Supplementary materials to "Cascading socio-economic and financial impacts of the Russia-Ukraine conflict"

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1 Scenario design for sensitivity analysis

To check for the robustness of results and identify key macroeconomic dynamics we also provide besides the base conflict scenario two additional scenarios within a sensitivity analysis. The additional scenarios lift the above mentioned assumptions i.e., *w/ reduced Armington Elasticities* and *w/ full Armington Elasticities* scenarios. The exact values can be found below in Table I.

Scenario name	Description
w/ reduced Armington elasticities	This Scenario considers the same shocks of the base conflict scenario for trade sanctions, production capacity, and trade disruption. The Armington elasticity is 50% lower than in the GTAP database. There are no supply elasticities for fossil fuels.
w/ full Armington elasticities	This Scenario considers the same shocks of the base conflict scenario for trade sanctions, production capacity, and trade disruption. Armington elasticities are set at the GTAP database level (ranging between 7.0 and 1.90). There are no supply elasticities for fossil fuels.

TABLE I: Specification of scenarios for sensitivity study of macroeconomic quantities.

2 Complementary results

2.1 Complementary macroeconomic results: a sensitivity analysis

Two main types of inputs characterize our scenarios: (i) shocks describing the sanction system as well as the productive capacity disruption due to the invasion, (ii) parameters, namely the so called *Armington elasticities of substitution* between imported and domestically produced commodities and *supply elasticities for fossil fuels* (namely coal, oil, and gas). CGE models are often criticized to rely on a structure where these elasticities play a major role in defining the model's results [1]. In several cases, as in ICES, they are often not econometrically estimated. To check the robustness of our results, we perform a sensitivity analysis to test these two key parameters: the Armington elasticity of international trade and the supply elasticity of the fossil fuel market. By comparing the w/ full Armington elasticities scenario and the w/ reduced Armington elasticities scenario, we highlight the role of international trade in cushioning the repercussions of the initial shocks worldwide. Furthermore, we investigate how increasing the rigidity for mitigating commodities supply disruptions through international markets affect the main macroeconomic variables (i.e., GDP, world and regional prices, sectoral production, and international trade). Moreover, to better mimic fossil fuels prices volatility we introduced the differentiated supply elasticities for fossil fuels (base conflict scenario), equal to 1 for coal, 0.25 for oil, and 0.6 for gas in following the model's elasticities validation performed

by [1], since these elasticities govern how supply of different fossil fuels respond to changes in price. By comparing the base conflict scenario with the w/ reduced Armington elasticities scenario, we quantify haw much is the effect of introducing the elasticities on main variables.

GDP effects

Base conflict scenario In the base conflict scenario real World GDP reduces by 0.6%. At the regional level, instead, we can identify four main cases for GDP effects (see figure 1, blue bars in the left panel). Firstly, Russia and Ukraine (see figure 1, blue bars in the right panel) experience the highest GDP losses, -53.3% and -13.7% respectively, since they are directly affected either by the sanctions or the capacity disruption caused by the war. The Ukrainian GDP loss is driven by a 4.0% reduction of private consumption, while total firms demand is almost the same. However at the sectoral level firms demand changes widely. The gas and electricity sectors' total intermediate demand is 50% less, while the oil and the non-mineral products demands fall by nearly 15%. Conversely, the construction and the other services sectors demand 20% and 12% more, respectively. Secondly, higher affected countries are located in the EU where the GDP losses range between 0.6% and 1.8%. Here, the driving force is the high dependency on Russian imports (mainly for energy products) that leads to a reduction in firms' and consumers' demand. To a lesser extent, Japan faces a 0.2% GDP loss caused by the import ban on Russian energy product. In 2020, indeed, the country modestly depends on Russian imports(2.7% of total country's import), mainly for oil, that counts for 41.7% of total Russian imports while 9% of total Japanese oil imports originates from Russia. Thirdly, few countries has slightly positive changes in GDP, such as Mexico (+0.05%), CIS countries (+0.3%) and Kazakhstan (+0.3%). The three countries, however, have different drivers for their positive GDP effects. Mexico and Kazakhstan face an expansion in household consumption (+0.2% and +5.7%, respectively), while CIS countries combine an increase in internal private demand with an export expansion in the energy products sectors i.e. oil, gas and oil products. Other countries have a GDP gain less than 0.1%, such as MENA, ET region, and SSA. Fourthly, other Asian countries, Latin American countries, and Australia are mostly unaffected in GDP terms.

W/ reduced Armington elasticities scenario In this scenario real World GDP loss reaches -0.6%. Removing the fossil fuels' supply elasticity assumption does not affect

the main regional trends for GDP effects. These are represented in figure 1 as teal bars in both panels. As in the base conflict scenario, Ukraine and Russia face the highest GDP losses (51.4% and 13.6%, respectively). Similarly, in the EU region GDP falls between -0.6% and -1.7%. This means that fossil fuel supply elasticities accounts for a further 0.3% - 1.0% GDP loss in the region. In the other countries, the total effect on GDP is nearly null with differences lower than 0.1% with respect to the base conflict scenario.

W/ full Armington elasticities scenario In this scenario real World GDP falls around 0.3%, with an improvement of nearly 50% respect to the w/ reduced Armington elasticities scenario. The reduced substitutability in international trade, indeed, lowers the possibility to supply commodities in the internal market when producing them domestically is too costly. This directly affects internal final consumption and intermediate demand exacerbating the negative effect already visible in the w/ full Armington elasticities scenario. At the regional level patterns of GDP losses does not change with respect to the previous scenario (see figure 1, golden bars in the left panel) with an improvement in quantitative terms especially for Russia (see figure 1, golden bar in the right panel). Ukraine faces the highest reduction of GDP with a 52.3% loss, while Russian GDP contraction is only 7.3%, nearly half of the value of the w/ reduced Armington elasticity scenario. Other main losers include the EU countries with GDP reductions between 0.2% and 0.7%. This means that having a more elastic international trade can provide a gain between 0.5% and 1.0% in GDP.

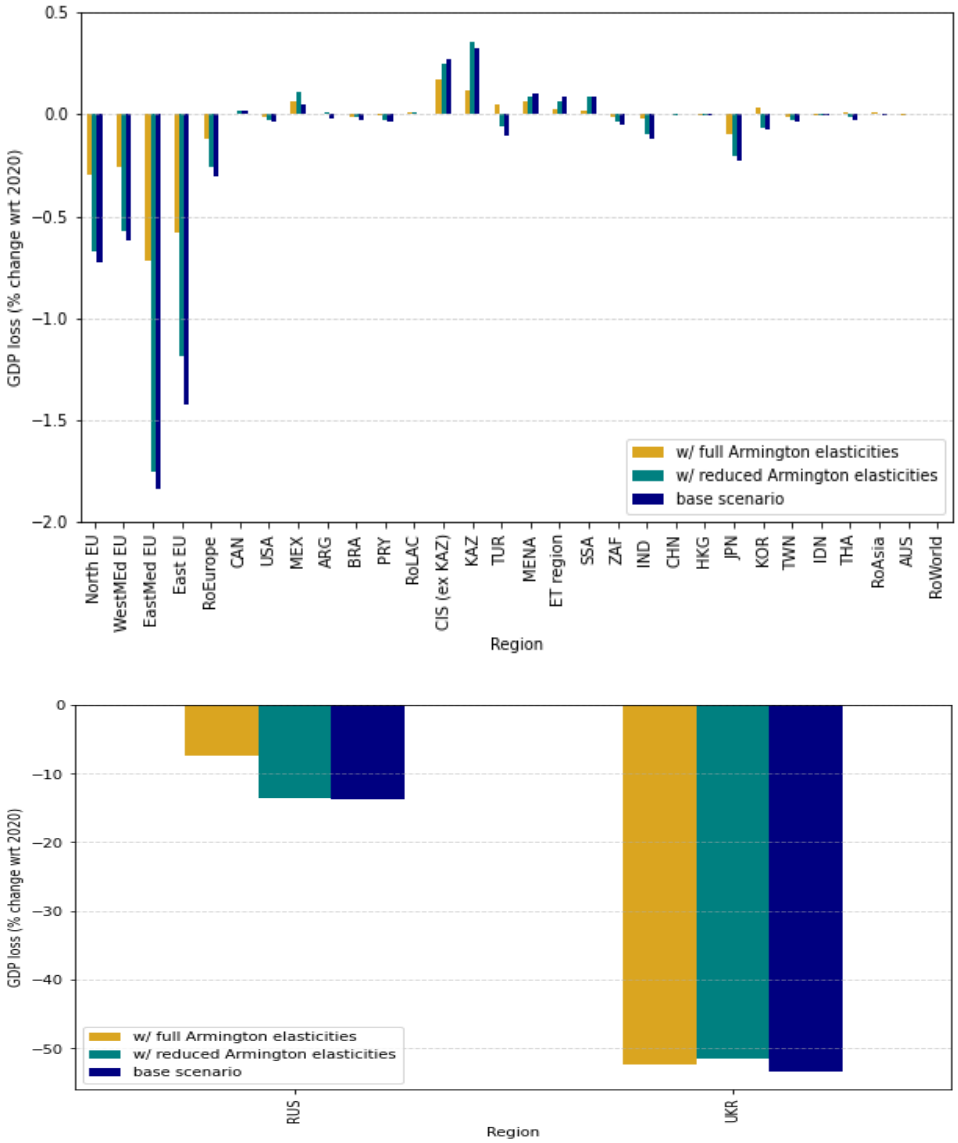

Figure 1: The grouped barplot shows percentage GDP losses in the three scenarios with respect to 2020. Top panel: grouped barplot with percentage GDP losses in all countries except belligerents. Bottom panel: grouped barplot with GDP losses for Ukraine and Russia. Gold bars are the GDP losses in the w/ full Armington elasticities scenario, teal bars are the GDP losses in the w/ reduced Armington elasticities scenario, and blue bars are the GDP losses in the base conflict scenario. Source: authors.

World commodity prices

Base conflict scenario The international price index, calculated as a weighted average of the regional export prices, increases by nearly 2.5% with respect to 2020 in this scenario. At the sectoral level, international prices generally spike for commodities directly affected by the bans imposed to Russia in the scenario building, such as wheat, other cereals, oil, gas, and oil products, and secondly transportation and electricity. Price increases originate from a reduction in total World commodity supply while demand is stable or slightly increasing. On the one hand, energy products' prices increase between 6.2% for oil and 8.5% for oil products with respect to 2020, while coal prices has less than 1.0% increase. Consequently, sectors that are highly dependent on fossil fuels, namely transportation, have price increases between 2.0% and 5.0%. At a lesser extent electricity price as well increase by nearly 1.0%. On the other hand, cereals' prices rise between 3.3% for wheat and 8.6% for other cereals. However, other agricultural products face price increases up to 2.0% mainly led by the increase in fertilizers' price induced by the ban on Russian fertilizers, as introduced in the scenario design.

W/ reduced Armington elasticities scenario The international price index rises by nearly 2.1% with respect to 2020. At the sectoral level, removing the assumption on fossil fuels supply elasticities does not affect the prices for agricultural products (reductions are lower than 0.1% respect to the base conflict scenario) but its main consequence is the evident reduction in prices for energy products. Indeed, price increases range between 3.4% for gas and 7.3% for oil products. This means that introducing the fossil fuels supply elasticities boosts energy products' price increases by 30% on average.

W/ full Armington elasticities scenario In this scenario international price index increase by less than 1%. Sectorally, international prices generally spike for commodities directly affected by the bans imposed to Russia in the scenario building, such as wheat, other cereals, oil, gas, and oil products. Price increases originate from a reduction in total world commodity supply. World prices of sanctioned agricultural products increase in the range of 1.3% (wheat) and 2.4% (cereals other than rice and wheat). Similarly, sanctioned energy products prices rise between 1.7% (oil) and 2.6% (oil products). Consequently, oil products dependent sectors, such as air and water transports, experience price increases in the order of 1.72% and 1.17%, respectively. In figure 2 gold bars show the World price increases for commodities in this scenario. Contrasting it with the

w/reduced Armington elasticities scenario (teal bars in figure 2), we can highlight that rigidities in the international markets induced higher international prices with differentiated trends according to commodities. While for agricultural commodities and cereals rigidities triple their prices, they even quadruple prices for energy products.

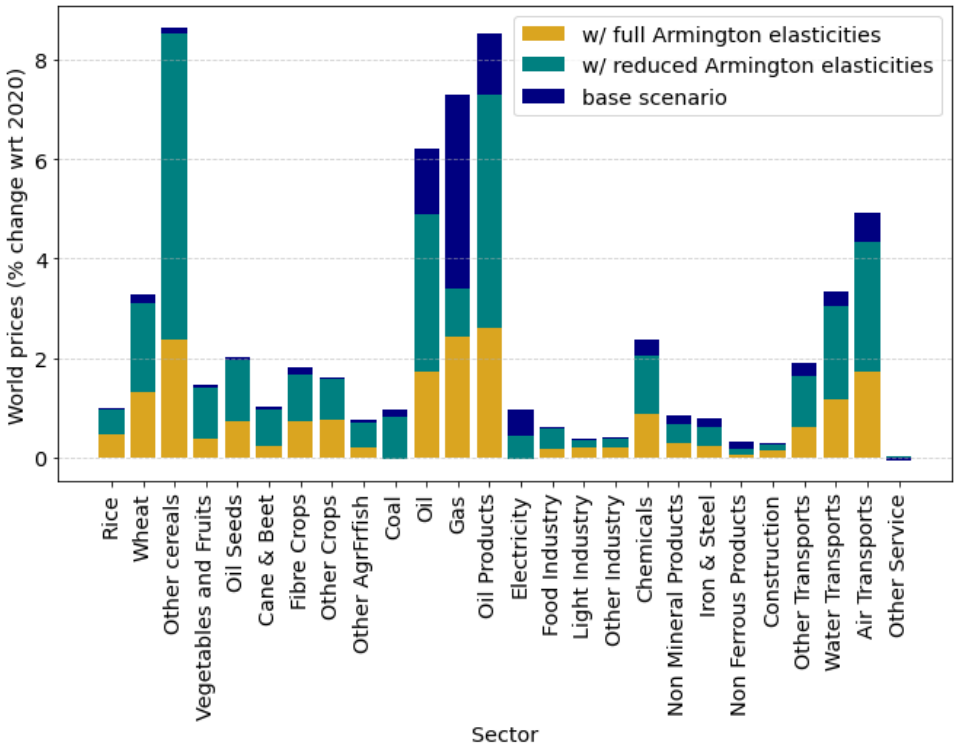

Figure 2: The stacked barplot shows percentage changes in World prices for selected commodities and the scenarios' contributions to price formation with respect to 2020. Gold bars represent the w/ full Armington elasticities scenario, teal bars represent the contribution of the w/ reduced Armington elasticities scenario, and the blue bars the changes induced by the base conflict scenario. Source: authors.

Regional commodities prices Regional prices are a combination of (i) domestic commodities prices, led by costs of production, and (ii) import prices, connected to the countries' dependence on commodities' imports.

Base conflict scenario Figure 3 in the top panel shows how regional commodities' prices changes with respect to 2020. It depicts four main cases. Firstly, only Russia and Ukraine face a price reduction generalised to all sectors. In particular, Ukraine has the most pronounced reduction in prices ranging from -6.7% (chemicals) to -68.0% (other crops), due to the assumptions about disruption of productive capacity. Significant price reductions are seen also in Russia between -7.4% (other crops) and -25.2% (wheat). In this case prices decrease because of the international price component. Secondly, regional prices for energy products increase more than 4.0% worldwide. In particular, EU prices spike on average by 35%, 4.6% in North America (mainly for oil and oil products), 4.4% in Latin America (mostly oil), 7.0% in Africa (for all energy products), 4.0% in Asia (especially gas) and 6.7% in Australia. Geographically, the price increase reach almost all Asian Countries with the only exceptions of South Korea, China and Hong Kong where energy products' prices rise on average by 2.0% only. Thirdly, agricultural prices increase for ET region, MENA, and Kazakhstan for almost all agricultural products more than 4.0% (specifically, on average 5.6%, 4.3%, and 9.7%, respectively) while in the EU the price increase is mainly concentrated for cereals in East Mediterranean (on average -11.5%) and Eastern EU Countries (on average -4.8%). Other hotspots emerge in Asia, namely Thailand and South Korea, where prices spike to +5.7% for wheat and +8.8% for other cereals, respectively; meanwhile in North America cereals prices modestly increase by 2.4% and Argentina face a general increase in agricultural prices of nearly 2.9% (with a peak of +4.7% for other cereals). Finally, chemicals and transportation prices increase more than 4.0% in the EU (8.0% on average with a peak of +15.0% in Eastern EU for chemicals, and an average 13.3% increase for transportation with a +33.7% maximum again in Eastern EU).

W/ reduced Armington elasticities scenario The effect of considering lower Armington elasticities and removing fossil fuels supply elasticities on regional prices with respect to 2020 is shown in the bottom left panel of figure 3. While Russia and Ukraine have the highest reduction in prices (well below 4.0%), this scenario is characterized by a reduced regional price increase worldwide with respect to the base conflict scenario. Main differences include regional prices for energy products. Higher prices increases, indeed,

are concentrated in the EU with oil and oil products' prices increase between 10.0% and 20.0% in the Northern and Western Mediterranean countries, and between 40.0% and more than 100.0% in Eastern Mediterranean and Eastern countries, respectively. In the American continent energy products' prices increase on average by 3.0%, in Asia by 2.0%, while in Australia they increase by nearly 5.0%.

W/ full Armington elasticities scenario Variations of regional commodities prices in the w/ full Armington elasticities scenario with respect to 2020 are shown in figure 3 in the bottom right panel. Here, regional prices are lower than in the other scenarios as a consequence of the higher elasticity of substitution between imported and domestically produced commodities. Domestic users, firms and households, can purchase cheaper commodities substituting among origins more easily. As in the other scenarios Ukraine has the most pronounced reduction in prices ranging from -2.1% (gas) to -75.1% (other crops), due to the assumptions about disruption of productive capacity. Significant price reductions are seen also in Russia between -4.7% (other crops) and -20.4% (wheat). Significant price decreases are recorded for CIS countries and Kazakhstan for energy products only (-6.8% and -4%, respectively). Moreover, several countries have declining prices in specific sectors, such as the EU for the industrial sectors, constructions, and other services, CIS countries, Türkiye, and South Korea, instead, experience a more generalized prices reduction involving several commodities. However, most of the countries have moderate price increases between 0% and 2.0%. Finally, price increases higher than 4.0% are limited to the EU region especially for agricultural commodities, energy products, and the transportation sector. Agricultural prices increase more in the Eastern Mediterranean EU with spikes of 5.1% for cereals (other than rice and wheat), 4.5% for oil seeds, and 4.9% for cane and beet. Conversely, the price increase for energy products is generalized across EU regions. In particular, Eastern EU and Eastern Mediterranean EU countries are more affected especially for oil (14.0% and 26.9%, respectively) and oil products (18.3% and 36.4%, respectively). Additionally, Eastern EU faces a further 19.2% increase in gas prices, due to its high dependence on gas imports from Russia that supplies nearly all the regional gas imports in 2020. Furthermore, Northern EU moderately faces increases in oil prices (+8.9%) and for oil products (+10.8%). Russia, indeed, supplies around 22.7% and 35.0% of Northern EU oil products and oil imports, respectively. The regional dependence on Russian gas is relatively low (in 2020 Russian imports counts only for 16% of total gas imports in Northern EU), and as a consequence gas price moderately increases by 4.7%. EU countries confront lower price increases for coal (usually between nearly 3% and 5%);

on the contrary, other countries, such as EFTA and non-EU Balkan countries, have higher price increase for coal (+6.5%). The price increase of energy products, especially oil and oil products, leads to a generalized price increase for transport with a peak of 7.6% and a 11.5% for air and water transport in Eastern EU, respectively.

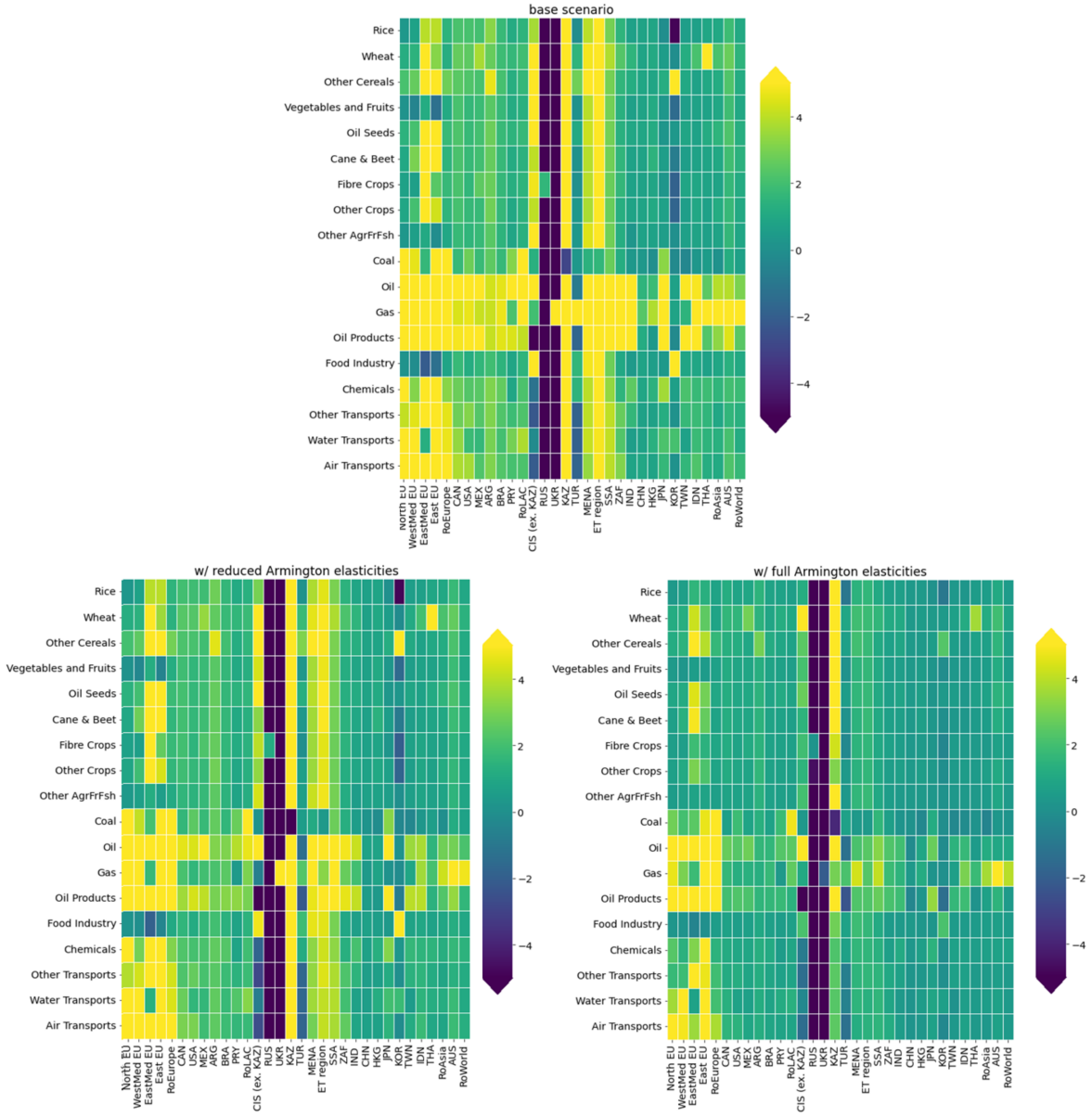

Figure 3: The heat maps show percentage changes in regional prices for selected sectors with respect to 2020 in the three different scenarios. Top panel: base conflict scenario; Bottom left panel: w/ reduced Armington elasticity scenario; Bottom right panel: w/ full Armington elasticity scenario. Source: authors.

Regional production

Base conflict scenario According to percentage changes in regional production depict in the top panel of figure 4, this scenario is characterized by four main trends. Firstly, regional production declines in almost all sectors in Ukraine due to the assumption of capacity disruption and the availability of less imported intermediates due to the Russian ban (in 2020 Ukraine imports from Russia counted for 18.5% of total imports). Reductions range between 81.7% for cereals to 9.2% for other crops. Similarly, Russia reduces most of its production especially in sanctioned sectors (namely cereals, oil products, chemicals, and construction) that fall at least 10.0%. In particular, wheat production declines by nearly 49.6% (it represented 9% of total Russian agricultural production in 2020) while cereals (other than rice and wheat) decrease by 13.7% (8% of Russian agricultural production in 2020). Oil products' production lowers by 11.1%, whereas fossil fuels face on average a 4.2% reduction in their production. Finally, the chemical sector production, that in 2020 was nearly 8% of the Russian industrial production, contracts by 11.2%. Secondly, to close the gap in international supply due to lower Russian and Ukrainian exports, other countries increase their sectoral production. For instance, while Ukraine reduces its wheat production by 80.5% and Russia by 49.6%, Northern and Western Mediterranean EU countries, Mexico, CIS countries, Türkiye, South Africa, and Thailand increase their production more than 10.0% although their shares of production are lower than 5.0% in total World wheat production in 2020. Main World producers increase their production as well but at a lower pace (e.g., India, producing nearly 10.0% of total wheat production in 2020, increases its production by nearly 2.3%). Eastern Mediterranean EU is an exception, the only region with a reduction higher than 10.0% in wheat production in the World except belligerents. On average, wheat World production (excluding belligerent countries) increase by 7.3%. Similarly, other cereals' production lowers in Ukraine and Russia (-82.9% and -13.7%, respectively) and this pushes other countries to increase their production, such as Northern, Western Mediterranean and Eastern EU countries, Argentina, CIS countries, Kazakhstan, Türkiye, MENA, and South Korea whose production increase more than 10.0%. In 2020 these countries represented around 15% of World production of other cereals. None of the countries worldwide declines its other cereals' production. Thirdly, Russia produced nearly 14% of World gas in 2020 whilst after the conflict it lowers its sectoral production by 1.9%. As a consequence, gas production increase worldwide. Highest production increases are concentrated in the EU (between 2.7% and 8.0%) but the EU share of gas production in 2020 was only 4%. Main

gas producers in 2020, such as the US, MENA, Canada, and Rest of Asia, increase their production between 3.9% (Rest of Asia) and 1.1% (Canada). Similarly for oil, in the face of a reduction in Russian production by 4.8%, main oil producers in 2020, namely MENA, the US, SSA and China (counting for 55% of 2020 World production all together) increase their joint production by 0.8%. Fourthly, as a consequence of the Russian and Ukrainian reduction of oil products production, Eastern Mediterranean and Eastern EU regions largely reduce their production (-56.5% and -25.6%, respectively) together with other oil products dependent sectors, such as transport, chemicals and other heavy industries. In Eastern EU, for instance, these sectors used on average 26% of imported intermediates of which 28% originated from Russia and Ukraine in 2020.

W/ reduced Armington elasticities scenario Percentage changes in production with respect to 2020 are shown in the bottom left panel of figure 4. In this scenario the main trends described in previous section are still valid. Removing fossil fuels' supply elasticities mainly affects energy products' production in the EU region. On average, EU countries produce 26.3% more than in 2020 and nearly 22% more than in the base conflict scenario as a response to the lower substitutability of domestic and imported commodities. Other production increases concentrate in the American Continent; oil production rises by an average 2.5% in the US, Canada and Mexico area, and by 3.8% in Paraguay, then gas production increases by 2.9% in the US. Moreover, Oil production increases by an average 2.9% in SSA, South Africa, and India. Finally, gas production moderately increase in some Asian countries, such as Indonesia, Thailand and Rest of Asia, and nearly doubles in Australia with respect to the base conflict scenario.

W/ full Armington elasticities scenario According to percentage changes in regional production depict in the bottom right panel of figure 4, this scenario is characterized by a generalized reduction of domestic production. Indeed, with full Armington elasticities, countries have a lower need to produce domestically what they can trade and pay less. In general four trends emerge. Firstly, regional production declines in almost all sectors in Ukraine with reductions range between 83.0% for cereals (other than wheat and rice) to 15.0% for non-ferrous products. Similarly, Russia reduces sanctioned sectors' production at least by 10.0%. In particular, wheat production declines by nearly 50.0%, while cereals (other than rice and wheat) decrease by 15.0%. Oil products production lowers by 14.0%, whereas fossil fuels' production diminishes on average by 4.0%. Finally, the chemical sector production contracts by 19.0%. Secondly, to compensate the

reduced international cereals' supply other countries increase their sectoral production. For instance, Western Mediterranean EU countries, Mexico, CIS countries, Kazakhstan, Türkiye, South Africa, and Thailand increase their production more than 10.0% although they are not major players in the World wheat production in 2020. Main World producers, instead, increase their production at a lower pace. On average, cereals' World production (excluding belligerent countries) increase by 5.5%. Thirdly, Russia lowers its gas production by 4.0%. As a consequence, it increases worldwide. Highest percentage increases are concentrated in the EU (between 10.4% and 100.0%). However, main gas producers in 2020 increase their production between 6.0% (Rest of Asia) and 1.1% (Canada). Similarly for oil, main oil producers in 2020 increase their joint production by 0.7%. Fourthly, Eastern EU region largely reduces its oil products' production together with other oil products dependent sectors, such as transport, chemicals and other heavy industries.

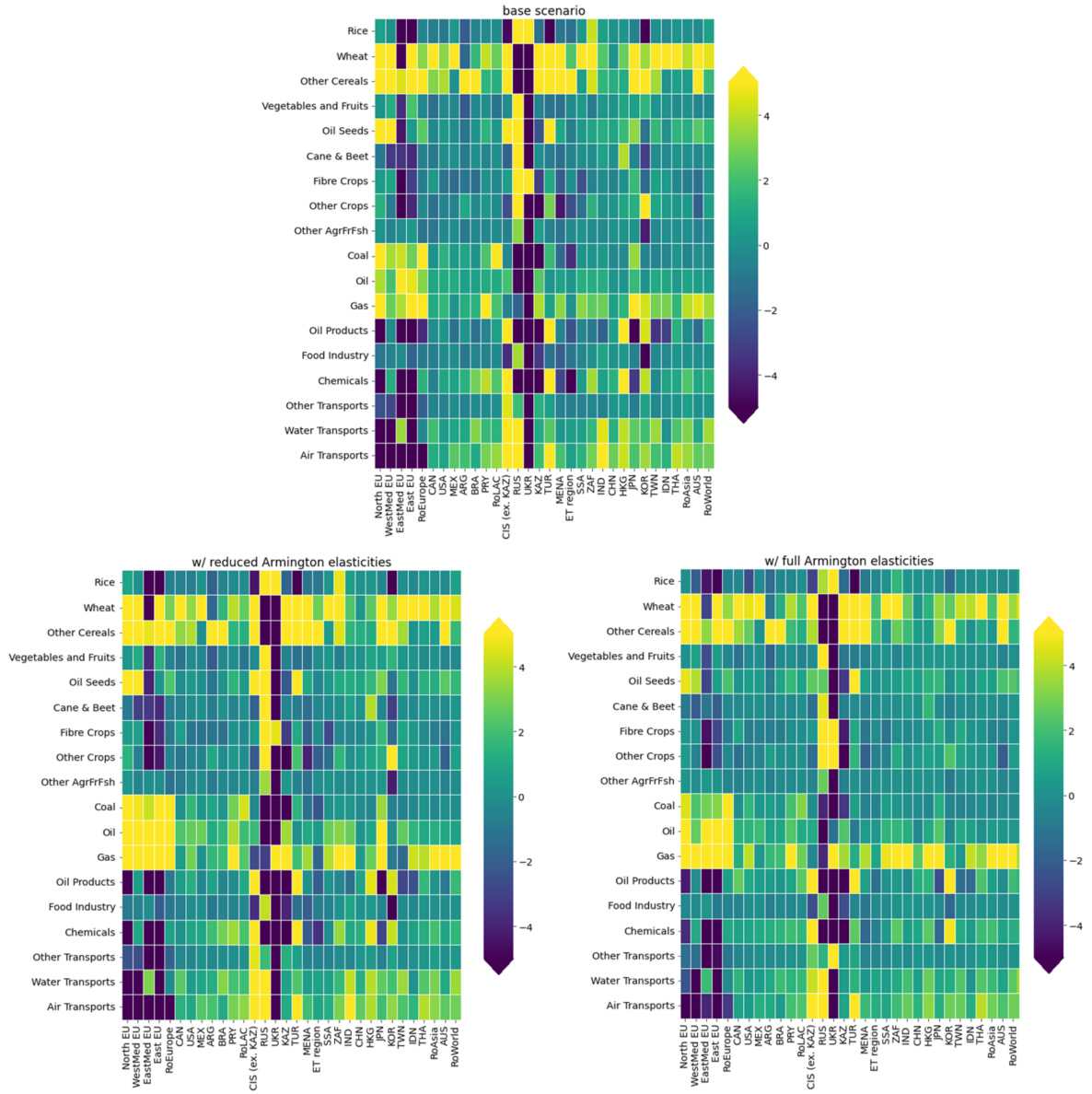

Figure 4: The heat maps show percentage changes in regional production for selected sectors with respect to 2020 in the three different scenarios. Top panel: base conflict scenario; Bottom left panel: w/ reduced Armington elasticity scenario; Bottom right panel: w/ full Armington elasticity scenario. Source: authors.

International trade

Base conflict scenario In the base conflict scenario exports volume reduces by 1.9% with respect to 2020. The rising World price level (+2.4% with respect to 2020) more than compensates the effects on volume such that total value of exports is 0.3% higher than in 2020 (figure 5, top of the right panel). The only countries that notably reduce their shares in international trade are Russia, moving from a 2.8% of the global volume to a 2.4% share, and Ukraine (from 0.3% to 0%) (see figure 6, top panel). Therefore, few countries, such as CIS countries, Kazakhstan, and MENA, have higher export (in value) in 2023 (+9.0%, +10.0%, and +5.0%, respectively). These countries concentrate their exports in sectors experiencing the highest price increases; for instance, MENA exports energy products for nearly 62.0% of its total exports after the conflict. Conversely, Eastern EU reduces its exports in value by 1.0%. On average, indeed, Eastern EU increases its exports in services (other than transports) whose price is almost stable with respect to 2020. Furthermore, Chinese export value reduces by 1.0% with respect to 2020 due to a strong contraction of the light industry sector's exports (-2.0%) whose price is steady. Results at the country level and the comparison between volume (gold bars) and value (teal bars) of exports flows are summarized in figure 5 top panel. For Russia and Ukraine, considering values instead of volumes of exports improves their performances. For instance, while Russian exports in volume decline by 33.0%, in value the decline is only 19.0%. Similarly, for Ukraine exports in volume lower by 86.7% while in value the reduction is 70.7% (see figure 6, top panel). At the commodity level cereal exports decline by 15% with respect to 2020 (with grains other than rice and wheat fall more than the sector average, i.e. 20.0%) while energy products' exports reduce by an average 7.8%, with gas and oil products declining more than the average (-9.9% and 14.1%, respectively).

W/ reduced Armington elasticities scenario Removing fossil fuels' supply elasticities ad assuming halving the Armington elasticities, total global exports' fall in volume reaches a reduction of -1.8%. As in the previous scenario, the increase in World price level (+2.1% with respect to 2020) offsets the effects on volume such that total value of exports is almost unchanged with respect to 2020 (figure 5, top of the mid panel). For countries, such as Western Mediterranean countries, EFTA and Balkan countries, Türkiye, MENA, Sub-Saharan Africa, and Australia, exports in value are higher than in 2020 in the range of +0.8% (Western Mediterranean countries) and +3.8% (Türkiye). Conversely, Chinese

exports' value decline by 0.5% with respect to 2020. In this scenario, instead, Russian exports' value benefits with a +0.5% increase with respect to the base conflict scenario, while Ukrainian ones are stable at the base conflict scenario level. Figure 5 in the mid panel shows changes in volume (gold bars) and value (teal bars) in each country, but Russia and Ukraine. For these countries changes in volume and value of exports with respect to 2020 are depicted in figure 6 in the mid panel. At the sectoral level, there are no remarkable changes. Only oil and oil products' exports improve more than 0.5%, while other commodities' exports are almost unchanged.

W/ full Armington elasticities scenario As a direct consequence of the scenario building, global exports' volume in this scenario declines by nearly 1.0% with respect to 2020. The only countries that notably reduce their shares in international trade are Russia, moving from a 2.8% of the global volume to a 2.4% share, and Ukraine (from 0.3% to 0%) (see figure 6, bottom panel). However, as a consequence of the World price increase (+0.9% with respect to 2020), global World exports' value is almost unaffected in the scenario (-0.1% with respect to 2020). The increase in prices is lower than in the other scenarios thanks to higher Armington elasticities but, however, it is enough to offset the negative effects on traded quantities. Therefore, countries having higher values than volumes (i.e., CIS countries, Kazakhstan, and MENA) have lower changes in values with respect to 2020 (+7.0%, +4.0%, and +2.0%, respectively) than in other scenarios. Similarly to the other scenarios, for Russia and Ukraine, considering values instead of volumes of exports improves their performances on average by 2.0% (see figure 6, bottom panel). At the commodity level this scenario shows milder reductions than other scenario since it assumes full Armington elasticity such that trade is able to cushion the negative impacts of supply chains disruption. Cereal exports decline on average by 5.8% with respect to 2020. While rice exports triple with respect to the base conflict scenario, wheat exports are double and other cereals ones even nearly four times higher. Energy products' exports reduce by an average 2.7%, with gas and oil products declining more (-6.8% and 5.3%, respectively). However, even for energy products, exports improve respect to the base conflict scenario; for instance, oil exports reduction with respect to 2020 is almost null, while in the base conflict scenario it is -2.7%.

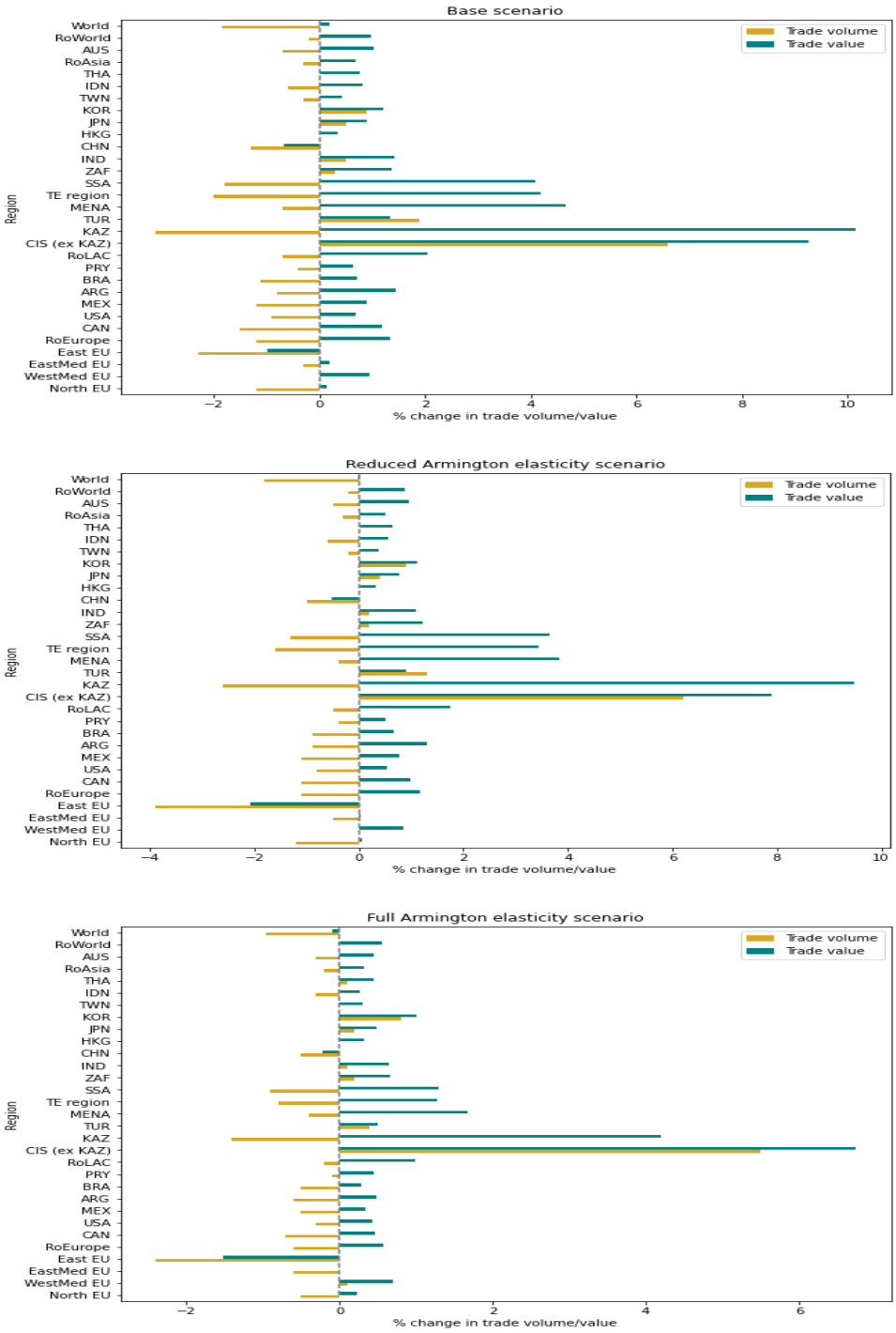

Figure 5: Grouped barplot with percentage export changes in terms of volume (gold) and value (teal) for non belligerent countries with respect to 2020 in the three different scenarios. Top panel: base conflict scenario. Mid panel: w/ reduced Armington elasticities scenario. Bottom panel: w/ full Armington elasticities scenario. Source: authors.

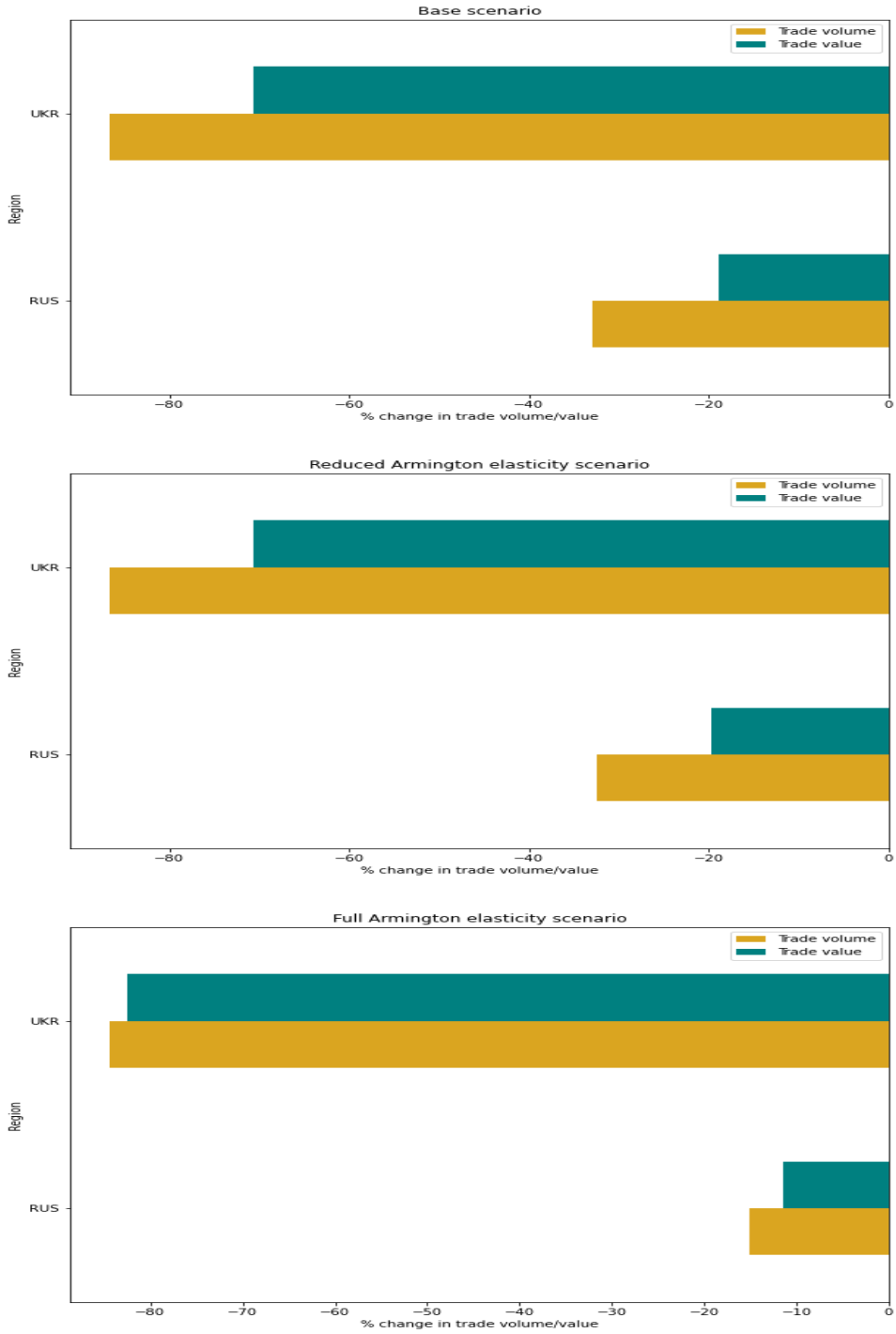

Figure 6: The grouped barplot show percentage export changes in terms of volume (gold) and value (teal) for Russia and Ukraine with respect to 2020 in the three different scenarios. Top panel: base conflict scenario. Mid panel: w/ reduced Armington elasticities scenario. Bottom panel: w/ full Armington elasticities scenario. Source: authors.

Bilateral international trade

Base conflict scenario Figure 7 in the top panel depicts changes in bilateral cereals' trade shares with respect to 2020. Here, we identify four main changes. Firstly, the strong reduction of cereals' bilateral trade originating from Russia and Ukraine is more evident in the EU (an overall reduction of 0.02), MENA (-0.06), ET region (-0.06), SSA (-0.09), and South Africa (-0.02). Moreover, several Asian countries are affected by a reduction in cereals' trade with Ukraine (on average a reduction of 0.03 with respect to 2020) and at a lesser extent few countries, such as Indonesia, South Korea, and Rest of Asia experience a reduction of imports from Russia as well (-0.03). The American continent is almost unaffected except Mexico that reduces its bilateral cereals' trade from Russia by -0.01. Secondly, to compensate the reduction of Russian and Ukrainian cereals' imports, EU region increases its bilateral share of cereal trade from India (0.09), China (0.08), Brazil, Paraguay and LAC countries (overall +0.05), Indonesia (0.05), SSA (+0.04), Türkiye (+0.02), MENA (+0.02), and Rest of Asia (0.01). Moreover, intra-EU bilateral cereal trade slightly increases (+0.02). However, EU subregions have differentiated trends; while Northern and Western Mediterranean countries increase more extra-EU cereal trade (+0.12) than intra-EU trade (+0.01), Eastern Mediterranean and Eastern EU countries have more balanced shares of intra- and extra-EU cereal trade, i.e., 0.06 and 0.09 respectively. Moreover, Northern EU increases its intra-EU trade by 0.06 towards all EU subregions. Thirdly, bilateral cereals' trade from the American continent towards Asia diminishes (overall -0.08) with a more pronounced fall for imports from the US in China (-0.01), Japan (-0.02) and South Korea (-0.01).In details, the share reduction towards Asia is primarily led by falls in bilateral trade from the US, Argentina, and Brazil (overall -0.08) that are not completely offset by the increase in the share of imports from other LAC countries (+0.01). Fourthly, SSA cereals trade share improves in nearly all countries (overall +0.1), as well as Chinese and Indian shares (+0.04 and +0.02, respectively). The top panel of Figure 8 depicts how shares of bilateral trade in energy products change with respect to 2020. In the base conflict scenario bilateral energy trade is polarised along three main axis. Firstly, Russian energy products exports decline towards the EU, Ukraine and Japan. Reasons for these reductions vary; while the EU and Japan do not import due to imposed sanctions, Ukraine reduces its imports because of the reduction in domestic production as an immediate consequence of the capacity disruption due to the conflict. At the same time, Russian exports towards other countries increase. In particular, Russian shares of energy trade towards neighbouring

CIS countries and Kazakhstan increase by an overall 0.05, towards Middle East (i.e., Türkiye, MENA, and ET region) by 0.06. Moreover, Russia mainly increases its exports towards China such that the bilateral trade share increases by 0.17. Growth in Russian exports towards other Asian countries, such as South Korea, Taiwan, Thailand and Rest of Asia is modest, with the overall bilateral energy trade share rising by 0.13. Secondly, energy trades towards the EU diverts with new imports' origins to compensate the reduction in Russian imports. The EU imports from different regions worldwide. Imports shares, indeed, grow from EFTA countries by 0.05 (mainly towards Northern EU due to the geographical proximity of the trading partners), from the American continent by 0.07 (mainly from the US and other LAC countries), from CIS countries and Kazakhstan by an overall 0.1, and finally from MENA (+0.23), ET region (+0.03), and SSA (+0.09). Thirdly, MENA and SSA reduce their energy trade share in Asia (-0.23) as a direct consequence of the region's increasing trade with Russia.

W/ reduced Armington elasticities scenario Figure 7, bottom left panel, depicts changes in bilateral trade shares of cereals with respect to 2020. In this scenario changes in cereal trade with respect to 2020 are modest and higher increases in bilateral trade shares (higher than 0.04) concentrate in five directions. Firstly, similarly to the base conflict scenario, Russian and Ukrainian cereals' trade falls. Secondly, there is an increasing cereal trade within the EU, where the increase is not limited to exports from Northern EU (as in the base conflict scenario) but also Western Mediterranean and Eastern EU countries' shares rise. Thirdly, MENA, and at a lesser extent ET region and SSA, raise its imports from sources other than belligerents. Differently from the base conflict scenario, imports increase from the American continent, as well as from India and Australia. Fourthly, several Asian countries, such as South Korea, import more from South America, or from the US, such as Thailand and Rest of Asia. Finally, Australia increase exports towards MENA, ET region, SSA and few Asian countries. Figure 8, bottom left panel, illustrates how bilateral shares of energy trade change with respect to 2020. There are no significant modifications in bilateral trade with respect to the base conflict scenario.

W/ full Armington elasticities scenario Figure 7, bottom right panel, illustrates how bilateral shares of cereals' trade change with respect to 2020. In this scenario there are not significant changes in bilateral cereals' trade shares with respect to the w/ reduced Armington elasticities scenario. Main hotpots remain unchanged but there

are several shares increasing between 0.02 and 0.04, such as intra-EU trade. Figure 8, bottom right panel, graphically presents how bilateral shares of energy trade change with respect to 2020. Similarly to cereals' bilateral trade, there are not significant changes with respect to the previous scenario. Slight increases (around 0.02) are recorded for energy bilateral trade originating from Asian countries, such as India, South Korea, and Rest of Asia, towards the US and Eastern EU.

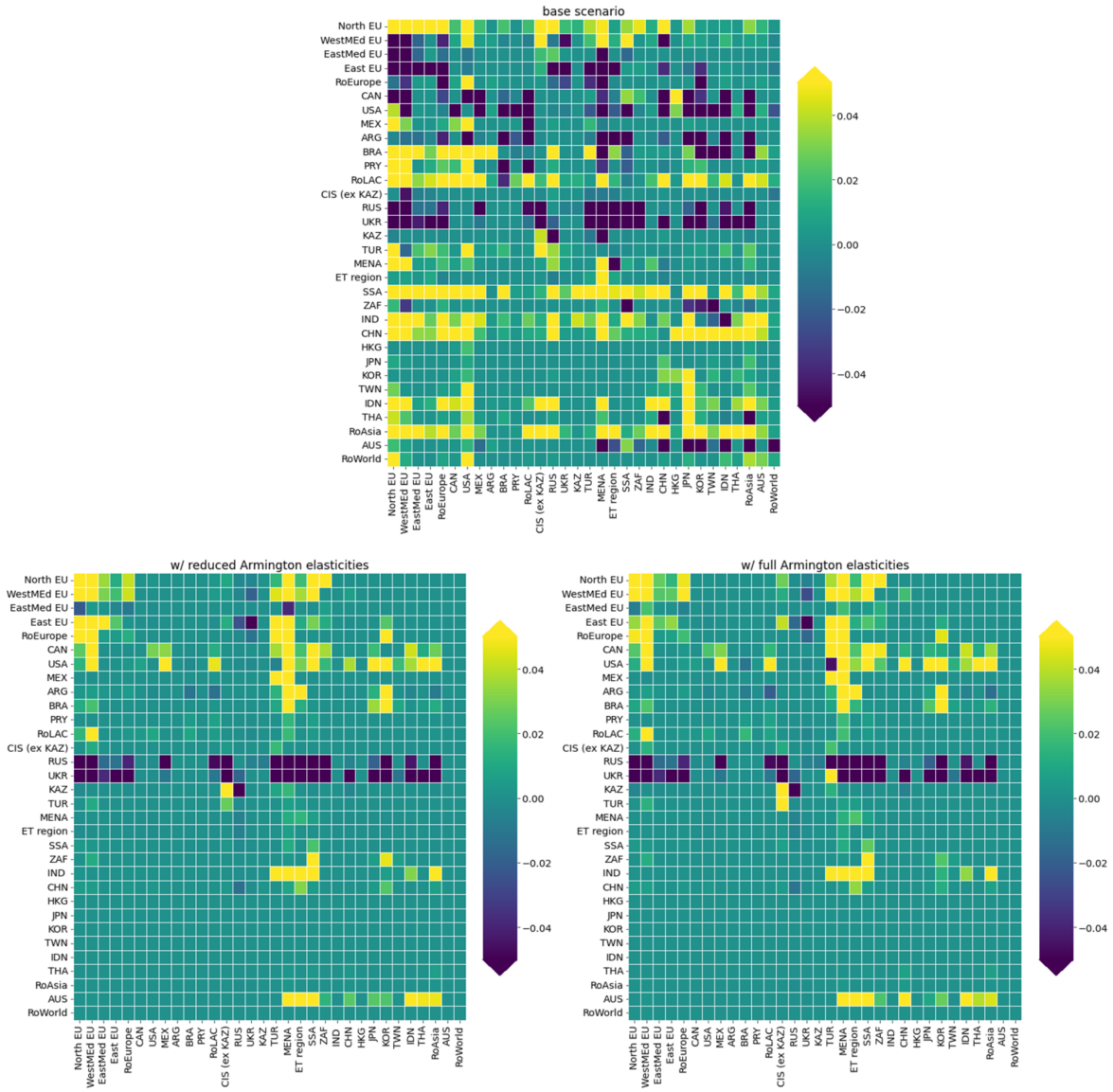

Figure 7: The heat map shows changes in cereals' bilateral trade shares with respect to 2020 in the three different scenarios. x-axis shows destinations of cereals' bilateral trade; y-axis shows origins of cereals' bilateral trade.Top panel: base conflict scenario; Bottom left panel: w/ reduced Armington elasticity scenario; Bottom right panel: w/ full Armington elasticity scenario. Source: authors.

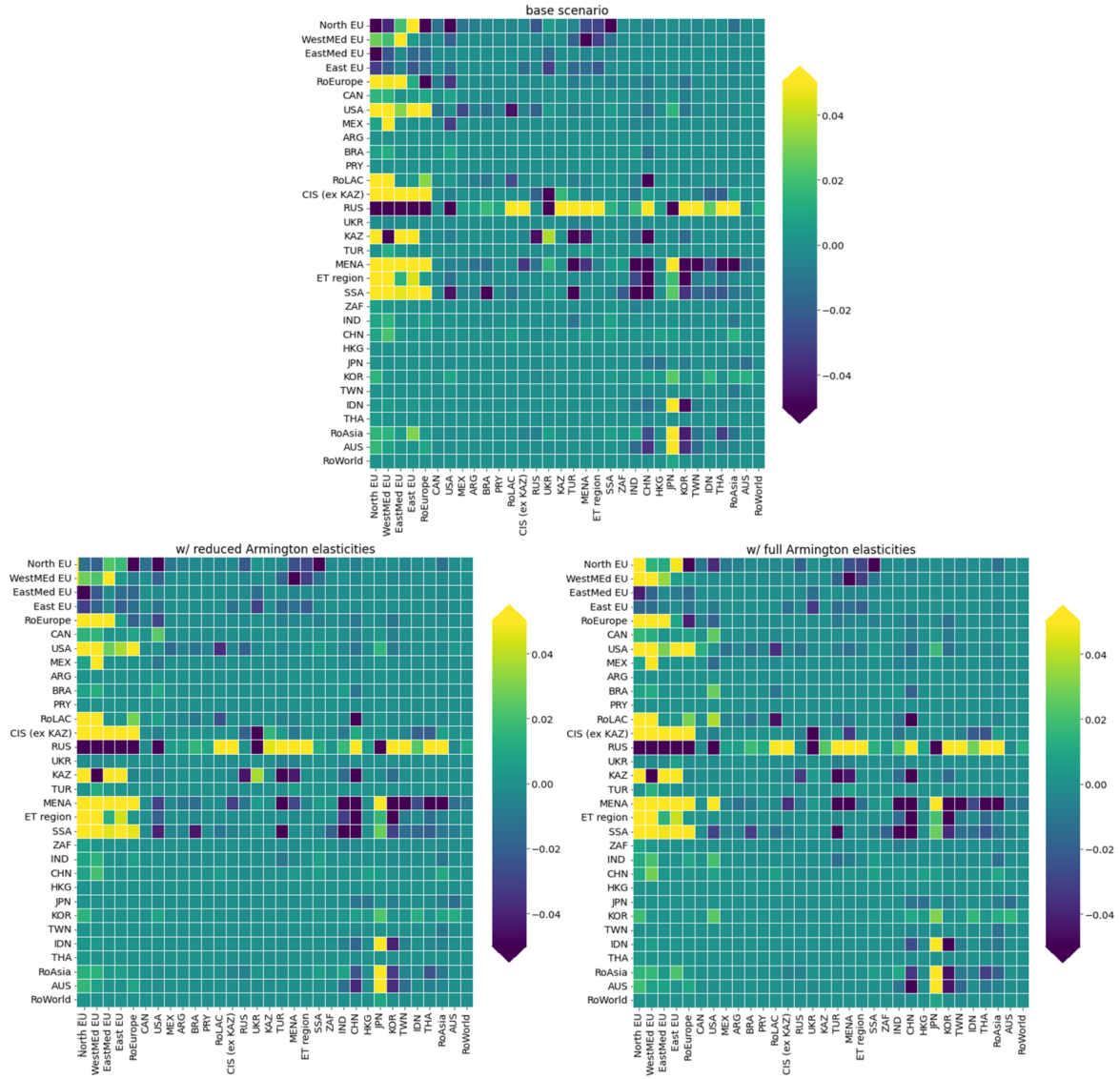

Figure 8: The heat map shows changes in energy products' bilateral trade shares with respect to 2020 in the three different scenarios. x-axis shows destinations of energy products' bilateral trade; y-axis shows origins of energy products' bilateral trade. Top panel: base conflict scenario; Bottom left panel: w/ reduced Armington elasticity scenario; Bottom right panel: w/ full Armington elasticity scenario. Source: authors.

2.2 Complementary financial results

Results underpinning the financial market analysis are presented in the following paragraphs. These include data on commodity markets overreaction (from price increases and the event study), which underpin the finance amplification case, and company-level and portfolio-level shocks propagation for both the base and finance amplification cases.

Commodity markets Commodity price reactions are heterogeneous on event day (February 24, 2022), as illustrated in Figure 9. Gas prices are most affected, followed by coal, wheat, palm oil, corn, and oil products. Oil, precious metals, softs (e.g. coffee, cocoa, sugar, etc.), cattle, hogs, and rice show limited price movements on event day. Most of the large price increases on event day undergo a partial price reversal on post-event day, largely due profit taking behavior (see Figure 10). The decrease was nevertheless short-lived as prices started to rise dramatically again the week after, reaching new highs (see Figure 11). Some notable facts shall be observed about the price increases from February 28th onward. First, US gas prices increase but much less than European and UK gas prices, and less than oil. This is true for the Henry Hub[1] and the other pricing points considered in this study.[2] A key reason is the lower dependence on Russian exports. In fact, most of the volatility at the main pricing points seems to stem from weather variability[3] (e.g. at the Algonquin pricing point[4]. Differently, gas prices in Europe and the UK spike in early March and return to lower levels only in late March. Second, the movements of European gas prices differ significantly from those of oil prices. Figure 12 shows the timeline of return for future gas (at the Title Transfer Facilities (TTF)[5]) and

[1]The main pricing point for US gas and main reference for natural gas futures at the Chicago Mercantile Exchange (CME), see e.g. https://www.spglobal.com/commodityinsights/en/our-methodology/price-assessments/natural-gas/henry-hub-natural-gas-price-assessments

[2]Namely, spot prices at the Transco Zone 6 New York (SNL Energy US Natural gas Hub Day Ahead Prices Transco Zone 6 New York, code: NG-CG-NY-SNL), Chicago citygate (SNL Energy US Natural gas Hub Day Ahead Prices Chicago, code: NG-CG-CH-SNL), Algonquin citygate (SNL Energy US Natural gas Hub Day Ahead Prices Algon Gates, code: NG-CG-BS-SNL) and the Dominion South (SNL Energy US Natural gas Hub Day Ahead Prices Dominion South, code: NG-PCN-APP-SNL).

[3]Temperature changes have a strong impact on gas demand, thus on prices. See https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2022/02_24/ for details on natural gas price movements in the US in February ahead of the invasion of Ukraine.

[4]The Algonquin Gas Transmission serves New England, New Jersey and New York (see https://infopost.enbridge.com/infopost/AGHome.asp?Pipe=AG). For details on gas pricing and weather variations ahead of the invasion of Ukraine, see https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2022/03_03/

[5]The TTF is the most liquid and main pricing point for European gas, see https://www.naturalgasintel.com/ttf/

Brent prices[6], together with the main events, in the period between 22 February 2022 and 15 March 2022. We obtain information on the sanction timeline from the dashboard published by the Peterson Institute for International Economics.[7] Divergences in patterns are significant. Gas futures undergo significant price increases even before the start of the invasion, in light of the decision from Germany to stop the certification of Nord Stream 2[8]. On the day of invasion, the spike in TTF price is much larger than the one for Brent. Nevertheless it is important to notice that Brent futures reached a price of 105 USD/barrel in intraday trading. No immediate sanctions were announced on energy commodities, until February 27 when BP exited the joint venture Rosneft[9], followed by other energy and non-energy companies[10]. Following these events, the oil price increased significantly too, peaking on March 8th, at the same time of announcement of the US ban on Russian oil import (followed by the UK the day after). Despite this, prices started to fall only following announcements by the International Energy Agency (IEA) [3] and the Organization of Petroleum Exporting Countries including non-members producers (OPEC+) [11] about possibilities to release strategic reserves or increase production. At the same time, demand destruction, i.e. the reduction of demand caused by too high prices, also played a role in lowering oil prices.[12] Third, a similar dynamic can be observed in wheat markets, where the first week of March was characterized by a strong price increase which stabilizes, towards the mid of the month, on a lower-than-peak (but still higher than pre-war) level. The retreat from peak levels was likely the consequence of profit taking behavior (i.e. the decision from investors to sell a security that had a significant price increase to materialize a financial gain) combined with reluctance from buyers to purchase at extremely high prices[13]. Still, price remained high until deals to

[6]Brent is one of the major international oil benchmarks, from the North Sea (https://www.investopedia.com/terms/b/brentblend.asp).

[7]https://www.piie.com/blogs/realtime-economics/russias-war-ukraine-sanctions-timeline

[8]https://www.theguardian.com/world/2022/feb/22/germany-halts-nord-stream-2-approval-over-russian-recognition-of-ukraine-republics

[9]https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bps-position-in-russia.html

[10]For a list of companies that left Russia, or are currently operating there, see [2].

[11]https://www.reuters.com/business/energy/opec-oil-output-march-resumes-trend-lagging-pledged-hikes-survey-2022-04-01/

[12]https://www.bloomberg.com/news/articles/2022-03-24/jpmorgan-says-oil-demand-destruction-is-here-amid-ukraine-war

[13]https://www.reuters.com/article/europe-grains-idAFL5N2VB5ML

export Ukranian grains were reached in May 2022[14] and July 2022.[15]

We use an event study model to quantify the abnormal returns around event day, i.e. differences between actual and expected returns over a certain period. We select the event window from 5 trading days before to 5 trading days after the invasion. Results for the event study are presented in Table II and confirm the intuition from the price analysis conducted above. Non-US gas futures show large, positive and significant Cumulative Abnormal Returns (CAR), while US gas CAR and Abnormal Returns (AR) are not significant. Similarly, oil futures show some abnormal returns around event day (e.g. on t+1) but CAR are not significant. Coal shows large and positive CAR, and gasoil and heating oil show positive but mild CAR. For agricultural commodities, wheat shows the largest CAR though there are regional differences in magnitude between Europe and US (large CAR), on one hand, and China and South Africa (small CAR) on the other. CAR on corn are positive and significant, but smaller in magnitude than wheat, while some softs as well as cattle and hog show negative CAR. Other commodity futures do not show significant CAR. Overall, our analysis shows clear heterogeneity of CAR across commodities and, for the same commodity, across regions. This most likely stems from the dependence on a given commodity in a given region on Russian and Ukrainian supply.

Company-level shocks Sectoral and price effects lead to changes in equity valuation of companies. Companies operating in sectors and countries that gain (lose) in a given scenario will see their equity value increase (decrease). Thus, some companies will benefit from the crisis (e.g. fossil energy companies capitalizing on higher oil and gas prices) while others will be negatively affected (e.g. air travel companies operating many routes nearby the conflict zone).

Figure 13 shows the regional and sectoral shock hotspots. The top panel shows the average shock on companies' equity value in a given region using a cartogram. The chart highlights the disproportionate and heterogeneous effects of the crisis on companies in different regions. Ukrainian and Eastern European companies are mostly affected, following by companies in Russia and the rest of Europe. Companies in Africa, South and Central America suffer only mild equity losses on average. The effects on US and Asian companies tend to be minimal. The bottom panel illustrates the average shock by sector. Companies in the fossil energy sector are the largest winners, especially in the

[14]The EU solidarity lanes, https://transport.ec.europa.eu/news/european-commission-establish-solidarity-lanes-help-ukraine-export-agricultural-goods-2022-05-12_en

[15]The Black Sea Grain Initiative, https://www.un.org/en/black-sea-grain-initiative

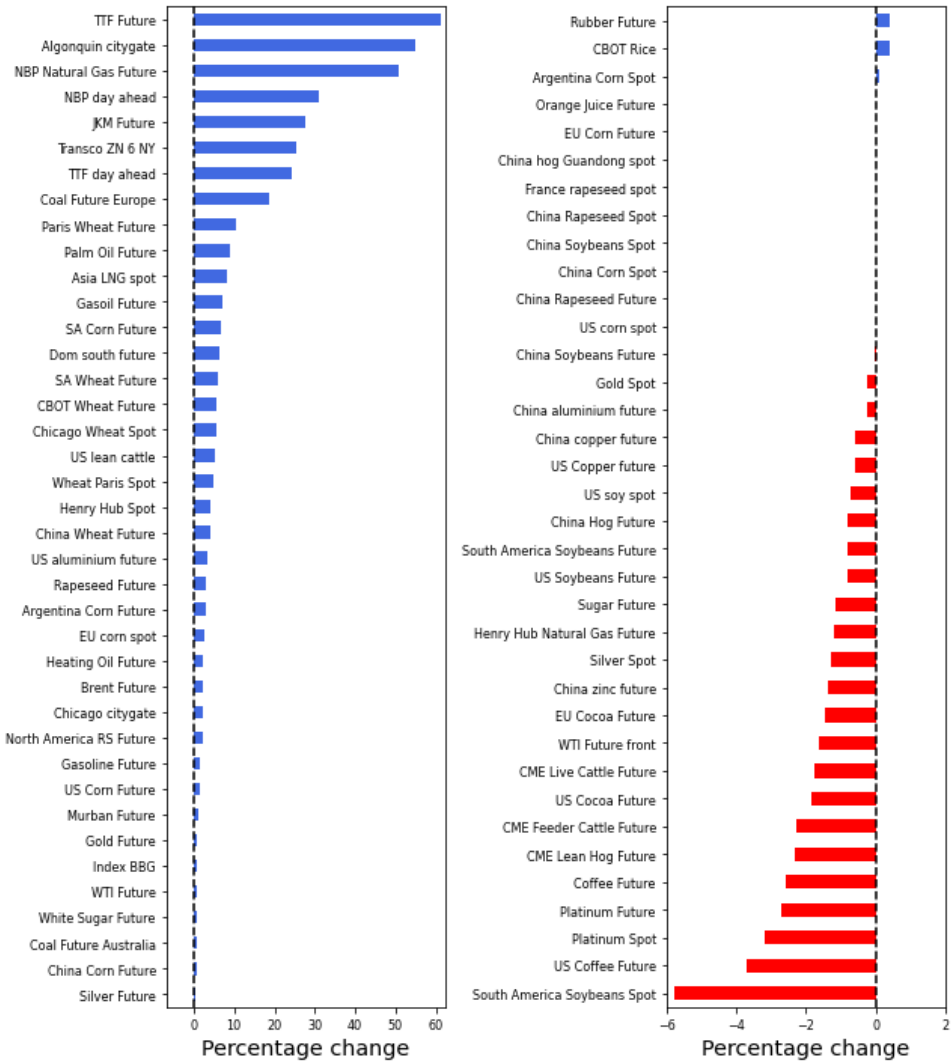

Figure 9: Percentage price changes on event day (24th February 2022). Horizontal axis: percentage change (note the different axis limit between the left and right panels). Vertical axis: commodity short names. Source: authors' elaboration on Refinitiv Eikon data.

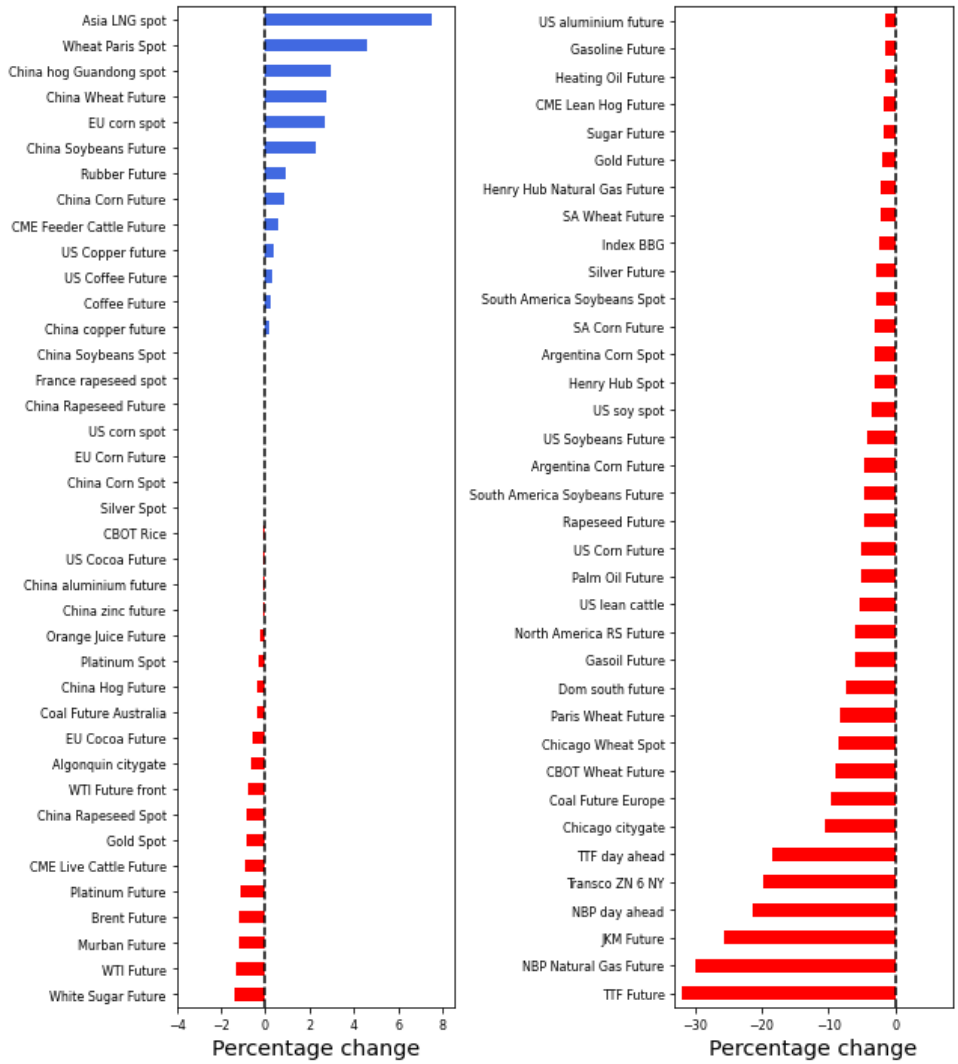

Figure 10: Percentage price changes on day after event day (25th February 2022). Horizontal axis: percentage change (note the different axis limit between the left and right panels). Vertical axis: commodity short names. Source: authors' elaboration on Refinitiv Eikon data.

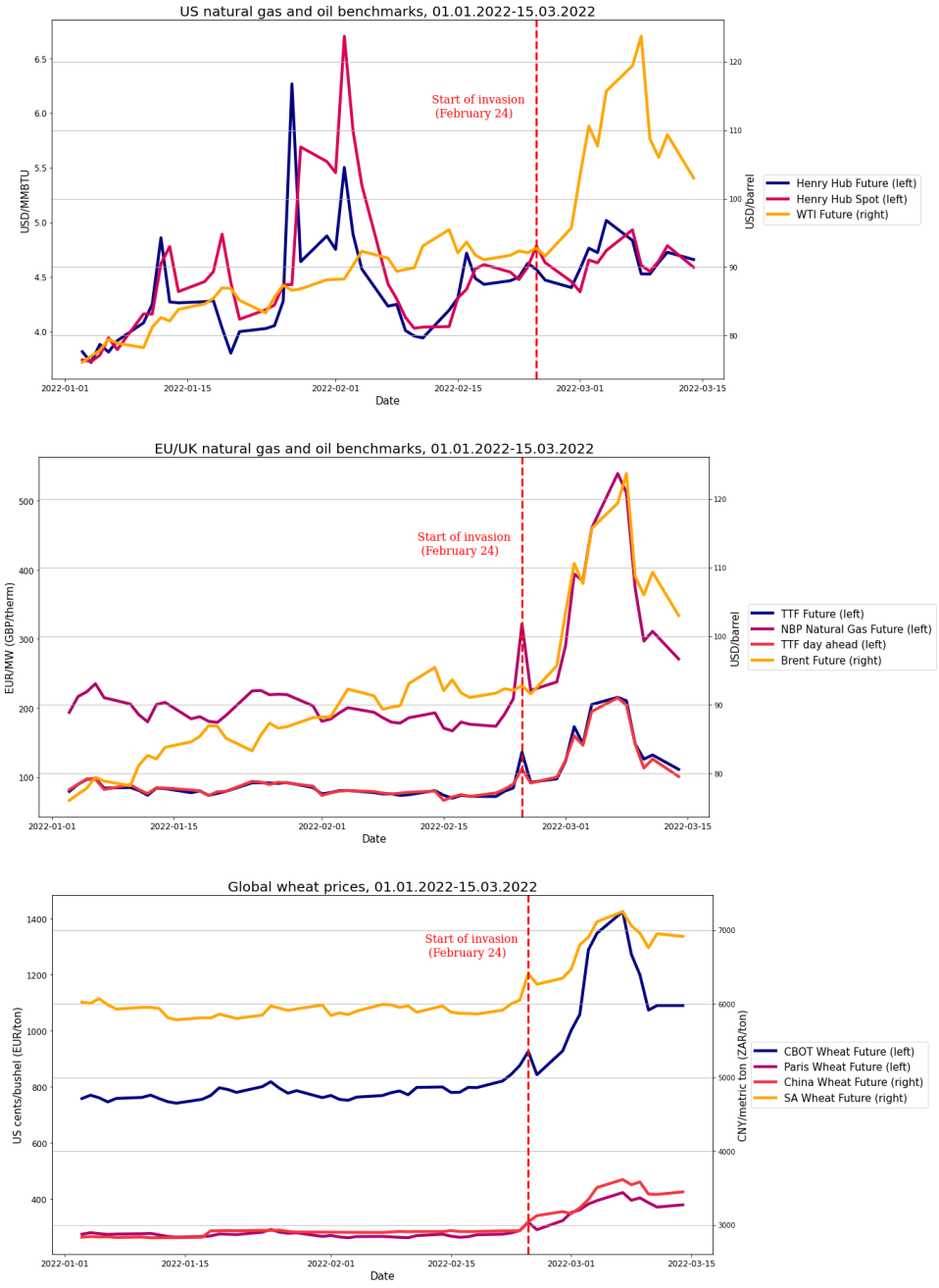

Figure 11: Time series of prices for selected commodities, 01.02.2022-01.04.2022. Top panel: WTI future, Henry Hub spot and futures. Vertical axis, left: prices in US dollar (USD) per million British Thermal Unit (MMBTU), applicable to Henry Hub spot and future contracts. Vertical axis, right: prices in USD per barrel, applicable to oil contracts. Horizontal axis: time (days). Mid panel: TTF, NBP and Brent. Vetical axis, left: euros (EUR) per megawatt (MW), for TTF future and spot; and British pounds (GBP) per therm, for NBP future. Vertical axis, right: USD/barrel, applicable to Brent prices. Horizontal axis: time (days). Bottom panel: Chicago, Paris, South African and Chinese wheat futures. Vertical axis, left: US cents per bushel, applicable to Chicago futures; and EUR per tonne, applicable to Paris futures. Vertical axis, right: Chinese Yuan (CNY) per metric ton, applicable to Chinese futures; and South African Rand (ZAR) per ton, applicable to South African futures. Horizontal axis: time (days). Source: authors' elaboration on Refinitiv Eikon data.

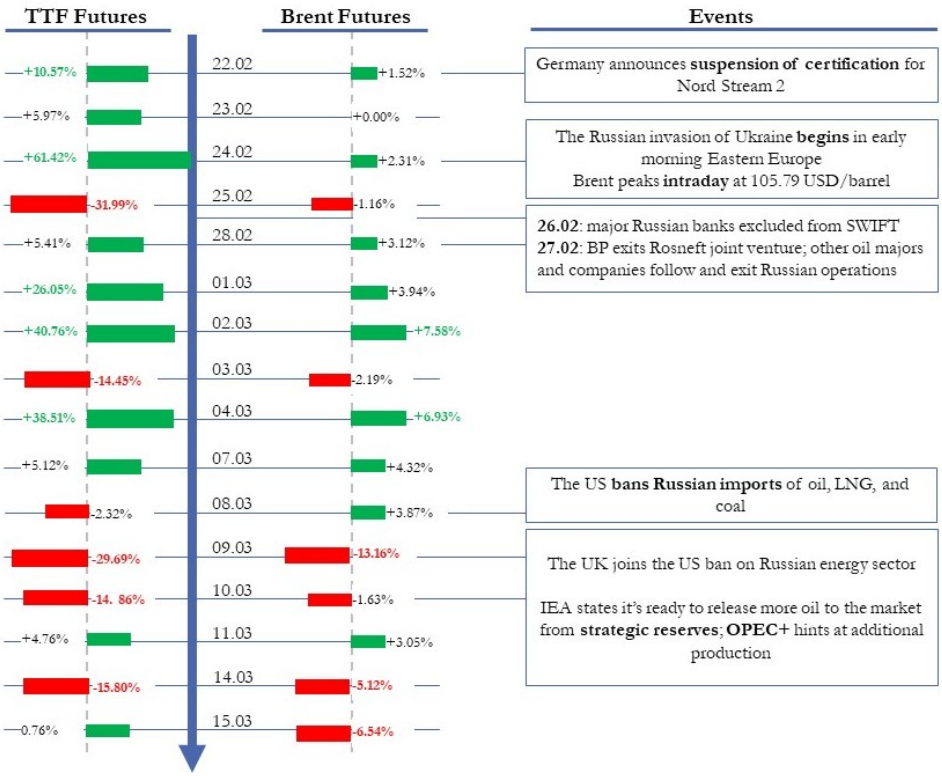

Figure 12: TTF and Brent price changes following event day. Left panel: daily future price changes in percentage. Right panel: list of selected event for given days. Source: authors' elaboration on Refinitiv Eikon data.

finance amplification scenario. On the contrary, companies in the electricity, agriculture, and transport sectors suffer negative shocks on average, with some companies reaching up to 80% losses on equity.

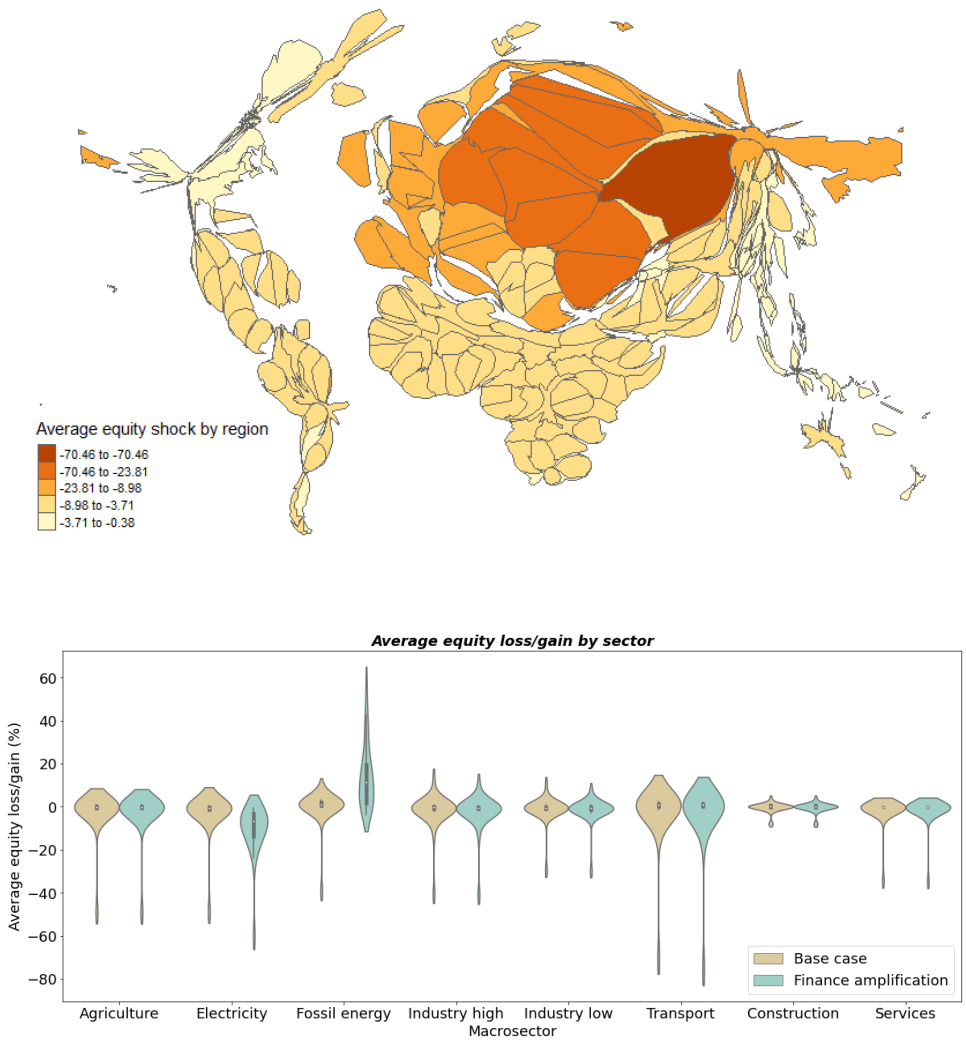

Figure 13: Top panel: cartogram of average company-level equity shock by region. Darker colors and areas indicate larger losses. The cartogram is obtained using the rubber sheet distortion algorithm for continuous area cartograms [4] as implemented in the R package *Cartogram* [5]. Bottom panel: violin plot showing the (estimated) distribution of average equity losses/gains for companies in a given macrosector. The distributions are estimated using a kernel density, which enables to estimate the distribution of a random variable using kernels. Source: authors.

Portfolio-level shocks The effects of equity revaluation cascade from companies to investors' portfolios. In the four upper panels of Figure 14 we show the portfolio loss/gains trends by macrosectors, as a function of the invested portfolio share, for the base and

finance amplification cases. Four salient trends shall be noted here. The electricity macrosector shows a flat or negative trend, due to increases in gas prices.[16] Thus, investors with portfolios largely exposed to electricity companies tend to experience larger losses in the finance amplification case. The opposite is true for the fossil energy macro-sector, where investors with larger fossil portfolios largely benefits from gas (finance amplification case) price increases. Thus, the impacts in the finance amplification case go beyond the production effects of the base case, flagging amplification mechanisms from the price overreaction, especially in the short run. Portfolios highly invested in the transport sector trend to losses as well, due to high dependency on oil and gas. In fact, losses are more severe when considering the amplification case. Lastly, mildly negative trends, with no significant distinction between scenarios, can be observed in industry and construction, while no trend can be detected for services.

In the two bottom panels of Figure 14 we show the trends in portfolio losses and gains by region. We highlight a negative trend for European exposure and a positive trend for exposure to countries in the Western Block. Thus, portfolios with larger exposure to Western block countries are more resilient, while portfolios with larger exposure to European countries suffer larger losses. Portfolios with larger exposures to Russia and Ukraine also tend to perform worse, while the performance trend is unclear for not-aligned countries. There are little differences between the the base case and the finance amplification case at the regional level.

[16]Reliance on gas for electricity production is relatively high in the cost structure of the ICES model, at 16.40% on average, with a maximum of 55.84%. Importantly, we assume the costs of electricity are not further passed down to users as increased prices, thus leading to large losses for electricity companies.

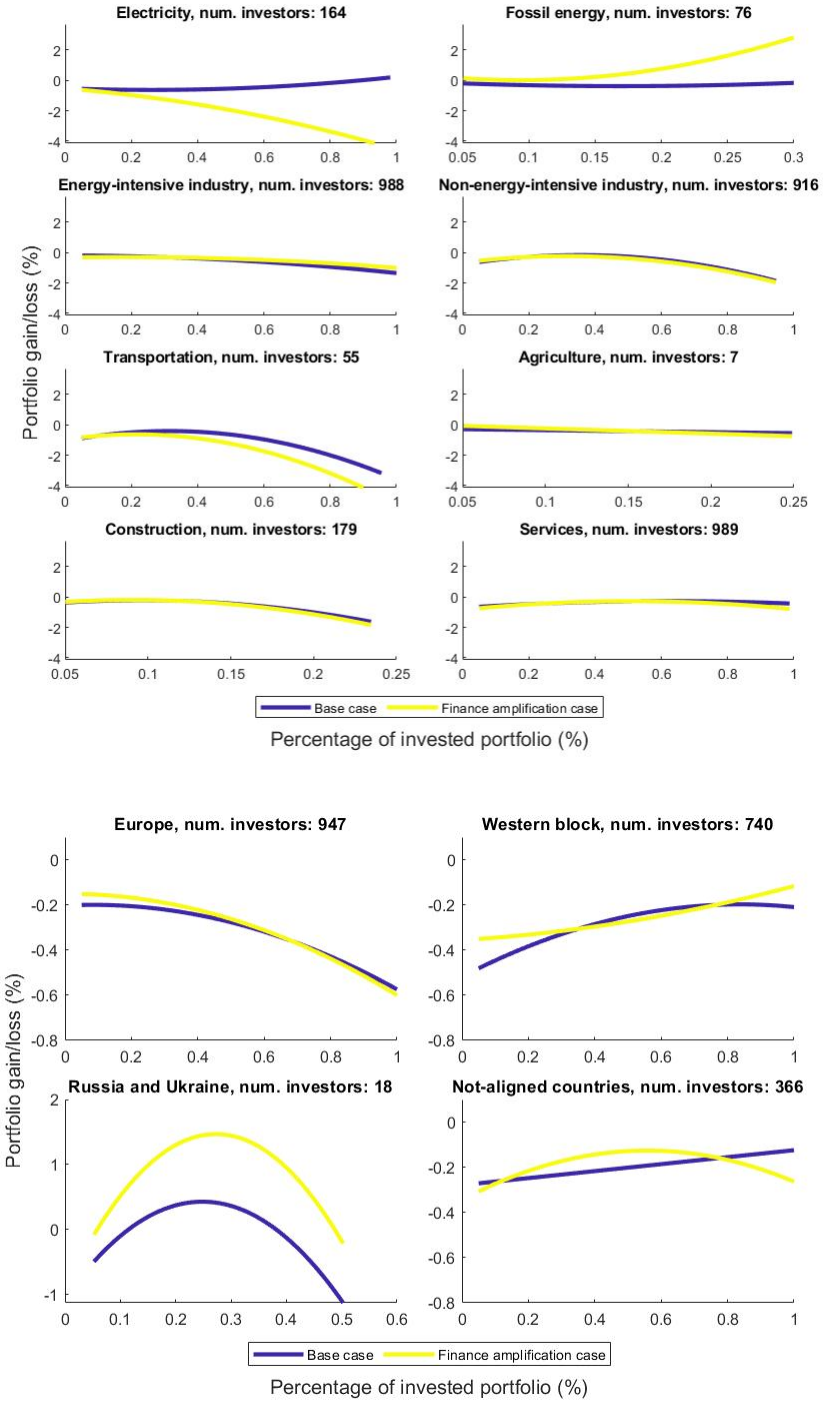

Figure 14: Trend of portfolio gains/losses by macrosectors (upper four panels) and region (bottom two panels) conditioned to the base case (blue) and the finance amplification case (yellow), depicted in the vertical axis. Horizontal axis: exposure of the portfolio to the macrosector/region, computed as share of portfolio invested in companies in the macrosector/region. The trend is computed as a second-order best-fitting trend to the scatter plot of individual investors' pairs for exposure-gain/loss. The number of investors' portfolios (points) used to compute the trend is indicated in the subtitles of the charts (e.g. "electricity": 164 investors' portfolios). Note that the trend for agriculture is linear instead of parabolic, due to the very low number of investors.

Commodity Type	Contract short name	AR t+0	CAR t+5
Grain & oilseed	CBOT Wheat Future	0.0508***	0.4466***
Grain & oilseed	Paris Wheat Future	0.0945***	0.3335***
Grain & oilseed	China Wheat Future	0.0399***	0.1312***
Grain & oilseed	SA Wheat Future	0.0591**	0.1761*
Grain & oilseed	US Corn Future	0.0113	0.0905**
Grain & oilseed	Argentina Corn Future	0.0261**	0.1453***
Grain & oilseed	SA Corn Future	0.061***	0.03
Grain & oilseed	EU Corn Future	-0.0021	-0.0233
Grain & oilseed	US Soybeans Future	-0.0135	-0.0062
Grain & oilseed	South America Soybeans Future	-0.013	-0.0077
Grain & oilseed	Rapeseed Future	0.0256	0.0796
Grain & oilseed	North America RS Future	0.0172	0.0322
Grain & oilseed	CBOT Rice	0.0015	0.0457
Grain & oilseed	Wheat Paris Spot	#N/A	#N/A
Grain & oilseed	Chicago Wheat Spot	0.0517***	0.3145***
Grain & oilseed	Argentina Corn Spot	-0.0032	0.1278***
Grain & oilseed	South America Soybeans Spot	-0.063***	-0.0556
Grain & oilseed	France rapeseed spot	#N/A	#N/A
Grain & oilseed	US soy spot	-0.012	-0.0175
Grain & oilseed	US corn spot	#N/A	#N/A
Grain & oilseed	EU corn spot	#N/A	#N/A
Key commodities index	Index BBG	#N/A	#N/A
Livestock	CME Live Cattle Future	-0.0198**	-0.0566**
Livestock	CME Feeder Cattle Future	-0.0238**	-0.0802**
Livestock	CME Lean Hog Future	-0.0251	-0.0214
Livestock	US lean cattle	0.0564	-0.0228
Oil	Brent Future	0.0116	0.0195
Oil	WTI Future	-0.0048	-0.0082
Oil	Gasoil Future	0.058**	0.1273*
Oil	Gasoline Future	0.0054	0.0714
Oil	Heating Oil Future	0.0127	0.0752
Oil	Murban Future	-0.0019	0.0198
Power complex	NBP Natural Gas Future	0.4026***	0.7278**
Power complex	Henry Hub Natural Gas Future	-0.0292	-0.2067
Power complex	Coal Future Australia	-0.0006	0.3565*
Power complex	TTF Future	0.4718***	0.6747**
Power complex	JKM Future	0.2393***	0.5699**
Softs	White Sugar Future	0.0043	0.0384
Softs	Sugar Future	-0.015	0.0028

TABLE II: Abnormal returns for commodities in the study on event day $(t+0)$ and cumulative abnormal returns for the $[t-5, t+5]$ event window. * = statistical significance at the 10% level, ** = statistical significance at the 5% level, *** = statistical significance at the 1% level. "#N/A" denotes commodities for which it is not possible to compute the CAR due to lack of data around event day. Source: authors.

2.3 Complementary food affordability results: affordability pre-war

Food affordability declined already before the Ukraine crisis, e.g. due to the COVID-19 pandemic. Thus, any price increase puts additional stress on people that were unable to provide the expenses in first place. According to our food affordability analysis a calorie sufficient diet was unaffordable for 140 - 360 million people (see Figure 15). The range stems from a lower bound estimate based on individual income levels and a upper bound estimate based on country income groups following the approach from the FAO in [6]. This means that pressure on these people was already high before the conflict started and the food inflation further increased it. A healthy diet, which is especially important for children and women at reproductive age was not affordable for 1.9 - 3.2 billion people at pre-war prices. Countries in Sub-Saharan Africa are most affected for both diets with shares higher than 80%. Below in figures 15 and 16 we show the percentage of the population that could not afford the respective diets already before the war.

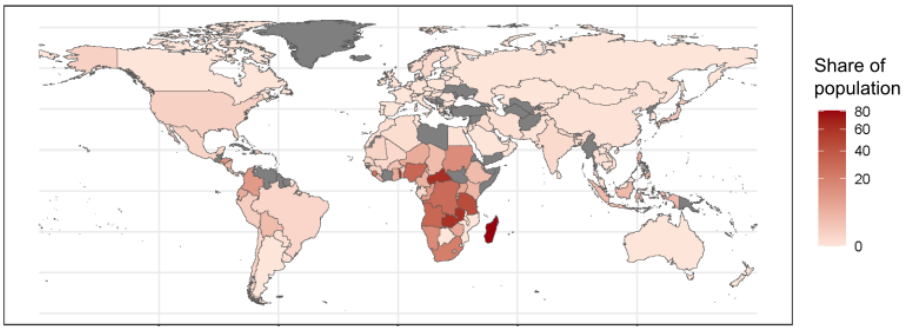

Figure 15: Share of population that could not afford a calorie sufficient diet before the war (color grey: no data available; map: Mercator projection). Source: authors

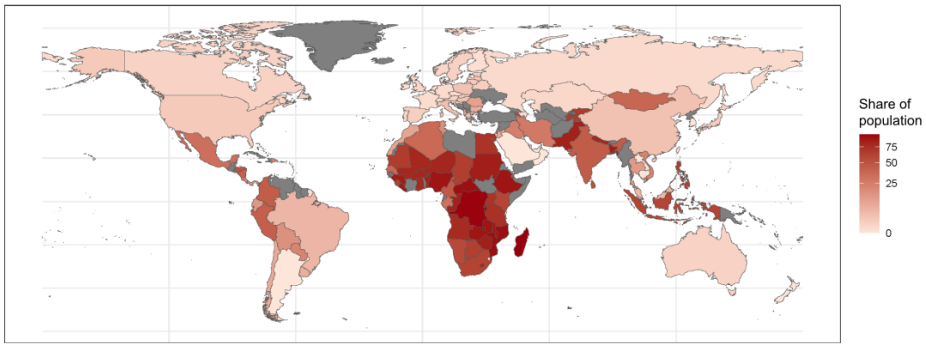

Figure 16: Share of population that could not afford a healthy diet before the war (color grey: no data available, map: Mercator projection). Source: authors

3 Complementary reality checks and limitations of models

We validate our results against real data as of one year after invasion. Many economic circumstances have changed between the start of the invasion and the time of writing. These include, for example, the monetary tightening from the US Federal Reserve, started in March 2022, or the policy efforts from the European Commission to counteract the negative effects of the invasion, to name but two. Hence, it is not possible to fully isolate the impacts of the invasion in the real world in the same way as we did in our modeling framework. Nevertheless, we aim to ensure a general consistency of our results with reality. Our reality checks are summarized in Table III.

Sector	Macro-sector	Region	Model effect	Real effect	Comment
Macro	Agriculture/ Redistribution of imports	World	Increase ⬆	Increase ⬆	Although a different geographical aggregation the model captures the redistributional dynamics and the same change in trade direction (e.g. bilateral trade of wheat redirected from Latin America to Sub-Saharan countries)
Macro	Agriculture / Prices	World	Increase ⬆	Increase ⬆	highest price peaks were reported for cereals. The model captures the dynamic and the ranking thus cereal prices show the highest increase

Macro	Agriculture / Substitution across food products	World	Mild ⇨	Increase ⇧	Due to the increase in several food commodities trade diverted towards other commodities (e.g. from wheat to rice). However given the model sectoral aggregation this effect is moderate
Macro	Industry / Exports	Russia	Sub-sectoral hetero-geneous decrease ↘	Decrease ⇩	Due to the scenario setting and the choice of sanctioned sub-sectors this decrease is led by the oil product and the chemical sub-sectors. Conversely, official data show the reduction was mainly caused by a downfall in electronics, equipment and machinery
Macro	All sectors / Exports	Russia	Decrease ⇩	Decrease ⇩	The model correctly suggests a decline in Russian exports towards the US, Northern and Eastern EU
Macro	All sectors / Exports	Russia	Increase ⇧	Increase ⇧	The model correctly suggests an increase in Russian exports towards China, India, and Türkiye
Macro	Agriculture /Cereal exports	Ukraine	Decrease ⇩	Decrease ⇩	The model captures the reduction of Ukrainian exports in cereals
Macro	Agriculture / Cereal prices	UE	Increase ⇧	Increase ⇧	The model captures the increase in cereal price. Given the different regional aggregation the model identifies differentiated increases in prices
Finance	Fossil energy	World	Increase ⇧	Increase ⇧	Higher oil and gas prices led to higher profits for fossil firms; similarly, oil- and gas-linked ETFs recorded significantly positive returns in 2022 in the US, Europe, and the sector as a whole. Previous studies [7] also found positive effects on the sector. See also Paragraph Fossil energy.
Finance	Air transportation	World	Decrease ⇩	Limited and hetero-geneous decrease ↘	Higher oil products prices, as well as changes to or closure of routes led to heterogeneous, but generally mildly negative, effects on air transport firms, especially in Europe, and the sector as a whole. Previous studies [8] also found negative effects on the sector. See also Paragraph Air transportation.

Finance	Water transportation	World	Decrease ⬇	Decrease ⬇	Disruptions in the Black Sea and globally, including higher shipping cost, risk of stranding crews and vessels, and sanctions on Russian vessels led to generally negative, but heterogeneous, sector performance. See Paragraph Water transportation.
Finance	Electricity	World	Decrease ⬇	Mixed ➡	The performance of the electricity sector varied by region and type of producer (renewable vs. non-renewable). See also Paragraph Electricity.
Finance	All sectors	EU	Decrease ⬇	Decrease ⬇	Literature has highlighted much more pronounced effects on Europe than elsewhere (see e.g. [9]). The negative performance of the EURO STOXX index (-14.38% in 2022, -9.18% in Q1-2022) further supports this view.
Finance	All sectors	US	Mild ➡	Mild ➡	The literature highglighted a milder reaction of US markets to the crisis (see e.g. [7]). Despite this, financial markets in the US registered a negative performance in 2022 (e.g. NYSE Composite Index -11.53% and SPDR S&P500 ETF Trust -19.48%).
Finance	All sectors	Russia	Mild ➡	Decrease ⬇	Russian companies have suffered large losses from the crisis as investors and companies fled the Russian market. This is a discrepancy with our study, stemming from scenario assumptions as we did not consider large withdrawal of funds from Russian companies in our set-up.
Food	-	Sub-Saharan Africa	Decrease ⬇	Decrease ⬇	Decrease of food security 2021 - 2022: minimum 12.8 mio more people food insecure, with IPC levels larger than three[17]) (Central & Southern Africa[18] 1.8 million, West Africa, Sahel and Cameroon[18] 11 million, East Africa[18] the highest level of acute food insecurity since GRFC records [10].)

[17]IPC acute food insecurity classification with classifying units (3) Crisis, (4) Emergency, (5) Catastrophe/Famine. Source: https://www.ipcinfo.org/ipcinfo-website/ipc-overview-and-classification-system/ipc-acute-food-insecurity-classification/en/

[18]Region classification source [10]

Food	-	MENA	Decrease ⬇	Decrease ⬇	Decrease 2021 - 2022: 2,2 million more people food insecure (IPC levels larger than three[17]) [10]
Food	-	Euphrates & Tigris	Decrease ⬇	Mixed ↘	Highly affected by worsening conditions due to rampant inflation. Iraq situation better then identified by our analysis, but additional funds by government for food price stabilization (0.4 million people less food insecure) [10, 11]
Food	-	Latin America & the Carribean	Decrease ⬇	Decrease ⬇	Worsening food insecurity of Dominican Republic and Honduras, Haiti, Guatemala [10] Note: Guatemala not identified by our analysis, Haiti excluded due to data gaps
Food	-	Rest of Asia	Decrease ⬇	Decrease ⬇	Worsening food insecurity of Afghanistan, Myanmar and Pakistan [10, 12]. Afghanistan and Myanmar excluded due to data gaps

TABLE III: Reality checks by sector (macroeconomic, finance, food). The results are specified by macrosector (see Table VII) and region (see Table IX). Fourth and fifth column describe the model and real effect respectively. Last column ("Comment") briefly discusses the reasoning behind the agreement or disagreement of the model results and reality. Source: authors.

3.1 Reality checks for macro variables

Generally, our macroeconomic results are supported by what happened during the the first year since invasion in terms of processes (i.e., redistribution of trade patterns for commodities with higher substitutability, change in trading partners to close the supply gap due to the invasion and subsequent conflict, price spikes in the agricultural and energy sectors).

Trade patterns Similarly to what the World Trade Organization (WTO) states [13], the CGE model results show a re-composition of trade for agricultural commodities with a high number of suppliers, such as cereals. Indeed, WTO takes as an example Ethiopia, whose imports were redirected from Ukraine and Russia (previously providing 45% of its imports) towards the US and Argentina, ICES results show a similar patterns for the Sub-Saharan region that imports more from US and Latin American countries after the conflict. Similarly, several cereals show a higher substitutability with other agricultural products. In ICES this trend is evident for wheat imports that are partially redirected towards rice. Total Ukrainian exports (in value) dramatically falls by 70% (-33% according to [14]) with a -9.5% contraction in cereals (while official data recorded a -28% short-

age). Russian exports decline less (i.e. -19%) although [13] argues that Russian exports increased in value terms remaining almost unaffected in volume. While ICES results quantify higher losses for the two countries, the model agrees with official data that the conflict has a more detrimental impact on Ukraine than on Russia. On the import side, Russia and Ukraine both saw a substantial decrease in 2022 (official statistics reported -29% and -23%, respectively [14]), similarly to ICES whose results show a reduction by 30% and 75%. Considering trading partners, several Western countries, such as the US, UK, and the EU reduce their imports from Russia between 29% and 74% according to ICES results. In particular official statistical data report that EU import value from Russia declines nearly 50% during the first year of war [19]. Similarly, the US reduce their imports by 70% [20] and the UK by almost 51% [15]. In the meantime China, India, and Turkey expand their Russian imports between 28% and 79% according to ICES results. Official data state a +41% increase in Chinese imports from Russia [16], a +90% for Indian imports [17], and a 107% for Turkish imports [18]. At the world level, ICES trade in energy products shrinks by 5%, almost the same amount as the 7.6% decrease reported by official data [13], World trade in agricultural products is supposed to shrink by 4.6% with respect to 2020 according to ICES results. Data from [14] report a downward trend in growth rates of global trade in agricultural products reduced from 18.7% in 2021 to 8.2% at the end of 2022.

Price trends Globally, the highest increases in prices occurred for agricultural products, such as wheat, grains and oil seeds; ICES outcomes confirm strong effects on agricultural product prices despite quantitative differences (for instance, ICES projection on maize price has a 17% peak, closer to the +18% growth in cereal price index reported in [19] than to the 24% increase in the maize price as in [13]).At the regional level, instead, ICES projects cereal prices increase in the EU with a peak of 15% in 2022 (while official statistics state nearly a 25% increase [20]. Price dynamics in ICES are not linked with the expectations of the financial system, which frequently leads to an underestimation of price increases.

3.2 Reality checks for company and portfolio financial results

In our results, we observed significant company and portfolio gains for fossil energy companies; company and portfolio losses for transportation companies, electricity companies,

[19] https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230504-2
[20] https://www.census.gov/foreign-trade/balance/c4621.html#2022

and European companies; and mild company and portfolio gains for US and Russian companies. We observe that these identified trends generally withstand a reality check. In summary, fossil energy companies recorded the highest profits ever in 2022, and Exchange Traded Funds (ETFs) related to fossil energy similarly showed strong performance. Air and water transportation ETFs and companies experienced mild and significant losses, respectively. Electricity companies showed a heterogeneous picture, with some companies suffering significant losses in line with our study but others benefiting from higher electricity prices passed on to consumers. Detailed references are given below. Note that Russian companies benefit in our framework because divestment from Russian financial markets in the aftermath of the invasion is not covered in our scenario assumptions.

Fossil energy We investigated whether, in reality, the fossil energy sector benefited from the crisis and indeed found evidence that this is the case. The increases in prices of oil and gas following the invasion have been substantial, thus leading to higher profits for oil and gas firms. For example, Saudi Aramco recorded the highest-ever profit by an oil and gas firm[21], while Shell reported one of the largest profits in UK corporate history.[22] Similarly, oil- and gas-linked ETFs (commodity and equity) experienced significantly positive returns in 2022. For example, the SPDR S&P Oil & Gas Exploration & Production ETF (ticker: SOP) a passive index which "seeks to replicate the performance of an index derived from the oil and gas exploration segment of a U.S. total market composite index" increased its price by +43.73% in 2022 [21]. The United States Oil Fund LP (ticker: USO), which "seeks to reflect the performance of the spot price of West Texas Intermediate light, sweet crude oil delivered to Cushing, Oklahoma", increased by +28.97% in 2022 [21]. Other oil-related US ETF shown similar performances.[23] In Europe, ETFs tracking the STOXX Europe 600 Oil & Gas also registered strongly positive performances.[24] Finally, the overall sector had a positive performance in 2022, according to the Refinitiv Global Oil & Gas Price Return Index, which raised by +27.09%.

[21] https://www.theguardian.com/business/2023/mar/12/saudi-aramco-161bn-profit-is-largest-recorded-by-an-oil-and-gas-firm

[22] https://www.theguardian.com/business/2023/feb/02/shell-profits-2022-surging-oil-prices-gas-ukraine

[23] E.g. the VanEck Oil Services ETF (ticker: OIH) and the ProShares Ultra Bloomberg Crude Oil (ticker: UCO), with performances of +64.49% and +39.71% respectively. Source: Refinitiv Eikon

[24] E.g., the iShares STOXX Europe 600 Oil & Gas UCITS ETF (ticker: SXEPEX.DE) registered a +23.98% return, and the Lyxor STOXX Europe 600 Oil & Gas UCITS ETF - Acc (ticker: LYXOIL.PA) registered a +29.53% return. Source: Refinitiv Eikon

Air transportation The transportation macrosector includes air transport, water transport, and other transport. Early assessment from the International Air Transport Association (IATA) highlighted that the war would have negative consequences on air passenger traffic, air cargo traffic, and jet fuel prices and fares [22]. Nevertheless, the scale of the consequences would likely be limited, due to the relatively low exposure of the global market to Russia and Ukraine. At the same time, negative effects would be geographically uneven, in light of e.g. physical proximity to Russia (thus, diversion of routes), fuel cost hedging practices, and participation in sanctions. For example, the share price of Deutsche Lufthansa AG (ticker: LHAG.DE) dropped sharply in March and June/July 2022 in relation to the war[25], although it subsequently recovered also in light of post-covid higher demand. On the contrary, the share price of Wizz Air Holdings PLC (ticker: WIZZ.BU) dropped 51.56% in 2022 and has not fully recovered to the time of writing [21]. An important factor in this decline is the prolonging war in Ukraine, due to the high exposure of the company to the country, as well as Russia and Moldova.[26] At the aggregate level, the US Global Jets EFT (ticker: JETS.K) also declined significantly in price in 2022. Finally, the overall sector had a negative performance in 2022, according to the Refinitiv Global Air Freight and Logistic Price Return Index, which lost 27.59%.

Water transportation The war also led to significant disruptions of the shipping industry in the Black Sea and globally. These include higher shipping costs, risk of stranding crews and vessels, and sanctions on Russian vessels.[27] Shipping ETFs also experienced losses in 2022, although with partial recovery by the end of the year in some cases.[28]

[25] https://investor-relations.lufthansagroup.com/fileadmin/downloads/en/financial-reports/annual-reports/LH-AR-2022-e.pdf

[26] https://wizzair.com/static/docs/default-source/downloadable-documents/corporate-website-transfer-documents/annual-reports/wizz_air-annual-report-and-accounts-f22_final---pwc-confirmed_061d7bd2.pdf

[27] https://unctad.org/news/war-ukraine-raises-global-shipping-costs-stifles-trade, https://www.agcs.allianz.com/news-and-insights/expert-risk-articles/shipping-safety-22-ukraine-war.html

[28] SonicShares global shipping ETF (ticker: BOAT.K), tracking "the performance, before fees and expenses, of the Solactive Global Shipping Index, which seeks to provide exposure to a global portfolio of companies engaged in the water transportation industry", lost only 6.60% in 2022, with recovery later in 2022 balancing significant losses from early 2022. On the contrary, Breakwave Dry Bulk Shipping ETF (ticker: BDRY.K), tracking "daily change in the price of dry bulk freight futures by tracking the performance of a portfolio consisting of exchange-cleared futures contracts on the cost of shipping dry bulk freight", lost 68.84% in 2022. Source: Refinitiv Eikon.

Electricity Effects on the electricity sector have been, in reality, heterogeneous and dependent on the circumstances of specific companies. In general, the electric utilities sector had a negative performance in 2022 according to the Refinitiv Global Electric Utilities Price Return Index (ticker: .TRXFLDGLPUELEC). Still, significant regional variations occurred, with the STOXX Europe Total Market Electricity index[29] losing 10.22% of its value, and the US correspondent, the S&P500 Electric Utilities[30] showing a positive performance. For individual companies, performance in 2022 depended mostly on the specific business model. For example, high renewable energy production improved performance (e.g. in the case of Iberdrola). On the contrary, high dependence on gas and regulatory risks worsened performance (e.g. EVN Group and RWE AG).

3.3 Reality checks for food affordability

In March 2022 the Food and Agriculture Organization (FAO) of the United Nations projected that between 8 million and 13 million [23] more people could become undernourished in 2022/23 as compared to 2021, which is in line with our results in the finance amplification case. Comprehensive official data for 2023 is not available to date, but several sources provide data for end of 2022, e.g. the Global Report on Food Crises (GRFC) [10], the Global Food Security Index ranking (GFSI) [12], and FAO's food security report [24]. Estimated numbers of people affected is not always provided, but where possible, we compare actual figures. In line with our results, Sub-Saharan Africa is strongly affected with at minimum 12.8 million more people experiencing food insecurity, with IPC levels larger than three [17]: Central & Southern Africa [18] 1.8 million, West Africa, Sahel and Cameroon [18] 11 million, East Africa [18] the highest level of acute food insecurity since GRFC records (no actual numbers of affected people given). The GFRC report [10] confirms that regions in Sub-Saharan Africa are severely impacted from the Ukrainian crisis, with partially soaring food prices, although local conflicts and climate extremes remain primary drivers of increased hunger. We could not include the food insecurity hotspots South Sudan, Zimbabwe, and Eswatini in our analysis as official diet prices [25] were not available for these regions. The numbers for food insecure people reflect complex settings that contribute to food insecurity. Other highly important factors were local conflicts and extreme weather impacts not covered by our analysis so our results might overestimate the contribution of financial markets. However, the 34000 additional people in

[29] https://qontigo.com/index/sxpelc/

[30] https://www.spglobal.com/spdji/en/indices/equity/sp-500-energy-sector/overview

Sub-Saharan Africa that we calculate without the amplification, strongly underestimate the real numbers [23, 24]. The Philippines, most affected within the ICES Region 'Rest of Asia' in our analysis, have been added recently to the GFRC report [10] as a "country of concern with data gaps". The report gives no numbers but describes a situation were hunger strongly correlates with poverty and the analysis of the GFSI confirms a worsening in food affordability [12] but gives no indication of the influence by the Russia-Ukraine conflict. Honduras and Dominican Republic are most affected in our analysis in the ICES Region 'Rest of LACA' (Latin America and Carribean) and, also in reality, [10] shows that for food security, both are most affected by economic shocks, with them having little fiscal means to counter food price shocks. Further reasons also were losses due to storms and hurricanes the years before. We could not include the hotspot Haiti as official diet prices [25] were not available.

For the affordability of a healthy diet it is harder to conduct a reality check, as to the best of our knowledge no recent data exists on how the situation has changed over time. Our analysis exhibits Rest of Asia as a hotspot with additional 94 million people not being able to afford a healthy diet. In the region, the food security situation has also worsened in reality. For Pakistan, which was identified as a hotspot in our analysis, the GRFC report [10] explicitly states "key nutrition challenges" hampering "access to healthy diets" as the first key driver. Again, we had to exclude hotspots like Afghanistan and Myanmar due to missing data. Furthermore, for the MENA region our analysis indicates that already due to the rather small inflation of the base case additionally 49 million people become unable to afford a healthy diet. The FAO report states that the increase in moderate or severe food insecurity from 2021 to 2022 was mostly due to moderate food insecurity, which is comparable with not being able to afford a healthy diet. Further, multiple sources [26, 27] alerted the potential of unrest due to heightened prices and compromises with nutrition. [10, 12] show that the Euphrates-Tigris region is affected by increased food insecurity. Unfortunately, our analysis could not be conducted for the hotspots Yemen, Syrian Arab Republic, Palestine, and Lebanon, as diet costs are unavailable. Iraq is affected in our analysis and also in reality. However, the country could dampen the effect in reality with state measures supported by increased profits from higher oil prices [12] that are no covered by our modeling framework.

4 Methods

4.1 Additional details on the macroeconomic model: the Computable General Equilibrium model ICES

The productive sectors For each productive sector, a typical firm maximizes its profits given a set of inputs (i.e. primary factors and intermediate inputs), the final output and the corresponding price. This means that factor remuneration (for capital,labour, and natural resources) equals their marginal costs based on endogenous relative prices. Consistent with Neoclassical theory, the production technology assumes constant returns to scale. Firstly, a capital/energy bundle is formed via a series of nested Constant Elasticity of Substitution (CES) functions which assumes substitutability among different energy sources, namely gas, oil, coal, petroleum products, and electricity from either fossil or renewable sources. The choice among primary factors (labour and natural resources) and the capital/energy bundle is achieved through a subsequent CES function. This specification allows to move from one combination of primary factors to another as a response in relative prices getting a final Value- Added/Energy (VAE) composite. Then, the composite is combined with intermediate inputs in a fixed proportion using a Leontief specification. The final price of the output is defined by the price of the value- added composite, the intermediates (gross of taxes) and the final output taxes (or subsidies).

International trade The standard GTAP model trade structure (known as Armington approach) allows for substitution between domestic and imported commodities in the domestic market through a two level CES function. Firstly, imports of a similar good sourced from different regions and destined to a region are collected at the borders and translated into a bundle of imports. Then, end users decide the ratio of domestic goods and import bundle defined by a cost-minimizing decision of domestic purchasers on the base of relative prices of imports and domestic goods (gross of relevant taxes or subsidies). After the introduction of the MRIO specification, instead, the international trade specification traces the exporting country and the use of each imported commodity. This allows each demanding agent, namely firms, private household and government to substitute imports across exporting countries, and to introduce differential tariff rates by agent and source. Accordingly, each agent determines the source of its own imports from different sources and only after they are aggregated in an import bundle for each use.

Final demand The model considers a representative regional household, which allocates its income into three main components, namely private consumption, public consumption, and savings according to fixed shares (equal to the base year) of the disposable income level. The regional household holds income from primary factors as well as tax revenues. Capital is mobile across sectors and, although fixed in each time period, it accumulates over time according to the recursive dynamics of the model. Aggregate private consumption is allocated among commodities following a Constant Difference Elasticity (CDE) utility function, while public consumption follows a Cobb-Douglas utility function. Regional savings are private savings only and are collected by a Global Bank which redistributes those resources as investments among regions according to GDP growth and the differentials in rates of return. The breakdown of investment into demand for final commodities is done using fixed shares, with changes in aggregate investment leading to proportional increases in the demand for individual commodities.

System constraints and Macroeconomic closures Equilibrium in the goods and services market is met when demand for commodities and services equals supply. Aggregate demand is composed of household and government consumption spending, investment, exports, and transaction services demand. Supply includes both domestic production and imported commodities. Equilibrium is achieved through the endogenous interaction of domestic and foreign prices: shifts in relative prices have effects on sectoral production and sectoral primary factor uses, and hence institutional incomes and demand. Both capital and labour are fully employed and perfectly mobile across sectors, implying that sector-specific returns adjust to ensure that demand for factors equals total supply. The trade balance is endogenously determined and the difference between export and imports is equal to the gap between regional investment and savings. Being ICES a neoclassical model, it assumes that the savings level determines an economy's level of investment. This suggests that savings is exogenous, and that investment adjusts to maintain the savings-investment balance.

4.2 Additional details on the finance models

Dividend discount models We use a two-stages dividend discount model in the form:

$$V_0 = \sum_{t=1}^{n} \frac{D_t}{(1+r)^t} + \frac{P_n}{(1+r)^n} \tag{1}$$

Where V_0 is the value of equity at time 0, t is the time index and n the time of the last available dividend, D_t is the dividend at time t, P_n is the price of the stock at time n, and r is the discount rate. The price at time n can be computed as a function of the last dividend and the long-run growth rate of dividends, g_L:

$$P_n = \frac{D_n(1+g_L)}{(r-g_L)}, \tag{2}$$

thus, for V_0 we have:

$$V_0 = \sum_{t=1}^{n} \frac{D_t}{(1+r)^t} + \frac{D_n(1+g_L)}{(r-g_L)}. \tag{3}$$

List of assumptions for financial models Tables IV, V, VI, VII, IX list the assumptions underpinning the event study analysis, financial valuation model, portfolio data presentation, and results presentation.

Num	Parameter/item	Value
1	Data sample	01.01.2018-21.12.2022
2	Future contract types	Continuation futures
3	Reference market index	Bloomberg Commodity Index
4	Interpolation	Forward interpolation up to 5 trading days
5	Returns	Using log returns
6	Normal window	[-125, -6] days to event
7	Event window	[-5, +5] days to event
8	Significance test	2-tailed t-test
9	Shock passes	Direct only
9b	Region/sector mapping of input shocks	See tab "mapping"

TABLE IV: Assumptions for the event study analysis and the input shocks. Source: authors.

Num	Parameter/item	Value
10	Dividend data	2021-2035 as of 31.12.2021
11	EPS interpolation	Linear for missing EPS where DPS are available
12	All EPS missing but dividends are available	Last EPS = last DPS
13	Forward fill for zero EPS	If EPS==0, it is forward filled with previous non-zero value
14	Payout ratio cap	100%
15	Last growth rate of EPS	Equal long-run growht rate of dividends
16	Companies with no EPS growht rate	The first growth rate set to 0
17	Filling missing EPS	Linear interpolation
18	EPS growth rate cap	100%
19	Payout ratio estimation	Same as EPS
20	Long run payout ratio	0.5
21	Long run dividend growth rate (g_L)	2.50%
22	Discount rate (r)	5%
23	Shock time dynamic	Linearly declining from t0 to tn
24	Shock computation if one dividend is available	Gordon model
25	Shock computation with no dividents available	Direct shock

TABLE V: Assumptions for the dividend discount model. Source: authors.

4.3 Materials

4.3.1 Sectoral aggregation of ICES sectors to sectors in result

Table VII describes the aggregation of sectors in the ICES model to single sectors and commodity futures and spots. Table VIII provides a detailed description for ICES sectors and respective GTAP codes.

ICES sectors	Description	GTAP Code
Rice	Rice: seed, paddy (not husked)	pdr
Wheat	Wheat: seed, other	wht

Other grains	Other Grains: maize (corn), sorghum, barley, rye, oats, millets, other cereals	gro
Vegetables and Fruits	Veg & Fruit: vegetables, fruit and nuts, edible roots and tubers, pulses	v_f
Oil seeds	Oil Seeds: oil seeds and oleaginous fruit	osd
Cane & Beet	Cane & Beet: sugar crops	c_b
Fibres crops	Fibres crops	pfb
Other crops	Other Crops: stimulant; spice and aromatic crops; forage products; plants and parts of plants used primarily in perfumery, pharmacy, or for insecticidal, fungicidal or similar purposes; beet seeds (excluding sugar beet seeds) and seeds of forage plants; natural rubber in primary forms or in plates, sheets or strip, living plants; cut flowers and flower buds; flower seeds, unmanufactured tobacco; other raw vegetable materials nec	ocr
Other Agr-Frs-Fsh	Cattle: bovine animals, live, other ruminants, horses and other equines, bovine semen	ctl
Other Agr-Frs-Fsh	Other Animal Products: swine; poultry; other live animals; eggs of hens or other birds in shell, fresh; reproductive materials of animals; natural honey; snails, fresh, chilled, frozen, dried, salted or in brine, except sea snails; edible products of animal origin n.e.c.; hides, skins and furskins, raw; insect waxes and spermaceti, whether or not refined or coloured	oap
Other Agr-Frs-Fsh	Raw milk	rmk
Other Agr-Frs-Fsh	Wool: wool, silk, and other raw animal materials used in textile	wol
Other Agr-Frs-Fsh	Forestry: forestry, logging and related service activities	frs
Other Agr-Frs-Fsh	Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing	fsh
Coal	Coal: mining and agglomeration of hard coal, lignite and peat	coa

Oil	Oil: extraction of crude petroleum, service activities incidental to oil and gas extraction excluding surveying (part)	oil
Gas	Gas: extraction of natural gas, service activities incidental to oil and gas extraction excluding surveying (part)	gas
Other industries	Other Mining Extraction (formerly omn): mining of metal ores; other mining and quarrying	oxt
Food industries	Cattle Meat: fresh or chilled; meat of buffalo, fresh or chilled; meat of sheep, fresh or chilled; meat of goat, fresh or chilled; meat of camels and camelids, fresh or chilled; meat of horses and other equines, fresh or chilled; other meat of mammals, fresh or chilled; meat of mammals, frozen; edible offal of mammals, fresh, chilled or frozen	cmt
Food industries	Other Meat: meat of pigs, fresh or chilled; meat of rabbits and hares, fresh or chilled; meat of poultry, fresh or chilled; meat of poultry, frozen; edible offal of poultry, fresh, chilled or frozen; other meat and edible offal, fresh, chilled or frozen; preserves and preparations of meat, meat offal or blood; flours, meals and pellets of meat or meat offal, inedible; greaves	omt
Food industries	Vegetable Oils: margarine and similar preparations; cotton linters; oil-cake and other residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues resulting from the treatment of fatty substances or animal or vegetable waxes; animal fats	vol
Food industries	Milk: dairy products	mil
Food industries	Processed Rice: semi- or wholly milled, or husked	pcr
Food industries	Sugar and molasses	sgr

Food industries	Other Food: prepared and preserved fish, crustaceans, molluscs and other aquatic invertebrates; prepared and preserved vegetables, pulses and potatoes; prepared and preserved fruits and nuts; wheat and meslin flour; other cereal flours; groats, meal and pellets of wheat and other cereals; other cereal grain products (including corn flakes); other vegetable flours and meals; mixes and doughs for the preparation of bakers' wares; starches and starch products; sugars and sugar syrups n.e.c.; preparations used in animal feeding; lucerne (alfalfa) meal and pellets; bakery products; cocoa, chocolate and sugar confectionery; macaroni, noodles, couscous and similar farinaceous products; food products n.e.c.	ofd
Food industries	Beverages and Tobacco products	b_t
Light Industries	Manufacture of textiles	tex
Light Industries	Manufacture of wearing apparel	wap
Light Industries	Manufacture of leather and related products	lea
Other industries	Lumber: manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	lum
Other industries	Paper & Paper Products: includes printing and reproduction of recorded media	ppp
Oil products	Petroleum & Coke: manufacture of coke and refined petroleum products	p_c
Chemicals	Manufacture of chemicals and chemical products	chm
Other industries	Manufacture of pharmaceuticals, medicinal chemical and botanical products	bph
Other industries	Manufacture of rubber and plastics products	rpp

Non Mineral Products	Manufacture of other non-metallic mineral products	nmm
Iron & Steel	Iron & Steel: basic production and casting	i_s
Non-Ferrous metals	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver	nfm
Other industries	Manufacture of fabricated metal products, except machinery and equipment	fmp
ligth industries	Manufacture of computer, electronic and optical products	ele
ligth industries	Manufacture of electrical equipment	eeq
ligth industries	Manufacture of machinery and equipment n.e.c.	ome
Other industries	Manufacture of motor vehicles, trailers and semi-trailers	mvh
Other industries	Manufacture of other transport equipment	otn
Other industries	Other Manufacturing: includes furniture	omf
Electricity	Electricity; steam and air conditioning supply	ely
Gas	Gas manufacture, distribution	gdt
Services	Water supply; sewerage, waste management and remediation activities	wtr
Construction	Construction: building houses factories offices and roads	cns
Services	Wholesale and retail trade; repair of motor vehicles and motorcycles	trd
Services	Accommodation, Food and service activities	afs
Other transport	Land transport and transport via pipelines	otp
Water transport	Water transport	wtp
Air Transport	Air transport	atp

Services	Warehousing and support activities	whs
Services	Information and communication	cmn
Services	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding	ofi
Services	Insurance (formerly isr): includes pension funding, except compulsory social security	ins
Services	Real estate activities	rsa
Services	Other Business Services nec	obs
Services	Recreation & Other Services: recreational, cultural and sporting activities, other service activities; private households with employed persons (servants)	ros
Services	Other Services (Government): public administration and defense; compulsory social security, activities of membership organizations n.e.c., extra-territorial organizations and bodies	osg
Services	Education	edu
Services	Human health and social work	hht
Services	Dwellings: ownership of dwellings (imputed rents of houses occupied by owners)	dwe

TABLE VIII: Detailed description of ICES sectors and respective GTAP codes. Source: authors.

4.3.2 Regional aggregation in ICES to groups in scenario setup

GTAP Code	Description	ICES final aggregation	Region classification
AUS	Australia	Australia	Western block
	- Australia, Christmas Island, Cocos (Keeling) Islands, Heard Island and McDonald Islands, Norfolk Island		
NZL	New Zealand	RoW	Non-Aligned countries
XOC	Rest of Oceania	RoW	Non-Aligned countries

	- American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Micronesia, Federated States of, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, United States Minor Outlying Islands, Vanuatu, Wallis and Futuna Islands		
CHN	China	China	Non-Aligned countries
HKG	Hong Kong, Special Administrative Region of China	HonKong	Non-Aligned countries
JPN	Japan	Japan	Western block
KOR	Korea, Republic of	South Korea	Non-Aligned countries
MNG	Mongolia	Rest of Asia	Non-Aligned countries
TWN	Taiwan	Taiwan	Non-Aligned countries
XEA	Rest of East Asia	Rest of Asia	Non-Aligned countries
	- Korea, Democratic People's Republic of, Macao, Special Administrative Region of China		
BRN	Brunei Darussalam	Rest of Asia	Non-Aligned countries
KHM	Cambodia	Rest of Asia	Non-Aligned countries
IDN	Indonesia	Indonesia	Non-Aligned countries

LAO	Lao PDR	Rest of Asia	Non-Aligned countries
MYS	Malaysia	Rest of Asia	Non-Aligned countries
PHL	Philippines	Rest of Asia	Non-Aligned countries
SGP	Singapore	Rest of Asia	Non-Aligned countries
THA	Thailand	Thailand	Non-Aligned countries
VNM	Viet Nam	Rest of Asia	Non-Aligned countries
XSE	Rest of Southeast Asia	Rest of Asia	Non-Aligned countries
	- Myanmar, Timor-Leste		
BGD	Bangladesh	Rest of Asia	Non-Aligned countries
IND	India	India	Non-Aligned countries
NPL	Nepal	Rest of Asia	Non-Aligned countries
PAK	Pakistan	Rest of Asia	Non-Aligned countries
LKA	Sri Lanka	Rest of Asia	Non-Aligned countries
XSA	Rest of South Asia	Rest of Asia	Non-Aligned countries
	- Afghanistan, Bhutan, Maldives		
CAN	Canada	Canada	Western block
USA	United States of America	USA	Western block
MEX	Mexico	Mexico	Non-Aligned countries

XNA	Rest of North America	Rest of LACA	Non-Aligned countries
	- Bermuda, Greenland, Saint Pierre and Miquelon		
ARG	Argentina	Argentina	Non-Aligned countries
BOL	Bolivia	Rest of LACA	Non-Aligned countries
BRA	Brazil	Brazil	Non-Aligned countries
CHL	Chile	Rest of LACA	Non-Aligned countries
COL	Colombia	Rest of LACA	Non-Aligned countries
ECU	Ecuador	Rest of LACA	Non-Aligned countries
PRY	Paraguay	Paraguay	
PER	Peru	Rest of LACA	Non-Aligned countries
URY	Uruguay	Rest of LACA	Non-Aligned countries
VEN	Venezuela (Bolivarian Republic of)	Rest of LACA	Non-Aligned countries
XSM	Rest of South America	Rest of LACA	Non-Aligned countries
	- Falkland Islands (Malvinas), French Guiana, Guyana, South Georgia and the South Sandwich Islands, Suriname		
CRI	Costa Rica	Rest of LACA	Non-Aligned countries
GTM	Guatemala	Rest of LACA	Non-Aligned countries

HND	Honduras	Rest of LACA	Non-Aligned countries
NIC	Nicaragua	Rest of LACA	Non-Aligned countries
PAN	Panama	Rest of LACA	Non-Aligned countries
SLV	El Salvador	Rest of LACA	Non-Aligned countries
XCA	Rest of Central America	Rest of LACA	Non-Aligned countries
	- Belize		
DOM	Dominican Republic	Rest of LACA	Non-Aligned countries
JAM	Jamaica	Rest of LACA	Non-Aligned countries
PRI	Puerto Rico	Rest of LACA	Non-Aligned countries
TTO	Trinidad and Tobago	Rest of LACA	Non-Aligned countries
XCB	Rest of Caribbean	Rest of LACA	Non-Aligned countries
	- Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Grenada, Haiti, Montserrat, Netherlands Antilles, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Grenadines, Turks and Caicos Islands, Virgin Islands, US		
AUT	Austria	North EU	Europe
BEL	Belgium	North EU	Europe
CYP	Cyprus	Rest_Med_EU	Europe

CZE	Czech Republic	East_EU	Europe
DNK	Denmark	North EU	Europe
EST	Estonia	East_EU	Europe
FIN	Finland	North EU	Europe
	- Aland Islands, Finland		
FRA	France	Med_EU	Europe
	- France, Guadeloupe, Martinique, Réunion		
DEU	Germany	North_EU15	Europe
GRC	Greece	Med_EU	Europe
HUN	Hungary	East_EU	Europe
IRL	Ireland	North_EU15	Europe
ITA	Italy	Med_EU	Europe
LVA	Latvia	East_EU	Europe
LTU	Lithuania	East_EU	Europe
LUX	Luxembourg	North_EU15	Europe
MLT	Malta	Rest_Med_EU	Europe
NLD	Netherlands	North_EU15	Europe
POL	Poland	East_EU	Europe
PRT	Portugal	Med_EU	Europe
SVK	Slovakia	East_EU	Europe
SVN	Slovenia	Rest_Med_EU	Europe
ESP	Spain	Med_EU	Europe
SWE	Sweden	North_EU15	Europe
GBR	United Kingdom	Rest of Europe	Europe
CHE	Switzerland	Rest of Europe	Europe
NOR	Norway	Rest of Europe	Europe
	- Norway, Svalbard and Jan Mayen Islands		
XEF	Rest of European Free Trade Association	Rest of Europe	Europe
	- Iceland, Liechtenstein		
ALB	Albania	Rest of Europe	Europe

BGR	Bulgaria	East_EU	Europe
BLR	Belarus	Transition Economies	CIS region
HRV	Croatia	Rest_Med_EU	Europe
ROU	Romania	East_EU	Europe
RUS	Russian Federation	Russian Federation	Russia
UKR	Ukraine	Ukraine	Ukraine
XEE	Rest of Eastern Europe	Transition Economies	CIS region
	- Moldova		
XER	Rest of Europe	Rest of Europe	Europe
	- Andorra, Bosnia and Herzegovina, Faroe Islands, Gibraltar, Guernsey, Holy See (Vatican City State), Isle of Man, Jersey, Monaco, Montenegro, North Macedonia, San Marino, Serbia		
KAZ	Kazakhstan	Kazakhstan	CIS region
KGZ	Kyrgyztan	Transition Economies	CIS region
TJK	Tajikistan	Transition Economies	CIS region
XSU	Rest of Former Soviet Union	Transition Economies	CIS region
	- Turkmenistan, Uzbekistan		
ARM	Armenia	Transition Economies	CIS region
AZE	Azerbaijan	Transition Economies	CIS region
GEO	Georgia	Transition Economies	CIS region

BHR	Bahrain	MENA	Non-Aligned countries
IRN	Iran, Islamic Republic of	MENA	Non-Aligned countries
ISR	Israel	MENA	Non-Aligned countries
JOR	Jordan	MENA	Non-Aligned countries
KWT	Kuwait	MENA	Non-Aligned countries
OMN	Oman	MENA	Non-Aligned countries
QAT	Qatar	MENA	Non-Aligned countries
SAU	Saudi Arabia	MENA	Non-Aligned countries
TUR	Türkiye	Türkiye	Non-Aligned countries
ARE	United Arab Emirates	MENA	Non-Aligned countries
XWS	Rest of Western Asia	Euphrates & Tigris	Non-Aligned countries
	- Iraq, Lebanon, Palestinian Territory, Occupied, Syrian Arab Republic (Syria), Yemen		
EGY	Egypt	MENA	Non-Aligned countries
MAR	Morocco	MENA	Non-Aligned countries
TUN	Tunisia	MENA	Non-Aligned countries
XNF	Rest of North Africa	MENA	Non-Aligned countries

	- Algeria, Libya, Western Sahara		
BEN	Benin	SSA	Non-Aligned countries
BFA	Burkina Faso	SSA	Non-Aligned countries
CMR	Cameroon	SSA	Non-Aligned countries
CIV	Côte d'Ivoire	SSA	Non-Aligned countries
GHA	Ghana	SSA	Non-Aligned countries
GIN	Guinea	SSA	Non-Aligned countries
NGA	Nigeria	SSA	Non-Aligned countries
SEN	Senegal	SSA	Non-Aligned countries
TGO	Togo	SSA	Non-Aligned countries
XWF	Rest of Western Africa	SSA	Non-Aligned countries
	- Cape Verde, Gambia, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Saint Helena, Sierra Leone		
XCF	Rest of Central Africa	SSA	Non-Aligned countries
	- Central African Republic, Chad, Congo, Equatorial Guinea, Gabon, Sao Tome and Principe		
XAC	South Central Africa	SSA	Non-Aligned countries
	- Angola, Congo, Democratic Republic of the		

ETH	Ethiopia	SSA	Non-Aligned countries
KEN	Kenya	SSA	Non-Aligned countries
MDG	Madagascar	SSA	Non-Aligned countries
MWI	Malawi	SSA	Non-Aligned countries
MUS	Mauritius	SSA	Non-Aligned countries
MOZ	Mozambique	SSA	Non-Aligned countries
RWA	Rwanda	SSA	Non-Aligned countries
TZA	Tanzania, United Republic of	SSA	Non-Aligned countries
UGA	Uganda	SSA	Non-Aligned countries
ZMB	Zambia	SSA	Non-Aligned countries
ZWE	Zimbabwe	SSA	Non-Aligned countries
XEC	Rest of Eastern Africa	SSA	Non-Aligned countries
	- Burundi, Comoros, Djibouti, Eritrea, Mayotte, Seychelles, Somalia, Sudan		
BWA	Botswana	SSA	Non-Aligned countries
NAM	Namibia	SSA	Non-Aligned countries
ZAF	South Africa	South Africa	Non-Aligned countries

XSC	Rest of South African Customs Union	SSA	Non-Aligned countries
	- Eswatini, Lesotho		
XTW	Rest of the World	RoW	Non-Aligned countries
	- Antarctica, Bouvet Island, British Indian Ocean Territory, French Southern Territories		

TABLE IX: Assumptions for the presentation of results, regional aggregations. Source: authors.

4.3.3 List of future contracts

Tables X and XI describe the future and spot contracts used in the study and present summary statistics. Data are obtained from Refinitiv Eikon.

Commodit Type	Contrac Type	Contract Ticker	Contract short name	Regional Scope	Unit	coun	mear	std	min	max
Grain & oilseed	Future	Wc1	CBOT Wheat Future	US	US cents/ bushel	1254	628	174	417	1425
Grain & oilseed	Future	BL2c1	Paris Wheat Future	Europe	EUR/ ton	1276	228	66	153	438
Grain & oilseed	Future	CWHc1	China Wheat Future	China	CNY/ met- ric ton	1208	2676	309	2082	3661
Grain & oilseed	Future	WEAc1	SA Wheat Future	Africa	ZAR/ ton	1246	5222	1101	3505	8409
Grain & oilseed	Future	Cc1	US Corn Future	US	US cents/ bushel	1254	477	143	303	818

Grain & oilseed	Future	MCRc1	Argentina Corn Future	South America	USD/ ton	1169	181	44	115	305
Grain & oilseed	Future	MAWc1	SA Corn Future	Africa	ZAR/ ton	1246	3140	814	1772	5471
Grain & oilseed	Future	BCCc1	EU Corn Future	Europe	HUF/ tat	638	87943	32133	0	145000
Grain & oilseed	Future	Sc1	US Soybeans Future	US	US cents/ bushel	1254	1138	286	791	1769
Grain & oilseed	Future	SJCc1	South America Soybeans Future	South America	USD/ 60kg	1232	25	6	18	39
Grain & oilseed	Future	COMc1	Rapeseed Future	Europe	EUR/ ton	1276	482	159	326	1081
Grain & oilseed	Future	RSc1	North America RS Future	North America	CAD/ ton	1244	659	231	430	1226
Grain & oilseed	Future	1RRc1	CBOT Rice	US	USD/ Cwt	1254	13	2	10	22
Grain & oilseed	Spot	W-FOBROUEN-P1	Wheat Paris Spot	Europe	EUR	1133	229	68	151	445
Grain & oilseed	Spot	SRW-RIVCHI-P1	Chicago Wheat Spot	US	USD	801	7	2	4	13
Grain & oilseed	Spot	C-FOBARG-P1	Argentina Corn Spot	South America	USD	1144	211	53	133	357

Grain & oilseed	Spot	SM-ARGPAR-P1	South America Soybeans Spot	South America	USD	1161	396	72	291	591
Grain & oilseed	Spot	RAP-RENRUEN-P1	France rapeseed spot	Europe	EUR	455	447	158	327	1080
Grain & oilseed	Spot	2YSB-USG-A1	US soy spot	US	USD/ ton	1243	452	116	303	703
Grain & oilseed	Spot	C-ICTRAIN-P1	US corn spot	US	US cents/ bushel	508	5	2	3	8
Grain & oilseed	Spot	MAZ-FOBRHI-P1	EU corn spot	Europe	EUR/ ton	905	215	65	148	415

TABLE X: List of grain and oilseed futures and spot contracts used in the study. Summary statistics are computed over the period 01.01.2018 - 21.12.2022. Source: authors' elaboration on Refinitiv Eikon data.

Commodit Type	Contrac Type	Contract Ticker	Contract short name	Regional Scope	Unit	coun	mear	std	min	max
Key commodities index	Index	.BCOM	Index BBG	Global	N/A	1254	89	17	59	137
Livestock	Future	LCc1	CME Live Cattle Future	US	US cents/ pound	1254	120	14	84	156
Livestock	Future	FCc1	CME Feeder Cattle Future	US	US cents/ pound	1254	149	14	108	184

Livestock	Future	LHc1	CME Lean Hog Future	US	US cents/ pound	1252	77	19	37	123
Livestock	Spot	BBF-TRD-FSH50	US lean cattle	US	USD/ lib	1221	83	25	0	293
Oil	Future	LCOc1	Brent Future	Europe	USD/ barrel	1286	70	20	19	128
Oil	Future	CLc1	WTI Future	US	USD/ barrel	1254	65	20	-38	124
Oil	Future	LGOc1	Gasoil Future	Europe	USD/ metric ton	1286	644	238	191	1523
Oil	Future	RBc1	Gasoline Future	US	USD/ gallon	1254	2	1	0	4
Oil	Future	HOc1	Heating Oil Future	US	USD/ gallon	1254	2	1	1	5
Oil	Future	MRBNc1	Murban Future	Middle East	USD/ barrel	451	88	16	61	127
Power complex	Future	NGLNMc1	NBP Natural Gas Future	UK	GBP/ therm	1264	101	104	8	640
Power complex	Future	NGc1	Henry Hub Natural Gas Future	US	USD/ MMBtu	1254	4	2	1	10
Power complex	Future	NCFMc1	Coal Future Australia	Global ex europe, Africa	USD/ ton	1286	147	114	49	458
Power complex	Future	TRNLTTFMc1	TTF Future	Europe	EUR/ MW	1285	45	53	4	311

Power complex	Future	JKMc1	JKM Future	Japan/ Korea	USD/ MMBtu	1254	14	13	2	70
Softs	Future	LSUc1	White Sugar Future	Global	USD/ ton	1260	411	83	294	623
Softs	Future	SBc1	Sugar Future	Global	US cents/ lib	1254	15	3	9	21

TABLE XI: List of livestock, oil, power complex and softs futures and spot contracts used in the study. Summary statistics are computed over the period 01.01.2018-21.12.2022. Source: authors' elaboration on Refinitiv Eikon data.

4.3.4 Dividend data

We retrieve data on Earnings Per Share (EPS) and Dividends Per Share (DPS) from S&P Global Ratings[31], for the years 2021 to 2035, as of 31.12.2021. We estimate dividends where not available.[32]

4.3.5 Portfolio data

We extracted from the Ownership Universe in the *Refinitiv Eikon Screener App*[33] the dataset of exposures via equity contracts to publicly listed companies of European financial actors, as of June 2020.

We consider exposures (as of June 30, 2020) of all European financial actors headquartered in the European Union (EU)[34]. In addition, we consider financial actors from the European Free Trade Association (EFTA) Member States[35], European microstates[36], the United Kingdom (GB) (together with its Crown dependencies[37]), and all the Overseas Territories[38] of the countries mentioned. Whenever the data on the country of

[31] https://www.spglobal.com/ratings/en/

[32] For the list of assumptions underpinning dividends' estimation, see Table V.

[33] https://eikon.thomsonreuters.com/index.html.

[34] Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czechia (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (GR), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), and Sweden (SE).

[35] Iceland (IS), Liechtenstein (LI), Norway (NO), and Switzerland (CH).

[36] Andorra (AD), Monaco (MC), and San Marino (SM).

[37] Guernsey (GG), the Isle of Man (IM), and Jersey (JE).

[38] Anguilla (AI), Bermuda (BM), British Virgin Islands (VG), Cayman Islands (KY), Curacao (CW), Gibraltar (GI), and Greenland (GL).

Num	Parameter/item	Value
26	Financial actors considered	See "Portfolio impacts" in Methods for the list of countries
27	Exclusion of invested financial companies from "services" sector	NA
27b	Exclusion of one company from Ukraine in the gas sector as outlier	NA
28	Computation of trends - number of positions	30
29	Computation of trends - position size	0.05
29b	Computation of trends - shape	Second order trends
29c	Computation of trends - fallback option	Linear trend

TABLE VI: Assumptions for portfolio level data and results. Source: authors.

headquarters (HQ) of an investor is not available, we use the country of incorporation. Furthermore, we consolidate investors at the level of ultimate parent[39]. Finally, building on the approach in [28], we group investors consolidated into five investor types based on their NACE Rev.2 4-digit codes.

After the consolidation of individual firms' ownership, the consolidation on investor parent - investor level, and the retaining of ordinary shares and American Depositary Receipts (ADRs)[40], we obtain a dataset of 617,826 individual equity holdings[41] of European investors[42] (as of June 30, 2020), in 21,162 companies[43] headquartered in 123 countries,

[39]For consolidating investors, we apply the methodology used by the Refinitiv Eikon, and assign investor consolidated if the direct or indirect ownership interest exceeds 50%. However, whenever the investor consolidated is a sovereign, a foundation, or a corporate entity domiciled outside of European countries considered, the entity that is a corporate located in one of the countries that are considered, and that is closest to the investor's ultimate parent on the ownership pathway, is assigned as investor consolidated.

[40]We consider ordinary shares (including both fully- and partly-paid ordinary shares) and American depository receipts (ADR) because the investors' equity exposures to these two types of financial instruments accounts for almost 90% of the total value of equity exposures held by legal entities in the the dataset originally retrieved from Eikon, and because to both of them, a similar equity valuation approach can be applied.

[41]Characteristics of equity securities held by a given investor include: security identifiers - Reuters Instrument Code (RIC) and International Securities Identification Number (ISIN), type of security, filing date and filing type, and holdings value in USD.

[42]Investors' characteristics include: *investor* name, Refinitiv PermID, Legal Entity Identifier (LEI), country of HQ, country of incorporation, NACE Rev.2 class (i.e., 4-digit code), and NACE Rev.2 section; and *investor consolidated* name, Refinitiv PermID, Legal Entity Identifier (LEI), country of HQ, country of incorporation, NACE Rev.2 class (i.e., 4-digit code), and NACE Rev.2 section.

[43]Characteristics of equity securities' issuers include: company name, Refinitiv PermID, Legal Entity Identifier (LEI), country of HQ, NACE Rev.2 class (i.e., 4-digit code), and NACE Rev.2 section.

Sector aggregation	ICES sectors	Commodity futures/spots
Agriculture	Vegetables and Fruits, Oil Seeds, Cane & Beet, Fibres Crops, Other crops, Wheat, Rice, Other Agr-Frs-Fsh	CBOT Wheat Future, Paris Wheat Future, China Wheat Future, SA Wheat Future, US Corn Future, Argentina Corn Future, SA Corn Future, EU Corn Future, US Soybeans Future, South America Soybeans Future, Rapeseed Future, North America RS Future, CBOT Rice, Wheat Paris Spot, Chicago Wheat Spot, Argentina Corn Spot, South America Soybeans Spot, France rapeseed spot, US soy spot, US corn spot, EU corn spot, CME Live Cattle Future, CME Feeder Cattle Future, CME Lean Hog Future, US lean cattle
Electricity	Electricity	
Energy fossil or energy products	Coal, Oil, Gas, Oil Products	Brent Future, WTI Future, Gasoil Future, Gasoline Future, Heating Oil Future, Murban Future, NBP Natural Gas Future, Henry Hub Natural Gas Future, Coal Future Australia, TTF Future, JKM Future
High energy intesity industry	Food industries, Other industries, Chemicals, Non-Ferrous metals, Iron & Steel	White Sugar Future, Sugar Future
Low energy intensity industry	Light Industries, Non-mineral products	
Transportation	Other transport, Water transport, Air transport	

TABLE VII: Assumptions for the presentation of results, sectoral aggregations. Source: authors.

with a total exposure value of 7.38 trillion USD.

We remove from the sample ownership positions in companies that are themselves financial investors. This is because it is not possible to assess these companies using the ICES macroeconomic model and in lack of detailed portfolio data. This step removes 101,512 equity positions, leading to a final sample of 516,314 positions in 18,201 companies.

4.3.6 Composition of calorie sufficient and healthy diets

Table XII gives an overview about the composition of a calorie sufficient and a healthy diet, respectively. Also the ingredients are mapped to the food commodities we use in our food affordability analysis.

Composition of diets	
Calorie sufficient diet	60% starchy staples, 11% protein-rich foods & dairy, 29% fruits, vegetables & fats
Healthy diet	12% starchy staples, 44% protein-rich foods & dairy, 44% fruits, vegetables & fats
Ingredients of diets mapped to commodities	
Starchy staples	Rice, wheat, other grains, other crops
Protein-rich foods and dairy	Food industries, other agr-frs-fsh
Fruits, vegetables and fats	Vegetables and fruits, cane beet, oil seeds

TABLE XII: Composition of diets and mapping of their ingredients to ICES commodities. Source: [29] and authors.

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