tomatoes	18.93	98.10	63.78	35.99	2.99	10.65	37.49

Table 4 summarizes the calculated missed incomes/gains.

Table 4 – Missed gain for selected crops in selected countries (%)

	Belgium	France	Germany	Italy	Netherlands	Portugal	Spain	UK
Apples, pear and peaches	15.68	8.45	0.02	1.10	5.42	12.21	4.49	2.22
Citrus fruits	-	0.86	-	0.17	-	0.90	0.33	-
Other fruits	0.10	5.06	1.17	0.85	3.26	7.50	2.78	1.41
Other oilseeds	0.37	1.42	0.07	0.56	4.23	0.01	0.18	0.81
Pulses	0.17	0.51	0.03	0.07	0.74	0.27	0.04	0.20
rapeseeds	0.78	1.44	0.10	0.94	0.25	-	0.62	1.17
Soya	-	0.96	0.27	0.21	-	-	0.72	-
Sunflower	-	1.21	0.00	0.48	0.63	0.01	0.15	1.19
Flax and hemp	0.05	0.98	0.03	0.16	1.26	-	0.00	0.33
Tomatoes	0.25	0.83	0.07	0.13	0.31	0.15	0.15	0.28

Table 5 summarizes the calculated hypothetical losses.

Table 5 – Hypothetical loss for selected crops in selected countries (%)

	Belgium	France	Germany	Italy	Netherlands	Portugal	Spain	UK
Apples, pear and peaches	22.15	0.08	18.39	3.30	14.55	2.00	4.22	16.78
Citrus fruits	-	0.04	-	0.37	-	0.14	0.32	-
Other fruits	13.57	0.07	11.28	1.83	9.05	1.23	2.64	10.27
Other oilseeds	5.13	0.0004	5.19	0.90	1.11	0.74	0.27	3.35
Pulses	1.27	0.00	1.44	0.23	0.69	0.70	0.09	1.03
rapeseeds	6.78	0.0001	7.40	0.86	8.09	-	0.18	4.39
Soya	-	0.0003	8.37	0.11	-	-	1.74	-
Sunflower	-	0.00	7.98	1.37	7.94	1.11	0.32	5.05
Flax and hemp	1.51	0.00	1.37	0.60	0.22	-	0.08	1.02
Tomatoes	1.35	0.0004	1.45	0.50	1.29	0.82	0.42	1.06

3.2 Missed gain exercise

This exercise is aimed to show the changes in production and trade in the absence of *Vespa velutina nigrithorax*. The country most affected by *Vespa velutina nigrithorax* are expected to have higher missed production and improved trade.

The production sector "vegetables, fruits and pulses" has been disaggregated for the missed gain exercise and the percentages to be used to shock "AO" in GTAP are reported in Table 6. The percentages for "vegetables, fruits and pulses" are lower and in some cases (e.g. France) not dominant anymore: in these countries the other crops that are part of "vegetables, fruits and pulses" according to GTAP classification have a high weight. For the Netherlands and Portugal the changes remain important.

Table 6 – Missed production caused by *V.velutina nigrithorax* invasion (%) with a disaggregated "Vegetable, fruits and pulses" sector, 2012

	Belgium	France	Germany	Italy	Netherlands	Portugal	Spain	UK
Vegetables, fruits, pulses	0.10	0.82	0.34	0.26	1.45	2.65	0.74	0.71
Oil seeds	0.37	1.42	0.07	0.56	4.23	0.01	0.18	0.81
Vegetable oils & fats	0.78	1.20	0.12	0.54	0.44	0.01	0.49	1.18
Plant based fibers	0.05	0.98	0.03	0.16	1.26	0.00	0.001	0.33

About the changes in production for "vegetables, fruits and pulses", the Netherlands record an increase of +3.2% and Portugal records +3.3%. A big difference with the previous exercise is about the ROW: in Figure 4 the changes for the affected crops were important: "vegetables, fruits and pulses" +12.3, "oilseeds" +15.5, "fiber plants" +5.23, "vegetable oil and fats" +11.2. By disaggregating the "vegetables, fruits and pulses" the ROW for the same sectors are on average -0.25%.

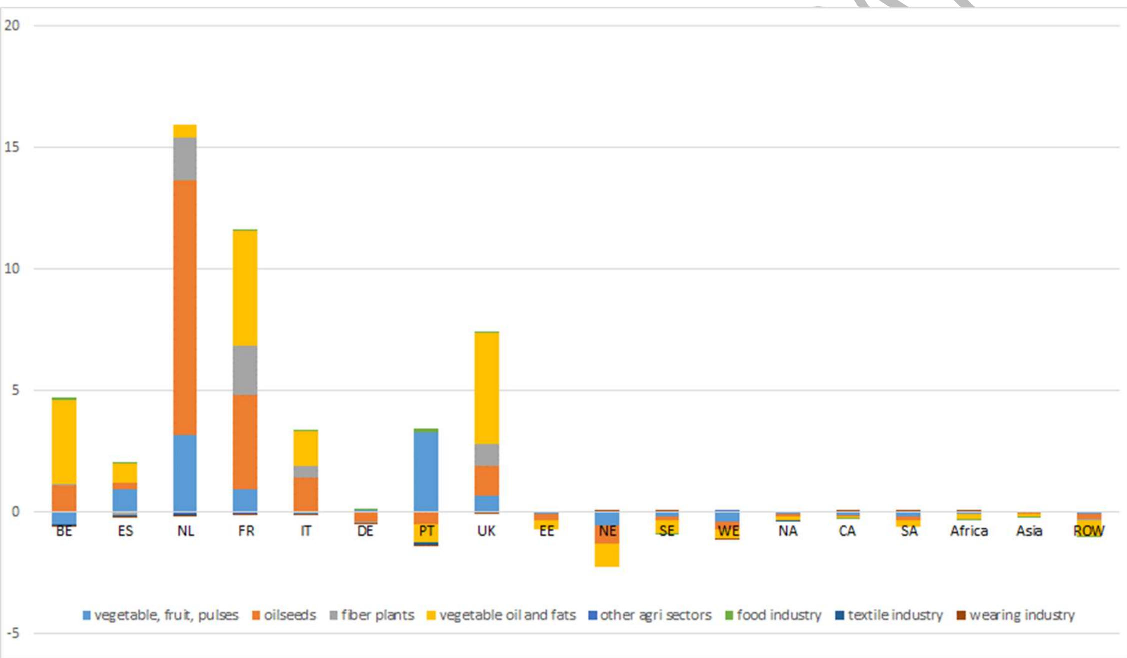

Figure 4 – Change in production for the "missed gain" exercise

The import prices for "vegetables, fruits and pulses" decreases for Portugal (-2.5%) and the Netherlands (-1.25%) proportionally less than in the previous computation (Figure 5).

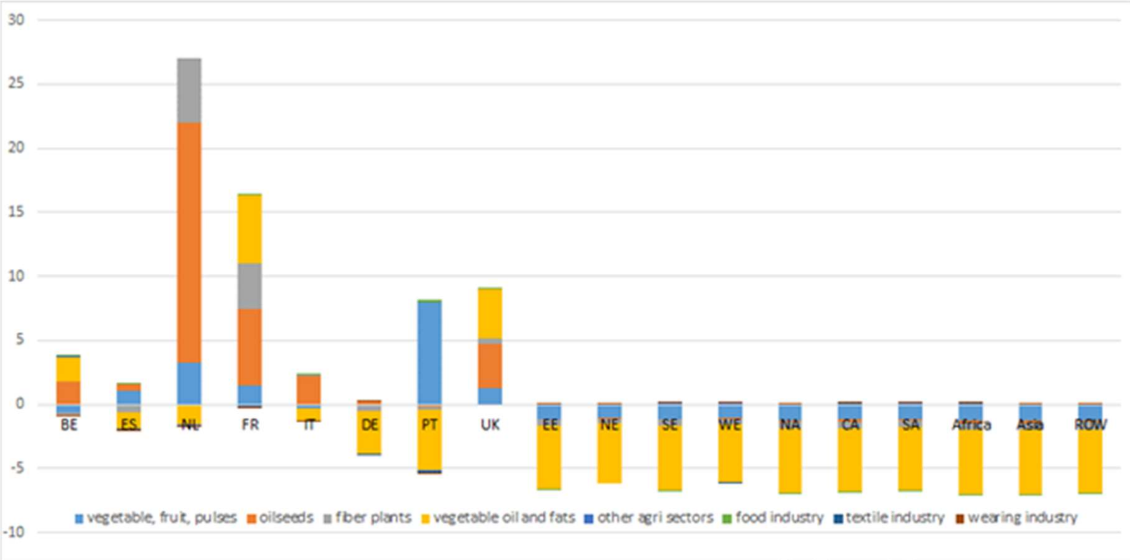

Figure 5 – Change in import prices for the “missed gain” exercise

About the quantity of export (Figure 6), it is important to notice that, compared to the previous run, the increase in exports for “vegetables, fruits and pulses” did not dramatically change for the Netherlands (+3.29%) and remains remarkable for Portugal (+7.9%).

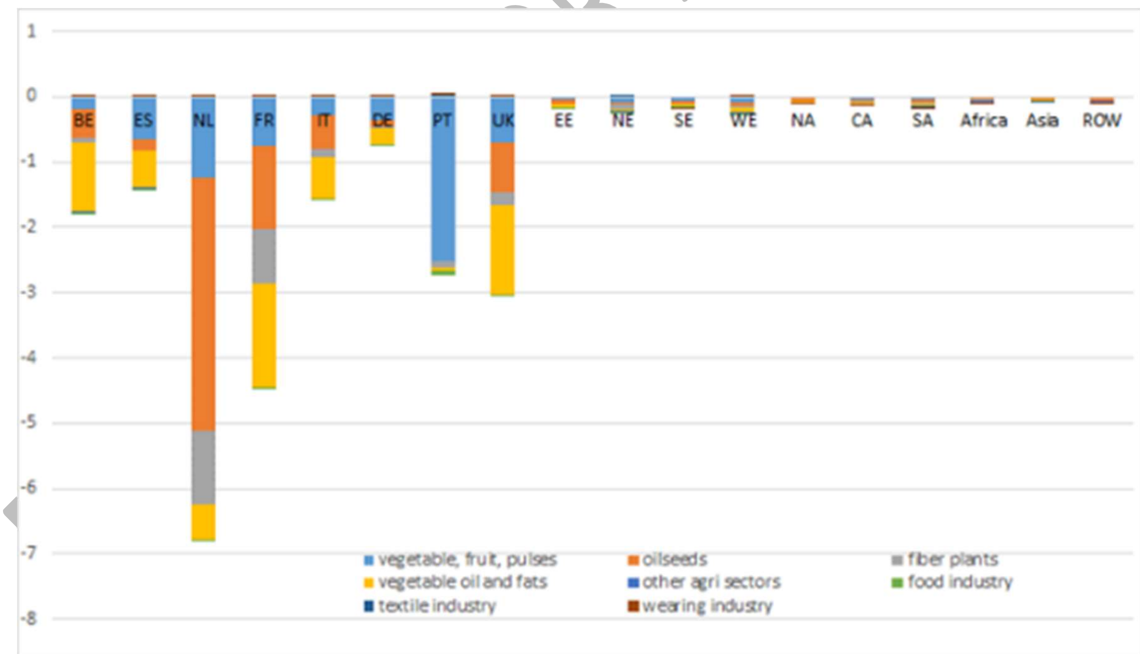

Figure 6 – Change in exports for the “missed gain” exercise

3.3 Hypothetical loss exercise

This exercise aims to show the changes in production and trade if the *V.velutina nigritorax* not only invaded affected regions but also expanded in all remaining regions (within the selected countries). The countries currently only slightly affected by *V.velutina nigrithorax* are expected to have higher hypothetical losses in production and trade if the species expanded to the whole territory. The first records of the presence of *V.velutina nigrithorax* in a country should trigger early warning and a rapid response underpinned by the risk of its expansion and potential impact on sensitive crops, and related sectors.

The sector “vegetables, fruits and pulses” has been disaggregated for the hypothetical loss exercise and the percentages to be used to shock “AO” in GTAP are reported in Table 7. Once again, the percentages for “vegetables, fruits and pulses” are lower, although in this exercise the same countries confirm sizeable (significant, sensible, noticeable) changes: Belgium, Germany, the Netherlands and the UK.

Table 7 – Loss of production in case *V.velutina nigrithorax* invades the rest of the country with a disaggregated “Vegetables, fruits and pulses” sector, 2012

	Belgium	**France**	**Germany**	**Italy**	**Netherlands**	**Portugal**	**Spain**	**UK**
Vegetables, fruits, nuts	5.58	0.01	3.49	0.70	3.81	0.62	0.74	5.00
Oil seeds	1.51	0.00	1.37	0.88	1.11	0.74	0.27	3.35
Vegetables oils & fats	5.13	0.00	5.19	0.78	8.01	1.11	0.74	4.71
Plant based fibers	6.77	-	7.91	0.60	0.22	-	0.08	1.02

Germany is more sensitive to crop aggregation (-5.7% versus -14%) compared to Belgium (-12% versus -20%), the Netherlands (-8% versus 13%), and UK (-6.9% versus 9.8%). France keeps its positive results even if slightly decreasing (+1.31%). However, while in the previous exercise Portugal recorded a positive change (+0.1%), in the current exercise it records a negative change (-0.06%); vice versa, Spain recorded a negative change in the previous exercise (-21%) and a positive change in the current exercise (+0.14%). This suggests that the importance of pollinator-dependent crops is (slightly) higher in Portugal than in Spain.

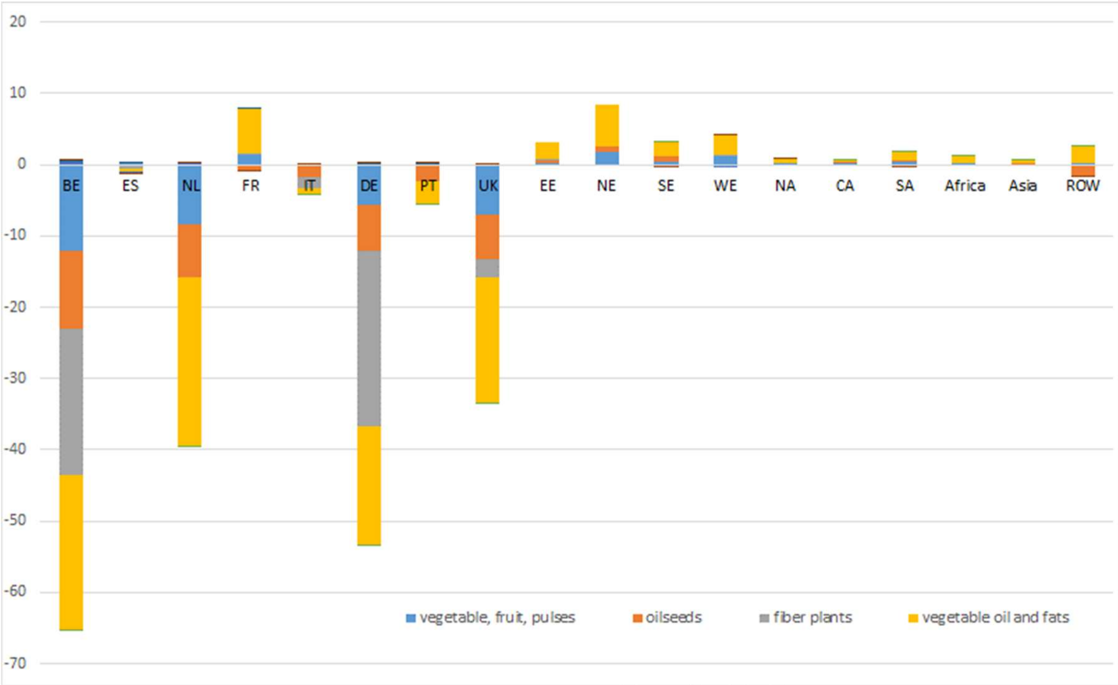

Figure 7 – Change in production for the “hypothetical loss” exercise

The remarkable changes in the price of imports for “vegetables, fruits and pulses” occur for the same countries where changes in production are high (Figure 8): Belgium +4.7%, the Netherlands +3.3%, Germany +2.9% and the UK +4.5%.

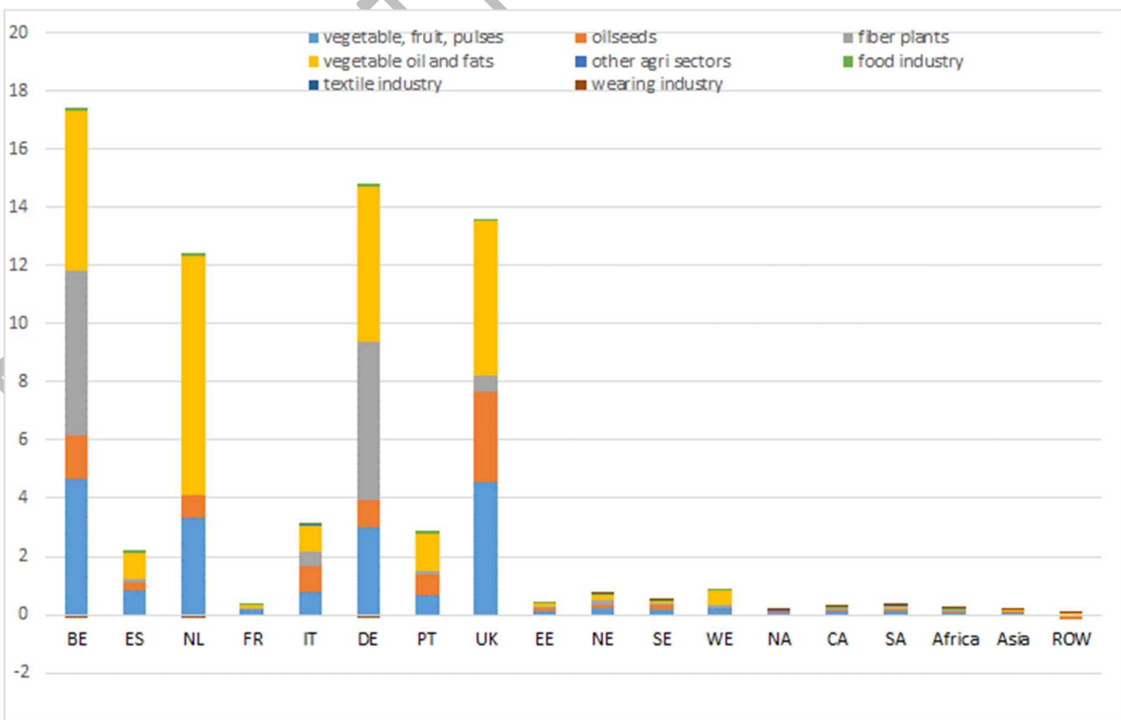

Figure 8 – Change in import prices for the "hypothetical loss" exercise

About the changes in exports (Figure 9) by recording a high difference between the two GTAP runs, Germany confirms to be less sensitive to pollinator-dependent crops (-8.2% versus 20%) compared to Belgium (-14% versus -24%), the Netherlands (-9.5% versus -15%) and the UK (-14% versus -19%).

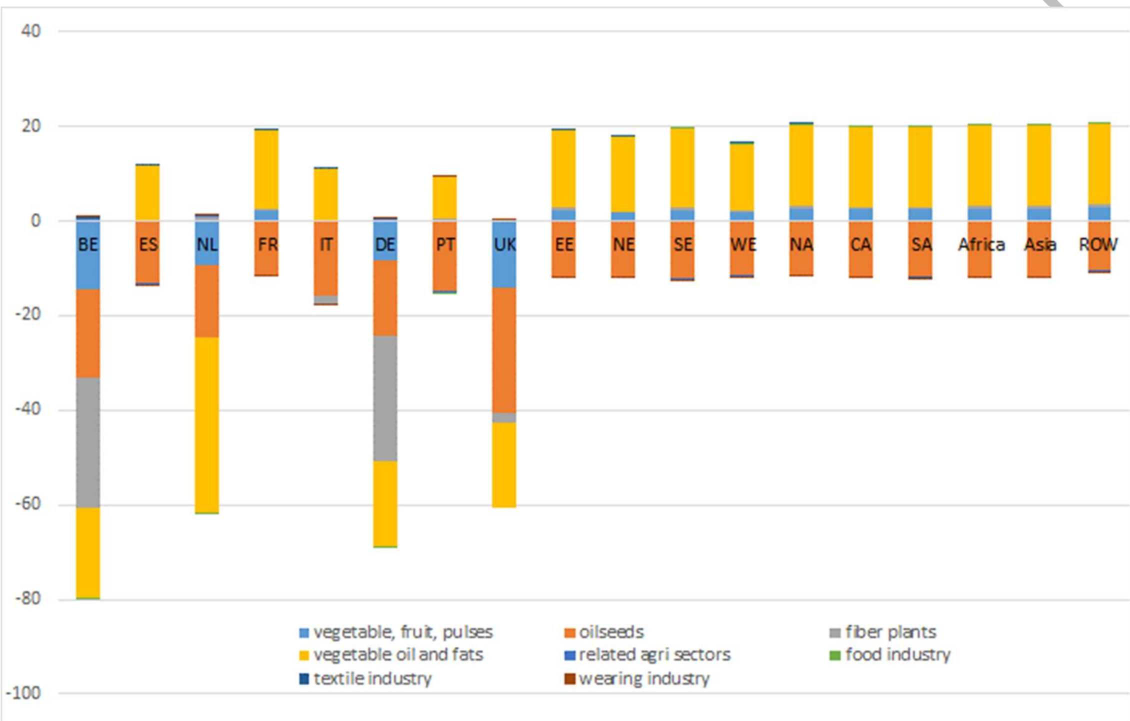

Figure 9 – Change in exports for the "hypothetical loss" exercise

3.4 Discussion

(…this section needs to be completed…)

Methodological framework

The aim of fitting ecological complexity into economic modelling is an extremely hard task. It involves first establishing cause-effect relationships, then modeling up functional forms and estimating/calibrating parameter values.
The degree of aggregation of the relevant variables is key when identifying causal relationship and when establishing functional building and parametrization. On the one hand, climate change literature is rich of examples of integrated models where low number of high level representative variables are taken as proxies for ecological and socio-economic spheres, e.g. increase in temperature and changes in GDP (e.g. RICE, (Nordhaus & Yang, 1996) and MERGE (Manne et al., 1995)). On the other hand, the

latest models (e.g. ICES (Eboli et al., 2010) and ENVISAGE (Roson and van der Mensbrugghe, 2012)) are able to attribute different impacts to different variables by retaining the sectoral details. When considering sectorial disaggregation, the drawback lies in the increase of data need and computational complexity, and the advantage is to be able to track how climate change affects the economy though many different mechanisms.

The same logic applies to ecosystems and their services. Ecosystems taken as a whole are extremely complex and it would be impossible to perform a holistic assessment without capturing the interactions between biophysical structures and functions. Any assessment of ecosystem based on an aggregated variable (like in the case of temperature for climate change) would lead to groundless results. Similarly to the case of climate change, sectorial details would highly increase the possibility to detect more precisely cause-effect mechanisms. In the case of ecosystems: the sectors are ecosystem types (such as cropland, woodland, wetlands) providing flows of ecosystem services (such as pollination, soil retention, water purification, nature-based recreation).

Content features

The two questions addressed by this work, which drove the GTAP runs, proved to be relevant from different policy perspectives. In fact, we need to consider that there are countries where *V. velutina nigrithorax* has already invaded many regions, such as France (the most affected country) and Spain. For these countries, the results addressing the first question are more relevant. It is an ex-post analysis that helps identifying the impacts on production and trade of *V .velutina nigrithorax* current invasion. In all the other countries, *V. velutina nigrithorax* has only invaded very few regions (e.g. in Germany and the UK). For those countries, the results addressing the second question are more relevant. It is an ex-ante analysis to quantity the risk of no-action on the *species* invasion in regions exposed but not invaded yet. Both questions are thus important, and their importance differs according to how extended is the *species* invasion currently recorded in each country.

Comparison with previous application

(…)

Limits of current application

The whole exercise offers many cues for discussion and further investigation. However, several assumptions had to be made to complete this application.

First, spatial data on species distribution need to be reliable and updated. For this application we chose a dataset collected in the context of a project specifically targeting *V. velutina nigrithorax*, i.e. the LIFE project Stop Vespa Asiatica[8]. The extracted data does not perfectly correspond in time with that of the ES accounts data (2012) and GTAP data (2011). However, it was considered suitable for testing the procedure here described. Once the procedure itself becomes a monitoring and early warning tool, then an information platform is needed. In Europe, the European Alien Species Information Network (EASIN[9]), constitutes the official information system of the EU Regulation on IAS, facilitating the access

[8] https://www.vespavelutina.eu/it-it/

[9] https://easin.jrc.ec.europa.eu/easin

to updated information on alien species, and IAS, from a network of data partners, among which are the LIFE project STOP Vespa Asiatica and national competent authorities.

Second, there is a lack of knowledge on the species' impact, specifically its predation rate. Studies have been undertaken about predation on honey bees but almost no information is available for wild bees and bumblebees. Predation has been studied almost exclusively on honey bees, whilst on wild bees there is a significant lack of knowledge We assumed the predation rate for honey bees in rural and forest areas is the same for wild and bumble bees. This assumption has a high uncertainty, and more investigation is needed on predation rates to make reliable estimates.

Third, INCA experimental accounts are run as pilot applications. To have systematic and continuous compilation, GIS tools have to be developed and made available to national statistical offices (ideally in collaboration with environmental protection agencies) and a data platform should be available to store, extract, and download data. The JRC is exploring the possibility of building an ad hoc GIS plug-in for each ES proposed within INCA (ref. Vallecillo et al. 2018, 2019). Within KIP INCA, ES accounts for Europe are available in a dedicated website where maps and tables can be downloaded[10].

Fourth, the "hypothetical loss" exercise was based on the simple assumption that *V.velutina nigrithorax* would invade all NUTS 2 regions. There are biological models able to forecast species spread in space and time, which should be considered to set plausible scenarios.

Fifth, when moving to GTAP classification of sectors, we faced data aggregation issues. From official available statistics we do not have enough information to disaggregate each crop-related-sector as needed. In this application the major sector affected by *V.velutina nigrithorax* is "vegetables, fruits and pulses" ("v_f" according to GTAP classification). An effort was made to fill the information gaps for this particular sector; but lack of data prevented us from disaggregating other sectors. Considering that the results can be different by disaggregating the affected sectors (ref. previous section), this procedure cannot be considered fully reliable until a proper disaggregation in GTAP can be performed.

Sixth, most ES have a direct impact on the primary sector, "Agriculture". A disaggregation of "Agriculture" would greatly enhance any assessment. The Social Accounting Matrices built for the bio-based and agriculture sectors (BioSAMs, Mainar-Causapé and Philippidis 2018) could help overcoming the aggregation issue and allow estimates that are more reliable. Since SAM represents the reference database for CGE models, BioSAMs could be an interesting option to link economic models to all those ES accounts that primarily depends and/or affect the agricultural sector.

Finally, GTAP provides a large range of outcomes. In this application, we only considered changes in production, trading and in a limited way the welfare. Thanks to GTAP, it is possible to assess not only primary, but also secondary effects, such as impacts on labor. However, it would be important to have (and thus provide) a guideline targeting the chain of impacts from ecosystems to the economy, to be sure that important messages will not be lost.

4 Conclusion

[10] Insert link for INCA (coming soon)

This paper proposes an illustrative case of how ecosystem services (ES) accounts can bridge economic modelling, and specifically general equilibrium models. This attempt was inspired by (Roson & Sartori, 2016) who modeled six damage functions to predict the effects of increasing temperature (driven by climate change) on sea level rise, crop yields, labor productivity, human health, tourism and household energy demand.

Rather than focusing on the impacts, which specifically relate to the issue under debate (in this case Climate Change), we focus on ES that generate different impacts under different pressures (including but not only Climate Change). For ES we followed classification systems (such as CICES[11] and TEEB[12]) which can be related to accounting frameworks (La Notte & Rhodes, 2020) and generate accounting tables in a systematic and continuous way (United Nations, European Union, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development, et al., 2014). Impact assessments could thus rely on a rigorously framed basis that allows for multiple analyses.

The purpose of this exercise is to check the feasibility of bridging ES accounts to economic modelling. ES accounts are in fact structured to be consistent with SNA that is in turn the source of data for economic modelling and analysis. Thanks to the rigorousness of the accounting framework, when the benefit of an ES is an SNA product, the linkage is straightforward and the bridging does not require to build intermediate functions. Still some work is foreseen, more on classification and disaggregation because, as tested, there are important differences (not in ranking but in the quantities) when a whole sector is affected or only part of it.

The advantage of establishing a systematic bridging between ES accounts and economic modelling does not require to build one integrated model to address one issue at the time *ex novo*. When a considerable number of ES accounts are available, many different issues can be quantified and assessed: e.g. impact assessment on government expenditures if forest coverage is considerably reduced (assessed through the ES flood control), impact assessment on agricultural production and trading with more stringent agri-payments regulation on nitrates (assessed through water purification).

On the one hand, ES accounts capture ecological content and complexity and keep the sectorial details needed to an effective cause-effect relationship. On the other hand, GE models (like in this case GTAP) capture linkages between agents, sectors and other economies. There is no need to simplify the ES component in economic modelling, and no need to simplify the economic component for ES integrated analysis: each block of the sequence can maintain its specificity and characterization.

This approach allows us to document transparently each step of the assessment sequence and identifying uncertainties and gaps by keeping each system separated from the other, and it uses the currently best available knowledge and tools without reinventing new procedures.

[11] https://cices.eu/

[12] http://www.teebweb.org/resources/ecosystem-services/

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Supplementary material

Legend

directly affected countries
closest countries
other countries
affected sectors
linked sectors

Code	Country
BE	Belgium
ES	Spain
NL	Netherlands
FR	France
IT	Italy
DE	Germany
PT	Portugal
UK	United Kingdom
EE	Eastern Europe
NE	Northern Europe
SE	Southern Europe
WE	Western Europe
NA	North America
CA	Central America
SA	South America
Africa	Africa
Asia	Asia
ROW	Rest of the World

S1

Missed gain. Disaggregated "vegetable, fruit, pulse" sector

S1.1 – Change (%) in quantity of production (q_0)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	-0.51	0.926	3.18	0.927	-0.046	0.103	3.29	0.686	-0.076	-0.557	-0.159	-0.395	-0.066	-0.109	-0.154	-0.053	-0.02	-0.066
oilseeds	1.1	0.289	10.5	3.89	1.42	-0.389	-0.476	1.2	-0.275	-0.739	-0.151	-0.333	-0.107	-0.048	-0.167	-0.026	-0.058	-0.235
fiber plants	0.079	-0.12	1.75	2.03	0.481	-0.041	-0.034	0.932	0.002	0.03	-0.017	0.018	0.005	0.008	0.016	-0.001	-0.002	-0.024
vegetable oil and fats	3.42	0.785	0.536	4.73	1.43	-0.023	-0.702	4.57	-0.363	-0.969	-0.528	-0.33	-0.158	-0.072	-0.269	-0.209	-0.077	-0.667
other agri sectors	0.027	0.008	-0.068	-0.045	0.019	0.005	-0.025	-0.007	0.002	0.002	0.018	0.025	0	0.01	0.013	0.005	0	-0.001
food industry	0.075	0.042	-0.012	0.017	0.024	0.018	0.136	0.01	0.001	0.005	-0.001	-0.003	-0.001	-0.002	0.001	-0.002	-0.001	-0.008
textile industry	-0.013	-0.037	-0.024	-0.023	-0.012	-0.007	-0.082	-0.009	0.003	0.001	0.01	-0.008	-0.001	0.005	0.009	0.012	0.003	0.006
wearing industry	-0.011	-0.026	-0.027	-0.018	-0.008	-0.002	-0.075	-0.01	0.003	0.007	0.01	-0.003	0	0.002	0.003	0.008	0.002	0.004

S1.2 – Change (%) in price of import (pms)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	-0.186	-0.658	-1.25	-0.752	-0.289	-0.355	-2.51	-0.691	-0.048	-0.081	-0.053	-0.082	-0.025	-0.042	-0.046	-0.021	-0.013	-0.016
oilseeds	-0.435	-0.164	-3.87	-1.28	-0.51	-0.099	-0.009	-0.776	-0.056	-0.037	-0.052	-0.046	-0.028	-0.031	-0.038	-0.023	-0.024	-0.04
fiber plants	-0.084	0.007	-1.13	-0.835	-0.131	-0.025	-0.087	-0.196	-0.013	-0.058	-0.016	-0.029	-0.01	-0.015	-0.02	-0.015	-0.009	-0.006
vegetable oil and fats	-1.06	-0.577	-0.535	-1.58	-0.625	-0.254	-0.054	-1.37	-0.032	-0.046	-0.016	-0.086	-0.014	-0.017	-0.025	-0.011	-0.015	-0.009
other agri sectors	-0.006	-0.001	0.006	0.01	-0.007	-0.003	0.01	-0.001	-0.004	-0.003	-0.009	-0.009	-0.005	-0.007	-0.008	-0.005	-0.004	-0.005
food industry	-0.039	-0.038	-0.01	-0.018	-0.023	-0.018	-0.083	-0.015	-0.009	-0.013	-0.008	-0.009	-0.003	-0.003	-0.009	-0.007	-0.003	-0.004
textile industry	0.003	0.008	0.005	0.005	0.003	0.002	0.014	0.003	0	0.001	-0.001	0.002	0	-0.002	-0.007	-0.004	-0.001	-0.003
wearing industry	0.003	0.007	0.006	0.005	0.003	0.002	0.017	0.003	0	0	-0.001	0.002	-0.001	-0.001	-0.007	-0.003	0	-0.002

S1.3 – Change (%) in quantity of exports (qxs)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	-0.646	1.1	3.29	1.45	-0.266	-0.023	7.94	1.22	-1.16	-1.04	-1.14	-1.03	-1.24	-1.18	-1.16	-1.26	-1.29	-1.28
oilseeds	1.83	0.501	18.7	5.97	2.2	0.185	-0.257	3.5	-0.026	-0.121	-0.047	-0.076	-0.163	-0.147	-0.113	-0.19	-0.183	-0.105
fiber plants	-0.162	-0.619	5.05	3.59	0.073	-0.456	-0.145	0.398	-0.514	-0.292	-0.501	-0.436	-0.529	-0.506	-0.479	-0.507	-0.537	-0.553
vegetable oil and fats	1.88	-1.27	-1.55	5.35	-0.954	-3.41	-4.72	3.94	-4.87	-4.77	-4.97	-4.51	-4.99	-4.97	-4.92	-5.01	-4.98	-5.02
other agri sectors	0.039	-0.012	-0.089	-0.132	0.052	0.011	-0.131	-0.011	0.021	0.013	0.074	0.074	0.029	0.055	0.065	0.029	0.02	0.028
food industry	0.108	0.103	-0.009	0.025	0.043	0.024	0.286	0.01	-0.011	0.004	-0.015	-0.014	-0.037	-0.037	-0.014	-0.021	-0.037	-0.034
textile industry	-0.014	-0.055	-0.033	-0.033	-0.016	-0.008	-0.099	-0.019	0.005	0.002	0.014	-0.005	0.01	0.021	0.06	0.035	0.017	0.027
wearing industry	-0.006	-0.036	-0.028	-0.022	-0.008	0.002	-0.113	-0.01	0.012	0.015	0.022	0.002	0.018	0.023	0.064	0.037	0.018	0.032

S1.4 – Change (mlln $) in the balance of payments (DTBALi)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	-9.79	60	105	76.7	-10.7	48.4	52.8	45.6	-14.6	3.37	-9.05	4.94	-40.6	-36.9	-65.9	-74.4	-98.5	-7.76
oilseeds	-24.6	-2.27	4.13	74.3	-2.43	8.92	2.83	5.57	-11.8	0.312	1.43	-0.515	-35.2	2.87	-33.2	-0.855	22.2	-4.67
fiber plants	0.032	-0.152	0.034	1.68	0.086	-0.028	0.011	0.226	0.049	0.021	0.017	0.053	-0.695	0.12	0.571	-0.518	-0.784	-0.918
vegetable oil and fats	76.7	80.8	4.93	182	75.7	0.323	-5.78	55	-51.2	-13.6	-13	-0.923	-40.8	-3.56	-158	-15.3	-137	-13.2
other agri sectors	0.725	-3.47	-30.3	-49.4	6.34	0.524	-5.98	-8.92	-1.17	-0.337	5.02	6.25	3.45	13.3	69.4	11.1	-23.9	-5.73
food industry	14.4	14.3	-4.78	5.61	7.34	4.44	11.8	1.37	-2.52	-0.575	-1.26	-3.96	-12.1	-3.1	-2.57	-1.56	-26	-2.94
textile industry	-1.03	-3.57	-0.954	-2.53	-3.6	-2.23	-3.04	-1.94	0.079	-0.227	0.179	-0.501	-0.76	0.421	3.93	2.99	11.7	0.418
wearing industry	-0.795	-3.1	-0.489	-2.83	-2.68	-1.57	-2.92	-1.99	0.384	0.069	0.411	-0.351	0.42	0.318	2.32	3.32	8.55	0.292

S2

Hypothetical loss. Disaggregated “vegetable, fruit, pulse” sector

S2.1 – Change (%) in quantity of production (q_0)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	-12.1	0.148	-8.28	1.31	0.054	-5.69	-0.063	-6.96	0.258	1.78	0.447	1.19	0.165	0.264	0.365	0.125	0.053	0.187
oilseeds	-10.9	-0.245	-7.42	-0.664	-1.73	-6.45	-2.26	-6.31	0.331	0.776	0.7	-0.229	0.111	0.06	0.33	0.084	0.172	-1.46
fiber plants	-20.6	-0.268	-0.004	0.36	-1.62	-24.6	0.112	-2.57	0.17	-0.011	0.08	0.262	0.019	-0.02	-0.032	0.034	0.008	0.088
vegetable oil and fats	-21.5	-0.509	-23.7	6.07	-0.645	-16.6	-3.1	-17.6	2.47	5.95	1.95	2.6	0.484	0.25	1.06	0.865	0.298	2.33
other agri sectors	0.431	-0.123	0.143	-0.044	-0.05	0.101	-0.03	0.05	-0.008	-0.01	-0.06	-0.07	0.004	-0.024	-0.031	-0.012	0	0.01
food industry	-0.141	-0.067	-0.121	0.008	-0.034	-0.168	-0.058	-0.027	-0.004	-0.046	0.009	0.007	0.006	0.006	0.001	0.005	0.004	0.031
textile industry	0.123	0.011	0.11	0.001	0.014	0.043	0.058	0.036	-0.012	-0.007	-0.034	0.022	0.005	-0.009	-0.025	-0.03	-0.007	-0.013
wearing industry	0.121	-0.003	0.115	-0.008	0.007	0.037	0.048	0.048	-0.011	-0.023	-0.034	0.011	0.001	-0.003	-0.008	-0.019	-0.005	-0.01

S2.2 – Change (%) in price of import (pms)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	4.67	0.822	3.32	0.175	0.781	2.99	0.677	4.56	0.136	0.248	0.157	0.228	0.051	0.1	0.107	0.051	0.036	0.017
oilseeds	1.48	0.314	0.78	0.005	0.877	0.963	0.735	3.1	0.099	0.063	0.187	0.02	0.042	0.067	0.083	0.057	0.068	-0.162
fiber plants	5.67	0.1	-0.02	0.053	0.486	5.45	0.082	0.533	0.066	0.18	0.052	0.112	0.021	0.036	0.048	0.039	0.024	0.008
vegetable oil and fats	5.49	0.863	8.22	0.09	0.933	5.32	1.29	5.36	0.096	0.186	0.045	0.457	0.022	0.03	0.055	0.03	0.038	0.017
other agri sectors	-0.044	0.04	-0.017	0.02	0.021	-0.026	0.015	-0.006	0.01	0.007	0.028	0.022	0.011	0.018	0.02	0.013	0.01	0.01
food industry	0.096	0.073	0.088	0.029	0.052	0.114	0.064	0.045	0.039	0.061	0.026	0.037	0.006	0.007	0.023	0.02	0.008	0.008
textile industry	-0.02	-0.003	-0.024	-0.001	-0.004	-0.011	-0.011	-0.013	0	-0.001	0.004	-0.004	0	0.004	0.019	0.01	0.003	0.006
wearing industry	-0.021	-0.002	-0.024	-0.001	-0.004	-0.011	-0.012	-0.013	0	0.001	0.004	-0.005	0.001	0.002	0.019	0.008	0.001	0.006

S2.3 – Change (%) in quantity of exports (qxs)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	-14.5	-0.25	-9.48	2.14	-0.096	-8.26	0.287	-14.1	2.29	1.87	2.21	1.95	2.6	2.42	2.4	2.61	2.66	2.73
oilseeds	-18.5	-12.8	-15.1	-11.3	-15.6	-16	-14.9	-26.5	-11.8	-11.6	-12.2	-11.4	-11.5	-11.6	-11.7	-11.6	-11.6	-10.5
fiber plants	-27.6	0.269	0.869	0.506	-1.66	-26.5	0.363	-1.89	0.442	-0.127	0.511	0.21	0.666	0.59	0.53	0.575	0.648	0.733
vegetable oil and fats	-19.1	11.4	-37.1	16.5	11	-18	8.63	-18.2	16.5	15.9	16.8	14.1	17	16.9	16.8	16.9	16.9	17
other agri sectors	0.544	-0.352	0.249	-0.141	-0.148	0.351	-0.083	0.139	-0.032	-0.003	-0.222	-0.165	-0.044	-0.116	-0.144	-0.061	-0.034	-0.035
food industry	-0.2	-0.104	-0.166	0.073	-0.019	-0.27	-0.068	0.008	0.032	-0.055	0.084	0.038	0.166	0.161	0.098	0.11	0.159	0.158
textile industry	0.169	0.04	0.198	0.021	0.046	0.1	0.099	0.114	0.014	0.023	-0.017	0.049	0.013	-0.014	-0.127	-0.057	-0.008	-0.031
wearing industry	0.101	-0.039	0.124	-0.046	-0.021	0.034	0.037	0.048	-0.049	-0.055	-0.084	-0.011	-0.055	-0.068	-0.189	-0.109	-0.058	-0.094

S2.4 – Change (mlln $) in the balance of payments (DTBALi)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
vegetable, fruit, pulses	-258	110	-267	71.6	26.4	-326	-2.78	-276	41.6	-8.59	26	-11.3	102	89.1	155	178	257	20.6
oilseeds	189	-14.1	200	-150	-11.9	198	5.28	-52	-77.5	-33.4	-3.66	-9.69	-1.22	-9.66	-66.8	-2.21	-106	-30.2
fiber plants	-1.47	-0.233	0.009	0.343	-0.418	-7.57	-0.033	-0.623	-0.303	-0.044	-0.035	-0.463	4.3	-0.26	-1.09	4.11	3.21	3.01
vegetable oil and fats	-477	-35.6	-421	214	-26	-968	-34.7	-204	323	101	48	7.18	130	13.5	614	60.4	532	47.1
other agri sectors	104	-55.7	84.9	-42.5	-24.4	149	-0.999	55.3	-17.9	-4.71	-16.7	-16.6	15.1	-31.4	-177	-31.6	20.2	31.1
food industry	-28.4	-17.5	-37.7	39.4	-1.5	-115	-2.66	-0.744	2.24	-19.4	5.43	8.85	45	9.77	12.7	4.9	89.2	11.6
textile industry	6.53	2.1	5	0.839	4.67	14.6	2.35	7.48	-0.817	0.554	-0.706	1.47	3.72	-0.806	-10.7	-7.47	-25.9	-1.02
wearing industry	6.37	1.25	2.43	0.033	3.35	13.4	1.93	8.42	-1.59	-0.274	-1.46	1.1	0.636	-0.513	-6.37	-7.62	-18.5	-0.694