



ERISC PHASE II:

HOW FOOD PRICES LINK ENVIRONMENTAL CONSTRAINTS TO SOVEREIGN CREDIT RISK



ERISC: Environmental Risk Integration
in Sovereign Credit Analysis

UNITED NATIONS ENVIRONMENT PROGRAMME



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KEY MESSAGES

Higher and more volatile food prices are key transmission mechanisms through which environmental risks and constraints such as climate change, ecosystem degradation and water scarcity will impact national economies. If these impacts are significant enough, they may affect a country's credit rating and the risk exposure of sovereign bondholders.

The global food system is vulnerable to changing environmental conditions. Climate change along with land and water scarcity will increasingly affect food production on the supply side. At the same time, demand for food will increase as a result of global population and income growth. The growing imbalance between rising demand for food and the capacity to supply it, will lead to greater variability in food production, higher and more volatile food commodity prices, and a higher likelihood of price shocks.

These food commodity price shocks will affect every country differently. To assess which countries would face the largest economic risks, we have modelled the impact of a rapid doubling in global food commodity prices on three macro-economic indicators for 110 countries: Gross Domestic Product (GDP); Current account balance; and Consumer Price Index (CPI).

KEY FINDINGS

- The risk exposure of individual countries is largely determined by their net food trade and the share of average household spending on food commodities. Countries such as **Egypt, Morocco, and the Philippines** that combine high food commodity imports and high household spending on these commodities see the worst effects in terms of reduction in absolute GDP, worsening of current account balances, and higher inflation. A number of large emerging market countries, including **China, Indonesia, and Turkey**, are also strongly impacted as they have high household spending levels on food commodities and moderate net imports of these commodities.
- Nine countries experience an increase in GDP, including South American cash crop exporters such as **Paraguay and Uruguay** and agricultural powerhouses such as **Brazil, Australia, Canada, and the United States**.
- Globally, negative effects massively outweigh positive effects in absolute terms. In the stress test, **China** experiences an absolute reduction in GDP of USD 161 billion, the highest negative value of any country. The highest positive effect on GDP, seen in the **US**, is 50 times smaller, at USD 3 billion.
- In 23 countries, a doubling in food commodity prices leads to an absolute increase in the consumer price index of more than 10 percentage points. These include many of the countries that experienced social unrest during the food price crisis of 2007-08, including **Morocco, Bangladesh, Egypt, and Indonesia**.
- Overall, countries with higher credit ratings tend to be less exposed to economic risks resulting from a food commodity price spike. Nonetheless, there is considerable variety in the economic risks highlighted by the stress test for each credit rating grade, and countries in each of these grades face potentially significant effects.
- Wealthy countries tend to contribute most to the environmental constraints that make food prices higher and more volatile as they consume the most natural resources and environmental services on a per capita basis. The resulting economic risk, however, is largely borne by poorer countries.
- A simulated integration of the results in a country risk assessment carried out by a participating financial institution in the ERISC project found that 58 out of 78 countries experience a downgrade in the quantitative rating module of at least one notch (in a 19-notch rating scale). Sixteen countries, including **India**, would be downgraded by three notches or more.

Ranking of Countries Most Affected by Food Price Shocks According to GDP Impact

RANK	COUNTRY/ REGION	GDP effect* (%)	Current account effect** (% of GDP)	CPI effect*** (%)	Net Food Commodity Imports, including embedded (% of GDP)	GNI, PPP (2014)	Gen. Govt. Debt/ GDP (2014)	S&P rating (foreign currency LT) ****
1	Benin	-8.6	-11.9	18.8	10.4%	2,020	34.0	-
2	Nigeria	-7.2	-1.4	47.8	1.0%	5,710	10.5	B+
3	Côte d'Ivoire	-7.0	-7.1	21.7	7.1%	3,130	36.6	-
4	Senegal	-6.6	-7.5	17.4	7.1%	2,300	53.1	B+
5	Ghana	-6.5	-1.0	35.7	2.2%	3,900	69.0	B-
6	Mozambique	-6.1	-1.5	29.0	4.1%	1,120	57.5	B-
7	Rwanda	-5.5	0.9	46.5	1.3%	1,630	30.2	B+
8	Malawi	-5.4	0.7	35.3	1.6%	790	-	-
9	Ethiopia	-5.4	-1.4	32.4	2.2%	1,500	22.3	B
10	Tanzania	-5.2	-0.1	30.0	1.2%	2,510	35.2	-
11	Burkina Faso	-5.1	-2.3	23.0	2.5%	1,600	28.5	B-
12	Cameroon	-4.9	-2.7	23.6	3.2%	2,950	25.4	B
13	Guinea	-4.6	-4.8	14.6	5.4%	1,130	41.1	-
14	Morocco	-4.5	-1.7	19.4	2.1%	7,290	63.4	BBB-
15	Kenya	-4.4	-0.6	28.4	1.8%	2,940	52.6	B+
16	Lao PDR	-4.1	-0.1	24.9	0.4%	5,060	62.5	-
17	Tunisia	-3.9	-1.9	15.7	2.2%	11,020	50.0	-
18	Bangladesh	-3.5	-1.3	19.0	1.3%	3,330	33.9	BB-
19	Egypt	-3.3	-2.2	13.2	2.4%	10,260	90.5	B-
20	Georgia	-3.2	-1.3	13.8	1.9%	7,510	34.8	BB-
21	Nepal	-3.2	-1.3	17.5	1.3%	2,410	27.7	-
22	Nicaragua	-3.2	-2.3	12.8	2.8%	4,790	29.5	-
23	Uganda	-3.2	0.0	19.1	0.9%	1,720	31.4	B
24	Togo	-3.1	-0.5	23.9	1.6%	1,290	58.7	-
25	Madagascar	-3.1	-1.9	14.9	2.6%	1,400	34.7	-
26	Jordan	-2.9	-3.7	4.8	3.3%	11,910	89.0	BB-
27	Kyrgyzstan	-2.8	-2.6	8.3	2.8%	3,220	53.0	-
28	Sri Lanka	-2.7	-0.3	13.7	0.6%	10,370	75.5	B+
29	Zambia	-2.6	0.8	15.0	-1.0%	3,690	35.2	B
30	Indonesia	-2.5	-0.6	11.0	0.7%	10,190	25.0	BB+
31	Honduras	-2.5	-2.8	4.8	2.6%	4,570	45.7	B+
32	India	-2.4	0.7	13.8	-0.6%	5,630	66.1	BBB-
33	Albania	-2.4	-1.4	8.6	1.7%	10,180	72.5	B+
34	Armenia	-2.3	-0.9	11.4	1.6%	8,450	41.3	-
35	Bolivia	-2.3	-0.4	11.1	0.3%	6,290	33.0	BB
36	Belarus	-2.2	0.0	10.7	0.2%	17,610	40.5	B-
37	Jamaica	-2.1	-2.4	4.0	2.3%	8,640	135.7	B
38	Mauritius	-2.1	-1.9	5.4	1.9%	18,150	56.2	-
39	Guatemala	-2.0	-1.1	11.1	1.3%	7,250	24.3	BB
40	Philippines	-1.9	-1.2	7.1	1.2%	8,450	36.4	BBB
41	Peru	-1.6	-0.8	5.9	0.8%	11,440	20.7	BBB+
42	Costa Rica	-1.6	-1.3	4.4	1.3%	14,420	39.7	BB-
43	China	-1.6	-0.5	7.4	0.5%	13,170	41.1	AA-
44	Dominican Republic	-1.5	-1.1	5.0	1.1%	12,600	35.0	BB-
45	Croatia	-1.5	0.0	7.5	0.0%	20,500	85.1	BB
46	Ecuador	-1.5	-0.6	5.8	0.6%	11,190	31.3	B
47	Botswana	-1.3	-1.2	3.9	1.1%	16,030	14.5	A-
48	El Salvador	-1.3	-0.7	10.3	1.0%	8,000	56.8	B+
49	Panama	-1.3	-1.2	3.4	1.2%	19,930	45.6	BBB
50	Namibia	-1.2	-0.6	4.3	0.7%	9,810	24.7	-
51	Romania	-1.2	0.6	8.9	-0.4%	19,020	40.6	BBB-
52	Colombia	-1.2	-0.5	4.4	0.6%	12,910	44.3	BBB
53	Turkey	-1.1	0.1	6.4	0.1%	18,980	33.6	BB+
54	Mongolia	-1.1	-1.0	3.3	0.9%	11,120	-	B
55	Venezuela	-1.1	-0.5	4.1	0.5%	17,700*	51.8	CCC
56	Kazakhstan	-1.0	0.7	6.3	-0.7%	21,710	14.9	BBB-
57	Malaysia	-1.0	-0.8	3.1	0.9%	24,770	55.2	A-

58	Saudi Arabia	-1.0	-0.9	4.3	1.0%	51,320*	1.6	A-
59	Israel	-1.0	-0.6	3.5	0.6%	32,830	67.1	A+
60	Cambodia	-0.9	1.0	12.0	-0.7%	3,080	33.9	-
61	Korea, Rep. of	-0.8	-0.4	3.0	0.4%	34,620	36.0	AA-
62	Mexico	-0.8	-0.5	2.7	0.5%	16,640	49.8	BBB+
63	Cyprus	-0.8	-1.1	1.2	1.0%	29,800	107.5	BB-
64	Portugal	-0.8	-0.7	1.8	0.7%	28,010	130.2	BB+
65	Russian Federation	-0.7	0.1	3.6	-0.2%	24,710	17.8	BB+
66	South Africa	-0.7	-0.2	2.5	0.2%	12,700	46.0	BBB-
67	Slovenia	-0.6	-0.4	2.0	0.4%	29,920	80.8	A-
68	Oman	-0.6	-0.7	1.9	0.8%	33,690*	5.1	BBB-
69	Bahrain	-0.6	-0.7	1.5	0.8%	37,680*	43.8	BB
70	Greece	-0.5	-0.1	2.3	0.2%	25,660*	177.1	B-
71	Spain	-0.5	-0.3	1.5	0.3%	33,080	97.7	BBB+
72	Kuwait	-0.5	-0.4	2.0	0.6%	79,850	6.9	AA
73	Hong Kong, China SAR	-0.5	-0.4	1.1	0.4%	56,570	0.1	AAA
74	New Zealand	-0.4	0.1	2.2	-0.1%	34,970	30.4	AA
75	Czech Republic	-0.4	0.2	2.3	-0.2%	28,020	42.6	AA-
76	Japan	-0.4	-0.2	1.5	0.2%	37,920	246.2	A+
77	Slovakia	-0.4	0.1	2.1	-0.1%	26,820	53.6	A+
78	Estonia	-0.4	0.1	2.0	-0.1%	26,330	10.4	AA-
79	Luxembourg	-0.4	-0.2	1.7	0.2%	65,040	22.1	AAA
80	Poland	-0.3	0.1	1.9	-0.1%	23,930	50.1	BBB+
81	Netherlands	-0.3	-0.2	1.1	0.2%	48,260	67.9	AAA
82	Chile	-0.3	-0.2	0.9	0.2%	21,580	15.1	AA-
83	Finland	-0.3	0.0	1.2	0.0%	39,940	59.0	AA+
84	Belgium	-0.3	0.0	1.3	0.0%	43,220	106.6	AA
85	Norway	-0.3	-0.2	0.9	0.2%	66,330	28.1	AAA
86	United Kingdom	-0.2	-0.1	1.0	0.1%	39,040	89.4	AAA
87	Austria	-0.2	0.0	1.1	0.0%	45,930	84.4	AA+
88	Italy	-0.2	0.0	1.2	0.0%	34,700	132.1	BBB-
89	Germany	-0.2	0.0	1.2	0.0%	46,850	74.6	AAA
90	Sweden	-0.2	0.0	1.0	0.0%	46,750	43.8	AAA
91	Qatar	-0.2	-0.2	1.5	0.3%	134,420	31.7	AA
92	Lithuania	-0.2	0.9	3.3	-0.9%	25,490	40.9	A-
93	Denmark	-0.2	0.1	0.9	-0.1%	46,210	45.2	AAA
94	Ireland	-0.2	0.2	1.1	-0.2%	42,270	107.6	A+
95	Switzerland	-0.2	-0.1	0.5	0.1%	57,960*	46.3	AAA
96	Singapore	-0.1	0.1	0.7	-0.1%	80,270	98.6	AAA
97	Thailand	-0.1	2.6	6.5	-2.8%	14,870	43.5	BBB+
98	France	-0.1	0.3	1.1	-0.3%	39,610	95.6	AA
99	Ukraine	-0.1	3.1	8.9	-2.9%	8,560	71.2	B-
100	Latvia	0.0	0.7	1.9	-0.7%	22,690	37.8	A-
101	Pakistan	0.0	2.0	11.5	-2.1%	5,090	64.9	B-
102	Viet Nam	0.0	3.6	11.4	-3.9%	5,350	57.2	BB-
103	Hungary	0.0	1.1	2.3	-1.1%	23,630	77.0	BB+
104	United States of America	0.0	0.3	0.7	-0.3%	55,860	104.8	AA+
105	Canada	0.0	0.5	0.9	-0.5%	43,360	87.9	AAA
106	Brazil	0.1	0.7	1.6	-0.7%	15,590	65.2	BB
107	Australia	0.1	0.5	0.7	-0.5%	42,760	33.9	AAA
108	Bulgaria	0.6	1.8	2.1	-1.9%	16,260	26.9	BB+
109	Uruguay	2.5	5.0	2.2	-5.0%	20,220	61.3	BBB
110	Paraguay	5.7	9.9	4.2	-10.7%	8,470	19.0	BB

The five highest and lowest effects for each variable are highlighted in orange and in green respectively.

* GDP effect refers to the change in a country's real GDP, expressed as a percentage of the total, as a result of a rapid doubling in food commodity prices.

** Current account effect refers to the change in a country's current account balance, expressed in percentage of the country's GDP, as a result of a rapid doubling in food commodity prices.

*** CPI effect refers to the increase in a country's consumer price index, expressed as a percentage of the total, as a result of a rapid doubling in food commodity prices.

****Ratings by S&P Global Ratings are as of April 5, 2016. Mozambique's rating is as of April 15, 2016.

FOREWORD

The increasing global competition for the planet's finite resources is becoming an ever more significant factor of economic performance. The 2016 Global Risk Report by the World Economic Forum, for instance, found that the risks related to ecosystem degradation, water scarcity and climate change are among the most severe the world faces in terms of their likelihood and their potential impact on our global economy. While the report underscores a growing understanding about the materiality of such environmental risks, their effects on national economies is largely absent from credit risk analysis in bond markets. Indeed, in the debate over the impacts of climate change and resource scarcity, the sovereign bond market has been a long overlooked portion of the financial system. However, with more than US\$ 40 trillion in outstanding debt, government bonds are one of the most important asset classes held by investors worldwide.

The Environmental Risk Integration in Sovereign Credit (ERISC) project, a joint collaboration of UNEP Finance Initiative (UNEP FI) and Global Footprint Network, assesses how environmental phenomena such as deforestation, climate change and resource scarcity affect a country's economy and therefore, potentially, its sovereign credit worthiness and country risk ratings. The first phase of the project was completed in 2012 with an introductory report showing that environmental risks are material, unevenly distributed between countries and not adequately reflected in sovereign credit risk analysis.

We are pleased to hereby release this report summarizing the second phase of ERISC, which looks specifically at how environmental risks affect food production and food prices and how this in turn can have material macroeconomic impacts. It was developed in collaboration with S&P Global Ratings, HSBC, Caisse des Dépôts, First State Investments, KfW, Kempen Capital Management, and Cambridge Econometrics.

Disruptions to our food system are an increasingly important risk to national economies, as climate change, changing diets, population pressure and competition for land push food prices higher and create more volatility. In this report, we examine the linkages between the resulting food price shocks and sovereign credit risk by submitting 110 countries to a stress test simulating a food commodity price shock. The results can inform bond investors and credit rating agencies, but also governments looking for ways to reduce economic impacts from environmental risks.

We invite both the financial industry and governments to collaborate with us to scale up this work.



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INTRODUCTION: ERISC AND FOOD PRICES

The Environmental Risk Integration in Sovereign Credit Analysis (ERISC) project is a pioneering exploration by UNEP FI and Global Footprint Network (GFN) in collaboration with financial institutions to uncover and quantify the economic risks at country-level resulting from environmental degradation. Poor environmental management by countries puts pressure on their ability to maintain and grow economies. Indeed, environmental risks such as water scarcity, climate change, and overuse of renewable natural resources can affect a country's economy in multiple ways, ultimately impacting its ability to manage its public debt.

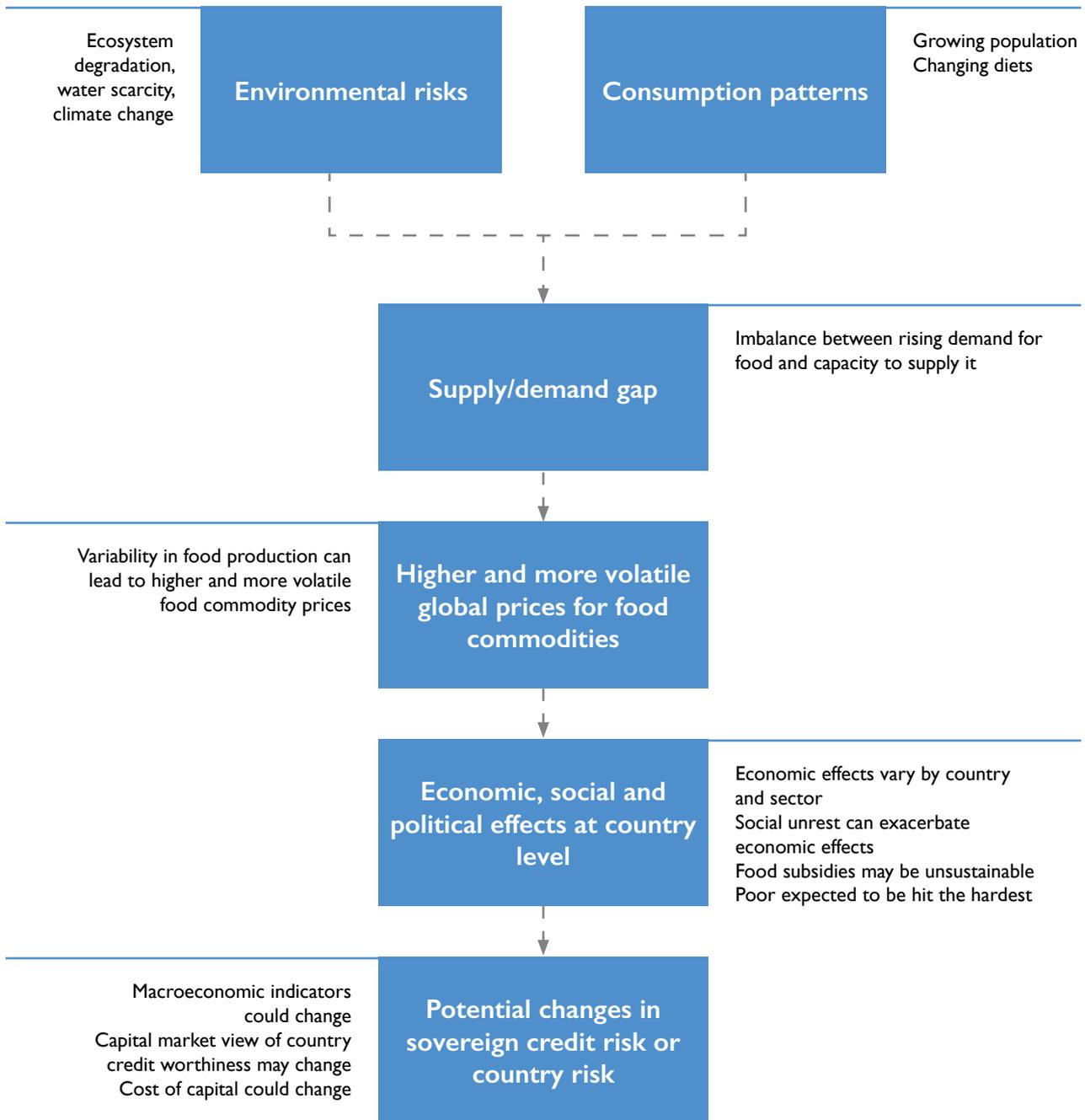
In the first phase of ERISC we showed that environmental risks can be material, but are not systematically incorporated into credit analysis. The consequences of environmental degradation have attracted more attention from the finance industry since the publication of the first report, with credit rating agencies and policy makers looking more closely at the effect of climate change in particular.¹⁻³ Research on the broader economic effects of long-term environmental degradation is, however, still rare. This phase of ERISC contributes to bridging this gap by analyzing one of the most direct and impactful channels linking environmental risk to economic effects: food price shocks. Further phases of ERISC will, with the continued support of the finance sector and others, build and expand the research in order to improve financial sector understanding of environmental risk and provide economic evidence for better environmental management by countries.

ENVIRONMENTAL RISK AND THE LINK TO FOOD PRICE SHOCKS

Food prices are one of the most important channels by which environmental risks affect national economies.

Food production represents a vital human demand on the natural world – a demand that is ever-growing as a result of increases in population and income. Food is also one of the largest drivers of humanity's negative impact on the environment (through its use of land and water and alteration of nitrogen and phosphorous cycles) and a major contributor to climate change (through energy use and greenhouse gas emissions). At the same time, agriculture stands to be significantly affected by climate change and other environmental constraints. This complex confluence of factors will result in supply-demand imbalances in the global food system, leading to higher food prices and volatility, with implications for economic risk at the country level and financial risk for sovereign bond holders.

Figure 1: How food price shocks link environmental constraints to sovereign credit risk



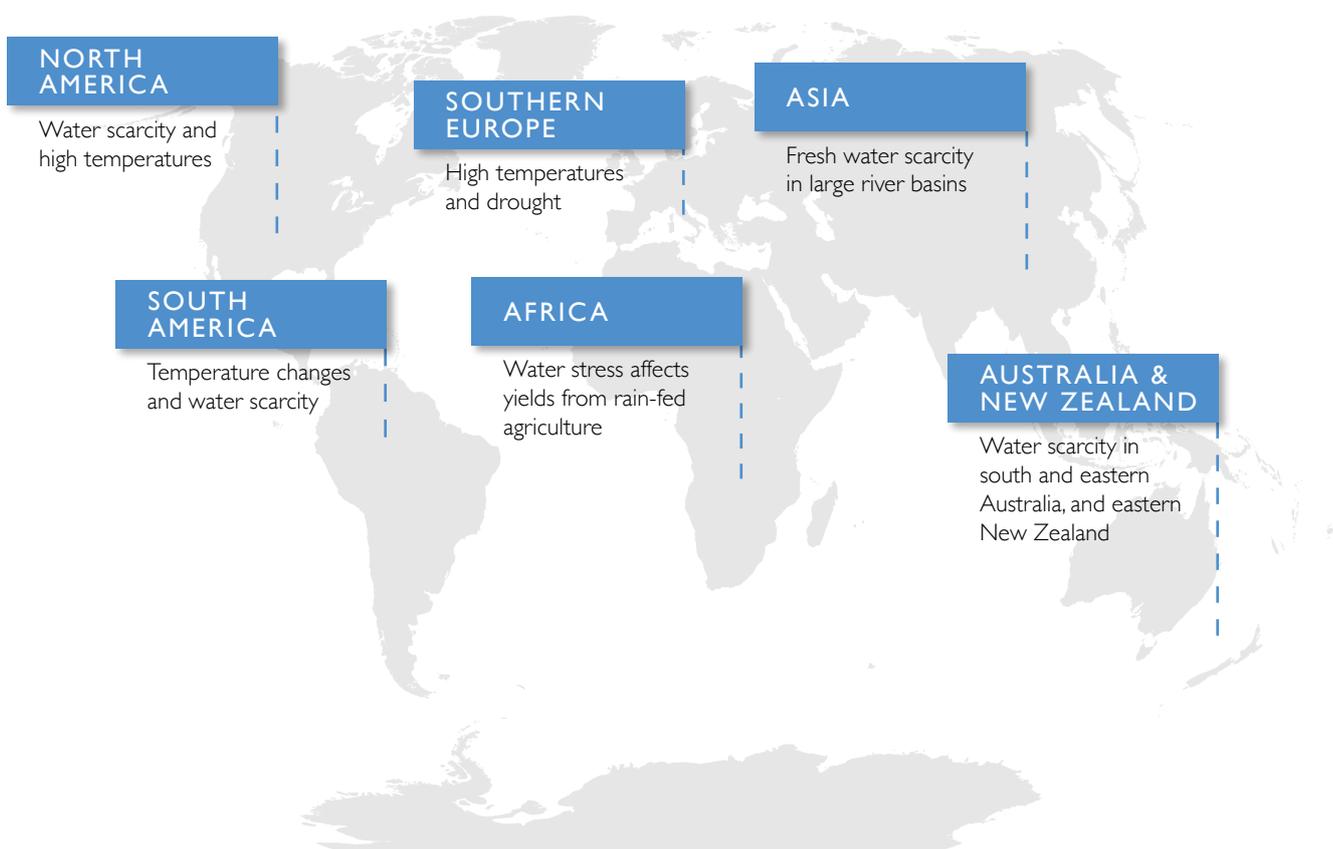
SUPPLY-SIDE CHALLENGES

Climate change is a significant threat to future food production. While food production may benefit in some regions from mild rises in temperature, negative effects prevail overall, especially as average global temperatures are expected to rise further, driving changes in precipitation patterns and an increase in extreme weather events.⁴⁻⁷ In the short term, extreme weather events may pose the greatest risk to food production.⁷⁻¹⁰

Climate change will increase the year-on-year variability of yields for crops, and higher temperatures may also affect food supply by increasing the incidence of pests and diseases affecting production and processing^{6,7,11}.

Global cereal production growth will be lower as a result of climate change, leading to an imbalance between supply and demand^{6,9}. It is estimated that each decade of climate change will reduce mean agricultural yields by 1 per cent, whereas the demand for food is forecast to increase by 14 per cent per decade.⁶

Figure 2: Areas identified as highly vulnerable to climate change.¹⁰



Water scarcity will be a growing constraint on future production. Agriculture is responsible for 70 per cent of water withdrawals globally and up to 90 per cent in developing countries.¹⁰ Surface water is already oversubscribed in many grain producing basins and groundwater is fast depleting.⁵ Despite this growing threat of water shortages, food production is forecast to become more water intensive. Higher incomes typically lead to higher consumption of meat, dairy, exotic vegetables and fruit, which require more water than the diets they replace. The combination of population and income growth therefore translate into an exponential increase in the amount of water demanded

by food production^{5,10}. Additionally, there will be increasing non-agricultural demand for water in the years ahead from industry, municipal, and energy uses. Increasing scarcity means that water for agricultural irrigation will become much more expensive in the future, which will push food commodity prices higher too⁴. Areas that are forecast to be severely affected by water shortages include some of the world's most significant agricultural production centres, including Northwest India, Northeast China, California's Central Valley, and the Midwest of the US^{10,12}.

Land scarcity will also constrain food production. Overall, agriculture is estimated to contribute between 12 and 14 per cent of global greenhouse gas emissions directly, mostly due to livestock production and nitrogen fertilisers.¹³ If the effects of agriculture on land use, land use change, and forestry are added, the figure more than doubles to around 30 per cent of global emissions.^{4,13}

Given the scale of its contribution, agriculture is likely to face increasing calls to reduce net emissions, which will have significant implications for land use, fertiliser use, production, processing, and transport, potentially contributing to rising costs or lower production. Additionally, there will be increased pressures to set aside forest lands for carbon sequestration and, in some countries, increase biofuels production, further constraining the supply of land for food^{4,9}.

Urbanisation is another competing demand for land. Rapid growth in urbanisation will increase the amount of potentially cultivable land that is used to host housing and infrastructure⁵. It is estimated that the built-up areas of cities with more than 100'000 inhabitants will increase by 175 per cent by 2030.¹⁴ With urban land only comprising about 3 per cent of the planet's land areas, the impact may seem globally modest. This growth is, however, highly concentrated geographically and could result in pressure on the availability of agricultural land at local or regional levels, in particular in China and India⁴. Amid these growing demands, however, more land is needed. It is estimated that, even if global agricultural productivity were brought to the current levels prevailing in the United States, feeding 9 billion people with current North American diets would require almost doubling cropland area.¹⁵

DEMAND-SIDE DYNAMICS

As the world's population grows and individual consumption levels increase with rising income levels, demand for food is ever-increasing. The world population is on track to reach 9.6 billion people in 2050, an almost 50 per cent jump from 2005¹⁶. In addition, conservative estimates foresee a doubling of per capita incomes at the global level by 2050¹⁷⁻²². Combined, these trends translate to an overall increase in food demand ranging between 54 and 98 per cent¹⁸. Partly as a consequence of rising incomes, demand for meat and other animal products is expected to grow faster than the average, contributing to rising demand for cereals and oilcrops, which include soy, to be used as feed.^{15,17,23} By 2050, demand for cereals is forecast to grow by 31 per cent, demand for meat by 43 per cent, and demand for oilcrops by 47 per cent¹⁷.

While the projected growth in demand for food is not significantly larger than what the world has seen in the past five decades, achieving the needed productivity increases will be harder than in the past due to the environmental constraints affecting the supply side. Indeed, the situation is depicted as a potential 'perfect storm' in which the global farm and food system will need to feed many more people in addition to serving other competing functions, such as carbon sequestration.⁴

PRICES ARE AFFECTED AS RISING DEMAND MEETS CONSTRAINED SUPPLY

Elevated and more volatile food prices are the forecasted result of this inevitable collision of supply and demand as climate change and other environmental constraints make food production more variable and less reliable²⁴. In the long term, average food commodity price levels are likely to rise. The more immediate risk to countries, however, is the likely increase in rapid and important food price movements or food price shocks. Indeed, many analysts believe that we are already witnessing the beginning of such trends^{5,6,8-10,13}.

While there is a range of opinion on the evolution of food price volatility depending on how volatility is measured and what time period is considered, we can plainly see a break from a period of fairly low volatility in the 1990s and early 2000s to one of high volatility in the past decade. Between 1991 and 2006, the average difference in the food price index from one year to the next was around 7 per cent. Between 2007 and 2015, it was just under 14 per cent (see figure 3). This conclusion is also upheld by comparing how far monthly prices of food diverge from their yearly average over time¹⁰. The number of monthly observations of a price level more than 4 relative standard deviations from the annual average rose from only 8 out of 187 between 1991 and 2007 to 48 out of 99 observations since then (see figure 4).

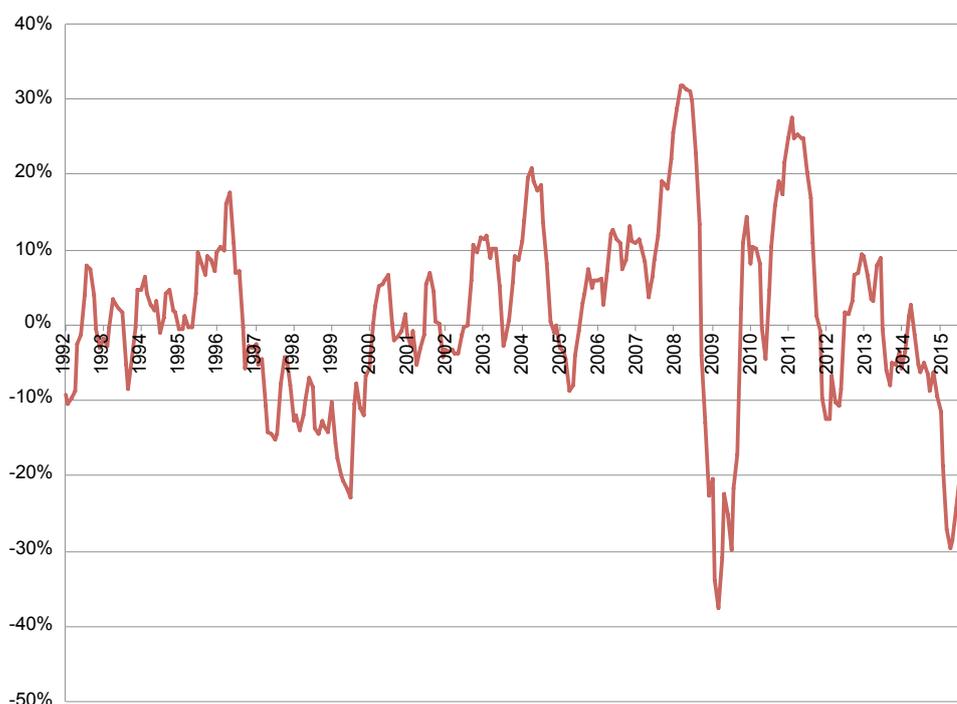


Figure 3: Year-on-year price swing for food prices, January 1991 to September 2015. *This figure is an update of the analysis done by HSBC⁹, realised with IMF Food price index data²⁵.*

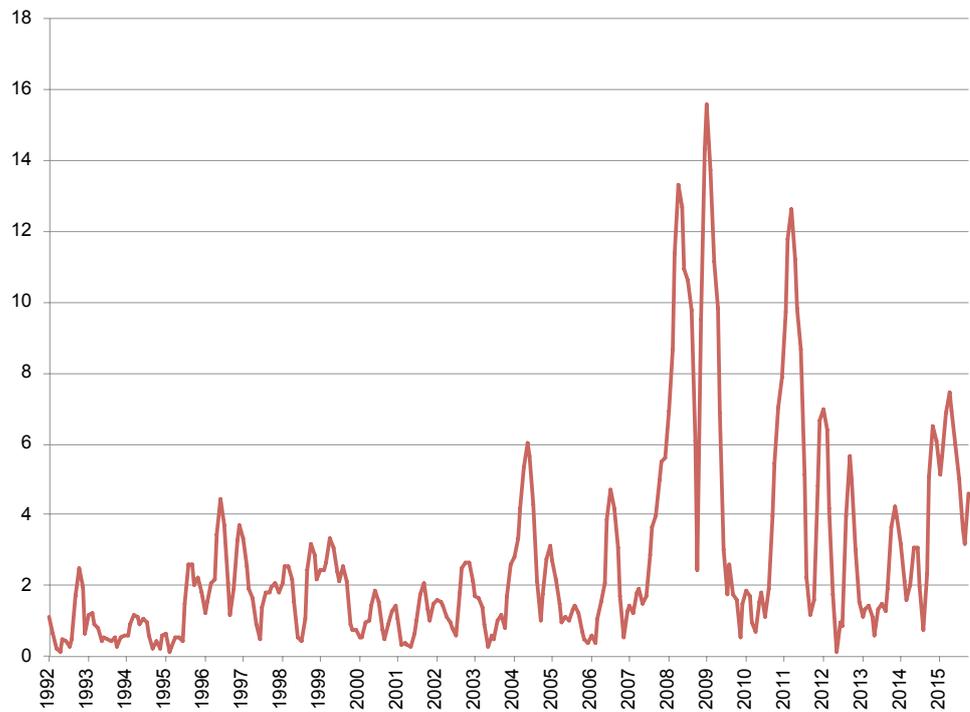


Figure 4: Relative standard deviations of monthly food price index from moving annual average, January 1991 to September 2015.

This figure is an update of the analysis done by Chatham House¹⁰, realised with IMF Food price index data.²⁵

In addition, the Intergovernmental Panel on Climate Change (IPCC) highlighted several recent instances of food price spikes following extreme climate events affecting major agricultural producers.⁶

Moreover, national economies are increasingly exposed to food price volatility in international markets as trade expands in the food system. A growing number of countries rely on net imports of food, while a smaller number of countries are ramping up their food exports to meet this demand. Food supply chains are growing increasingly complex, and movements in international markets affect the price of domestically produced food. This means that domestic prices are impacted by events happening far beyond the local context of supply and demand. While the globalisation of food commodity markets may be generally positive for food security, it deepens the vulnerability of countries to production shocks happening outside their borders.²⁶

These mounting, inter-related environmental pressures on the global food system and their contribution to food price volatility led us to create a stress test to assess the impacts of a food price crisis on 110 countries. While the economic impacts on industrialised high-income countries are limited, a number of developing countries may see significant impacts on their inflation, current accounts and even economic growth.

MODELLING FOOD PRICE SHOCKS

Which countries will be most affected by increased volatility of global food prices occurring as a result of environmental constraints?

Environmental constraints to food production, combined with rising demand for food, will result in an increase in the severity and magnitude of food commodity price shocks²⁴. While it is not possible to predict the precise nature and timing of the next food crisis, countries can be assessed and compared in terms of their sensitivity to food commodity price shifts. In order to assess which countries will be facing the most severe impacts from elevated and volatile food prices, a standardised stress test was applied to 110 countries for which sufficient data is available. The stress test simulates a rapid one-time doubling of food commodity prices (covering cereals, cereal preparations and soybeans), as seen in the 2007-08 food crisis. For more details on the model see appendix.

DATA SOURCES

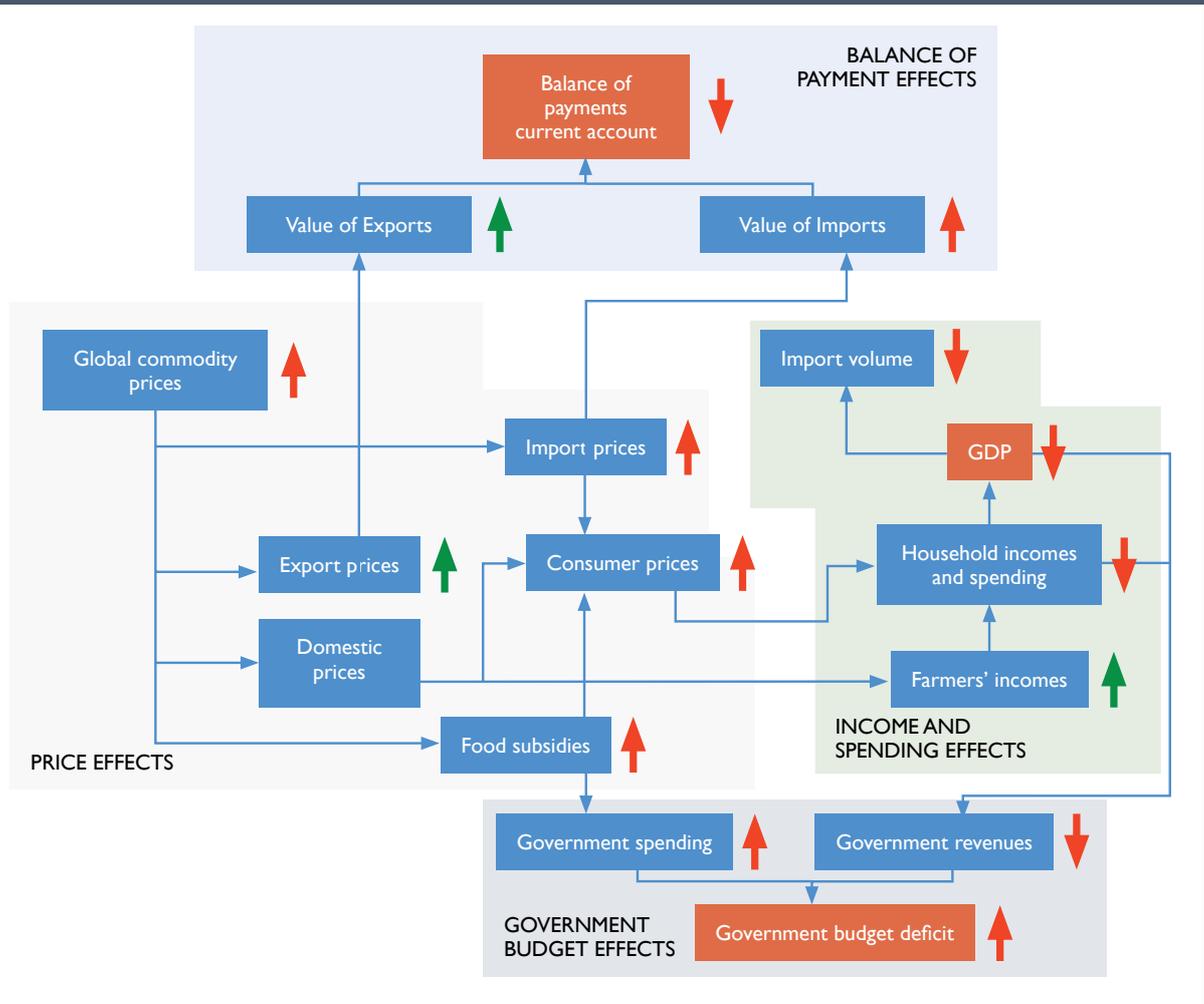
Data	Source
Share of household consumption spent on food commodities both raw and embedded in processed products	Calculated from Purdue University's Global Trade Analysis Project (GTAP)
Food trade	Food and Agricultural Organisation of the United Nations
Household expenditure	World Bank
Current account of the balance of payments	World Bank
Gross Domestic Product	World Bank

HOW ARE NATIONAL ECONOMIES AFFECTED BY FOOD PRICE SHOCKS?

Price effects: Increases in international food commodity prices affect import and export prices, as well as the prices of food produced for domestic consumption.

Income and expenditure effect: Higher consumer prices reduce real incomes, resulting in lower consumer spending, partly on food but particularly on income-elastic products, also leading to reductions in imports and domestic output and employment, with multiplier effects. The negative impact is partially offset by higher farm incomes in some countries.

Government budget effects: Lower incomes and private spending in the economy result in lower government revenues. If the government operates a



food subsidy scheme then government spending rises. To the extent that the government operates welfare programmes, spending on these will be triggered as employment falls.

Current account effects: If a country is a net importer, the net effect is a deterioration in the current account of the balance of payments, mitigated partly by the reduction in imports associated with lower real spending in the economy.

Exchange rate effects: The analysis presented in this report has assumed no change in the exchange rate. If financial markets respond to the less favourable prospects for the country's economy by selling its currency, the impact on the current account of the balance of payments will be mitigated by a lower exchange rate, which will curb imports and boost exports

RESULTS

The outcomes of the stress test are calculated for three key variables: countries' real GDP, current account balance, and consumer price index. The impact on GDP provides a comprehensive measure of the economic impact of a food commodity price shock on a country. The impact on current accounts shows how this shock affects its foreign exchange earnings and/or reserves. The impact on consumer prices shows how a rise in food price commodities will impact household spending on non-food goods and services for the average consumer. Although not modelled, the impact on household spending can also be a cause for socio-political unrest in some cases, as witnessed in the 2007-08, and 2011 food price crises, which can exacerbate economic effects.

The effect on countries' GDP offers the most comprehensive view of the economic impacts of a food price shock on the economy. While a handful of countries experience GDP increases as a result of a rapid doubling in food commodity prices, most (101 out of 110) experience a negative impact on GDP.

Highest Positive Effect		Highest Negative Effect	
Country	Real GDP Effect (%)	Country	Real GDP Effect (%)
Paraguay	5.7	Benin	-8.6
Uruguay	2.5	Nigeria	-7.2
Bulgaria	0.6	Côte d'Ivoire	-7.0
Australia	0.1	Senegal	-6.6
Brazil	0.1	Ghana	-6.5
Canada	<0.1	Mozambique	-6.1
United States of America	<0.1	Rwanda	-5.5
Hungary	<0.1	Malawi	-5.4
Viet Nam	<0.1	Ethiopia	-5.4
		Tanzania	-5.2

Table 1: Countries experiencing the largest positive and negative effects on real GDP from a doubling in food commodity prices.

The **effect on countries' current account** reflects the balance of their external trade in food commodities. Of the 110 countries covered by this analysis, 41 are forecast to see improvements in their balance of payments as a result of a food price spike. For the 69 remaining countries, the impact on the balance of payments is negative, and in some cases very strongly so. The vulnerability to a deterioration of the balance of payments is perhaps most concerning for those countries who are already experiencing a negative current account balance and who would see a further deterioration in the event of a food price spike.

Highest Positive Effect		Highest Negative Effect	
Country	Current account effect (% of GDP)	Country	Current account effect (% of GDP)
Paraguay	9.9	Benin	-11.9
Uruguay	5.0	Senegal	-7.5
Viet Nam	3.6	Côte d'Ivoire	-7.1
Ukraine	3.1	Guinea	-4.8
Thailand	2.6	Jordan	-3.7
Pakistan	2.0	Honduras	-2.8
Bulgaria	1.8	Cameroon	-2.7
Hungary	1.1	Kyrgyzstan	-2.6
Cambodia	1.0	Jamaica	-2.4
Lithuania	0.9	Burkina Faso	-2.3

Table 2: Countries experiencing the largest positive and negative effects on the current account from a rapid doubling in food commodity prices.

A group of outliers enjoys positive current account effects from a food price spike. These are net food exporters that are either middle income countries such as Thailand, Uruguay, Viet Nam, Brazil, Paraguay, and Pakistan or higher income countries such as Italy, Bulgaria, and Hungary. While such countries benefit from increases in food prices and therefore stand to gain from the longer term trend towards higher prices, they are conversely negatively affected when these prices fall and therefore vulnerable to increases in food price volatility.

The effect on countries' consumer price index reflects the relative importance of food commodities, including those embedded in processed foodstuffs, in the total spending of households. In 37 countries, a doubling in food commodity prices leads to an increase in the consumer price index of more than 10 per cent. In previous food crises, such as those of 2007-08 and 2011, higher food prices led to socio-political unrest in a number of countries notably in North Africa and the Middle East as well as in South East Asia. Many of these same countries show high exposure to price increases in our stress test, including Morocco (19.4%), Bangladesh (19%), Tunisia (15.7%) and Indonesia (11%).

Smallest Impact on CPI		Largest Impact on CPI	
Country	CPI Effect (%)	Country	CPI Effect (%)
Switzerland	0.5	Nigeria	47.8
Australia	0.7	Rwanda	46.5
Singapore	0.7	Ghana	35.7
United States of America	0.7	Ethiopia	32.3
Chile	0.9	Mozambique	29.0
Norway	0.9	Tanzania	30.0
Canada	0.9	Mozambique	29.0
Denmark	0.9	Kenya	28.4
United Kingdom	1.0	Lao PDR	24.9
Sweden	1.0	Togo	23.9

Table 3: Countries experiencing the largest and smallest effects on their consumer price index from a doubling in food commodity prices.

Furthermore, in the event of a food price crisis, the effects on GDP, current accounts, and consumer prices are closely correlated. The most vulnerable countries are likely to face all three of these effects simultaneously.

DISCUSSION OF FINDINGS

Major drivers of economic impacts from food commodity price shocks

Net trade in food commodities and share of household spending on them are major determinants of food shock impacts. Countries that are most exposed combine high household spending on food and high levels of net imports of food. These include emerging market countries such as Egypt, the Philippines and Morocco, as well as many sub-Saharan African countries.

Other countries, however, are not immune to impacts. Some of the largest emerging market economies such as China, Turkey and Indonesia are in the highest categories for one of the variable but only medium-high on the other. These countries also face significant negative impacts from a food price crisis. In table x below we have divided countries into 10 categories based on their net trade in food commodities and their household spending on food. The average impact on GDP (in %) is shown for each category. The impact on GDP ranges from a 2.2 per cent increase for net food exporters with low household spending on food to a 4.1 per cent decrease for net food importers with high household spending on food. The countries or regions in each category are shown below the table listed by size of GDP in 2014.

		Net trade in food commodities (value in % of GDP)			
		Imports worth more than 1% of GDP	Imports worth between 0 and 1% of GDP	Exports worth between 0 and -1% of GDP	Exports worth more than 1% of GDP
Household spending on food commodities (% of total household spending)	Over 5%	-4.1% ¹	-2.6% ²	-1.6% ³	0.0% ⁴
	Between 2% and 5%	-1.8% ⁵	-1.0% ⁶	-0.4% ⁷	2.2% ⁸
	Less than 2%	-	0.4% ⁹	-0.1% ¹⁰	-

Table 4: Average effect on GDP for countries based on net trade in food commodities and household spending on food

1. Egypt, Philippines, Bangladesh, Morocco, Dominican Republic, Kenya, Guatemala, Ethiopia, Tunisia, Tanzania, Ghana, Côte d'Ivoire, Cameroon, El Salvador, Nepal, Georgia, Mozambique, Senegal, Albania, Mauritius, Burkina Faso, Nicaragua, Armenia, Madagascar, Benin, Rwanda Kyrgyzstan, Equatorial Guinea, Togo, Malawi
2. China, Indonesia, Turkey, Nigeria, Peru, Ecuador, Sri Lanka, Belarus, Croatia, Bolivia, Uganda, Lao PDR
3. India, Kazakhstan, Romania, Zambia, Cambodia
4. Thailand, Pakistan, Viet Nam, Ukraine
5. Saudi Arabia, Costa Rica, Panama, Jordan, Honduras, Botswana, Jamaica
6. Republic of Korea, Mexico, Colombia, South Africa, Malaysia, Israel, Greece, Namibia, Mongolia, Venezuela (no GDP data for 2014)
7. Russian Federation, Czech Republic, New Zealand, Slovakia, Lithuania
8. Hungary, Uruguay, Bulgaria, Paraguay
9. Japan, United Kingdom, Spain, Netherlands, Switzerland, Belgium, Norway, Austria, Hong Kong (China SAR), Finland, Chile, Portugal, Qatar, Kuwait, Oman, Luxembourg, Slovenia, Bahrain, Cyprus
10. USA, Germany, France, Brazil, Italy, Canada, Australia, Sweden, Poland, Denmark, Singapore, Ireland, Latvia, Estonia

Negative economic impacts far outweigh positive impacts

The absolute value of the economic shock reveals important potential shortfalls for large emerging market countries. We calculate this absolute value by taking the projected effect on GDP and multiplying it by the most recent GDP value for each country. While net food exporters do see a positive effect that can amount to several billion dollars, this is dwarfed by the downside risk facing the most negatively affected countries. The potential losses for China are, for example, roughly 50 times larger than the gain experienced by the US.

Highest Positive Effect		Highest Negative Effect	
Country	Effect on GDP (million \$)	Country	Effect on GDP (million \$)
United States of America	3'282	China	-161'301
Paraguay	1'775	India	-49'470
Australia	1'502	Nigeria	-40'659
Uruguay	1'458	Indonesia	-22'239
Brazil	1'178	Japan	-19'360

Table 5: Highest positive and negative effects on GDP in absolute terms.

How economic impacts compare to sovereign credit ratings

Higher credit ratings correlate to lower vulnerability to food price shocks. Overall, because both the share of household spending on food commodities and the importance of food trade in the economy tend to decline as per capita incomes rise, the effects of a food price crisis are more severe for countries with lower incomes than for wealthy countries. As per capita incomes also carry significant weight in determining a country's existing sovereign credit rating, we can observe that better credit ratings tend to be correlated with lower exposure to food price shocks.

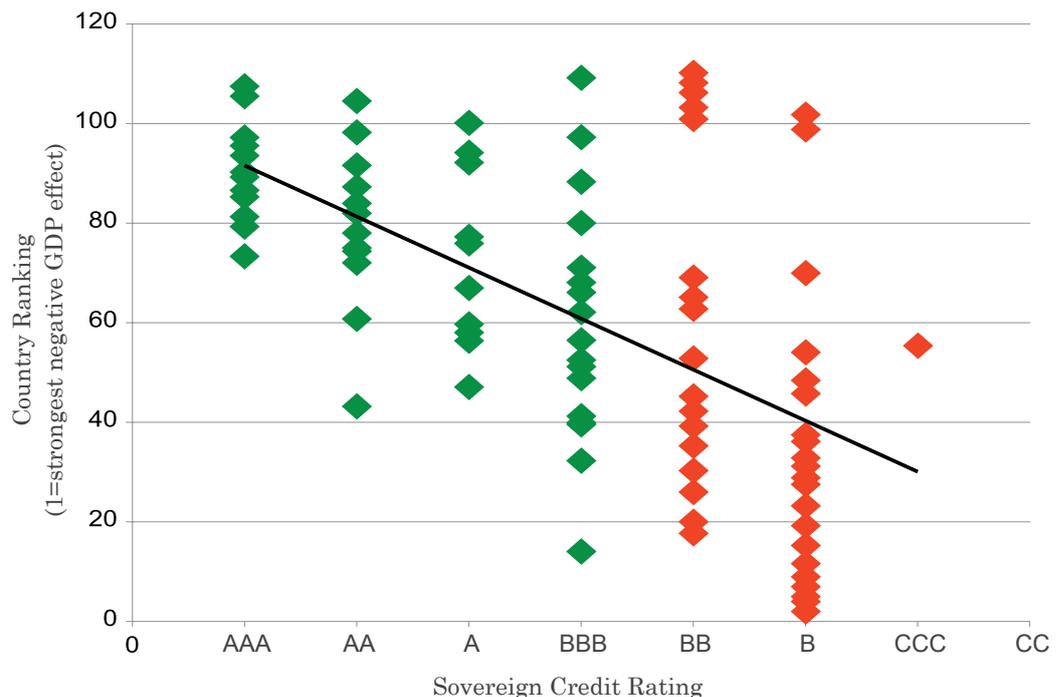


Figure 5: Country ranking of GDP effects of a food price crisis by S&P sovereign rating. Ratings below BBB, in red above, are considered to be below investment-grade.

Despite the overall correlation between better ratings and lower exposure to food price crisis effects, **there are countries in each rating grade that face potentially significant effects.**

AAA	AA	A	BBB
Hong Kong (China SAR) (-0.5%)	China (-1.6%)	Botswana (-1.3%)	Morocco (-4.5%)
Luxembourg (-0.4%)	Republic of Korea (-0.8%)	Malaysia (-1.0%)	India (-2.4%)
Netherlands (-0.3%)	Kuwait (-0.5%)	Saudi Arabia (-1.0%)	Philippines (-1.9%)

Table 6: Countries or regions experiencing the largest negative GDP effects from a rapid doubling of food commodity prices per S&P rating category.

Environmental constraints to production could exacerbate the impacts of high prices

The scope of the report covers the impact of environmental constraints on commodity prices and does not attempt to forecast production shocks at the individual country level. The effects shown here reflect what would happen in the event of a global event that would double commodity prices *but would not impact the country's own production*. However, the effects depicted would be strongly enhanced if a price shock occurred at the same time as a production shock, as the higher revenue for producers would not offset the higher costs for consumers. A number of the countries most vulnerable to elevated and volatile prices are also among those forecast to be most heavily affected by climate change (see figure 6). They face risks not only from the impact of environmental constraints on food prices, but also on their own domestic production. The economic impacts of such a combined shock have not been estimated, but are likely to be many times greater than the shocks modelled here for the most vulnerable countries.

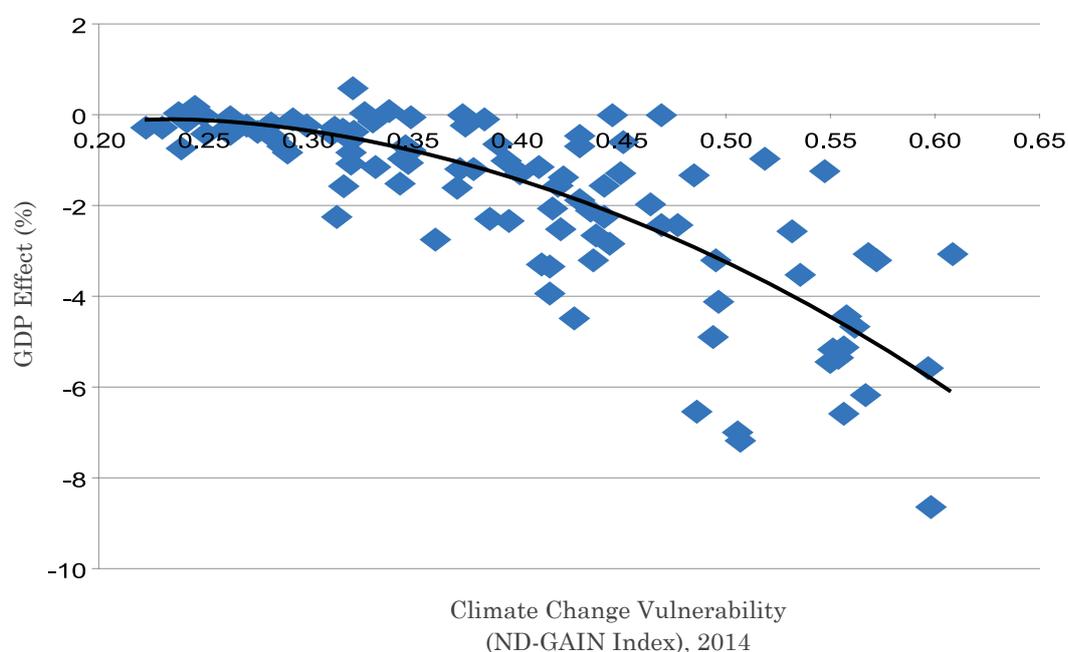


Figure 6: Cumulative effects on real GDP of a doubling in food commodity prices and climate change vulnerability index (2014).²⁷

The Notre Dame Global Adaptation Index of vulnerability to climate change measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change. 0.00 is low vulnerability and 1.00 is high vulnerability.

There is an inverse correlation between risk and responsibility.

The countries whose population have the highest consumption of natural resources and services, and are therefore **most responsible for the environmental constraints** that make future food prices higher and more volatile, tend to **face the lowest risk exposure**. The Ecological Footprint, developed by Global Footprint Network, is a framework that measures human demand for renewable natural resources and ecosystem services, including demand for fruits and vegetables, meat, fish, wood, cotton for clothing, and forests for carbon dioxide sequestration. A comparison of countries' average per capita Ecological Footprints with their exposure to the consequences of food price crises shows that the countries with the highest per capita Ecological Footprints are the least exposed to food prices shocks. Conversely, those facing the largest negative economic effects from food price shocks are poorer countries who have played little or no part in causing environmental constraints to expanded food production. This situation is analogous to that of climate change, where the countries responsible for the greatest greenhouse gas emissions tend to be more resilient to the economic effects of climate change than the less developed countries that often bear little historical responsibility for the accumulation of these gases in the atmosphere.

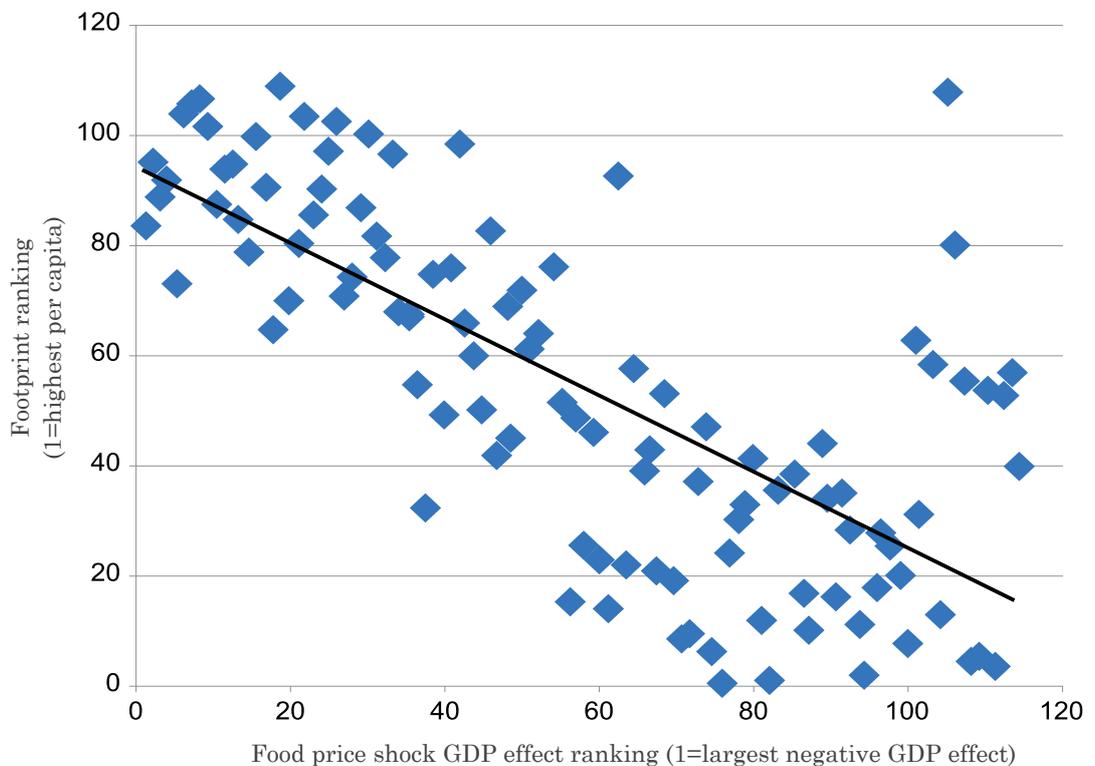


Figure 7: Comparison of country rankings according to their per capita Ecological Footprints and the impact of a rapid food commodity price on their GDP.

	Per capita footprint (gha)	Footprint ranking (1=highest per capita)	Food price shock GDP effect (%)
Qatar	10.80	1	-0.2
Australia	9.31	2	0.1
United States of America	8.22	3	0.0
Canada	8.17	4	0.0
Kuwait	8.13	5	-0.5

Table 7: Countries with the highest per capita footprints. *Global hectares (gha) are the accounting unit for the Ecological Footprint. They represent a hectare with world average biological productivity. The globally available biocapacity per person is 1.73 gha.

HOW CAN RESULTS INFORM COUNTRY RISK ASSESSMENT?

This report establishes that food prices are a principal channel through which environmental constraints will affect national economies. The results from the stress test provide quantitative and comparative information on how a global food price crisis would impact key macroeconomic performance indicators. Financial institutions can integrate this information into their models and analysis to inform their risk assessments of countries and ultimately their investment decisions.

To assess how the integration of these findings would affect risk assessment, a participating financial institution in the ERISC project used the GDP and consumer price index results to simulate the impact that the food shock might have on their internal country risk ratings. The institution carried out this exercise for the 78 developing countries that are covered by both the stress test and its country risk assessment methodology.

In the exercise, 58 out of the 78 countries were downgraded in the quantitative rating module by at least one notch in a 19-notch rating system. The countries facing the most severe impacts were downgraded by four notches. No country experienced an upgrade, suggesting that the positive GDP effect that some experience is not large enough to offset the higher inflation caused by rising food prices. Overall, the countries already rated as relatively high risk experience the largest downgrades.

Rating action	Number of countries/regions (out of 78)	Examples
No change	20	South Africa, Czech Republic, Saudi Arabia, Poland, Chile
1 notch downgrade	26	China, Hong Kong (China SAR), Israel, Mexico, Russia
2 notch downgrade	16	Indonesia, Nigeria, Pakistan, Ghana, Sri Lanka
3 notch downgrade	14	India, Morocco, Egypt, Tunisia, Kenya
4 notch downgrade	2	Cameroon, Rwanda

Table 8: Changes in the institution’s quantitative rating module resulting from stress test.

It should be noted that the downgrades listed above only affect the quantitative part of the rating procedure. This is followed by a qualitative assessment of other factors that can influence a country’s creditworthiness. This second step can modify the rating up or down, meaning that the final impact on ratings may be different from that presented above.

The institution indicated they see the results as useful for running a scenario to stress test their investment portfolio in line with regulatory requirements, or in response to specific market events such as a food price shock. This underscores the stress test results’ usefulness in the event of a market signal or price event. Due to the uncertainty in timing such an event, however, it is not yet considered appropriate to make any changes to their internal rating methodology to reflect the higher risks facing some countries as a result of environmental risks and constraints to food production. This is because the probability of a food commodity price shock is judged to be low in comparison with other risk factors in their short-term rating horizon.

CONCLUDING REMARKS AND FUTURE WORK

The ERISC project, short for Environmental Risk Integration in Sovereign Credit Analysis, aims to help financial institutions to integrate environmental risks in their risk assessments and investment decisions by identifying and quantifying how they can affect countries' economic performance and thereby their cost of credit in the sovereign debt market. The project's premise is that sovereign credit risk can be materially affected by environmental risks such as climate change, ecosystem degradation, water scarcity, and deforestation. Phase I showed that environmental risks are material, and quantified this for five countries. In this second phase of research, we focus on food prices as one of the key transmission mechanisms between environmental risks and economic impacts and quantify these impacts for 110 countries.

The results show that many countries can face material risks to their credit quality from a food price shock. Further, the global pressure on food prices is driven by overconsumption in mainly advanced economies, which adversely affects a number of small developing economies. Institutional investors and asset managers would therefore be well served by understanding these risks and their dynamics, and incorporating them into their risk models. Uncertainty in the timing of a food price shock might delay incorporation of these results into current ratings without a strong signal that such a shock may indeed be imminent, especially given the short time horizon of most credit ratings (typically less than two years for sub-investment grade and five years for investment grade). However, analysts should note that the probability of such a shock is likely to increase in the coming years.

Governments are coming to realize that climate change could have a significant material impact on their economies. They should also recognize that the consumption patterns of their populations can have environmental and economic impacts far beyond their borders. Those countries with the highest consumption levels, thus contributing most to global environmental degradation, often face little risk themselves from the food price shocks that can occur as a consequence. By taking steps towards more sustainable production and consumption, these countries can help to alleviate the demand pressures that result in higher and more volatile food prices, thereby reducing both the food security and the economic risks facing poorer countries.

As a next step we therefore encourage governments, investors, credit rating agencies, and banks to work together with us to further investigate the linkages between environmental risks, economic and socio-political impacts, and to better integrate this information in their sovereign credit risk assessments and investment decisions.

APPENDIX I

MODEL ASSUMPTIONS

To gauge the scale of impact of a global food price shock for a wide range of countries, we established a simple model with the following logic:

1. An increase in world dollar food crop prices is passed on to consumer prices in proportion to the direct and indirect importance of food crops in household consumption; domestic food crop prices move in line with world food crop prices. The model does not incorporate the effect of food subsidies.
2. Household incomes are increased (in nominal terms) by the value of the increase in revenue of the country's food crop producers.
3. The net impact on household real incomes depends on the balance between the scale of the increase in consumer prices and the scale of the increase in revenues of the country's food crop producers. This depends on whether the country is a net food crop importer or exporter.
4. Real household final expenditure changes in response to real household incomes, with an elasticity of 0.9; no distinction is made between households that gain (food crop producers) and those who lose (food consumers).
5. The model does not have an explicit time dimension. The historical record of recent food crises however suggests that estimated impacts should be interpreted as cumulative over a period of about two years.
6. No attempt is made to model the impact of each country's tax regime or food subsidy arrangements.
7. No switching of spending between higher-priced food crops and other household consumption items is incorporated; we expect that, for food crops taken as a whole, the price elasticity is low.
8. No exchange rate adjustment is incorporated; the likely change in the short run would be a depreciation in the currencies of the net food crop importers, exacerbating the impact on local consumer prices and increasing the differential impact between food crop consumers (negative) and producers (positive).

APPENDIX 2

THE 2007-08 FOOD CRISIS: THE FOUNDATION FOR OUR MODEL

The food crisis of 2007-08 provided the parameters of the food price shock for our stress test, which modelled a doubling of food commodity prices.

During this crisis, commodity prices for the main traded cereal crops increased between 80 and 105 per cent. Between early 2007 and mid-2008, the UN Food and Agriculture Organisation's cereals price index nearly doubled while the price of food in general increased by nearly 60 per cent.²⁸

In large part, the food crisis was a consequence of a long-term trend of increasing demand for food driven by population and average income growth. When extreme weather events hit several major grain producing areas in 2006, the imbalance between supply and demand pushed prices upwards.

A number of factors intervened to make the price crisis more severe. The price of oil, a key input to agricultural production in the form of fertilisers and fuel for machinery and transportation, was climbing rapidly. The increasing diversion of agricultural production for biofuel production was also reducing the amount of food being produced. In addition, the depreciation of the US Dollar (the currency in which international commodity prices are set) made crops more expensive in a number of countries. The initial policy response to the rapid jump in food prices only worsened the crisis. A number of important cereal exporters announced export restriction measures in 2008: India, Viet Nam, Cambodia, and Egypt for rice; Russia, Ukraine, Kazakhstan, and Argentina for wheat. These measures led to large precautionary orders by importing countries that moved food commodity prices significantly higher.

The food crisis pushed 130 million to 155 million people into poverty and contributed to socio-political unrest, with massive public protests over higher food prices held in Egypt, Indonesia, Mexico, Morocco, Peru, and Yemen. Many food importing countries also experienced negative macroeconomic effects, including deteriorations in the balance of payments, exchange rate appreciation against the dollar, diminishing foreign exchange reserves, and reduced government revenues.

The food price crisis was brought to an abrupt end by the 2008 financial and economic crisis, which led to a dramatic decrease in global demand. Nonetheless, food prices never fell back to their pre-crisis levels. Indeed, they experienced another spike in 2011, again following drought in some key producing areas. Although they have come down from that peak, food prices remain at levels well above their historical average.

Many of the factors that led to the 2007-08 crisis are still present today. As extreme weather events that can severely disrupt food production become more frequent, a repeat of the sequence of events leading to price spikes and severe socio-economic effects is becoming more likely.

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ABOUT

GLOBAL FOOTPRINT NETWORK

Global Footprint Network is an international research organization that is changing how the world manages its natural resources and responds to climate change. Since 2003 Global Footprint Network engaged with more than 50 nations, 30 cities, and 70 global partners to deliver scientific insights that have driven high-impact policy and investment decisions. Global Footprint Network's finance initiative helps financial institutions quantify and integrate environmental risk in their investments, credit ratings, and country risk analysis.

www.footprintnetwork.org

UNEP FINANCE INITIATIVE

The United Nations Environment Programme Finance Initiative (UNEP FI) is a unique global partnership between the United Nations Environment Programme (UNEP) and the global financial sector. UNEP FI works closely with over 200 financial institutions who are Signatories to the UNEP FI Statements, and a range of partner organizations to develop and promote linkages between sustainability and financial performance. Through peer-to-peer networks, research and training, UNEP FI carries out its mission to identify, promote, and realise the adoption of best environmental and sustainability practice at all levels of financial institution operations

www.unepfi.org

NATURAL CAPITAL DECLARATION

The NCD was launched at the UN Conference on Sustainable Development (Rio+20 Earth Summit) in 2012 by UNEP FI and the UK-based non-governmental organisation, Global Canopy Programme (GCP). It is a worldwide finance led initiative to integrate natural capital considerations into financial products and services, and to work towards their inclusion in financial accounting, disclosure and reporting. Signatory financial institutions are working towards implementing the commitments in the Declaration through NCD projects. These are overseen by a steering committee of signatories and supporters and supported by a secretariat formed of the UNEP FI and GCP.

www.naturalcapitaldeclaration.org

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The ERISC project, short for Environmental Risk Integration in Sovereign Credit Analysis, aims to help financial institutions to integrate environmental risks in their risk assessments and investment decisions by identifying and quantifying how they can affect countries' economic performance and thereby their cost of credit in the sovereign debt market. The project's premise is that sovereign credit risk can be materially affected by environmental risks such as climate change, ecosystem degradation, water scarcity, and deforestation. Phase I showed that environmental risks are material, and quantified this for five countries. In this second phase of research, we focus on food prices as one of the key transmission mechanisms between environmental risks and economic impacts and quantify these impacts for 110 countries.