Potential medium-run impacts of the Russia-Ukrainian war on the Dutch agriculture and food system: an assessment

Roel Jongeneel, Ana Gonzalez-Martinez, Myrna van Leeuwen, David Verhoog

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De Russische invasie in Oekraïne heeft gevolgen voor landbouwproductie en voedselprijzen in de wereld, de EU en in Nederland. In deze modelgebaseerde scenariostudie worden de potentiële middellange termijn effecten van de oorlog op landbouwmarkten (prijzen) en de landbouwproductie en voedsel consumptie in Nederland gekwantificeerd. De scenario's richten zich op de mogelijke gevolgen van de afname van de landbouwproductie in de Oekraïne en ook de gevolgen van handelssancties tegen Rusland, en de daarmee samenhangende hogere energieprijzen. De middellange termijn directe gevolgen van de Oekraïneoorlog op de productie en consumptie volumes in de Nederlandse agrofoodsector zijn volgens de uitgevoerde simulaties beperkt. Dit ondanks de verstoring van de prijzen. Als meer specifiek rekening wordt gehouden met de effecten van de energie- en kunstmestprijsstijgingen op de landbouwproductie en voedselconsumptie wereldwijd, zijn de gevolgen voor de landbouwmarkten (prijzen) groter, maar kan ook een groter deel van de kostenstijgingen worden goedgemaakt door meegestegen opbrengstprijzen, waardoor ook dan de effecten voor de Nederlandse agrosectoren beperkt blijven. De EU beleidsmaatregel die toestaat om in de EU tijdelijk meer grond voor landbouw in productie te nemen heeft slechts een marginaal effect.

The Russian invasion of Ukraine has consequences for agricultural production and food prices in the world, the EU, and in the Netherlands. This model-based scenario study quantifies the potential medium-term effects of the war on agricultural markets (prices) and agricultural production and food consumption in the Netherlands. The scenarios focus on the possible consequences of the decline in agricultural production in the Ukraine and also on the consequences of trade sanctions against Russia, and the related higher energy prices. According to the simulations carried out the medium-term direct consequences of the Ukraine war on production and consumption volumes in the Dutch agri-food sector are limited. This is despite the disruption to prices. When the effects of energy and fertiliser price increases on agricultural production and demand worldwide are taken into account, the consequences for the agricultural markets (prices) are greater, but a larger part of the input cost increases can also be compensated by increased output prices, so that still the effects for the Dutch agro sectors remain limited. The EU policy measure that allows for temporarily taking more land into production in EU agriculture has only a marginal effect.

Key words: Ukraine, war, agriculture, supply chains, trade, energy, self-sufficiency, scenarios, economic modelling

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Preface

Wageningen Economic Research uses scenarios to carry out explorations and ex-ante evaluations. The Ministry of Agriculture, Nature and Food Safety (LNV) commissioned research into the impact of the Russian invasion of Ukraine and its implications on Dutch agriculture and food markets. At the time of the analyses and writing (May-June 2022) the war is still going on and the outcome is still unclear. Given the uncertainty, the ministry commissioned various studies that cover a part of the complexity and uncertainty.

In a first study, Bergevoet et al. (2021) provided insights into the trade of agricultural products from and to Ukraine, Russia and Belarus, with a focus on economic relations of these countries with the Netherlands. In Berkhout et al. (2022) a first analysis of the first consequences for food security in the short term (that is, less than 6 months) is given. In this study, medium-term effects (that is, impacts over 2 years ahead) of the war on global agricultural production, trade flows, market prices, and food security are quantified. Van Meijl et al. (2022) analysed of the effects on international markets, with a special focus on worldwide food security issues.

This study focuses on the medium term (period 2022-2025) impacts on the Dutch agri-food sector. Whereas it makes use from previous studies (especially Van Meijl et al, 2021) it also extend these studies by providing a more in-depth assessment of the consequences of the war in Ukraine for various agricultural sectors in the Netherlands, including part of the EU policy response. The impact assessment is based on simulations made with a partical equilibrium model, which has a refined sectoral and policy respresentation of Dutch and EU agriculture, which is complemented by a cost-benefit/input-output assessment (KOBALAMI) to assess upstream and downstream impacts on food supply chains, both in terms of added value, as well as in terms of employment.

This publication reports on this research. A word of thanks is due to the members of the LNV supervisory committee who have supported this research with their knowledge and experience, namely:
- Maarten Paquaij, directorate European, International en Agro-economic Policy (EIA, chairman)
- Gerty Horeman, directorate Strategy, Knowledge and Innovation (SK&I)

Finally, we would like to thank everyone who has further contributed to the preparation of this report.

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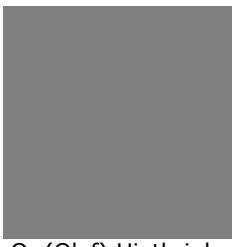

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Uitgebreide samenvatting

S.1 Inleiding en doel

De invasie van Rusland in Oekraïne vormt niet alleen een ernstige bedreiging voor de mondiale voedselvoorzieningsketens van basisproducten zoals granen en zonnebloemolie, maar raakt ook de EU en de Nederlandse landbouw- en voedingssector. De oorlog heeft in Oekraïne geleid tot de directe vernietiging van voedselvoorraden en opslagfaciliteiten, het verlies van een deel van de Oekraïense oogst voor de huidige campagne en verstoorde logistieke en transportoperaties (bijvoorbeeld geblokkeerde havens, beschadigde infrastructuur, enzovoort). Dit leidt tot extra schaarste, vooral bij granen en oliezaden (zonnebloemzaad) en daarvan afgeleide producten (bijvoorbeeld zonnebloemolie) die zowel de Nederlandse akkerbouwsector (opbrengstprijzen) als de dierlijke sectoren raken (stijgende voerkosten, en prijsstijgingen voor dierlijke producten zoals vlees en melk). De oorlog heeft ook de prijsstijgingen voor energie en meststoffen die zich al sinds voorjaar 2020 voordeden nog verder versterkt. Dit leidt nog tot een extra stijging van de kosten voor de landbouw en de aan de landbouw toeleverende en verwerkende sectoren. Als reactie op deze ontwikkelingen heeft de Europese Commissie specifieke maatregelen genomen (waaronder de mogelijkheid voor lidstaten om tijdelijk ecologische focus gebieden en/of braakland in productie te nemen) om daarmee de mogelijke gevolgen voor het voedselsysteem van de EU te verzachten. Verder heeft zij verschillende sanctiepakketten ingesteld om daarmee druk uit te oefenen op Rusland en zo bij te dragen aan de beëindiging van de oorlog.

Om de mogelijke gevolgen van de oorlog in Oekraïne voor de Nederlandse landbouw- en voedselsector in kaart te brengen (bijvoorbeeld het effect op prijzen, het aanbod van landbouwproducten, de vraag, de handel, en de zelfvoorzieningsgraad), heeft het ministerie van Landbouw, Natuur en Voedselkwaliteit in Nederland een studie laten uitvoeren met als doel de potentiële gevolgen voor de Nederlandse agri-foodsector voor de middellange termijn (2022-2025) in kaart te brengen. De kwantitatieve inzichten die in dit rapport worden gepresenteerd, vormen een aanvulling op de inzichten die in een eerdere fase van het project zijn verkregen met het MAGNET-model (Van Meijl et al., 2022), dat zich richtte op voedselzekerheid op mondiaal niveau en een kortetermijn-horizon (6 maanden - 2 jaar) had. Zie voor een overzicht van specifieke uitkomsten van deze studie Tabel S2.

S.2 Methode

In deze studie formuleren we drie scenario's om de impact van de oorlog tussen Rusland en Oekraïne op de Nederlandse landbouw- en voedselsector in te schatten. Elk van de scenario's bestaat uit aannames die een afspiegeling zijn van enkele (nu al) bekende of verwachte gevolgen van de oorlog, zoals terugval in de landbouwproductie van Oekraïne als gevolg van de oorlog, de beleidsreactie van de Europese Unie om tijdelijk extra land in productie te nemen en de gevolgen van de energieprijsstijgingen en sancties.

De focus ligt in de deze analyse op de middellangetermijneffecten (periode van 4 jaar). Daarvoor was het nodig om een inschatting te maken van het verdere verloop van de oorlog. Aangenomen is dat er een *frozen conflict* zal ontstaan, waarbij een zuidelijk-oostelijk deel van Oekraïne onder Russische controle zal komen te staan. Aangenomen is dat de landbouwproductie in de rest van Oekraïne geleidelijk weer op gang zal komen en dat ook de infrastructuur zal worden hersteld (met hervatting van exporten).

Om de effecten van de scenario's op de Nederlandse landbouw- en voedselsector in te schatten wordt een driestapsprocedure gebruikt:

1. Analyse van de markteffecten (prijs, aanbod, vraag) van de schokken die deel zijn van het betreffende scenario (bijvoorbeeld de afname van de productie van granen en oliezaden in Oekraïne als gevolg van de oorlog). Hiervoor wordt het AGMEMOD-model gebruikt (een partieel-evenwichtsmodel met een

gedetailleerde weergave van de belangrijkste agrosectoren voor alle EU-lidstaten, inclusief Nederland) al dan niet in combinatie met het MAGNET-model (een algemeen evenwichtsmodel, waarin rekening wordt gehouden met de landbouwproductie en handel in landbouwproducten in de gehele wereld en ook met effecten op de energiemarkt, consumptie en factormarkt (arbeid).
2. Gegeven de uitkomsten van stap 1) worden de effecten op de aanbodketen (supply chain) geanalyseerd met behulp van het KOBALAMI-model. Het KOBALAMI-model kan de effecten (toegevoegde waarde/inkomen en werkgelegenheid) op toeleverende en verwerkende industrieën (inclusief de distributie) meenemen die samenhangen met veranderingen in de primaire productie (resultaat van stap 1).
3. Om een meer specifiek inzicht in de energie-afhankelijkheden van zowel de primaire als de toeleverende en verwerkende sectoren te krijgen is een input-outputmodel van de Nederlandse landbouw- en agrosectoren gebruikt om het effect op de productiekosten in te schatten (zie scenario 3). Deze informatie is gebruikt ter aanvulling en als extra input voor stap 2 (alleen in geval van scenario 3).

De kwantitatieve resultaten van de analyse zijn ter validatie met experts en de begeleidingsgroep besproken.

S.3 Uitgangspunten

Uitgaande van een middellangetermijnperspectief (4 jaar) wordt in deze studie een beeld geschetst van de mogelijke gevolgen van de Russische inval in Oekraïne voor de Nederlandse en EU-agrofoodsector. Daartoe zijn de vier in tabel S1 beschreven scenario's (inclusief de baseline) gesimuleerd.

Tabel S1 *Scenario's in één oogopslag*

Narratief/drivers	**Baseline**	**Scenario 1 – De oorlog in Oekraïne**	**Scenario 2 – De EU-beleids-reactie**	**Scenario 3 – Energieprijs-stijging**
Narratief	AGMEMOD outlook van januari 2022 (consistent met de Midterm Outlook van de Europese Commissie)	Simulatie van de directe gevolgen van de Russische invasie in Oekraïne: terugval in de productie en export van landbouwproducten en rol van hogere kunstmestprijzen in de EU (en Nederland)	Als aanvulling op scenario 1 wordt de EU-maatregel om in 2022 tijdelijk extra braakland in productie te nemen mede in beschouwing genomen	Simulatie van het effect van een structurele energieprijsstijging, ook rekening houdend met de aanpassingen die dit teweegbrengt in de landbouwproductie en handel in landbouwproducten in de rest van de wereld
Factoren die uitkomsten beïnvloeden	Voorgenomen beleid en verwachte macro-economische en wereldmarktprijs ontwikkelingen per januari 2022	Aanpassingen in wereldmarktprijzen (endogeen); aanpassingen in bruto binnenlands product (BBP) in EU lidstaten (exogeen), het effect van kunstmest-prijsstijgingen	Aanpassingen in wereldmarktprijzen (endogeen); aanpassingen in bruto binnenlands product (BBP) in EU-lidstaten (exogeen), het effect van kunstmest-prijsstijgingen	Wereldmarktprijzen exogeen (gebaseerd op MAGNET-studie); aanpassingen in bruto binnenlands product (BBP) in EU-lidstaten, het effect van kunstmestprijsstijgingen ; de gestegen energieprijzen (wereldwijde gevolgen op landbouw/voedselproductie, handel, en consumentenvraag en vraag in verband met niet-humane consumptie

Bron: Auteurs.

De belangrijkste resultaten per thema zijn hieronder samengevat:

Wereldmarktprijzen
De oorlog in Oekraïne leidt tot een terugval in de landbouwproductie die leidt tot extra schaarste, in een situatie waarin de prijzen ook voor de oorlog in Oekraïne al substantiële stijgingen lieten zien. De extra stijging van de wereldmarktprijzen als gevolg van de oorlog (scenario 1) ligt voor granen en oliezaden op de korte termijn (1 jaar) in de orde van grootte van 7 tot 12%. Deze stijging wordt op de middellange termijn grotendeels tenietgedaan omdat Oekraïense productie zich gaat herstellen en er ook elders in de wereld meer zal worden geproduceerd als reactie op de hogere prijzen. Voor dierlijke producten zijn de verwachte procentuele prijsstijgingen lager dan voor gewassen (in alle gevallen kleiner dan 3% voor scenario's 1 en 2). Dat komt omdat veevoer slechts een van de inputs en kostencomponenten is die de prijs van dierlijke producten bepalen en door het gebruik van ruwvoer/gras dat vaak beperkt verhandelbaar is en daarom ook minder in prijs stijgt dan de akkerbouwgewassen. Voor scenario 3, dat ook rekening houdt met de wereldwijde doorwerking van stijgende energie en kunstmestprijzen, variëren de stijgingen van de gewassen prijzen op de wereldmarkt tussen de 12 en 28% (zonnebloemzaad). Ook in dit geval zijn de prijsstijgingen bij de dierlijke producten lager (kleiner dan 6%).

Productie landbouw in Nederland
De tijdelijke toename in de prijzen op de landbouwmarkten leidt tot (zeer) beperkte aanpassingen in de productie (scenario 1). Deels wordt dat veroorzaakt doordat niet alleen de kosten, maar ook de (verwachte) opbrengstprijzen stijgen, waardoor de boeren weinig prikkels hebben om hun productie aan te passen ten opzichte van wat ze normaal al doen. Bij de melkveehouderij is er bovendien de neiging om de veestapel op het niveau te houden dat vanuit de fosfaatquotering wordt toegestaan. De optie om tijdelijk extra land in productie te nemen (scenario 2), een maatregel die Nederland zelf niet toepast, verandert nauwelijks iets aan het beeld zoals al geschetst voor scenario 1.

Toeleverende- en verwerkende sectoren
Als gevolg van de beperkte aanpassingen in de primaire productie (scenario 1) zijn ook de gevolgen in de keten (agrocomplexen) beperkt. Het totaal verwachte verlies aan toegevoegde waarde voor de agrocomplexen zuivel, rundvlees, varkensvlees, pluimvee en akkerbouw (gevolgen voor de primaire productie en de toeleveringsketen) voor de periode 2022-2025 is geraamd op ongeveer 700 miljoen euro (scenario 1; circa 3% van de gerealiseerde totale toegevoegde waarde in 2020). In scenario 3 is het toegevoegde waardeverlies lager dan in de beide andere scenario's, vanwege de relatief hogere wereldmarktprijzen. Die hogere prijzen worden veroorzaakt door de negatieve impact van de gestegen energieprijzen op de agrarische productie en consumptie elders in de wereld. Deze hogere prijzen leiden voor de Nederlandse agrosectoren tot hogere opbrengsten (inkomsten) die de gestegen energiekosten zelfs meer dan volledig kunnen compenseren.

Energieprijs-afhankelijkheid
Uit een afzonderlijke beoordeling van de structurele energieprijsstijging met 20% (scenario 3) bleek dat een dergelijke energieprijsstijging zou kunnen leiden tot een extra energierekening voor de vijf geanalyseerde Nederlandse agrosectoren van ongeveer 112 miljoen euro per jaar. Als gevolg van het doorberekeningseffect van een dergelijke energieprijsstijging in de mondiale landbouwmarkten (stijgende wereldmarktprijzen voor landbouwproducten) zullen de extra kosten in belangrijke mate worden gecompenseerd door extra inkomsten, waardoor het negatieve effect van de oorlog in Oekraïne op de toegevoegde waarde voor de Nederlandse landbouw wordt afgezwakt.

In tabel S2 worden een aantal specifieke resultaten voor de geanalyseerde scenario's met betrekking tot de Nederlandse agroproductie gegeven.

Tabel S.2 *Geselecteerde uitkomsten van de studie: gevolgen voor primaire productie, aanbodketens en overige effecten*

Scenario's	Primaire productie	Supply chain impacts	Overige impacts
Scenario 1 – De oorlog in Oekraïne	Beperkte toename in rund- en kalfsvleesproductie (0,8% in 2022)	De gevolgen voor de productie (volume) zijn in het algemeen beperkt (kleiner dan 1%) Het geaccumuleerde werkgelegenheidsverlies bedraagt circa 1.250 FTE in 2025	Het verlies aan toegevoegde waarde in de akkerbouwsector is circa 0,3% van de gemiddelde toegevoegde waarde van het akkerbouwcomplex in de periode (2022-2025). Ook voor de dierlijke sectoren maken de gestegen productprijzen veel van de extra voerkosten goed
Scenario 2 EU-beleidsmaatregel	Financiële gevolgen zijn iets minder negatief dan in scenario 1 door kleine extra productie in de EU als gevolg van de EU-beleidsmaatregel	De gevolgen op de productie zijn in het algemeen beperkt (vergelijkbaar met scenario 1) Het grootste negatieve effect op de toegevoegde waarde doet zich voor in de pluimveesector (daling toegevoegde waarde 0,78% in 2022) Het geaccumuleerde werkgelegenheidsverlies bedraagt bijna 1.300 FTE in 2025	Verwaarloosbare aanpassingen in de consumptie per capita (vergelijkbaar met scenario's 1 en 3)
Scenario 3 – Structurele energieprijsstijging	Net als in scenario's 1 en 2, wordt er een terugval in de productie van pluimveevlees (-1,1%) en varkensvlees (-0,4%) verwacht in 2022. Door de hogere wereldmarktprijzen (sterker kosten doorberekeningseffect) in dit scenario is het totale toegevoegde waarde verlies lager dan in scenario's 1 en 2	De toegevoegde waarde in de pluimveeketen zal in 2022 naar verwachting 1% dalen Het geaccumuleerde werkgelegenheidsverlies bedraagt circa 350 FTE in 2025	In 2022 wordt de veehouderij vanuit handelsoogpunt het meest getroffen door varkensvlees (daling van de netto-uitvoer met 1,847%). De nettokosten voor de akkerbouwsector dalen, aangezien de stijging van de productprijzen de stijging van de energieprijzen compenseert

Bron: Auteurs.

Werkgelegenheid

De Oekraïneoorlog heeft in alle drie de scenario's een negatief effect op de werkgelegenheid, variërend van 350 (scenario 3) tot 1.250 (scenario 1) FTE. Er is een beperkte uitstoot van arbeid door een negatief effect op de primaire productie. Er is rekening mee gehouden dat een deel van de arbeid die in de landbouw en toeleverende- en verwerkende industrie wordt afgestoten, elders in de economie weer aan het werk komt.

Consumptie

De effecten op de consumptieve vraag zijn verwaarloosbaar. Enerzijds werkt de stijging van agrarische grondstofprijzen beperkt door in de retailprijzen van voedselproducten. Dit komt omdat de grondstofkosten maar een beperkt onderdeel uitmaken van de totale kostprijs van voedselproducten. Anderzijds geldt dat de prijselasticiteiten van de vraag en de inkomenselasticiteiten klein zijn (inelastisch), terwijl het inkomenseffect van de oorlog voor de Nederlandse burger bovendien zeer beperkt is (in de orde van grote van maximaal enkele procenten). Dit geldt voor alle drie scenario's.

Voedselvoorziening

De voedselzekerheid in Nederland wordt niet bedreigd door de oorlog in Oekraïne. Dit blijkt uit de gevonden marginale aanpassingen in de zelfvoorzieningsgraad van Nederland. De oorlog in Oekraïne en de spanningen met Rusland kunnen wel bijdragen aan algemene stijgingen van de voedselprijzen die specifieke relatief arme huishoudens kunnen treffen.

Summary

S.1 Introduction

Russia's invasion of Ukraine implies a severe threat to the global food supply chains of basic products such as grains and sunflower oil. The war has caused the direct destruction of food stocks, storage facilities, the loss of (part of) the Ukrainian harvest for the current campaign and disrupted logistics and transport operations (e.g. blocked harbours, damaged infrastructure, etc.). The war has also exacerbated price increases in energy and fertilisers, resulting in a tremendous cost rise that even has temporarily put at halt the activities of some farmers carrying out energy-intensive farming. Agricultural markets have already reacted showing sharp increases in the prices of agricultural commodities. As a response, the European Commission has implemented specific actions to mitigate the potential consequences for the EU food system, as well as several packages of sanctions to contribute to ending the war by reducing Russia's economic base.

To assess the potential consequences for the Dutch and EU agri-food sector of the war in Ukraine (e.g. effect on prices, product supply, demand, trade, self-sufficiency), the Ministry of Agriculture, Nature and Food Quality in the Netherlands has commissioned a study with the objective of simulating a set of medium-term forward-looking scenarios. The quantitative insights presented in this report supplement those provided in an earlier stage of the project by the MAGNET model (Van Meijl et al., 2022), which have a focus on food security at the global level.

S.2 Main results

A number of key findings can be drawn from the simulation exercise conducted for the purpose of this study:

- The medium-term impacts of the Ukraine war on Dutch product supply, demand, trade, self-sufficiency, and agri-food supply chains are expected to be very limited since the Dutch trade dependency on Ukraine is in general very low (sunflower oil being an exception) and the trade with Russia was already limited because of the existing trade sanctions imposed in 2014;
- The expected loss in value added for the dairy, beef/veal, pig, poultry and arable agrocomplexes (primary production and supply chain impacts) for the period 2022-2025 has been estimated to be around 700 million euros (Scenario 1).
- From a separate 20% structural energy price increase assessment (Scenario 3) it appeared that such an energy price increase could lead to an additional energy bill for the five assessed Dutch agri-sectors of about 112 million euros per annum. Due to the passing-on effect of such an energy price increase in global agri-markets (leading to increasing world market prices for agricultural commodities) the additional costs will be partly compensated by additional revenues, thereby mitigating the impact on agricultural value added.
- The EU policy response (temporarily taking fallow land into production) is likely to have very limited effects on product supply and markets (prices) since the area of fallow land in the EU is rather limited (less than 3%) and its productivity is below average; and
- Food security in the Netherlands is not really threatened by the Ukraine war, although the Ukrainian war contributes to general food price increases that may affect specific relatively poor households.

Table S1 further elaborates on the results of the present modelling exercise.

Table S1 *Selected outcomes*

Scenarios	Primary production	Supply chain impacts	Other impacts
Scenario 1 – The war in Ukraine	Small increase in beef & veal production (0.8% in 2022)	In general impacts are small (less than 1%) Cumulative employment loss of around 1,250 FTE jobs in 2025	Value added loss in for the arable sector is equivalent to 0.27% of the average 2022-25 value added of the total agrocomplex
Scenario 2 – EU policy responses	Impacts are slightly less negative than in Scenario 1	Impacts are relative small (similarly as in Scenario 1) The largest negative impact on value added is expected for poultry (-0.78% in 2022) Cumulative employment loss of almost 1,300 FTE jobs in 2025	No significant changes in consumption per capita (similarly as in Scenarios 1 and 3)
Scenario 3 – Further energy and fertiliser price impacts	As in Scenario 1 and 2, declines in poultry and pig production are expected (-1.1% and -0.4% respectively in 2022). Due to higher world market prices the total costs are lower than in Scenario 1 and 2	A 1% decline in the value added of the poultry sector is expected in 2022 Cumulative employment loss of around 350 FTE jobs in 2025	In 2022, the most affected livestock sector from a trade perspective is pig meat (1.847% decline in net exports). The net costs for the arable sector decline, as the increase in product prices partly compensates for the increase in energy prices

Source: Authors.

S.3 Methodology

Adopting a medium-term (4 year) perspective, this paper aims at anticipating the potential consequences of Russia's invasion of Ukraine on the Dutch and EU agri-food sector. In doing so, the four scenarios described in Table S2 have been simulated.

Table S2 *Scenarios at a glance*

Storyline/drivers	Baseline	Scenario 1 – The war in Ukraine	Scenario 2 – EU policy responses	Scenario 3 – Further energy and fertiliser price impacts
Storyline	AGMEMOD outlook as available in January 2022	Simulation of the direct impacts of the Russian invasion of Ukraine	Assessment of the effectiveness of the EU policy responses implemented to mitigate the consequences of the war	The impacts on the oil, gas and fertiliser markets and their indirect impact on agricultural production in the rest of the world are taken into account
Scenario drivers	Expected developments as per January 2022	World market prices, GDP shocks, energy prices, fertiliser prices, fertiliser availability/yield impacts, use of fallow land		

Note: This table presents a 'generic' list of drivers. Not all drivers are used in the same way across all scenarios.
Source: Authors.

First, the scenarios are simulated by means of the AGMEMOD model which represents primary agriculture and delivers indicators on both supply and demand for agricultural commodities. Subsequently, these outcomes are also used as input for the KOBALAMI model, which provides insights on how the developments of the Dutch primary agriculture affect the upstream and downstream industries. The quantitative results generated by the two models have been discussed with market experts to ensure plausibility.

1 Introduction

1.1 Background

Since December 2019 food supply chains across the Globe have been learning how to cope with a pandemic, showing an important capacity to adjust to a changing and more volatile demand as well as to deal with labour shortages and bottlenecks in the transportation system. By the time the picture of empty supermarket shelves in the early days of the pandemic was an old memory, the agri-food sector was shaken by the turmoil of Russia's invasion of Ukraine. The war means a severe threat to food supply chains in Ukraine and elsewhere, especially in the case of basic products such as grains and sunflower oil for which Ukraine is an important world supplier.[1] The war has caused the direct destruction of food stocks, storage facilities and the loss of the Ukrainian harvest for the current campaign. The consequences of this dramatic event also include other side effects like increases in energy and fertiliser prices, resulting in a tremendous cost rise that could have temporarily put at halt the activities of some farmers outside Ukraine carrying out energy-intensive activities.[2] Often the aforementioned impacts are exacerbated due to the disrupted logistics and transport operations (e.g. blocked harbours, damaged infrastructure).

Although some of the consequences for the food system are still to come, e.g. increases in food insecurity in low-income countries (The Economist, 2022a), agricultural markets have already reacted showing sharp increases in the prices of agricultural commodities. For example, grain prices are expected to rise by almost a third this year, in addition to the 40% increase observed in the course of 2021 (The Economist, 2022b).[3] Another element around which there are rising concerns in countries like the Netherlands is organic production, particularly in the case of livestock farming which heavily relies on feed inputs traditionally imported from Ukraine (Bionext, 2022).

As a response to the military aggression to Ukraine, the European Commission has implemented specific actions to mitigate the potential consequences for the EU food system, as well as several packages of sanctions to contribute to ending the war by reducing Russia's economic base.[4] More specifically, the packages of sanctions includes the following items: (i) individual sanctions, mainly assets freeze and travel ban; (ii) financial measures, e.g. SWIFT ban; (iii) transport, e.g. closure of EU airspace to Russian-owned aircrafts; (iv) energy, e.g. ban on coal imports from Russia; (v) defence, e.g. ban on exports to Russia of technology for military use; (vi) raw materials and other goods, e.g. ban on exports of luxury goods, ban on imports of iron, etc; (vii) restrictions on media; and (viii) diplomatic measures, e.g. suspension of visa facilitation provisions to Russian diplomats.

In terms of food policy-related interventions a variety of measures has been put in place (Council of the European Union, 2022). A novelty is the European Food Security Crisis preparedness and response Mechanism (EFSCM) that has been implemented by the European Commission on 9 March, with the aim of improving the coordination among the relevant stakeholders in different EU and non-EU Member States to ensure food supply and food security during crises. Apart from a financial package[5] to support farmers helping them to deal with the current unusual high input costs, the European Commission has temporarily

[1] According to FAO (2022a), over the period 2016/17 to 2020/21, Ukraine's production of wheat represented on average around 10% of the total global market for this commodity. Looking at the same period, FAO (2022a) also indicates that Ukraine's maize export share is 15%. For sunflower oil, Ukraine's world market share is 44%. More than 80% of the Dutch sunflower oil imports in 2021 originated from Ukraine, while for corn this percentage was about 40%.

[2] See FloralDaily (2022), for further details on the impact of high energy prices on the Dutch floriculture sector. See HortiDaily (2022), for additional expert insights on the challenges that the current energy crisis has imposed to Dutch horticulture growers.

[3] FAO (2022b) reports that in February 2022 the FAO Food Price Index was 21% higher in February 2021.

[4] At the time of writing this report, five packages of sanctions have been adopted. Further details on each package are available at: https://www.consilium.europa.eu/en/policies/eu-response-ukraine-invasion/.

[5] The Netherlands received about 8 million euros from the EU crisis reserve, which is surely not enough to compensate farmers for the recent input price increases. As it is not clear how these funds will be allocated to farmers, this financial package has not been included in this assessment since its consideration within the assessment would require making too many assumptions.

permitted Member States to derogate from certain greening obligations, allowing production on fallow land from the Ecological Focus Areas (Council of the European Union, 2022).

1.2 Objective

The aim of this piece of research is to assess the potential impacts of the war in the Ukraine on different agricultural sectors in the Netherlands both with and without taking into account the EU/national policy response. The focus will be on the medium-term impacts (often referring to a period of 3 to 5 years), considering the period 2021-2025 (including 2021 as a pre-Ukraine war reference point). The assessment will address the impacts on primary production (volume of production, value added), as well as on upstream and downstream industries (value added). Moreover, potential impacts on employment will be taken into account. Finally, the impact on domestic use (including consumption) and on the Dutch net trade position will be evaluated.

1.3 Approach

Adopting a medium-term perspective (as distinguished from a short-run (1-2 year) perspective), the focus of the present analysis is on assessing the potential consequences of the war in Ukraine for the Dutch agri-food sector, which is highly connected to the European market. From a methodological point of view, this study relies on the simulation of a set of **four scenarios** by means of two connected models. More specifically, the scenarios that will be simulated are the following ones: (i) Baseline; (ii) Scenario 1 – The war in Ukraine; (iii) Scenario 2 – EU policy responses; and (iv) Scenario 3 – Further energy and fertiliser price impacts.

The modelling process (Figure 1.1) starts with the simulation of a scenario by means of the **AGMEMOD** (*Agricultural Member State Modelling*) model which delivers indicators on primary agriculture, e.g. prices, production, yields, domestic use, apparent consumption per capita, etc. Subsequently, the calculated production (and yield) impacts are used as input for KOBALAMI (KOsten-BAten LAndbouw Model) which is a modelling tool with an input-output (IO) component. This feature permits KOBALAMI to 'track' the impact of changes in the primary sector on the upstream and downstream industries (**agrocomplexes**). As usual, the modelling outcomes of AGMEMOD and KOBALAMI will be discussed with market experts for final validation.

A limitation of this approach is that not all the agricultural sectors are individually represented within the models or at a sufficient level of detail, e.g. in the case of horticulture only the tomato sector is represented within AGMEMOD, flower bulbs are also excluded from AGMEMOD, etc.

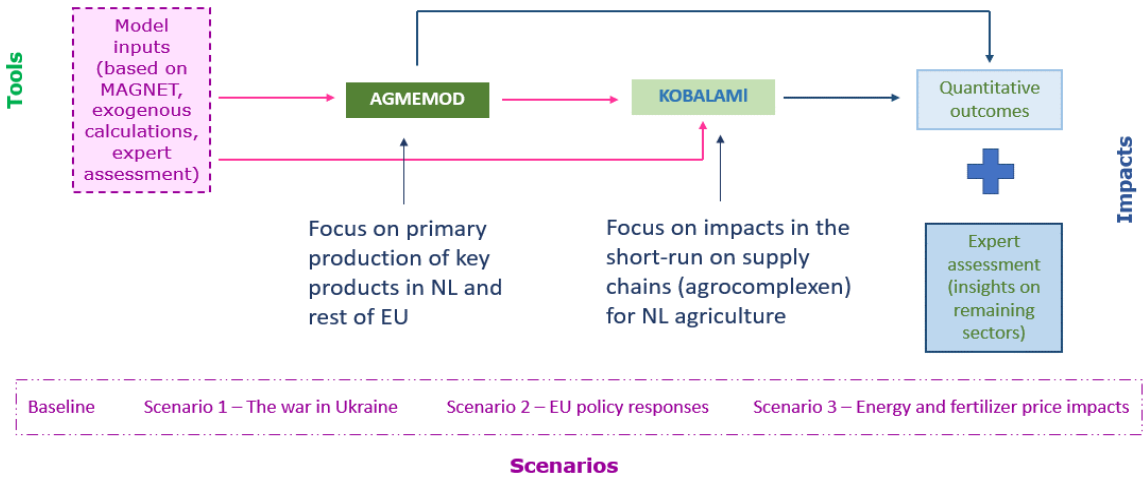

Figure 1.1 *Methodological approach*
Source: Authors.

A specific topic is to assess the impact of fertiliser price increases **on crop yields** (see, Appendix 2). As is shown in the literature, the yield response to crop price is quite inelastic (Berry and Schlenker, 2011; Jongeneel and Gonzalez, 2020). As can be easily shown using micro-economic theory of production, the optimal yield will be determined by the relative fertiliser/crop price ratio (p_f/p_c). In the case of profit maximising farmers, an increase in the (relative) fertiliser price will induce a reduction of fertiliser application and a derived reduction in crop yield. The yield relationships in AGMEMOD have a linkage with the crop price (deflated by a general cost index), but miss the impact of specific N, P, or K fertiliser prices. Since, due to the Russian-Ukraine war, especially N fertiliser prices have significantly increased and this shock may affect crop yields, it has been chosen to follow a two-step procedure to identify the crop yield effect. First the change in the p_f/p_c price ratio has been estimated. In a second step the yield impact has been estimated using information on yield-crop price response elasticities. These yield impacts, which are scenario specific, are then used as shifters of the yield in the yield equations of the AGMEMOD model.

1.4 Structure of this report

After this introduction, this report is structured in the following chapters:

- Chapter 2 elaborates on the conceptual framework for analysis and describes the simulated scenarios;
- Chapter 3 presents the scenario results and discusses them further;
- Chapter 4 provides some conclusions;
- Appendix 1 provides some technical details on the modelling tools used in the context of this study;
- Appendix 2 further discusses the interaction among fertiliser use, yields and farmer behaviour from a conceptual perspective; and
- Appendix 3 reflects on the implications for agricultural supply of logistic infrastructure and fertiliser input availability.

2 Approach and methodology

2.1 Overview

This chapter discusses the different 'channels' through which the war in Ukraine can affect the developments of the agri-food market in the Netherlands and the EU. First, Section 2.2 presents the conceptual framework underlying the present analysis. Second, Section 2.3 describes the alternative scenarios that have been simulated by means of the AGMEMOD and KOBALAMI models.

2.2 Conceptual framework

As is well-known by now, Russia's invasion of Ukraine has imposed several challenges to the agri-food market in the EU and elsewhere. Focusing on the EU, for which food security is less of a concern, the main shocks derived from the war are: (i) a supply/trade shock due to reduced crop exports from Ukraine and Russia; (ii) a shock on the energy market, which has been translated into a sharp increase in energy costs which will be aggravated by the EU policy responses (e.g. EU and UK bans on Russian coal); (iii) a shock on the fertiliser market due to high energy prices, subsequently resulting in strong price increases and the reduction of fertiliser availability due to the destruction of production facilities in Ukraine.

The general 'picture' at the moment of writing of this study (April/May 2022) is also shaped by strong inflation, with double-digit short-run inflation rates already recorded in Lithuania and Estonia (estimates are around 15.6%, 14.8% respectively) and almost reached in countries like the Netherlands (according to the latest estimates the inflation rate is around 9.7%).[6] These unusual price developments will have a negative impact on consumers' purchasing power, limiting the possibilities for low-income households of accessing healthier and more expensive products. In other words, the combination of high food and energy prices is creating important dietary challenges for low-income households, who were already dealing with increasing food prices since the start of the COVID-19 pandemic.

As an outcome of this turmoil, in which logistics problems also play a role, the effects of supply disruptions have already been observed in EU retail. The lack of supply of sunflower oil in the Dutch and Belgian supermarkets is an example worth mentioning.

To cope with this challenging context, this dramatic event has required the implementation of additional policy responses to mitigate its negative consequences on top of the 'standard' policy framework targeting the agricultural markets. These policy interventions can be categorised into two broad groups: (i) policies or interventions at **macroeconomic** level with the ultimate aim to contribute to stopping the war, e.g. sanctions to individuals, trade bans, 'disconnection' from the SWIFT mechanism, etc.; and (ii) targeted policy responses to mitigate the impact on the **agri-food** market, e.g. allowing MS to 'withdraw' from their existing fallow and greening commitment. A recap of all these elements and how they are interlinked is presented in Figure 2.1.

[6] Available at: https://english.news.cn/20220401/16b5bea1a52a4172ab7350bed846af2a/c.html; and https://www.cbs.nl/en-gb/news/2022/14/inflation-rate-up-to-9-7-percent-in-march.

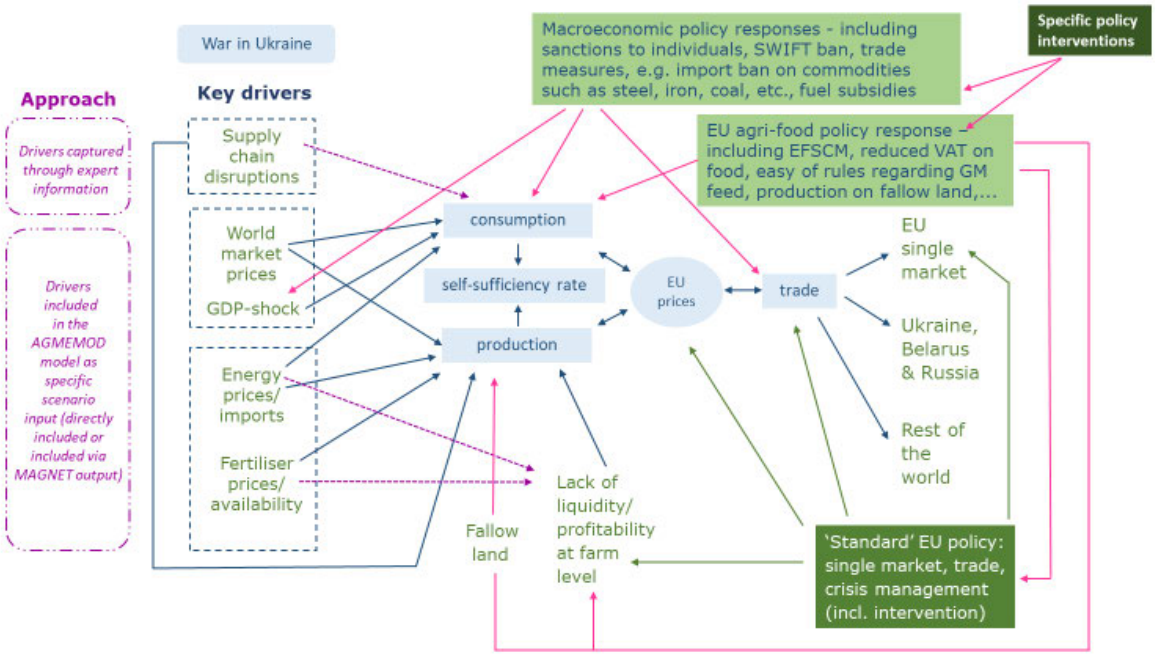

Figure 2.1 *Conceptual framework*[7]
Source: Authors.

2.3 Methodology

For assessing the impact of the Ukraine war on EU and Dutch agriculture three tools have been utilised. (i) For calculating the market impacts (volume, trade, prices) a partial equilibrium model, known as AGMEMOD, is used, which has a focus on EU agriculture and a refined presentation of EU policy measures. This model is also used for EU and Member State market outlook studies. (ii) As AGMEMOD especially focuses on primary agriculture and only to a limited extent on the processing industry, in order to cover the complete supply chain impacts a second tool, KOBALAMI, is applied, including the input- and output-related industries associated with 6 distinguished agrocomplexes[8]. This tool can calculate the impacts on value added and employment for changes in primary production outputs. Moreover, it has a cost-benefit component allowing for the calculation of the aggregated net costs for a specific period (here as a period covering the intermediate run the period 2022-2025 will be used). (iii) The third tool used was an input-output tool representing the Dutch agro-food economy in a detailed way (see remarks below).

Because related to the Ukraine war there is a strong (further) increase in energy prices it was felt that the energy aspect needed a refined treatment. Partly this was realised by refining the approach to estimate the impact of fertiliser increases on crop yields (see the appendix for more details). Partly this was done by making use of a separate input-output approach (a so-called cost-push approach) to the (aggregated) primary agricultural sectors (arable and animal husbandry) and their key related processing industries (e.g. the relating the dairy processing industry and slaughter houses to the primary animal husbandry sector). By this it was possible to provide a more specific insight into potential impacts of an energy price increase on the value added (using an fixed-output price assumption).

It should be noted that the modelling exercises, although able to capture many facts simultaneously, still provide stylised representations of reality. For example issues like market power in agricultural supply chains and the role of contractual arrangements that (re)distribute risks along the supply chains are not captured by

[7] Dotted arrows mean indirect effect or weak impact, blue arrows represent direct effects, while pink arrows indicate policy interventions.
[8] Note that in AGMEMOD beef & veal are aggregated, while in KOBALAMI a split between beef and veal is made, and the veal agrocmplex is a separate supply chain linked to the production of meat from home produced and imported calves.

the models used. This could imply that in reality the impacts for primary agriculture are potentially more negative and those for the related industries somewhat more positive than the presented simulation results (e.g. Deconinck, 2021).

More important is that the Russian-Ukrainian war and its evolution contain large uncertainties. For this study a snapshot of the situation until early April 2022 has been the basis for the assessment. Because this is a medium-term assessment some assumptions had to be made with respect to the near future developments in Ukrainian agricultural production and the recovery and (re)use of the logistic infrastructure and trade possibilities regarding the Black Sea-region (see Appendix 3), which are of course subject to considerable uncertainty.

2.4 Alternative scenarios for the medium term

The focus in this study is on the impacts of the Russian-Ukraine war on Dutch agri-food economy, taking into account the EU context and interactions (e.g. changed trade flows) between EU member states. The specified scenarios reflect this focus. An overview of the narratives that are explored in each scenario is presented below and summarised in Table 2.1.[9]

The assessment starts with a **baseline**, for which the EU Medium-term Outlook (MTO), as published in December 2021, is the basis. Whereas the EU MTO focuses on the EU aggregate and main EU regions (EU15, EUN), this paper uses a detailed Member State level outlook, which is consistent with the EU Outlook and based on AGMEMOD outlook simulations.

The **first scenario** comprises the impacts of the **Russian-Ukraine war**. It takes into account the shocks this creates to Ukrainian agricultural production for the 2022 season, trade impacts caused by the production decline as well as the destruction and restrictions imposed on the infrastructure and logistics (ports) of Ukraine as a consequence of the war. In addition, it takes into account the subsequent restrictions on trade imposed by the EU on trade with Russia and Belarus as well as the increase in energy prices as a consequence of the growing international tensions. Also the impact on the (N) fertiliser market, both in terms of prices (as a consequence of increased energy prices) and availability (Russian export ban on fertilisers,[10] and other war impacts, e.g. on production facilities in Ukraine and sanctions with respect to Belarus). These shocks have been assessed in the MAGNET-food security study, the results of which are used as an input for this scenario. From the MAGNET study impacts on world market prices due to the increased 'scarcities' resulted, as well as GDP effects, for not only the Ukraine, Russian and Belarus economies, but also for the EU. The MAGNET study also contains the more general macroeconomic impacts as a result of the Russian-Ukraine war, the boycott of Russia, and energy market disturbances on economic activities and economic growth in the EU. Scenario 1 is equivalent to Scenario 3 in the MAGNET-study (Van Meijl et al., 2022).

The **second scenario** is similar to the first scenario, but adds the impacts of the **EU and NL policy responses,** especially those targeted at the agri-food sector. As has been described these policy responses include the EU's allowance to use land that is currently part of ecological focus areas for crop production for the current season and financial support from the crises reserve to EU Member States to support farmers in severely affected sectors.[11] Member States can 'top up' this EU support with national means. Moreover, several Member States as a response lowered taxes on energy, thereby reducing the energy price increases below the level of Scenario 1. In addition, some flexibility has been introduced regarding the blending

[9] This assessment has been feasible since Ukraine and Russia are regions individually represented in the AGMEMOD model. Nevertheless, this study is not exempt from limitations which are partly related to the assumptions that were adopted regarding the evolution of the war, which has been assumed to be contained in the East of Ukraine. This study also assumes that Ukraine production capacities will be restored by 2026. Following Van Meijl et al. (2022), a 50% reduction of Ukrainian agricultural production in 2022 has been assumed. For further details on the specific assumptions with regard to the evolution of the war and recovery of Ukrainian production, the reader is referred to Appendix 3.

[10] The ban concerns potassium fertilisers but does not cover nitrogen fertilisers. For nitrogen fertilisers the relation with rising energy prices is important, while in the case of potassium fertilisers there is a direct relation to the export ban.

[11] This is only allowed in 2022. The crisis reserve payments to Member States have not been explicitly modelled in Scenario 2. The main reason for that has been the lack of information about the sectors/farmers on which these means have been spent. Note that these payments are likely to have a 'decoupled' character, creating an impact on short-run farm incomes but hardly on primary agricultural production (see, also, Jansens et al., 2021).

proportion of biofuels, permitting MS to reduce the contribution of biofuels. In short, lower energy prices help to accommodate cost increases for farms and firms and may reduce the indirect energy price impact on yields in Scenario 2 relative to Scenario 1.

The **third scenario** is similar to the second scenario, but it adds the direct and indirect impact of increased energy prices on agricultural markets worldwide. The increased energy and fertiliser prices are expected to be important in the sense that they will lead to adjustments in agricultural production (decline) and food consumption (decline) also in other regions of the world, where this will lead to rising scarcity and an additional increase in the world market prices relative to those that are already considered in the previous scenarios. These additional world market price increases will in turn affect EU and Dutch agriculture.

Table 2.1 *Scenarios at a glance*

Storyline/drivers	**Baseline**	**Scenario 1 – The war in Ukraine**	**Scenario 2 – EU policy responses**	**Scenario 3 – Further energy and fertiliser price impacts**
Storyline	AGMEMOD outlook as available in January 2022	Simulation of the direct impacts of the Russian invasion of Ukraine	Assessment of the effectiveness of the policy responses implemented to mitigate the consequences of the war	The impacts on the oil, gas and fertiliser markets and their indirect impact on agricultural production in the rest of the world are taken into account
Scenario drivers				
World Market prices	Outlook 2021-31	Endogenously calculated	Endogenously calculated	MAGNET study; scenario 3
GDP shocks	Outlook 2021-31	Derived from MAGNET	As in Scenario 1	MAGNET study; scenario 3
Energy prices	Outlook 2021-31	Derived from MAGNET	Exogenously calculated taking into account policy responses	MAGNET study; scenario 3
Fertiliser prices	Outlook 2021-31	Exogenously calculated and assessed outside AGMEMOD	Exogenously calculated taking into account policy responses	MAGNET study; scenario 3
Fertiliser availability/yield impacts	Outlook 2021-31	Exogenously calculated to derive AGMEMOD input	Exogenously calculated to derive AGMEMOD input taking	Exogenously calculated to derive AGMEMOD input taking
Use of fallow land	Outlook 2021-31	Not included	Included – fallow land brought into production in 2022	Included – fallow land brought into production in 2022

Source: Authors.

2.5 Further considerations

Before moving onto the discussion of the specific scenario outcomes, some remarks regarding the assumptions adopted in the study are due. More specifically, an important input for this study is what happens to world market prices and GDP or economic growth. As regards world market prices, prices have increased as a consequence of the war. But as Figure 2.1 shows, prices were already increasing since 2020. There are several reasons for these developments. Aside of the Ukraine war and the potential loss of Ukrainian exports and trade tensions with Russia and Belarus, already since late 2020 there has an increased global demand, led by China and also contributed to by other economies that started to gradually recover from the COVID-19 pandemic; drought-reduced supplies in some regions, recently including the MENA countries; tightening wheat, corn, and soybean stocks in major exporting countries; high energy prices pushing up the costs of fertiliser, transportation, and agricultural production; and countries imposing export bans and restrictions, further tightening supplies (USDA, 2022). Whereas Figure 2.2 focuses on crop prices,

the 'Other food' price should capture the impact on animal products, be it in an aggregated way. When focusing on short-run price statistics, e.g. annual prices, animal product prices seem to react less strongly and/or with a delay to the increases of crop prices.

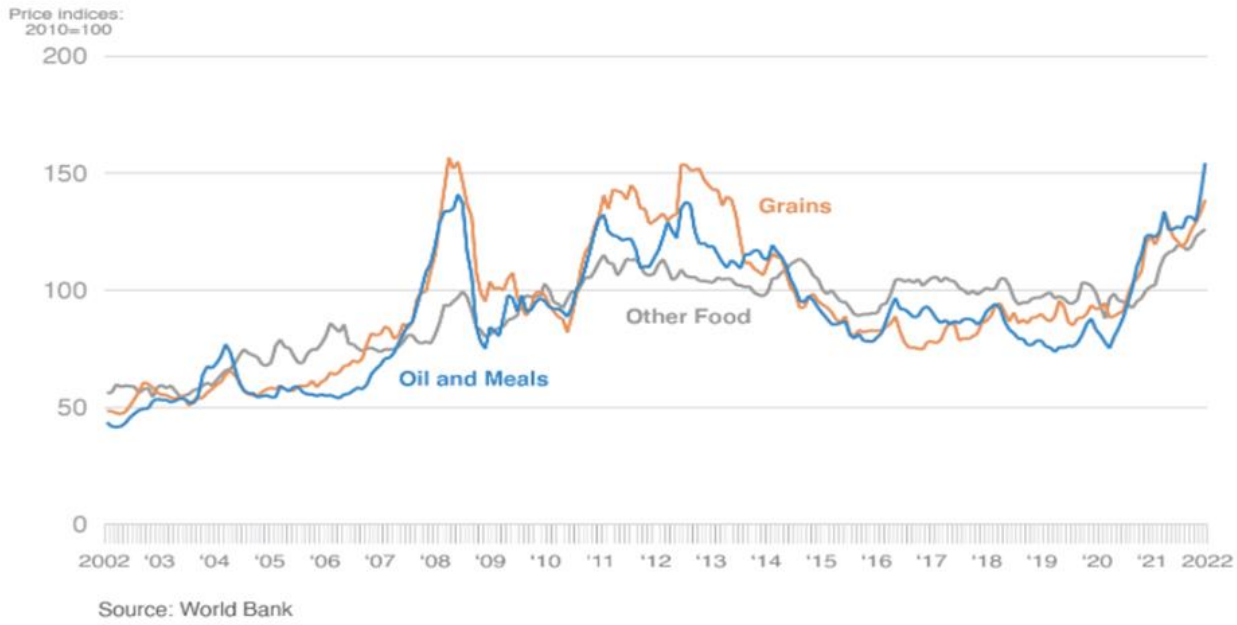

Figure 2.2 *World market price changes for grains, oils and meals and other food (indexes 2010=100) Source: Reproduced from World Bank.*

In this study, the focus is on the impact of the Ukraine war on Dutch agriculture, given the expected impacts on world market prices for agricultural products, agricultural inputs (e.g. fertiliser), energy and GDP-impacts. Our focus is on the medium run, for which the period 2022-2025 is chosen (4 years). As was indicated before, world market prices are endogenously calculated by the AGMEMOD model for Scenarios 1 and 2. For Scenario 3, world market price information from the MAGNET-model study has been used, after appropriate adjustments. The MAGNET model includes all world regions and as a CGE-model has a detailed representation of energy (and derived products) and its impacts on the macro-economy, as well as worldwide agriculture (Van Meijl et al., 2022). For further details on the GDP impacts, underlying this study, the reader is referred to Van Meijl et al. (2022), since the GDP shocks of the war in Ukraine are based on the MAGNET study and taken as exogenous input for the model assessment performed in this study. GDP shocks on EU Member States are negative, but small (in general less than 1%) at their maximum impact level and even substantially smaller when taking into account the recovery pathway assumed in this study.[12]

[12] In the case of Russia, a 10% decline in GDP was considered for the MAGNET study. For Ukraine, a 30% GDP reduction was assumed (2-year average impact). For the EU, small negative GDP impacts from Van Meijl et al. (2022) for all EU Member States have been included in the scenarios.

3 Assessing the potential impacts of the war in Ukraine for Dutch agri-business

3.1 Introduction

For a better understanding of the economic impacts of Russia's invasion of Ukraine on the Dutch agri-food sector, this chapter elaborates the outcomes of the scenario simulations carried out by means of AGMEMOD and KOBALAMI. More specifically, Section 3.2 explores the potential consequences of the war by means of a scenario in which no policy responses are implemented. Then, Section 3.3 presents the outcomes of a scenario including several policy responses to mitigate the negative consequences of this event. Finally, in Section 3.4, the forward-looking insights provided earlier in this chapter are supplemented with further discussion and additional insights from relevant market experts.

3.2 Scenario 1 – The war in Ukraine

To begin with, Figure 3.1 provides an overview of the impacts of the war in Ukraine on world market prices for specific commodities as endogenously calculated by AGMEMOD. The largest price increases have been registered for 2022 in the case of cereals, with prices above the 'pre-war' level being also expected for the coming years. For beef a small net price decline is projected, which is due to a relative decline in world demand for beef as a response the decline in income. The 'recovery' process of prices is mostly driven by the fact that land use reduction in Ukraine is gradually reversed over the period under consideration.

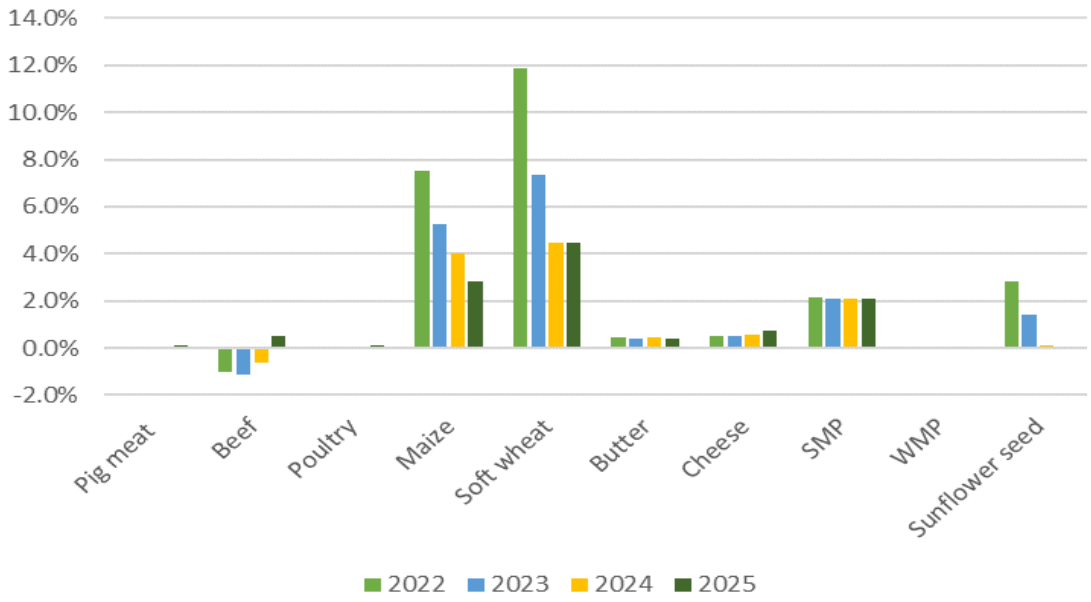

Figure 3.1 *Impacts on world market prices (changes compared to Baseline, %)*
Source: AGMEMOD calculations.

As has been observed in the market, due to the war feed prices have substantially increased, with particularly significant increases in the case of the energy rich feeds (containing a relative high share of cereal products). More specifically, this has a negative impact on egg production, a sector in which feed costs represent about 65% of the per unit cost of production. An additional factor is the contractual arrangements made with the retail sector, which limit or delay the alignment of egg prices to the increased cost of

production and then cause (temporal) margin squeezing.[13] The case of broiler production differs from this in that at least in the short run the revenues have been observed to increase more than the feed costs (Agrimatie, 2022). The increased profitability is a factor supporting broiler meat supply rather than curtailing it. According to our simulation supply increases by 1.4% could be expected in 2023 in Scenario 1.

Focusing on the period 2021-25, Table 3.1 reports on the impacts on primary production of Dutch agriculture, as well as the cumulative impact over the mentioned 5-year period. For dairy only a negligible impact is expected on Dutch milk production. A reason for this is that in the Netherlands a phosphate quota system has been in place since 2018, which effectively constrains the dairy cow herd. Moreover, given the policy uncertainty prevailing in the Netherlands, farmers have an incentive not to further reduce their dairy herd below what the phosphate quota system is allowing them to produce. This implies that changes in milk production should then mainly come from adjustments in yields. But under the prevailing price incentives there is according to the model projection hardly any incentive to reduce the milk yields.[14] The milk supply projection is in line with the recent Short Term Outlook, which also indicates a flat milk supply for 2022. With respect to the meats, some slightly negative impacts on production are expected for pork and poultry meat. This is mainly driven by the increase in feed costs to which especially intensive livestock productions are sensitive, as the feed costs are representing a relatively high share of the per unit production costs and as the margins are small, feed costs changes also impact profitability. For beef and veal a potential small production increase is expected, which is driven by the increased worldwide 'scarcity' in beef (e.g. recent declines in US cow herds)[15] and the induced relative beef price increase related to that. Moreover, as in the Netherlands beef and veal are mainly driven by dairy production rather than being the result of specialised beef production, and these activities rely to a substantial extent on roughage input (grass, silage) rather than purchased feed, its profitability relative to other meats is increasing. Finally, also the increase in import of live animals (calves) adds to beef and veal production.

As regards the arable crops, overall a limited decline in production is expected, which is driven by two factors. First, the increase in costs (especially fertiliser and fossil fuel costs) which is expected to induce a more frugal use of these inputs, which is likely to have a small negative impact on yields (see also Appendix 2), especially for those crops that heavily rely on such inputs (e.g. potatoes more than cereals). A second factor is the adjustment in land use (crop mix as well as the competition for land for feed by the land-based animal sectors (e.g. silage maize use by the dairy sector). When looking at individual crop level, the AGMEMOD results suggest declines in potato and sugar beet production in 2022 (by -1.5% and -0.06% respectively). In the case of potatoes, these dynamics are reflecting marginal changes in the cultivated area (around 0.007% in 2022 and -0.04% in 2023) and lower yields (-1.5% in 2022 and -1% in 2023) compared to the baseline case. Focusing on the expected developments for sugar beet in 2022, yield declines of around -0.14% could occur, while the relevant cultivated area could increase by 0.07%. For soft wheat, the simulation indicates declines in acreage and yields in 2022 (around -0.3% and -1% respectively). Compared to the baseline, the AGMEMOD results also indicate a potential expansion of the cultivated areas for barley, with expected increases of 1.2% and 1.5% in 2022 and 2023 respectively. In the case of maize, the relevant scenario-baseline comparison also indicates an increase of around 0.09% in 2023. Overall, we expect that over time the initial market shock will 'fade out' as a result of the gradual restoration of the prevailing 'pre-war' conditions, i.e. lower energy and fertiliser prices, as well as increased fertiliser availability which will lead to higher yields.

[13] The model used is not able to take such contractual issues directly into account, although it may be partly captured by lags included in it price transmission equations.

[14] A small negative impact on milk yield of 0.01% or 1,430 tonnes of raw milk at national level has been identified relative to the baseline, with the differences between the scenarios being even smaller.

[15] Note that in AGMEMOD beef and veal meats are lumped together, whereas in the KOBALAMI tool veal is treated as a separate agrocomplex.

Table 3.1 *Impacts on primary production (% difference relative to baseline)*

Sector	2021	2022	2023	2024	2025	Cumulative impact
Dairy	0.000	0.000	0.000	0.000	0.000	0.000
Pig meat	0.000	-0.440	-0.171	-0.016	-0.080	-0.706
Poultry meat[16]	0.001	-0.922	-0.506	-0.276	-0.268	-1.971
Beef & veal	0.000	0.753	0.902	0.902	0.235	2.792
Arable crops	0.000	-0.855	-0.705	-0.460	-0.206	-2.226

Source: AGMEMOD calculations.

When interpreting the results presented in Table 3.1, the reader should keep in mind that the changes reported above are smaller than what can be considered as 'normal' market fluctuations. However, these impacts are purely reflecting the 'knock-on' effects that the war in Ukraine has on Dutch agriculture.[17]

As usual, the effects on primary production spread over the entire supply chain, affecting the related upstream and downstream industries. For the assessment of these impacts, the outcomes of the KOBALAMI model are reported in Table 3.2. Note that the impacts on related industries largely follow the impact on the volumes of primary production as were described above. Both are relatively small. An exception is veal, where the supply chain is expected to be negatively affected, mainly as a result of an expected induced decline in imports of calves.

Table 3.2 *Supply chain impacts - value added (% difference relative to baseline)*

Sector	2021	2022	2023	2024	2025
Dairy	0.000	0.000	0.000	0.000	0.000
Pigs	0.000	-0.015	-0.122	-0.445	-0.899
Poultry (incl. eggs)	0.000	-0.865	-0.728	-0.699	-0.545
Veal	0.000	-0.261	-0.505	-0.690	-0.608
Arable crops	0.000	-0.855	-0.705	-0.460	-0.206

Source: KOBALAMI calculations.

Looking at the entire agri-food complex, Figure 3.2 provides an overview of the aggregated unemployment effects in the Netherlands (over all sectors and supply chains) for the period under consideration. Due to the declines in turnover in the supply chains, be it that these are small in percentage terms, less labour is needed. Despite the reemployment of some workers, the medium-term employment loss could reach 1,250 full-time equivalents (about 0.2%) by 2025, whereas the short-run impacts could be more than double (conditional on the assumption of no specific strategic labour force policies of agri-business firms).

[16] This indicator only focuses on poultry meat as defined as an individual sector in the AGMEMOD model. Therefore, the impacts on egg production are not included in this table.

[17] The advantage of the use of a model assessment is that it allows the researchers to 'isolate' the specific impact of the Ukraine war from other impacts, which simultaneously may play a role. Here no account has been taken for weather variation, but rather a normalised or average weather pattern has been assumed, both for the baseline as well as the other scenarios. In reality, of course, weather variation always plays a role. And the results suggest that when there is a drought this could easily overrule the 'pure impact' of the Ukranian war.

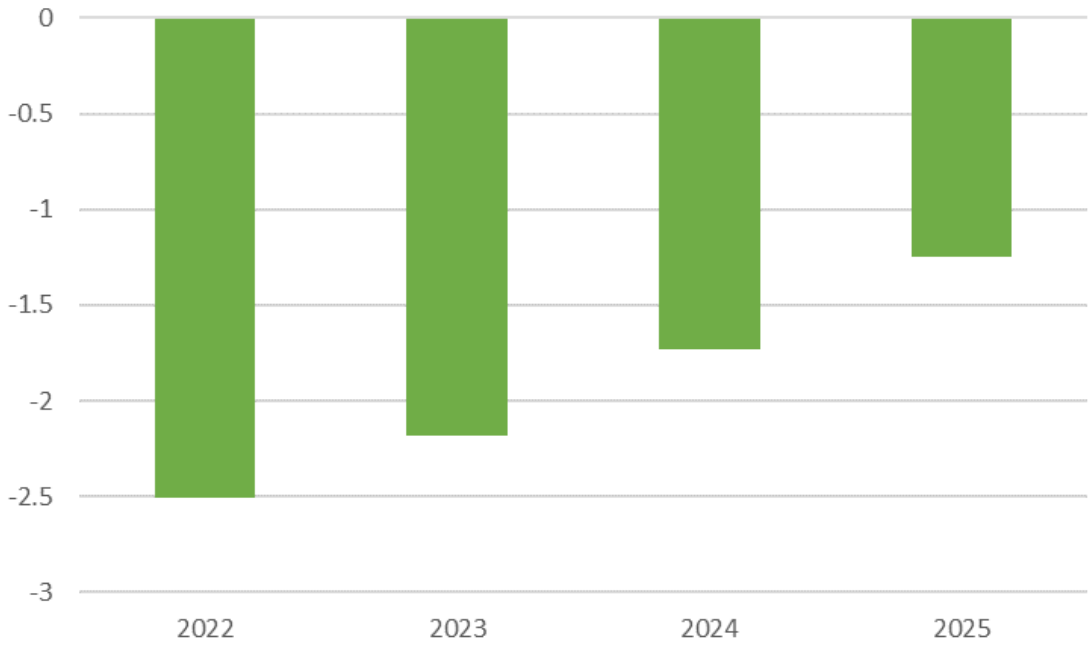

Figure 3.2 *Employment effects (1,000 jobs, absolute difference relative to baseline)*
Source: KOBALAMI calculations.

Table 3.3 provides net cost estimates for the different stages of the supply chain of the five selected agrocomplexes (with the total agricultural complex contributing to around 7% of the total value added generated in the Dutch economy in 2019).[18] The largest impacts are found for the arable sector, with a total (accumulated) loss of nearly 570 million euros (net present value (NPV), assuming a 2.5% discount rate) over the whole period 2022-2025. This total accumulated loss of the arable sector (primary and related industries) is equivalent to around -0.27% of the expected total average value added generated by the agrocomplex during the same period. The agrocomplex least impacted is the dairy sector. Except for the arable sector, the negative impact on value added turns out to be the highest for the related industries, with more modest impacts experienced in primary agricultural production (see also Jongeneel et al., 2021). This result is related to the structure of most agrocomplexes, where the share of the upstream and downstream industries in the total value added generated is substantially larger than the value added-share of primary agricultural production (Bergevoet et al., 2021). The stronger impacts on the related industries are a combination of both high energy costs as well as lower (and more expensive) input supply. The aggregated impact on the five assessed sectors in the period 2022-2024 is about 700 million euros (or 183 million euros per annum).

Table 3.3 *Annual average costs and NPV calculations (changes relative to baseline)*

Average cost 2022-25 (million euros)	**Dairy**	**Pigs**	**Poultry (incl. eggs)**	**Veal**	**Arable crops**
Primary production	0.000	-2.201	-1.850	-0.796	-6.867
Related industries	0.000	-12.186	-10.464	-8.240	-141.372
NPV (million euros)	**Dairy**	**Pigs**	**Poultry (incl. eggs)**	**Veal**	**Arable crops**
Primary production	0.000	-8.144	-7.027	-2.995	-26.274
Related industries	0.000	-45.094	-39.754	-30.986	-540.930

Note(s): Negative impacts indicate value added losses. 'Related industries' accounts for all related processing industries, including: processing foreign agricultural products, processing industry, input suppliers and distribution.
Source: KOBALAMI calculations.

[18] In this particular context, costs are measured as 'value added' losses.

Moving to the consumption side, Figure 3.3 reports annual per capita consumption values for 2022 by type of product. As shown below, no significant impacts are expected since in general terms income elasticities are low and the GDP shocks are small. Moreover, the impact of the increased agricultural commodity prices on final consumer prices is likely to be limited as for most products the ingredient costs from primary agricultural production are limited. However, the increases in costs along the supply chain (energy, labour) are likely to generate increasing food prices, thereby adding to inflation. The inflationary impact may have been underestimated in the current assessment since the AGMEMOD modelling tool, being a partial equilibrium rather than a general equilibrium model, is not well-suited to capture such impacts.

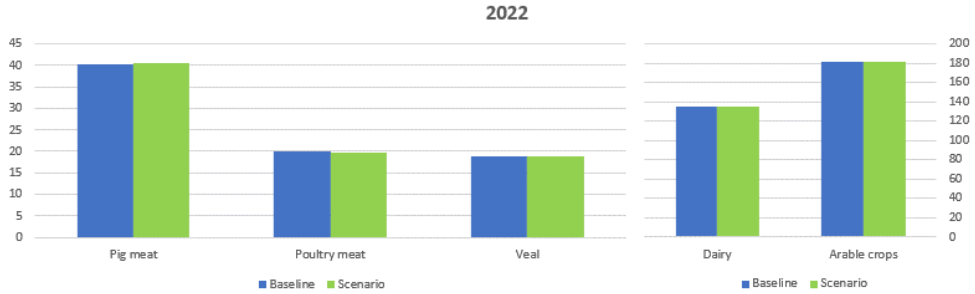

Figure 3.3 *(Apparent) Consumption per capita (kg/head)*
Source: AGMEMOD calculations.

Finally, Table 3.4 shows the impacts on Dutch net trade and self-sufficiency rates (SSR) for the different agricultural sectors. As regards net trade impacts, these are in percentage terms stronger than the earlier noted impacts on domestic production and per capita food use, although they are still relatively limited. Regarding the self-sufficiency degree, only small expected negative changes are estimated (beef and veal, and arable products being exceptions), which indicates the food security situation, viz. food availability in the Netherlands is not at stake. Here the Netherlands has a favourable position relative to countries outside the EU, e.g. the MENA countries (see Van Meijl et al., 2022).

Table 3.4 *Net trade and self-sufficiency rate (% difference relative to baseline)*

		2021	2022	2023	2024	2025
Dairy	Net trade	0.000	-0.004	-0.040	-0.085	-0.109
	SSR	0.000	-0.290	-0.600	-0.826	-0.629
Pig meat	Net trade	0.000	-2.081	-1.603	-1.402	-0.651
	SSR	0.000	-1.318	-1.204	-1.198	-0.502
Poultry meat	Net trade	0.001	-1.359	0.228	0.665	0.740
	SSR	0.001	-0.922	1.555	1.967	2.047
Beef & veal	Net trade	0.000	3.040	3.640	3.684	0.976
	SSR	0.000	0.741	0.893	0.914	0.244
Arable crops	Net trade	0.000	0.381	0.216	0.014	0.312
	SSR	0.000	-1.162	-0.724	-0.291	-0.273

Source: AGMEMOD calculations.

3.3 Scenario 2 – EU policy responses

Price impacts at world market level in the case of Scenario 2 are presented in Figure 3.4. As in Scenario 1, the largest price increases are expected for cereals. For example, looking at 2022, soft wheat prices are simulated to be around 10% above the baseline levels. The calculated world market price responses as a result of the additional land taken into production in the EU in most cases only marginally differ from the

ones presented for Scenario 1 (cf. Figure 3.1). However, for soft wheat the 2022 world price is just over 10% in this scenario, while in Scenario 1 the world price increase was almost 12%. For maize there is about a 0.5 percentage point lower world price then in case of Scenario 1.

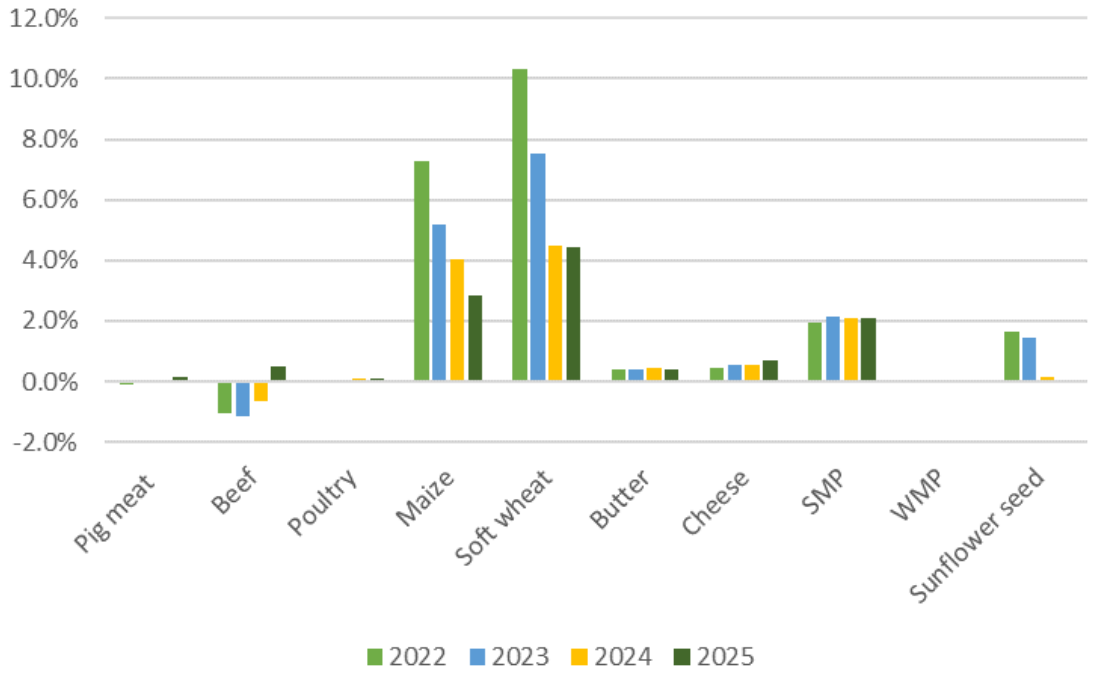

Figure 3.4 *Impacts on world market prices (changes compared to Baseline, %)*
Source: AGMEMOD calculations.

Table 3.5 provides an overview of the impacts on Dutch primary agricultural production, as well as the cumulative impact over the period 2021-25. As Table 3.5 shows, the impacts of Scenario 2 are slightly less negative than in Scenario 1. The key difference between Scenarios 1 and 2 is that Scenario 2 allows for a temporary use of fallow land. As a result about 2.7% additional land comes into production in the EU as a whole (but not in the Netherlands as the Netherlands is one of the few EU Member States that did not participate in the fallow-land reuse crisis-measure). The additional land leads to a small increase in EU agricultural production, thereby slightly increasing the domestic availability of feed in the EU, and contributes to a slight decline in the purchased feed bill) of livestock farmers and an increase in arable crop production, sales and income for crop farmers.

Table 3.5 *Impacts on primary production in the Netherlands (% difference relative to baseline)*

Sector	2021	2022	2023	2024	2025	Cumulative impact
Dairy	0.000	0.000	0.000	0.000	0.000	0.000
Pig meat	0.000	-0.380	-0.190	-0.015	-0.081	-0.666
Poultry meat[19]	0.000	-0.785	-0.515	-0.281	-0.266	-1.847
Beef & veal	0.000	0.758	0.902	0.909	0.237	2.805
Arable crops	0.000	-0.856	-0.687	-0.450	-0.200	-2.193

Source: AGMEMOD calculations.

The impact of the changes of primary production with respect to the remaining components of the supply chain, i.e. upstream and downstream industries are shown in Table 3.6. As they are almost similar to the

[19] This indicator only focuses on poultry meat as defined as an individual sector in the AGMEMOD model. Therefore, the impacts on egg production are not included in this table.

ones found in Scenario 1, the explanation provided for Scenario 1 still holds for this scenario and is not repeated.

Table 3.6 *Supply chain impacts in the Netherlands - value added (% difference relative to baseline)*

Sector	2021	2022	2023	2024	2025
Dairy	0.000	0.000	0.000	0.000	0.000
Pigs	0.000	-0.018	-0.129	-0.456	-0.915
Poultry (incl. eggs)	0.000	-0.780	-0.733	-0.702	-0.544
Veal	0.000	-0.262	-0.505	-0.692	-0.610
Arable crops	0.000	-0.856	-0.687	-0.450	-0.200

Source: KOBALAMI calculations.

Figure 3.5 reports on the aggregated unemployment effects (over all sectors and supply chains) for the period 2021-2025. The overall employment impact is negative and could reach a loss of almost 1,300 job places by 2025 (about 0.2%), with substantial larger short-run impacts (i.e. almost 2,500 job places could be lost in the course of 2022).

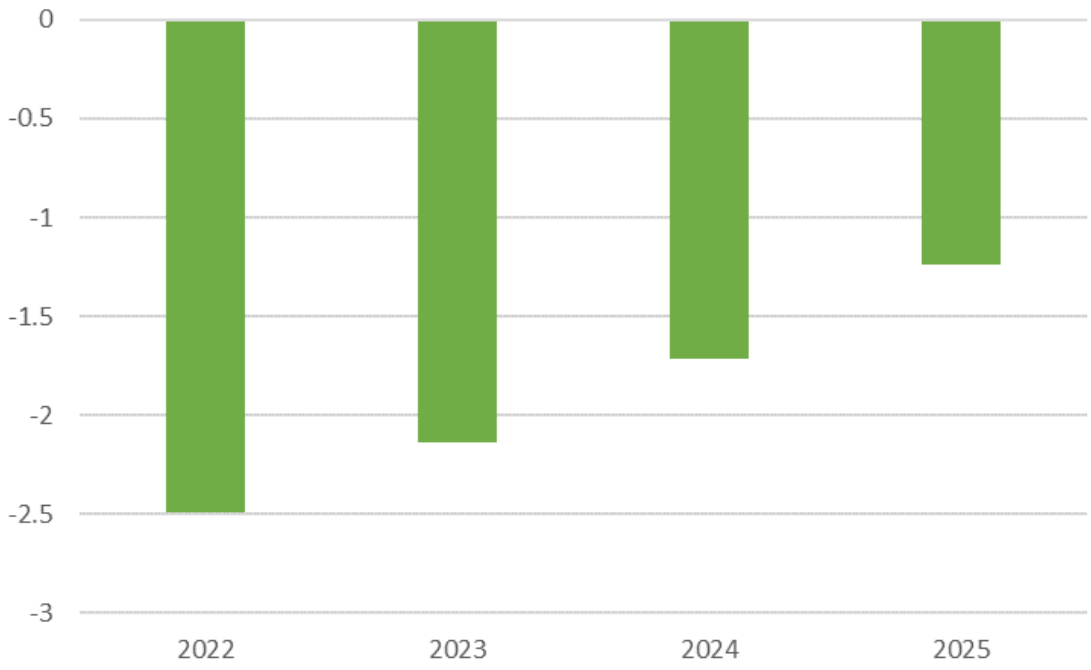

Figure 3.5 *Employment effects (1,000 jobs, absolute difference relative to baseline)*
Source: KOBALAMI calculations.

Table 3.7 provides costs estimates, similar to those provided in Table 3.3 presented in Section 3.2. Similarly as in the case of Scenario 1, the total accumulated loss for primary production is equivalent to -0.02% of the expected total average value added that could be generated by the agrocomplex during the period 2022-2025. When jointly considering primary production and related industries, the total accumulated loss is equivalent to -0.32%. The aggregated impact on the five assessed sectors in the period 2022-2024 is about 693 million euro (or about 180 million euros per annum).

Table 3.7 *Annual average costs and NPV calculations (changes relative to baseline)*

Average cost 2022-25 (million euros)	Dairy	Pigs	Poultry (incl. eggs)	Veal	Arable crops
Primary production	0.000	-2.255	-1.799	-0.798	-6.765
Related industries	0.000	-12.488	-10.179	-8.260	-139.272
NPV (million euros)	**Dairy**	**Pigs**	**Poultry (incl. eggs)**	**Veal**	**Arable crops**
Primary production	0.000	-8.347	-6.829	-3.002	-25.890
Related industries	0.000	-46.221	-38.635	-31.059	-533.022

Source: KOBALAMI calculations.

Note(s): Negative impacts indicate value added losses.

Figure 3.6 shows the annual per capita consumption values for 2022 by type of product. As in the case of Scenario 1, no significant impacts are expected which is explained by low income elasticities.

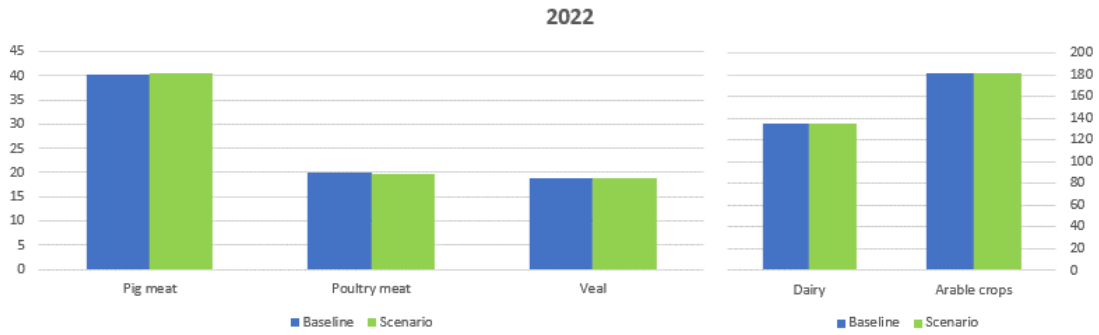

Figure 3.6 *(Apparent) Consumption per capita (kg/head)*
Source: AGMEMOD calculations.

Moving on to the trade effects, Table 3.8 presents the impacts on Dutch net trade and self-sufficiency rates for the different agricultural sectors. When interpreting these changes, the reader should be aware that the Netherlands is self-sufficient for dairy commodities and meat products, while its self-sufficiency is around 37% in the case of arable crops. The overall picture is similar to the one presented in the case of Scenario 1, the negative trade balance in the case of poultry is slightly larger in Scenario 2.

Table 3.8 *Net trade and self-sufficiency rate (% difference relative to baseline)*

		2021	2022	2023	2024	2025
Dairy	Net trade	0.000	-0.005	-0.040	-0.085	-0.109
	SSR	0.000	-0.304	-0.595	-0.826	-0.629
Pig meat	Net trade	0.000	-1.950	-1.646	-1.402	-0.653
	SSR	0.000	-1.261	-1.225	-1.198	-0.502
Poultry meat	Net trade	0.000	-1.158	0.216	0.659	0.743
	SSR	0.000	-0.785	1.549	1.962	2.049
Beef & veal	Net trade	0.000	3.059	3.640	3.712	0.985
	SSR	0.000	0.745	0.893	0.921	0.246
Arable crops	Net trade	0.000	0.455	0.220	0.007	0.314
	SSR	0.000	-1.211	-0.732	-0.289	-0.275

Source: AGMEMOD calculations.

3.4 Scenario 3 – Further energy and fertiliser price impacts

Scenario 3 follows a recent study assessing the macroeconomic, world market price and food security impacts of the Ukraine war (Van Meijl et al., 2022), which suggests a structural increase of energy prices of about 20%. However, the authors indicate that their estimate is subject to significant uncertainties. An overview of the price impacts used in this study, as these are based on the study of Van Meijl, with added assumptions on the recovery pathway, is presented in Figure 3.7, this set of price changes is used as input for the AGMEMOD simulation.

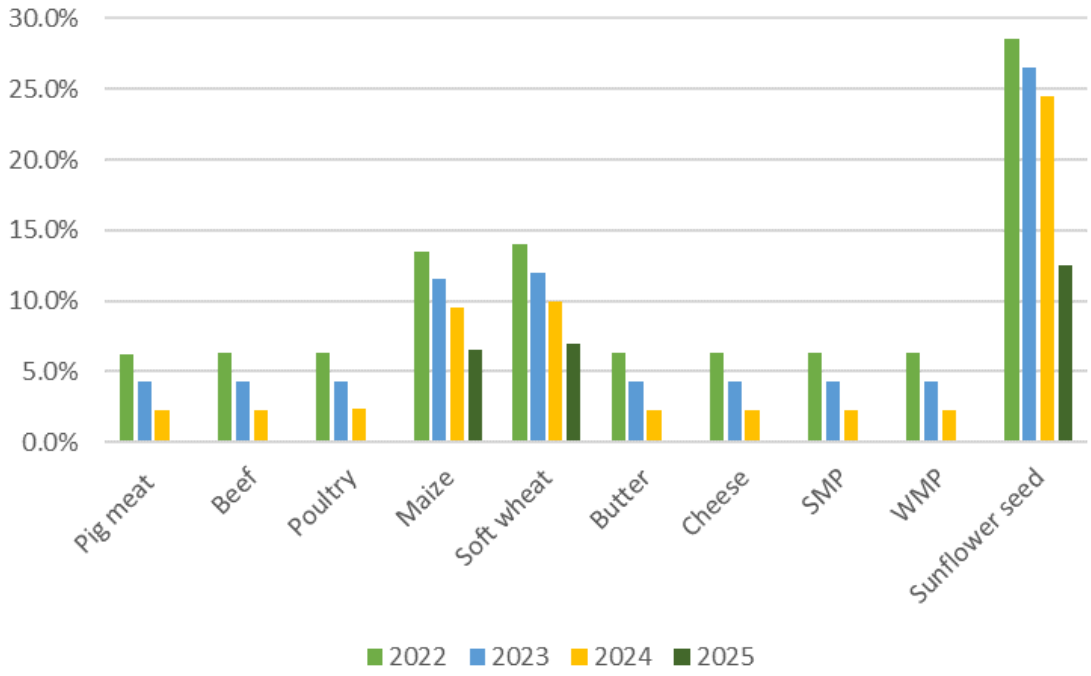

Figure 3.7 *Impacts on world market prices (changes compared to Baseline, %)*
Source: Van Meijl et al. (2022) with the dynamic structure and oilseed crop disaggregation added by the authors.

Tables 3.9 and 3.10 indicate the impacts on the volume of Dutch primary agricultural production and related industries. Relative to Scenario 1, this scenario suggests less negative impacts for the pig sector, while stronger declines for poultry (related to stronger feed price increase). As indicated for Scenarios 1 and 2, Scenario 3 also suggests a potential increase in beef production.

Table 3.9 *Impacts on primary production (% difference relative to baseline)*

Sector	2021	2022	2023	2024	2025	Cumulative impact
Dairy	0.000	0.000	0.000	0.000	0.000	0.000
Pig meat	0.000	-0.406	-0.198	0.004	0.059	-0.541
Poultry meat[20]	0.000	-1.159	-0.690	-0.404	-0.184	-2.436
Beef & veal	0.000	0.114	0.517	0.796	0.417	1.844
Arable crops	0.000	-0.068	-0.011	0.030	-0.013	-0.063

Source: AGMEMOD calculations.

[20] This indicator only focuses on poultry meat as defined as an individual sector in the AGMEMOD model. Therefore, the impacts on egg production are not included in this table.

Table 3.10 *Supply chain impacts - value added (% difference relative to baseline)*

Sector	2021	2022	2023	2024	2025
Dairy	0.000	0.000	0.000	0.000	0.000
Pigs	0.000	0.101	0.203	0.105	-0.171
Poultry (incl. eggs)	0.000	-1.018	-0.830	-0.757	-0.470
Veal	0.000	-0.090	-0.300	-0.543	-0.573
Arable crops	0.000	-0.068	-0.011	0.030	-0.013

Source: KOBALAMI calculations.

Focusing on the impacts on the labour market, Figure 3.8 presents an overview of the aggregated unemployment effects (over all sectors and supply chains) for the period 2022-2025. The overall or cumulative employment loss could be equivalent to around 350 jobs in 2025 (about 0.05%).

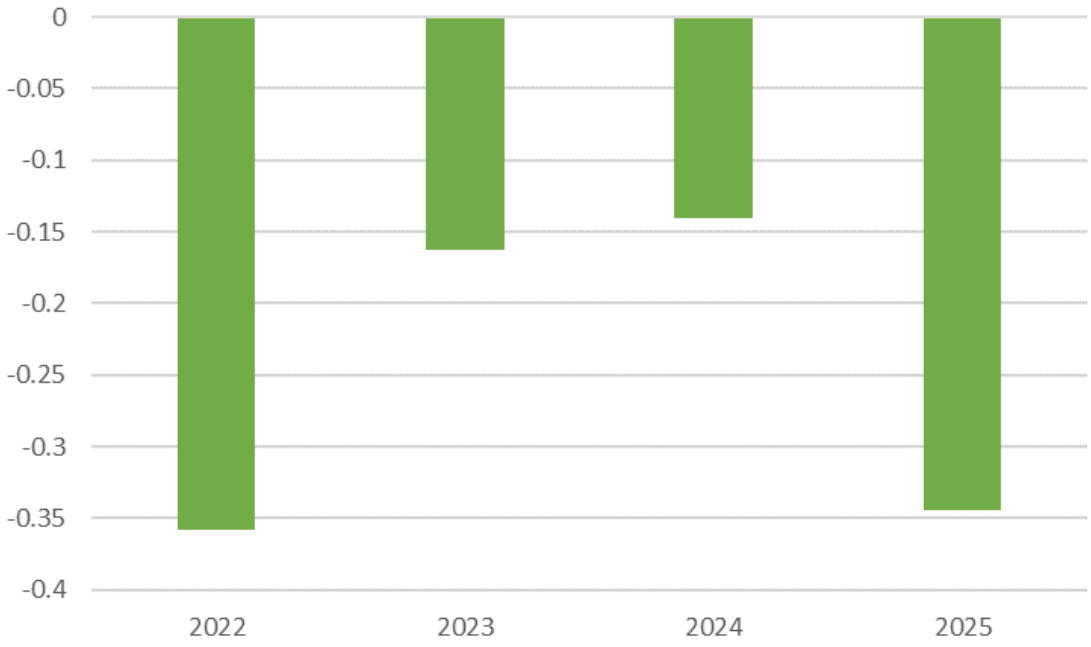

Figure 3.8 *Employment effects (1,000 jobs, absolute difference relative to baseline)*
Source: KOBALAMI calculations.

Table 3.11 gives an overview of the net cost estimates (as measured in terms of value added losses) for the different stages of the supply chain of the selected five agrocomplexes. The largest impacts are found in the case of poultry, while in Scenarios 1 and 2 the largest impacts in absolute terms occurred for the arable sector (equivalent to -0.27% and -0.26% of the total value added for the sector in Scenarios 1 and 2 respectively). In this case, the expected total acumulated loss is equivalent to -0.034% of the expected total average value added that could be generated by all the agrocomplexes during the period 2022-2025 in the baseline case. Note that this scenario takes the impacts of a 20% structural increase in energy costs on agricultural production and consumption worldwide into account, which leads to a different impact on world market prices (higher world market prices relative to those obtained under Scenarios 1 and 2). As the relative world market prices for agricultural commodities also increase, the revenues for farmers, especially the position of the arable farmers, in this scenario improves relative to Scenarios 1 and 2. The aggregated impact on the five assessed sectors in the period 2022-2024 for Scenario 3, including the 20% energy price increase direct cost impact (see a further explanation below in Table 3.12) is about 510 million euros (or about 190 million euros lower than in Scenario 1).

Table 3.11 *Annual average costs and NPV calculations (changes relative to baseline)*

Average cost 2022-25 (million euros)	Dairy	Pigs	Poultry (incl. eggs)	Veal	Arable crops
Primary production	0.000	0.358	-2.004	-0.580	-0.193
Related industries	0.000	1.981	-11.337	-5.997	-3.978
NPV (million euros)	**Dairy**	**Pigs**	**Poultry (incl. eggs)**	**Veal**	**Arable crops**
Primary production	0.000	1.411	-7.631	-2.166	-0.758
Related industries	0.000	7.812	-43.171	-22.416	-15.612

Source: KOBALAMI calculations.

Note(s): Negative impacts indicate value added losses.

As regards the role of a 20% increase in energy costs, additional calculations have been made to provide some further insights into the role of energy costs in the total costs of production and its potential impact on the added value of primary agriculture and its related industries (Table 3.12). The total potential impact is estimated to be an annual loss of about 36 million euros for primary agriculture and almost 77 million euros for its related processing industries. For all five sectors considered, the aggregate costs of this increase are about 110 million euros per annum (or nearly 430 million euros for the period 2022-2024). Note that in this scenario the simulated increase in energy costs is mitigated by increases in world market prices, which lower the value added loss as a result of farm output and input prices (excluding direct energy costs) (see Table 3.11 above).

Table 3.12 *The indicative impact of a 20% energy price increase on the value added of primary agriculture and its related industries*

	Share of energy bill in total costs (incl. labour costs)	Change in value added due to 20% energy price increase (million euros)	% Change of value added
		Primary agriculture	
Arable sector	2.923%	-6.6	-0.594%
Animal sector	1.436%	-29.6	-1.436%
Total		-36.2	
		Related processing industries	
Arable sector	1.007%	-47.0	-0.704%
Animal sector	0.740%	-29.4	-0.661%
Total		-76.4	

Source: Own simulations with an input-output model while assuming that the cost increase cannot be passed on to downstream sectors.

Figure 3.9 displays the annual per capita consumption values for 2022 by type of product, with marginal changes expected for 2022.

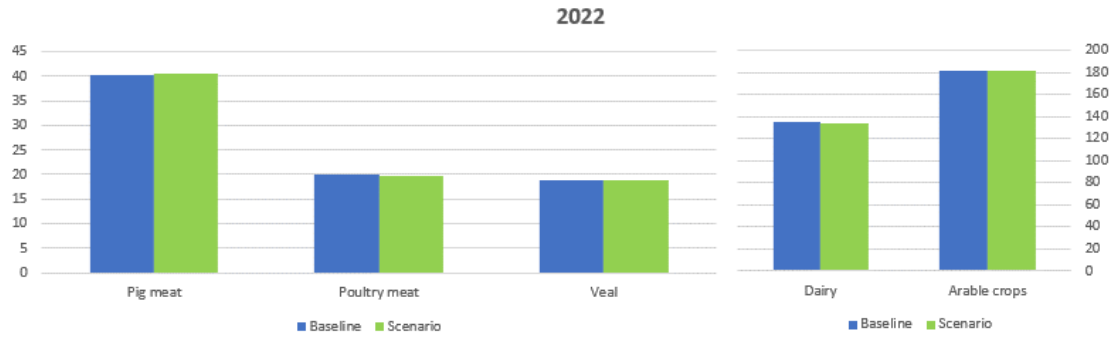

Figure 3.9 *(Apparent) Consumption per capita (Kg/head)*
Source: AGMEMOD calculations.

Finally, Table 3.13 summarises the impacts on net trade and self-sufficiency rates for the different agricultural sectors. As shown in the table, overall the largest changes are expected in the case of poultry and veal, although focusing on 2022 the most affected livestock sector from a trade perspective seems to be pig meat.

Table 3.13 *Net trade and self-sufficiency rate (% difference relative to baseline)*

		2021	2022	2023	2024	2025
Dairy	Net trade	0.000	0.072	0.049	-0.004	-0.056
	SSR	0.000	-0.030	-0.449	-0.828	-0.726
Pig meat	Net trade	0.000	-1.847	-1.575	-1.336	-0.380
	SSR	0.000	-1.159	-1.158	-1.158	-0.386
Poultry meat	Net trade	0.000	-1.709	-0.125	0.590	1.097
	SSR	0.000	-1.159	1.193	2.081	2.615
Beef & veal	Net trade	0.000	0.457	2.073	3.227	1.641
	SSR	0.000	0.111	0.508	0.799	0.402
Arable crops	Net trade	0.000	0.094	-0.496	-0.932	-0.637
	SSR	0.000	-1.062	-0.311	0.292	0.346

Source: AGMEMOD calculations.

3.5 Discussion of results

When comparing the results for the various scenarios the generic finding is that the medium-term impacts of the Ukraine war are expected to be very limited. This does not preclude that short-run impacts and the impacts faced by specific sectors could still be significant (Berkhout et al., 2022). Our general finding is in accordance with the estimates obtained in some other analyses and is plausible in the more general context when realising that the world, EU and Dutch dependence on Ukrainian exports is limited. Moreover, the trade in agricultural crops has largely been excluded from international trade sanction measures, allowing international trade to maintain its principal buffering role. However, it should be realised that this will be hampered by the transport and logistics operations related to Ukrainian and Russian agricultural products, which have been greatly disrupted due to the war.

The EU policy response allowing the re-use of fallow land (e.g. ecological focus areas and other fallow land), to the extent this could be modelled (see, Scenario 2) is likely to have very limited intermediate-run impacts. This is even more so for the Netherlands, because this is one of the few Member States that does not make use of this option (the Netherlands now only experiences some minor second-order effects due to indirect impacts coming from other Member States). The main explanatory factor is that the area of fallow land in the EU is rather limited (less than 3%), and the productivity of this land is below average. Moreover, this crisis-measure is expected to have a temporary nature (only applicable in the year 2022). Other impacts from the EU policy response, such as the short-term emergency funds made available to Member States to support affected farm sectors, are likely to offer relieve to these farms in the short-run, but no intermediate-run impacts are expected from this.[21]

An important factor (and uncertainty) determining the medium-term impacts is what will happen at the energy market and the subsequent impacts this may have on fossil fuel, natural gas, fertiliser and chemical prices. Scenario 3 tries to provide some further insight and shows that the energy price (availability) can have significant impacts on agricultural product and food prices. As such energy price increases contribute not only to food price inflation, but also to price inflation in general and could induce further negative impacts on economic growth, which have not been taken into account in the current analysis. This finding suggests that the national measures taken in several EU Member States, including the Netherlands, to temporarily

[21] As indicated before there is still a lack of information about how these funds are spend and what national top-ups Member States may implement. As such, they have not been separately addressed in the assessment made in this study. However, the impacts of this financial support, which has an ex-post nature and can be argued to be largely decoupled from production, on the volumes of production are expected to be limited and as such is not likely to lead to a bias in the results as they are presented here.

lower excise duties on fuels and by that mitigating the effective energy price increase is likely to have a positive impact on the various stages of the food system, including primary agriculture and food processing. The Netherlands has so far the policy of not providing specific support to agriculture to compensate them for increased energy prices with the aim not to erode incentives for energy saving and investments in renewable energy solutions. An uncertainty is what the longer-run impacts of the Ukraine war will be on the geopolitical relationships and energy provision of the EU and the Netherlands.

Our world market price impact estimates (which are endogenously calculated for Scenarios 1 and 2) match reasonably well with those obtained by Van Meijl et al. (2022). For Scenario 3 direct estimates from the MAGNET study by Van Meijl et al. (2022) were used, as their model has a world-scope and is better able to account for world trade adjustments and the impact of fertiliser and energy price increases on world agricultural production, food and feed consumption and prices. As the present study focuses on intermediate run impacts (e.g. considering a period of 4 to 5 years) the study follows a more dynamic approach relative to Van Meijl et al. (2022), which uses a comparative static approach. As a consequence, our study provides more insight into potential recovery pathways, although we acknowledge that these are subject to assumptions and uncertainties.

Bergevoet et al. (2022) carry out a refined analysis on the trade dependency of the Dutch agri-food system. The authors mention that Ukraine is the most important origin country of organic feed (especially organic maize and wheat). The production and trade disruption is likely to create a specific negative impact for organic agriculture (organic milk production, organic laying hen production depending on sunflower meal feed) that may also have medium-run consequences. In our study it was not possible to make a specific assessment for the organic sector. Although this sector plays a relatively small role in Dutch agricultural production (share estimates vary between 3 to 5% depending on the type of activity) the war may create specific problems for this sector, which are not sufficiently addressed in this study. Another specificity that could not be further addressed within the current modelling assessment is the impact of a trade disruption (EU sanctions) to the Dutch seed potato exports to Russia and Ukraine. The trade sanction with respect to Russia is likely to remain for the medium run and may induce the need to search for alternative outlets, which is likely to be feasible in the medium run, though it may create short-run problems (Berkhout et al., 2022).

Berkhout et al. (2022) in their bottleneck assessment also conclude that food security in the Netherlands is not really threatened by the Ukraine war (the Netherlands does and did not import any food grains from Ukraine). However, the Ukrainian war contributes to general food price increases that may affect specific relatively poor households (Berkhout et al., 2022). As the modelling tools used in this study did not differentiate between different households, we could provide no further insight into these aspects, even though our results demonstrated that due to the crisis unemployment in the agri-food system is likely to increase (with expected negative income effects on the concerned households).

4 Conclusions

The impacts found for the different scenarios suggest that the medium-run impact of the Ukraine war on Dutch agriculture is relatively limited. The aggregated impact over the period 2022-2024 on the five considered sectors is about 700 million euros, which is less than 1% of the total value added generated in the related agrocomplexes. This outcome is plausible when one realises that Dutch trade dependency on Ukraine is in general very low (sunflower oil being an exception) and trade with Russia was already limited because of the existing trade sanctions imposed in 2014 when Russia invaded the Crimean area. The war started (24 February 2022) at a moment when energy prices and agricultural commodity prices were already increasing because of other factors, including the recovery of the world economy from the COVID-19 pandemic and the role of droughts.

To recapitulate, Table 4.1 provides an overview of the scenario outcomes in terms of the impacts on primary production, their distribution along the supply chain, and the overall effects in terms of trade.

Table 4.1 *Selected outcomes*

Scenarios	Primary production	Supply chain impacts	Other impacts
Scenario 1 – The war in Ukraine	Small increase in beef & veal production (0.8% in 2022)	In general impacts are small (less than 1%) Negative impact on value added in veal supply chain due to decline in veal imports Cumulative employment loss of around 1250 fte jobs in 2025	Value added loss in for the arable sector is equivalent to 0.27% of the average 2022-25 value added of the total agrocomplex
Scenario 2 – EU policy responses	Impacts are slightly less negative than in Scenario 1	Impacts are relative small (similarly as in Scenario 1) The largest negative impact on value added is expected for poultry (-0.78% in 2022) Cumulative employment loss of almost 1300 fte jobs in 2025	No significant changes in consumption per capita (similarly as in Scenarios 1 and 3)
Scenario 3 – Further energy and fertiliser price impacts	As in Scenario 1 and 2, declines in poultry and pig production are expected (-1.1% and -0.4% respectively in 2022). Due to higher world market prices the total costs are lower than in Scenario 1 and 2	A 1% decline in the value added of the poultry sector is expected in 2022 Cumulative employment loss of around 350 fte jobs in 2025	In 2022, the most affected livestock sector from a trade perspective is pig meat (1.847% decline in net exports). The net costs for the arable sector decline, as the increase in product prices partly compensates for the increase in energy prices

Source: Authors.

The relative strong increase in crop prices has a negative impact on the cost structure of animal productions as their feed costs increase. Here intensive livestock productions (pigs, poultry) are more affected than animal productions relying on roughage intake (dairy, beef).

The relative increase in crop prices has as such a positive impact on the profitability of the arable sector and could outpace the increase in input costs (fossil fuel, fertiliser). However, due to the uncertainties and the important role of farmers' expectations when making planting decisions a more sparse input use could even generate a slightly negative impact on the supply of the sector.

The uncertainty with respect to energy prices and energy related inputs (fertiliser, pesticides) is likely to be one of the most pronounced impacts from the Ukrainian war on Dutch agriculture in the short to medium term. An energy price increase is likely to have worldwide impacts on agricultural production and consumption (see scenario 3) and will create passing on-effect to agricultural product prices. This implies that both costs as well as revenues will be further affected. For the five sectors that were assessed this could lead to an energy bill increase of about 110 million euros per annum). But even those effects seem to be of an order of magnitude that could be considered 'manageable' since the energy dependency is there, but was found to have on average a limited impact on total costs and the value added of primary agriculture as well as of that of the related processing industries.

Although the impacts on agricultural commodity prices will trickle down into consumer prices, it was found that the impacts on Dutch per capita food consumption for crop and animal based products are expected to be rather limited.

The EU policy response with regard to allowing the re-use of fallow land has only a very limited but positive impact. This is due to the limited increase of the added crop area in the EU (less than 3%). Moreover, since the Netherlands does not make use of this option, the impacts are even lower.

Finally, it is important to mention that the actual developments for the agri-food sector in the near future could deviate from the insights provided in this report due to several uncertainties, such as the length of the war, the potential for restoring Ukrainian production or the possibilities for the continuation of trade flows with the Black Sea region.

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Appendix 1 Model description

AGricultural MEmber states MODelling (AGMEMOD)
AGMEMOD (https://agmemod.eu/) is a dynamic, partial, multi-country, multi-market equilibrium system which solves in a GAMS environment. It can provide significant detail on the main agricultural sectors in each EU Member State, with most equations being estimated econometrically at the individual Member State level. Where estimation was not feasible or meaningful, parameters have been calibrated. The country models contain the behavioural responses of economic agents to changes in prices, policy instruments and other exogenous variables on the agricultural market. Within AGMEMOD, all commodity prices clear all markets under consideration. The current AGMEMOD version consists of the EU28 Member States, the Former Yugoslav Republic of Macedonia, Turkey, Russia and Ukraine. For each commodity in each country, agricultural production as well as supply, demand, trade, stocks and domestic prices are derived from econometrically estimated equations. One element of the supply and demand balance for each commodity is used as a closure variable to make the balance consistent. In particular, AGMEMOD provides output for the following agricultural commodities: (i) cereals (soft wheat, durum wheat, barley, maize, rye, other grains); (ii) oilseeds (rapeseed, sunflower seed, soybeans, cotton seeds, vegetables oils and meals); (iii) livestock and meat (beef and veal, pork, poultry, sheep and goats); (iv) milk and dairy products (butter, skimmed milk powder and cheese); (v) fruits and vegetables sector (tomatoes, oranges, apples, olive oil); (vi) industrial crops (sugar beets tobacco and cotton) and potatoes; and (vii) bioethanol (from grains) and biodiesel (from oilseeds).

KOsten-BAten LAndbouw Model (KOBALAMI)
The cost-benefit tool 'KOBALAMI' developed at Wageningen Economic Research relies on cost-benefit analysis (CBA). Besides the usual functionalities of the CBA approach, e.g. net present value calculations, consolidated indicators of total costs and total benefits of a particular investment, etc., this model acts as an 'integrator' tool that brings together elements from different aspects of the Dutch food system and provides a quantification in monetary terms of the economic consequences of shocks to the system. The tool is set up in a MS Excel environment and provides a sectoral representation of the Dutch 'agrocomplexes', covering primary production, upstream and downstream industries. KOBALAMI has been developed with the purpose of calculating the net benefits overtime of a given shock, e.g. changes in animal herd numbers due to a policy, changes in the availability of inputs, etc. Using as the 2019 as the reference year, the structure of KOBALAMI is set up to provide yearly outcomes for the period 2020-50, although shorter periods can be selected depending on the focus of the study.

General considerations
When using quantitative models, an element that deserves attention is the type of model inputs that are required. In this particular case, KOBALAMI 'receives' information from AGMEMOD or insights from market experts. Key inputs for AGMEMOD are world market prices, and usually, for each AGMEMOD scenario, **world market prices** are provided exogenously. However, in the case of this study, there are two options that have be considered: (i) world market prices are derived from the simulation carried out by the MAGNET model in a previous task of the project; and (ii) world market prices are endogenously calculated by the AGMEMOD model, being in this case an output of the modelling exercise rather than an input. As explained in the main body of the report both approaches have been used. As AGMEMOD is a partial equilibrium model potential impacts on GDP have to be added from other sources. For the baseline, IHS-information (as derived from DG-Agri) on **GDP** has been used, while for the scenarios information based on the MAGNET-food security-study will be used.

Appendix 2 Fertilisers, yields and farmer behaviour

Conceptual framework

The increase in energy prices affects the price of fertilisers, since about 80% of the production costs of fertiliser consists of the costs associated with natural gas input. As the yield impacts are important, and may lead not only to short-term but also medium-term impacts, specific attention has been paid to address this issue. The point of departure is the optimisation process farmers are involved in: maximising their profits, subject to the agronomic crop function comprising the 'production technology', viz. the yield per hectare as a function of fertiliser input (f) and other inputs (z). Figure A-1 provides a graphical overview of this setting. As the figure and the algebra of the iso -profit lines (IP(0) and IP(1) in the yield-fertiliser-space shows, it is the relative fertiliser price/crop price ratio that is important in determining the farmer's optimum (tangency point of 'highest' iso-profit line with the crop production function). An increase in the fertiliser price, will make the iso-profit curve more steep (e.g. IP(0) -> IP(1)), and lead to a lower fertiliser application and a lower crop yield. An important co-determining factor is the curvature of the yield-fertiliser-crop function. Based on some literature, it has been assumed that this curvature, indicated as $\Delta y/\Delta f$ = 1/3. This implies that a 15% decline in fertiliser application is expected induce a 5% loss in yield, evaluated at the margin. A final factor of impact is the share of fertiliser costs in total costs of production or in the total crop returns. A low share implies also a relatively low sensitivity of the crop for fertiliser price increases.

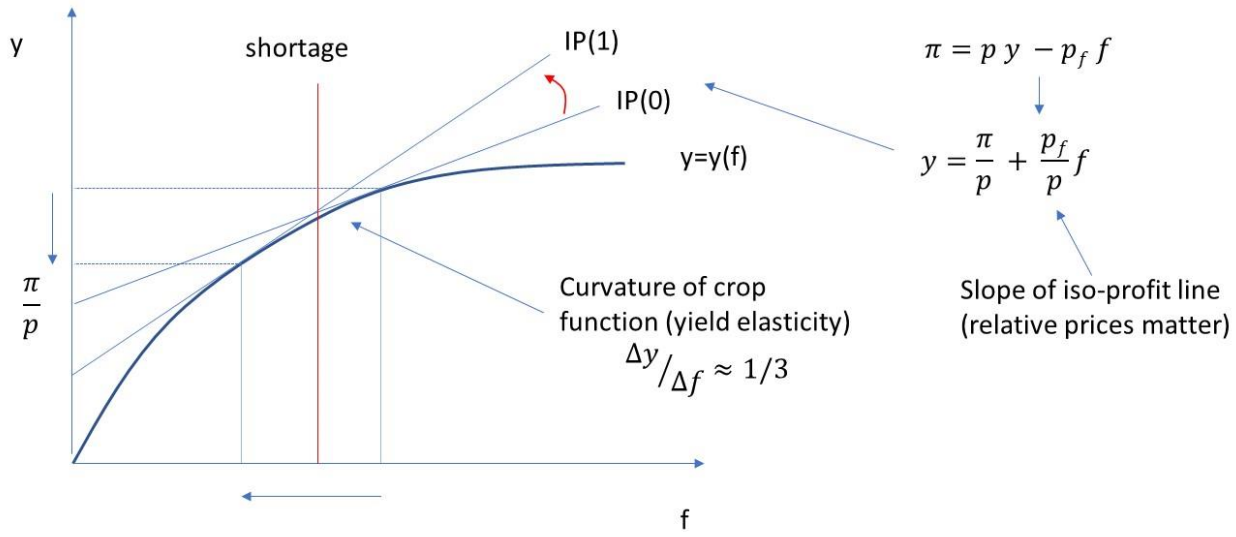

Figure A.1 *Farmer behaviour and the optimal fertiliser application choice*
Source: Authors.

Based on a stylised presentation of Dutch conditions the following example is given: The returns form a wheat crop (yield about 8 tonnes/ha) could be about 1,500 euros/ha. The fertiliser application (205 kg KAS) costs 200 euro/ha and the crop margin over fertiliser costs is 1,300 euros/ha. The share of fertiliser costs in the total revenue is 13%. Note that given this 'structure' a fertiliser increase by 30% would lead to an increase in fertiliser costs of 60 euros/ha. When at the same time the crop price would increase by only 5%, revenue would increase by 75 euros per hectare. Note that the margin of fertiliser costs would then increase by 1,390 euros/ha (=1,650-260). So even a substantial fertiliser price, when combined with a modest (expected) crop price increase, could already induce the farmer to apply fertiliser according to the old (agronomic-economic) optimum. Fertiliser may be applied with 'a certain abundance' since fertiliser has some crop insurance-properties. However, when the relative price of fertiliser increase farmers my save on this and apply with a more 'narrow margin'. Moreover, not only fertiliser costs, but also other tillage and

cropping costs may increase, especially since fuel (diesel), and plant protection products will also be affected by rising energy prices.

For Scenario 1 it has been assumed that the yield effects are -5% for crop yields in the EUN-region of the EU (implying a 15% reduction in fertiliser application), whereas for the 'EU-15' a yield decline of 1% is used (implying a 5% decline in fertiliser application). The reason to differentiate the farmer yield responses is based on some further background calculations that were made and crop expert information. For France and Germany there is information that farmers bought already about 70% of their first (and main) fertiliser application in advance of the growing season (partly as a response to the already steadily increasing fertiliser prices in advance of the Russian invasion).

Appendix 3 Ukraine agricultural production, logistic infrastructure and fertiliser input availability

Assessment of the impacts of the war on current and future Ukrainian agricultural production
The war in Ukraine affects its agricultural production in several ways. In the regions where there are war activities production will be especially affected. This holds partly for the Kiev region, the most southern region and the eastern region, including the Donbas area. This is likely to (partly) affect corn (growing areas in north and north-east part), wheat (south, south-east), sunflower (east, and middle part), and to a lesser extent rapeseed production (central east part). Due to the war, currently labour is diverted from agriculture. Moreover, because of needs to feed the own population a switch from export products like corn and oilseeds to other food crop is likely. The lack of fuel and other inputs (fertiliser) may further constrain land preparation, sowing and harvesting of crops at least in the short run. As regards international trade the logistics and available functioning infrastructure is an uncertain factor. Currently, key harbours in the Black Sea coastal area have been blocked and may be damaged. In addition, trade measures, including the measures of Russia against 'unfriendly nations' with respect to fertiliser trade (Russian export ban) as well as the problems with Ukrainian fertiliser production and exports are likely to contribute to increased or relatively high fertiliser prices.

Fertiliser availability
In our assessment we follow for 2022 the assumption made in the MAGNET study, which 'approximates' the current situation by halving Ukrainian production and separately adding measures with respect to fertiliser production and Russian fertiliser trade. For 2022 we think this assumption is reasonable, however, when time proceeds there are reasons to relax these impacts, although there is still a lot on uncertainty. Here it has been assumed that somewhere in 2023 the situation will end in a frozen conflict.[22] As a consequence Ukrainian agricultural production and trade will still be severely negatively affected in 2023.

Recovery of production, trade and stabilisation of fertiliser markets
After 2023 some 'normalisation' may start, including a gradual recovery in agricultural production and trade, be it that the war-related factors will still impact production. Table A3.1 provides an overview of the assumed recovery in production.

Table A3.1 *Assumed recovery path and levels of Ukrainian agricultural production of cereals and oilseeds (expressed as a percentage of the production before the war (2021))*

Item/year	2021	2022	2023	2024	2025
Corn /wheat	100	50	60	65	70
Sunflower /rapeseed	100	50	50	55	60

Source: Authors.

Fertiliser prices and availability will to an important extent depend on the evolution of energy prices and the restrictive trade measures (especial the Russian export ban on fertiliser export to 'unfriendly nations', including the EU. Here we assume that will move in a proportional way to the energy prices (especially that of natural gas).[23] It is assumed that the price of fertiliser will decline in two annual steps of 5% in 2023 (relative to 2022) as well in 2024 (relative to 2023) and then stay at that level.

[22] See, also: https://www.atlanticcouncil.org/content-series/the-big-story/how-will-the-russia-ukraine-war-reshape-the-world-here-are-four-possible-futures/.
[23] See, also: https://www.eia.gov/outlooks/steo/.

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