



Real-time monitoring of food price policy interventions during the first two years of COVID-19

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ABSTRACT

COVID-19 has resulted in a shock to agrifood systems around the world, with the potential for low- and middle-income countries to be particularly affected. Although policy responses were more muted than during the 2007–2008 world food crisis, efforts to insulate from supply shocks and ensure local availability during COVID-19 have generally included export restrictions and import tariff reductions, among other responses. In an effort to enable rapid market monitoring and realignment, we develop a new indicator defined as a monthly nominal rate of protection “express” which seeks to indicate how policies enacted are affecting prices domestically in real-time in order to understand how they responded. This analysis examines changes to this indicator during the first two years of the pandemic in 24 low- and middle-income countries for the most-consumed staple cereals of the poor and food insecure. We show that gaps between domestic and international prices declined by a median of 20.3 percentage points compared to the same months in recent previous years. While policies were enacted to mitigate price increases that would have eventually been transmitted to poor consumers, other factors related to international demand and supply chain disruptions may also have contributed to the observed trend in the analyzed countries. Moreover, impacts on prices varied across countries and commodities, depending on region, net trade, and previous gap levels. Finally, this indicator can contribute to examining primary drivers of changes and conducting causal analysis to facilitate adequate agrifood policy responses to support economic recovery in the post-COVID-19 era.

1. Introduction

The COVID-19 pandemic has resulted in a shock to agrifood systems around the world as containment measures have disrupted agricultural value chains and hampered economic activity, with the potential for low- and middle-income countries (LMICs) to be particularly affected (FAO, 2021a). However, the full mid- to long-term effects of the pandemic on agrifood markets are yet to be observed, and timely monitoring and analytical tools are important to provide a better understanding of markets, define national and regional strategies and policy responses, and determine where to direct international cooperation efforts.

When analyzing the effects of COVID-19 on staple food markets, efforts have largely focused on global food security concerns (e.g., Laborde et al., 2021; Swinnen and Vos, 2021) and changes to global

market prices (e.g., Falkendal et al., 2021; Sulser and Dunston, 2020; Elleby et al., 2020), which can indeed trigger economy-wide effects in developing countries depending on the extent to which they are transmitted through domestic prices. These effects, in the case of agricultural commodities and food items, may result in impacts to developing countries' food security levels, especially for low-income and net food importing developing countries (Torero, 2021). Studies examining changes to domestic prices during the pandemic have typically done so on an individual country level (e.g., Hirvonen et al., 2021; Mahajan and Tomar, 2020; Santeramo and Dominguez, 2021; Varshney et al. 2020).

This analysis provides a cross-country examination of how domestic prices changed relative to world prices during the first two years of COVID-19. For the purposes of this study, we define the first two years as March 2020 to February 2022. Out of fear of acute shortage and price volatility, COVID-19 disruptions in agrifood supply chains prompted a

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variety of policy responses, such as export restrictions, import tariff reductions, and price stabilisation and food aid measures (Laborde et al., 2020a; Vickers et al., 2020).¹ With the intent of better understanding the effect of trade and market policies on domestic prices and in an effort to generate the type of evidence that can support policy decision-making, this paper builds upon the so-called nominal rate of protection (NRP) indicator (Anderson, 2010a) for further developing a novel, simplified, adapted monthly version (monthly NRP “express,” or monthly NRPx) for more timely monitoring to inform decision making in the short term. This novel monthly indicator can track in the closest to what we could call real-time how COVID-19 market responses, including the implementation of policies, are affecting food prices across different countries and value chains. In addition to contributing to the understanding of the pandemic’s disruptions to key staple food markets, the monthly NRPx indicator, when examined in conjunction with documented policy responses, can help signal where and to what extent policies need to be realigned to be more supportive of an economic recovery in the post-COVID-19 era.

In this paper, we outline the data and methodology used to calculate and compare changes to levels of monthly prices for some of the most-consumed staple cereals of the poor and food insecure in 24 LMICs as a means of generating empirical evidence on the intra-annual relationship between international and local markets. Primarily, our indicator (the monthly NRPx) shows a clear decline of 20.3 percentage points in the gap between domestic and reference prices (measured as percentage of the reference price) during the first two years of the COVID-19 pandemic. We discuss common potential drivers of these changes and how the monthly NRPx indicator can inform ongoing policy monitoring as the pandemic and its economic consequences continue to evolve.

This paper is organized as follows. Section 2 overviews the conceptual framework surrounding price interventions for agricultural value chains in LMICs. This is followed in Section 3 with a description of the methodology and empirical application, and Section 4 with an overview of the main findings. Finally, Section 5 provides a discussion of the results, followed by Section 6 with concluding comments.

2. Conceptual framework: Price interventions for staple food value chains in LMICs

Some of the most seminal applications of nominal rates of protection (NRPs) and related concepts include Krueger et al. (1988), Monke and Pearson (1989), Tsakok (1990), and Anderson and Masters (2009).² A detailed comparison of such applications can be found in Balić and Maetz (2011). Derived from the indicator in Krueger et al. (1988), the NRP indicator used today likewise measures the percentage by which domestic producer prices diverge from “international-equivalent prices” that would have prevailed in a well-functioning market at free trade. Relevant international-equivalent (reference) prices are generally prices found at the country’s border (adjusted for access costs such as transportation, marketing and processing costs) and are considered to be undistorted by national policies and free of influence of domestic market failures.³

Even today, a large part of the income of the rural poor comes from agriculture (FAO et al., 2020). Historically, earnings of farmers in

developing countries were often depressed by their own country’s policies, such as heavy taxation of agricultural exports, which had pro-urban, anti-agricultural and anti-trade biases (Anderson, 2010a). This situation has changed dramatically over the last 40 years, giving way to different patterns of agricultural production incentives through price interventions worldwide. Efforts to monitor changes to prices through international trade and domestic market policies are currently coordinated by the International Organisations Consortium for Measuring the Policy Environment for Agriculture, and NRPs (among other indicators) are calculated by participating organisations on an annual basis, typically with a two-year delay due to the challenges of gathering updated data on access costs (IFPRI, 2020). An important contribution of the price incentives literature has been quantifying the effects of policy and market environments on levels of price incentives in developing countries and providing insight into policy options for price stabilisation (Pernechele et al., 2018; Anderson and Nelgen, 2012). In this study we create a simplified, modified monthly version of the NRP indicator that allows for timely understanding of how the pandemic is disrupting agricultural markets and value chains. Future developments of analysis of this monthly indicator will include the incorporation of seasonality and other aspects derived from intra-annual trade variation.

Considering data availability, our analysis covers the three most-consumed staple cereals – rice, wheat and maize – as well as sorghum and potatoes, when available. We focus on LMICs, where agricultural production constitutes a larger share of household income and changes in prices present more of a food security concern (FAO et al., 2020). The poor spend more than a quarter of their income on staple foods such as rice, wheat, and maize (Laborde et al., 2020a), which together account for as much as half of the calorie supply in developing regions (FAO, 2016). Cereal prices are of critical importance for nutrition, as higher cereal prices can crowd out expenditures on nutrient-rich nonstaples such as fruits, vegetables, eggs, and dairy, and even more so when coupled with income declines of poor households (Laborde et al., 2021).

As many of the poor are both producers and consumers of food, the impact of high domestic prices with respect to food security can vary by country and commodity; however, research has shown that the poorest are often net buyers of food and thus can benefit from lower prices of staples (Ivanic and Martin, 2014; Lederman and Porto, 2015). Thus, LMIC governments may respond to a shock to food systems with policies intended to insulate consumers from world price fluctuations and ensure adequate supplies of staple foods, especially in light of falling income levels and contracting economic growth during a crisis such as COVID-19 (Laborde et al., 2020a). The so-called “food price dilemma” encompasses the reality that a single market-clearing food price cannot satisfy all consumers and producers simultaneously, and therefore “additional policy instruments are needed” (Timmer, 2017, 6–7). As seen during the 2007–2008 world food crisis, policy responses such as export bans (to prevent domestic prices from increasing at the same rate as international prices) and import tariff reductions (to offset increases in international prices) can translate into a decline in price incentives (measured by the gap between domestic and international prices), highlighting the tradeoff between reducing consumer prices levels and volatility and incentivising agricultural production (Anderson and Jensen, 2017; Anderson and Nelgen, 2012).⁴ Such tradeoff implies that by incentivizing consumers (by reducing prices through export restrictions or lowering import tariffs) the country may end up disincentivizing agricultural production, hence incentives on the demand side may

¹ These policy responses were similar in nature to those enacted during the 2007–2008 world food crisis, albeit implemented to a much lesser extent. For example, 22 countries imposed food export restrictions at the beginning of the COVID-19 crisis, none of which are currently active, compared with 33 countries in 2007–2008 (Anderson and Nelgen, 2012; Hepburn et al., 2020).

² The four regional volumes of the World Bank’s Distortions to Agricultural Incentives (DAI) program, including Anderson and Masters (2009), are synthesized in Anderson (ed., 2009). Anderson (2010b) were generated from the project’s second stage.

³ See Section 3.1.2 for a further description of reference prices.

⁴ However, alterations to trade policies that decrease incentives do not necessarily guarantee lower consumer prices: in addition to risking declines in local agricultural production, changes to trade policies collectively contributed to the global price spikes during the 2007–2008 world food crisis (Anderson and Jensen, 2017). For example, around one-third of the increase in the international price of rice from 2007 to 2008 was attributed to changes in border restrictions (Anderson and Jensen, 2017).

mirror disincentives on the supply side and viceversa. Against this conceptual background, since trade restrictions were limited and temporary during the first two years of the COVID-19 pandemic, we hypothesize that the price gap between domestic and international prices for staple cereals had a moderate change, with an overall median decline, though impacts may vary across countries and commodities.

3. Data and methodology

3.1. Monthly NRPx indicator

In order to calculate the monthly nominal rate of protection “express” indicator, we first calculate the monthly price gap “express” as the difference between the monthly domestic price (P_{wh} at the point of competition or P_{rt} at the consumer level) and the monthly reference price “express” (RPx_{wh} at the point of competition or RPx_{rt} at the consumer level). Thus, the monthly price gap “express” is given as $PGx_{wh} = P_{wh} - RPx_{wh}$ for the point of competition and $PGx_{rt} = P_{rt} - RPx_{rt}$ for the consumer level.⁵

The monthly nominal rate of protection “express” is then calculated by dividing the monthly price gap “express” by the monthly reference price “express,” in order to make the indicator comparable across different commodities, countries, and time periods (MAFAP, 2015). This is given as $NRPx_{wh} = PGx_{wh}/RPx_{wh}$ for the point of competition and $NRPx_{rt} = PGx_{rt}/RPx_{rt}$ for the consumer level.

3.2. Data

Since our analysis focuses on understanding price deviations of staple cereals in LMICs on a monthly basis, we follow the selection criteria used in Dawe and Morales-Opazo (2009).⁶ Our first step was to bound the period of analysis: monthly domestic and border prices are compiled from January 2017 to February 2022 in order to be able to examine changes to monthly levels of price gaps during the first two years of the COVID-19 pandemic. The analyzed period ends before the outbreak of the Ukrainian conflict in order to avoid aggregating the effects of the two different shocks.

We term each selected country and commodity combination (e.g., Ecuador - maize) a “case study.” As shown in Table 1, 39 case studies for rice, wheat, maize, sorghum, and potatoes were ultimately used across 24 LMICs, and price data was available for the whole period (with some eventual missing internal months) for more than 80 % of case studies. There were 13 case studies for rice, 12 for maize, 11 for wheat, and only 2 for potatoes⁷ and 1 for sorghum. Case studies were primarily from Africa (13 case studies from 9 countries), Latin America and the Caribbean (12 case studies from 5 countries), and Asia and the Pacific (8 case studies from 5 countries), with four countries included from Eastern Europe and one from the Near East (Egypt).

3.2.1. Domestic prices

FAO’s Global Information and Early Warning System (GIEWS) Food Price Monitoring and Analysis (FPMA) Tool (FAO, 2022b) was used to

⁵ The “express” distinguishes the monthly, adapted estimation of components of the price incentives indicators given in MAFAP (2015). Note that the monthly domestic price is not considered an “express” version as it is used directly as-is from the FAO-GIEWS FPMA Tool (FAO, 2022b).

⁶ Dawe and Morales-Opazo (2009) examined changes to monthly domestic staple food prices in developing countries during the world food crisis of 2007–2008, finding a median increase of 48 percent.

⁷ Kyrgyzstan potatoes, initially an included case study, was deemed an outlier and eliminated from the sample due to extraordinarily high changes in monthly NRPx values, largely a result of country-specific factors outside the primary policy scope of this analysis, such as currency depreciation (IMF, 2021) and a large spike in demand due to fear of supply shortages at the onset of COVID-19 that exacerbated seasonal demand (FAO, 2021b).

Table 1

Included case studies by region, commodity group and end-date.

		Case studies	Countries
Region	Africa	13	9
	Asia and the Pacific	8	5
	Eastern Europe	4	4
	Latin America and the Caribbean	12	5
	Near East	2	1
	Total	39	24
	Commodity group	Rice	13
	Maize	12	
	Wheat	11	
	Potatoes	2	
	Sorghum	1	
Case study end date	January 2021	3	
	September 2021	2	
	January 2022	2	
	February 2022	32	

obtain monthly nominal domestic prices.⁸ The ultimate data sources in most cases are official government sources; full details of the sources for each country are available in FAO (2022b). Nominal prices are used because recent monthly consumer price index (CPI) values are not available for many included countries, and the nature of the indicator as a ratio yields similar results using either nominal or real prices.

Additionally, wholesale or retail prices are used rather than producer prices since prices at the farm gate are typically only available at the annual level and are not accessible on a monthly basis in a widespread, timely manner.⁹ Measuring price gaps at the wholesale and consumer (retail) level can provide important insights from a food security and affordability perspective. Moreover, the use of these prices may also provide insight into how policies created deviations between domestic and international prices of main staple foods.

This is a simplification of the NRP methodology detailed in MAFAP (2015) due to lack of monthly data on farm gate prices, with the assumption that gaps between domestic and international prices are transmitted equally throughout the value chain. Consequently, the monthly NRPx indicator only provides a sense of changes in price gaps in the value chain, regardless of the point in which these are measured. Hence, the monthly NRPx indicator should be used as a way to understand roughly whether policy responses to external shocks have translated into price deviations from the (international) reference price, to which consumers (and wholesalers and retailers) may react on the short term, while producers could react to them if these policies are prolonged. Collection of more frequent and systematic farm-level price data should be a major priority for understanding supply responses.

Once we determined which nominal domestic price data were available, our next step was to select the case study for each country and commodity combination. Within a given country for a given staple food, nominal price data are often available for multiple locations, multiple qualities, and multiple levels of the marketing chain (i.e., both wholesale and retail), or some combination thereof. To choose which data series to analyze for a given case study, a set of ordered criteria were applied. To avoid skewing the sample, only one case study for each commodity in any given country was considered, (e.g., either prices for whole wheat or wheat flour, or either rice at the wholesale or retail level). The first

⁸ Only Senegal rice had a different source: the price for local broken rice from the Market Regulatory Agency (DPEE, 2022) was used rather than the FAO-GIEWS FPMA Tool’s imported rice price.

⁹ Though farm gate prices are used by FAO’s MAFAP programme to calculate NRPs as well as in other existing approaches of policy monitoring, they are not as widely available on a recent monthly basis. For the cereals included in this study, producer prices are available on the FAOSTAT database for a range of countries, but only on an annual level (FAO, 2021c).

criterion was to use, whenever possible, wholesale price data (obtained for 27 case studies), as the wholesale level is the point of competition between domestic and imported production and is the closest point to farm gate with available information. However, if no wholesale price data were available, retail prices were used (12 case studies). The second criterion was to use, whenever possible, data on the primary output. For example, in the case of wheat, if price data for both whole wheat and wheat flour were available, data on whole wheat was preferred.

The third criterion was to use the lowest quality of the commodity available, considering that lower qualities are usually more widely consumed by poor households. For example, 25 % broken rice in Thailand was selected over 5 % broken rice. Our last criterion was to use national average prices when available. When national average prices were unavailable, an unweighted average price was calculated from all markets in the given country for which data were provided, or a single market price was utilized if it was the only price available.¹⁰ National average domestic price data were available for 12 case studies, an unweighted average was calculated for 18 case studies, and data from only a single location was available for the remaining 9 case studies.

3.2.2. International reference prices

To determine the net trade position and thus the relevant border (benchmark) price, annual data from the UN Comtrade Database (United Nations, 2022) was used, with monthly UN Comtrade data supplemented when needed. The trade status was assessed for each year, and in cases where the trade status varied between years, the country was considered a net importer if had been a net importer in two of the previous three years, and vice versa for net exporters (OECD, 2016). The benchmark price was selected either as the monthly nominal CIF (cost, insurance, and freight) price for net importers (26 case studies) or FOB (free on board) price for net exporters (13 case studies).

To calculate a reference price comparable with the domestic price at the point of competition (for wholesale) or at retail, typically adjustments are made to the benchmark price for the quantity (e.g., physical transformation of wheat into wheat flour) and quality (e.g., imported yellow maize compared to domestic white maize) (Krueger et al., 1988; MAFAP, 2015). To minimize the need for these adjustments, UN Comtrade data were selected to match the commodities that domestic prices were obtained for as closely as possible by using the corresponding Harmonized System (HS) code (United Nations, 2017).¹¹ Benchmark prices are also adjusted to reflect access costs from the border, which can include transport, processing, marketing and storage costs as well factors such as bribes, roadblocks, and profit margins for marketing agents (Krueger et al., 1988; MAFAP, 2015). Here given time and resource constraints to obtain the necessary data on access costs, the monthly NRPx indicator assumes a standardized ten percent adjustment to the benchmark price. In the ideal case with sufficient data, actual access costs for each case study would be calculated according to the FAO-MAFAP methodology as outlined in MAFAP (2015), but here the assumption of a ten percent adjustment allows for rapid monthly calculations of reference prices for a broader range of countries. Therefore, for CIF prices, ten percent of the price was added to the benchmark, and for FOB prices, ten percent was subtracted from the benchmark. We acknowledge that this assumption limits the accuracy of the monthly NRPx indicator and can underestimate the actual levels of access costs,

¹⁰ Due to time and data constraints, this criterion differs slightly from the methodology detailed in MAFAP (2015) to calculate annual NRPs, where the relevant market pathway is identified and only corresponding prices for those markets are utilized, when possible. This approach could be taken for all case studies in future expansions of monthly NRPx calculations.

¹¹ While at this stage further quality and quantity adjustments were not made, in updates to monthly NRPx calculations, the need for these adjustments should be examined more closely, especially in the case of white maize relative to yellow maize.

but implement this standard measurement given the constraints faced.¹²

For countries without sufficient import or export data from UN Comtrade to determine the trade status or calculate a monthly benchmark price, we first sought to leverage the data sources used for countries where FAO's MAFAP programme has previously calculated annual indicators.¹³ This resulted in a combination of utilizing benchmark data from national statistics websites (see online Appendix B for a list of sources), or when not available, estimating benchmark prices using neighbouring country wholesale prices (especially for cases of informal trade) or using FOB prices from exporting countries, which were then either used directly as a proxy or adjusted for transportation costs.¹⁴ Rather than adjusting the benchmark by ten percent in all cases for FAO-MAFAP countries, the average ratio between the reference and benchmark price from the most recent five years of FAO-MAFAP's NRP calculations was used to determine the adjustment factor, which often was much greater than ten percent depending on the level of access costs and quantity and quality adjustments for the case study.¹⁵ The countries where this approach was taken are noted in online Appendix B, and this further highlights how the standard ten percent adjustment likely underestimates access costs for other case studies, though levels of access costs can certainly vary by country and commodity.

Furthermore, it is important to note that case study selection was first based on availability of monthly domestic prices from the FAO-GIEWS FPMA Tool, and then further refined based on availability of monthly benchmark price data from UN Comtrade and sources previously used by FAO-MAFAP. Thus, the results of this analysis are by nature shaped by the characteristics of the 24 LMICs that were able to be included in the sample. Countries were not intentionally selected in an effort to be as reflective as possible of the various changes to levels of NRPx in LMICs after the outbreak of COVID-19.

3.3. Methodology

3.3.1. Pre- vs Post-COVID-19 comparison and NRPx change categories

As stated in Section 3.1, the monthly NRPx is calculated for each case study at the point of competition, if available, and at the retail otherwise, for all the months between January 2017 and February 2022. The computations include a three-year period prior to the pandemic to have a reliable period of comparison to levels after the resurgence of COVID-19.

Due to the fact that the timing and effects of the COVID-19 outbreak varied across different countries and regions (and, as a consequence, over its effects on the commodities analyzed), for each case study a comparison was made for the three-year period before the beginning of the pandemic (i.e. from January 2017 to February 2020) against the period since the first lockdown measures were implemented and onwards (i.e. from March 2020 to February 2022). To do so, the average monthly NRPx indicator was computed for each month in the "pre-COVID period", and it was then compared with the "post-COVID" (i.e.

¹² In future extension of this analysis, this standardized adjustment could be further refined to reflect changes in levels of access costs over time, such as by adjusting for transport fuel price levels. By doing so, the accuracy of the monthly NRPx would get closer to the one that characterizes its annual version, in which more data is available at a more granular level. To assess the similarity between the two indicators, we have plotted monthly NRPx values for selected case studies alongside their corresponding annual MAFAP NRP values calculated at the point of competition in Appendix A.

¹³ We were able to replicate the trade status determination and benchmark data sources for all countries where FAO-MAFAP has previously calculated indicators (FAO, 2022a) besides Benin, Burundi, Ethiopia, Ghana, Kenya, and Mali.

¹⁴ Table B1 in online Appendix B provides a full description of all non-UN Comtrade benchmark sources.

¹⁵ The adjustment factor for access costs across FAO-MAFAP case studies ranged from 11 to 52 percent, with a median of 29 percent.

“following the insurgence of the virus”) average NRPx for the same month. For instance, the indicator was computed for June 2020 and 2021, then it was averaged, and it was subtracted from the average of the indicators for June 2017, 2018, and 2019. By doing so, the percentage points change from the (average) level of the indicator in June before the COVID-19 outbreak to the (average) level of the indicator in June after the insurgence of the virus was computed. The same computation was performed for all months of the year, as well as for successive three months averages, i.e., the average monthly NRPx of February, March, and April “pre-COVID-19” compared to the same three months “post-COVID-19”, followed by the “pre-COVID-19” March–April–May average compared to the same three months “post-COVID-19”, and so on.

By using this methodological strategy, an emphasis is given to COVID-19 as a treatment, whose effects are assumed to span (although with varying magnitude) the whole period since March 2020. Indeed, such an approach gives the opportunity to investigate a potential general shift in the food price gaps after the COVID-19 outbreak, by comparing the average level of the incentives before the outbreak of the virus against their average level after the spreading of COVID-19. The month-to-month comparison comes to (at least a partial) aid against the typical seasonality of the commodities analyzed, while avoiding the need to go into the details of seasonal patterns for each case study. On the other hand, the averaging procedure smoothens potential data recording or collection errors, which are particularly likely when it comes to international trade in emergency or unstable situations, such as a pandemic.

Clearly, other approaches could have been used, and this method has its own pros and cons. A possible drawback of this methodological approach is that it does not provide insights into potential case study-specific trends that develop over the January 2017 – February 2022 period. On the other hand, it gives the opportunity to make use of all the months included in the dataset without, for instance, limiting the analysis to a specific pre-COVID-19 reference year.

Once the changes in price gaps (NRPx) for each month and case study are computed, we assign to each country-commodity pair the value of the NRPx change ($\Delta\text{NRPxMAX1}$) corresponding to the month in which the pre- vs post-COVID-19 NRPx percentage points change is maximum (in absolute value). By doing so, we are identifying the maximum changes in NRPx for each case study that are correlated with the outbreak of the virus, and thus $\Delta\text{NRPxMAX1}$ signals the value of the NRPx change of the month in which, on average, the largest change occurred from the pre-COVID-19 period to the post-COVID-19 one for a case study.

While the analysis focuses on maximum one-month changes, as a robustness check to determine whether such changes were (on average) more persistent, we also calculate the maximum change in three-month averages ($\Delta\text{NRPxMAX3}$) for each case study. This check also provides us with an insight into one of the hypotheses of our methodological approach. Indeed, if $\Delta\text{NRPxMAX1}$ and $\Delta\text{NRPxMAX3}$ do not largely differ, this result would point in the direction that changes in the price gap after the insurgence of COVID-19 occurred across several months and could suggest a general shift in NRPx levels with respect to the pre-COVID-19 period.

To be able to summarize and examine different change effects, we attribute an “incentives change category” to each case study (Table 2).

Table 2
Price incentives change categories.

	Incentives change category	Description
Pre-existing incentives	Category 1	Incentives increased
	Category 2	Incentives decreased
Pre-existing disincentives	Category 3	Disincentives became less negative, or became positive
	Category 4	Disincentives became further negative

This categorization allows for cross-country comparisons of changes in price gaps across like-effects and provides a mechanism to characterize the general effect at the individual case study level.¹⁶ We also clustered the case studies according to other characteristics, such as region, commodity, documented policy-response to COVID-19, trade status of the commodity, etc.

In most of the case studies (29 out of 39), the changes in NRPx levels were both positive and negative, depending on the month in consideration. However, it was only for 5 case studies that the negative and positive changes were comparable in magnitude and frequency. Indeed, for all the remaining cases, one of the two directions of the change was easily identifiable as the predominant one, with the opposite direction changes being both remarkably smaller in magnitude and occurring only in a few months. In any case, alternative effects should be examined when conducting country-specific analysis, especially for the 5 cases where the pre- versus post-COVID-19 NRPx changes were highly heterogeneous and volatile.

3.3.2. Median levels of change

Finally, once the maximum change values were determined for each case study, they were summarized by calculating the median values of $\Delta\text{NRPxMAX1}$ and $\Delta\text{NRPxMAX3}$. The median was used, rather than the mean, to avoid having large change values skew the effect. When computing the overall median effect, the positive and negative changes can tend to cancel out, thus lowering the overall magnitude of the median. Therefore, we also compute the median change for each category; by comparing only increases with increases and vice versa, the median magnitude is more accurately calculated for each type of change. We also computed the median change by cluster (region, trade status, commodity, etc.), in order to obtain preliminary insights at a more granular level.¹⁷ Indeed, the overall median effect is helpful in determining the general direction of changes to incentives across all case studies, but the various additional comparisons by categories convey additional information and can provide a more reflective depiction of the incentives' changes, as discussed further in Section 4.3.

4. Results

The results show a decline in NRPx levels during the first two years of the COVID-19 pandemic that largely align with our hypothesis. The median decline of the $\Delta\text{NRPxMAX1}$ (maximum one-month pre- versus post-COVID-19 change) across all 39 case studies was 20.3 percentage points (Table 3). The quartiles in Table 3 indicate a change that was widely varied across case studies, as also depicted in Fig. 1, with a slight majority (22 case studies from 20 countries) that experienced a decrease in NRPx levels.

77 percent of the decreases were from case studies with pre-existing positive NRPx that declined (44 percent of all case studies). 28 percent of

Table 3
Quartiles of maximum pre- vs post-COVID-19 percentage point changes in incentives.

	$\Delta\text{NRPxMAX1}$	$\Delta\text{NRPxMAX3}$
Minimum	−91.4	−62.2
Quartile 1	−37.6	−28.0
Median	−20.3	−11.8
Quartile 3	24.9	18.3
Maximum	62.8	54.2

¹⁶ In all the cases, the direction of the maximum changes to monthly NRPx values corresponded with the representative change category.

¹⁷ For the list of case studies and their corresponding assigned categories, please see Table C1 on Appendix C.

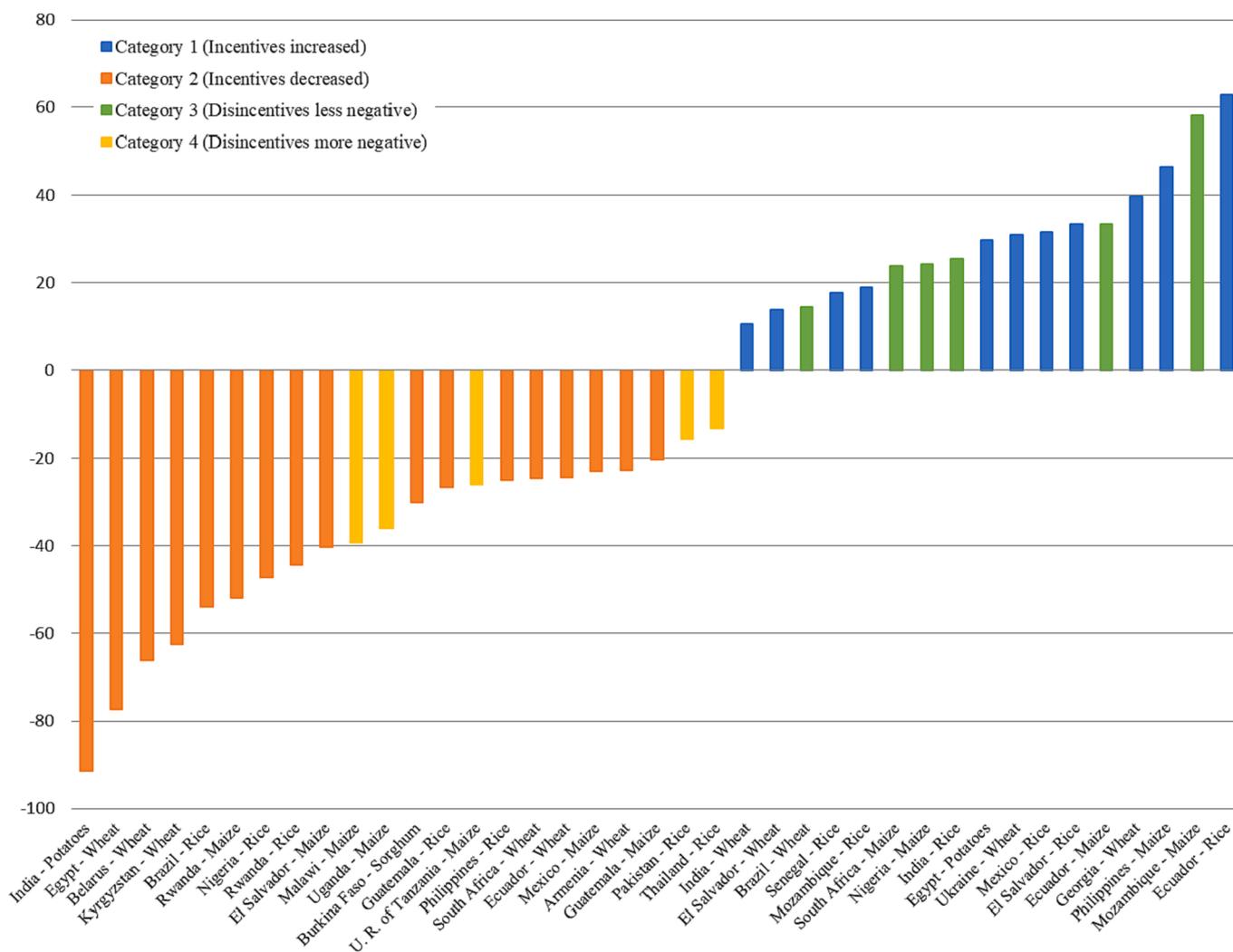


Fig. 1. Maximum pre- vs post-COVID-19 percentage point changes in NRPx levels, by incentives change category.

all case studies had pre-existing positive NRPx that increased, and 15 percent had pre-existing negative NRPx that became less negative or reversed to positive.¹⁸ As shown in Table 3, the median change in three-month averages of NRPx was a decrease of 11.8 percentage points, which is in line with the negative median one-month change and indicates that impacts were not restricted to a one-month period, though in some cases were slightly more pronounced during the month of maximum change.

To further characterize the changes for different types of case studies, Table 4 gives the median change by category (as described in Table 2 in Section 3.2.2), as well as by commodity type. Fig. 2 depicts the fact that all the commodities included in this analysis had median declines in NRPx levels. Maize and wheat show decreases of, respectively, -21.6 and -22.8 percentage points that are similar in magnitude to the overall result. Rice had a smaller decline of 13.2 percentage points. Finally, potatoes and sorghum showed a greater decline than the overall median decline, but these results must be taken with caution since only 2 case studies regard potatoes and only 1 sorghum. Indeed, all these commodities are staple foods, and thus following that classification, we included sorghum and potatoes in the overall analysis, even with few case studies.

As shown in Table 4, the effects by price incentives change category

¹⁸ Fig. 1, along with Table C1 in online Appendix C, show the direction of change for each case study.

show median changes that are, in absolute value, as much as twice the magnitude of the overall median change, ranging from an increase of 30.9.7 percentage points for the category in which the price gap increased (Category 1) to a decline of -40.2 when it decreased (Category 2). The fact that, for each category, the change is quite significant (and, in absolute value, larger than the median change) further indicates the dispersion of changes in the sample: the overall median across all case studies is driven by both positive and negative changes of greater magnitude.

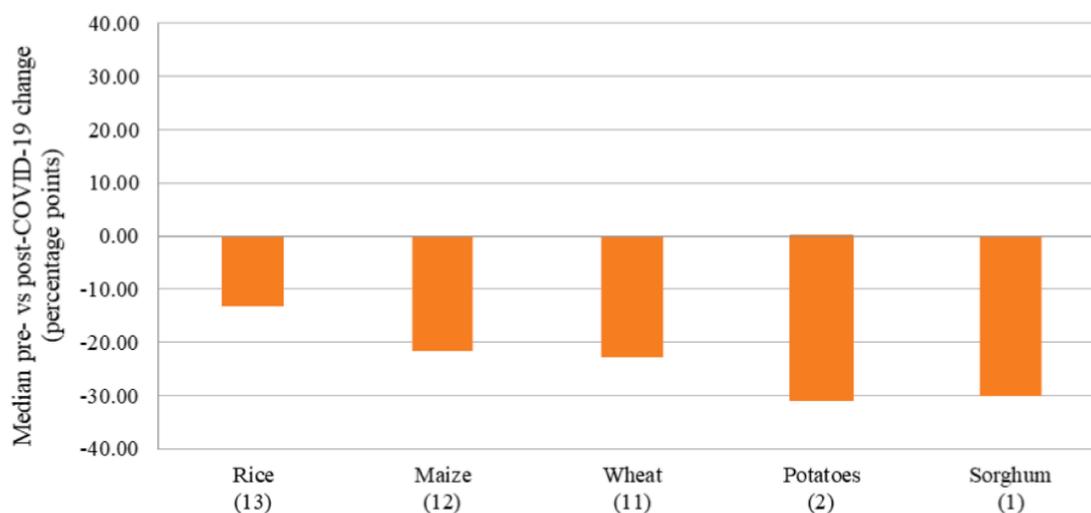
Next, we computed the median changes by region and trade status. As seen in Table 5, the prevalence of decreases in the monthly NRPx across all categories suggests that the median decline was not concentrated in a specific region or confined to solely net exporters or net importers, even though some of the categories seem to have a larger influence on the overall effect. Indeed, Africa drives the results with the largest number of case studies (13 cases) and a median decline in NRPx levels of 25.9 percentage points, which is very close to the overall median decline. The same situation is for the Near East region, even though it includes only two case studies, both for Egypt. The Asia and Pacific region shows a smaller decline of 14.4 percentage points, which is still relatively close to the overall median result. Finally, the Latin America and Caribbean region and Eastern Europe show smaller median changes (respectively, a decline of 3.2 and an increase of 4.1 percentage points). With respect to trade status, net importers constitute the driving force of the change in the monthly NRPx. Indeed, those countries are the majority of the case studies (25 out of 39) and they show a median decline

Table 4

Pre- vs post-COVID-19 median maximum percentage point changes in NRPx levels, by commodity and incentives change category.

Commodity	Count	Incentives		Disincentives		Overall median
		Category 1 Increased	Category 2 Decreased	Category 3 Less negative	Category 3 Further negative	
		11	17	6	5	
Rice	13	31.7	-44.3	25.4	-14.4	-13.2
Maize	12	46.4	-31.6	28.9	-36.0	-21.6
Wheat	11	22.3	-43.5	14.5		-22.8
Potatoes	2	29.8	-91.4			-30.8
Sorghum	1		-30.1			-30.1
Overall median		30.9	-40.2	24.9	-25.9	-20.3

Note: Blank cells indicate the commodity did not have a case study in that specific category.



Note: Case study numbers in parentheses

Fig. 2. Pre- vs post-COVID-19 median maximum percentage points changes in NRPx levels, by commodity. Note: Case study numbers in parentheses.**Table 5**

Pre- vs post-COVID-19 median maximum percentage points changes in NRPx levels, by region and by trade status.

		Case Study Count	Median Δ NRPxMAX1
Region	Africa	13	-25.9
	Latin America and the Caribbean	12	-3.2
	Asia and the Pacific	8	-14.4
	Eastern Europe	4	4.1
	Near East	2	-23.8
Trade Status	Net Importer	25	-22.9
	Net Exporter	14	-1.3

of 22.9 percentage points, while the net exporters' decline is only 1.3 (so, virtually null).

As previously mentioned, the heterogeneity of the results we obtained could be due to a combination of different domestic and international factors, and detailed case-by-case analyses are needed in order to investigate each case study in its peculiarity. However, one of the potential determinants of the heterogeneity in changes in NRPx levels after the COVID-19 outbreak are the policies that each country implemented (or did not implement) to face the pandemic. To briefly investigate this potential cause, we categorized each case study according to the policy that the country implemented for the considered commodity as a response to the insurgence of the virus. Each case study was assigned to its corresponding category according to the "main" commodity-

related policy that was implemented.¹⁹ Indeed, when various policies belonging to different categories were implemented, we considered as the main one the one that was maintained for the longest or that was potentially the most impactful.

Fig. 3 shows the median changes in monthly NRPx from the pre-COVID-19 period to the post-COVID-19 one clustered by the five main policy categories we identified. The results we obtained are consistent with the hypothesis that countries reacted to the COVID-19 outbreak and its potential impacts on food markets through domestic market and international trade policies, leading to changes in the gap between domestic and international prices for agricultural value chains. Price control mechanisms, export restrictions and imports tariff reductions (aimed at preventing price increases in domestic markets) indeed show a median decline in NRPx very close to the overall result of this study. On the other hand, support to domestic prices shows a virtually null median change in the monthly NRPx. Finally, when no policies were implemented at all the relative gap between the domestic and the reference one showed a median increase of 13.8 percentage points.

¹⁹ The main sources used to gather information on the commodity-related policies were FAO's FPMA (Food Price Monitoring and Analysis) Food Policy and Market Developments repository (FAO, 2022c) and IFPRI's COVID-19 Food Trade Policy Tracker (Laborde et al., 2020b).

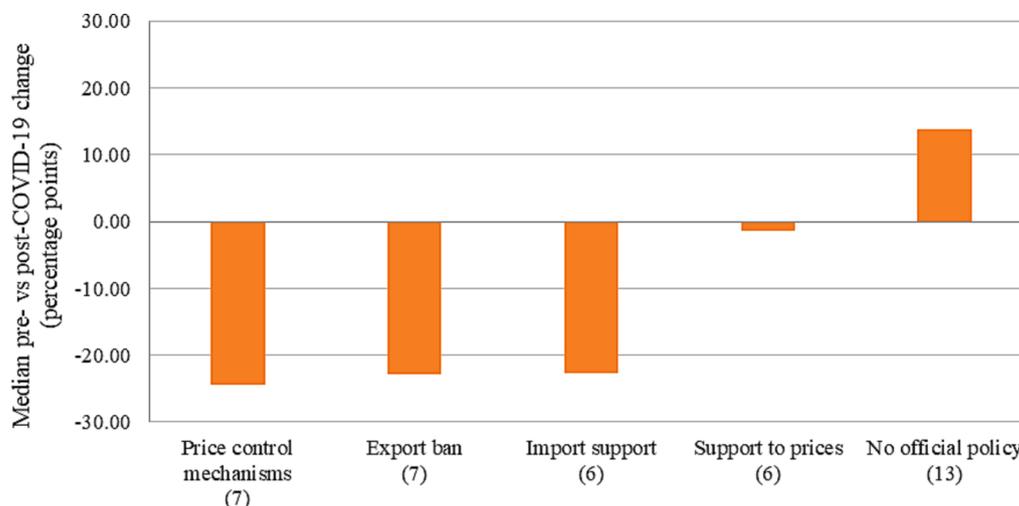


Fig. 3. Pre- vs post-COVID-19 median maximum percentage points changes in NRPx, by COVID-19 related policy for the considered commodity.

5. Discussion

The results suggest that domestic markets in the 24 LMICs included in the sample may have been affected by a mix of market factors during COVID-19 and policy changes introduced by governments in response to them (Kennedy and Resnick, 2020; Vickers et al., 2020). In this section we will briefly examine these various factors that may have contributed to the overall negative trend of NRPx levels since the insurgence of COVID-19; however, a deeper understanding of all the different variables that affect price dynamics warrants further empirical analysis to develop country-specific policy recommendations.

The containment measures implemented in response to the pandemic limited access to labour supply, agricultural inputs, and agricultural extension and advisory services and interrupted logistics, processing, and market access (FAO, 2020a). While these measures seemed to have had an initial muted effect on the first wave of COVID-19 that ended around May 2020, international prices for staple cereals spiked afterward (International Grains Council, 2022). Indeed, as highlighted in Fig. 4, after an initial decrease from the beginning of the pandemic to around May 2020,²⁰ the international prices for wheat, maize, and rice experienced a steep increase that lasted throughout our period of analysis (until February 2022). Compared to the levels of February 2020, prices for these commodities were 55 % and 65 % higher in the first quarter of 2022. As for rice, after an initial increase of about 15 %, international price plateaued until the first months of 2022, when it gradually decreased back to its pre-COVID-19 levels.

Fig. 4 also shows that international prices of wheat and maize experienced a larger increase after the insurgence of COVID-19 than the one of rice; and this could be one of the factors that contributed to the median decrease of the NRPx. Indeed, keeping all the other domestic market and policy conditions constant, an increase in the reference price of a commodity will lead to a negative variation of the price gap and of the NRPx indicator. This could be true especially for markets with limited price transmission from international trade, due to poor connection with international markets, to internal production and food availability characteristics, or because of policies implemented to prevent price shocks at domestic level.

Contrary to the 2007–08 and 2010–11 food crises, when trade restrictions strongly exacerbated the food supply disruption and largely contributed to the prices surge, recent literature suggests that the 2020–22 spike in food prices, in particular grains, was mainly driven by

the demand side of the market. Indeed, during the first and most dramatic phase of the global COVID-19 pandemic, the demand for grains, in particular the one for animal feed and industrial use, decreased sharply due to lockdowns, restrictions on social mobility, and value chain disruptions. However, after this initial decrease, demand rebounded sharply, driven mainly by increased demand from China (Vos et al., 2022).

On the other hand, supply shortages initially played a lesser role for two main reasons. The first is that production prospects for wheat, maize, and rice were particularly good in 2020 (Hepburn et al., 2020; Mogues, 2020; FAO, 2021a); their global stock-to-use ratios were at their maximum, different than in 2007–08 (Falkendal et al., 2021), and this situation may have had a mitigating effect on the supply side of the market in the first months of the pandemic. Second, international trade restrictions such as export bans or quotas were fewer and less persistent (Hepburn et al., 2020; Vos et al., 2022).

Moreover, other factors may have affected the supply of key commodities, especially in 2021, such as droughts in major wheat exporting countries, increase in fertilizer prices and international freight costs (Vos et al., 2022). The latter, together with labor shortages along value chains and the consequences on stockpiling of containers in key ports, may have contributed importantly to inflation and international prices of food commodities (Suárez Ricaurte, 2022).

This, in turn, may have prompted governments to counteract the rise in international food prices through trade measures, release of food stocks, and agricultural policies to increase domestic supply. As shown in the previous section, results by policies implemented are consistent with the expected effect of each policy as, for instance, export bans and quotas prevent domestic production from leaving the country and hence keep domestic prices from increasing at the same pace as the international (reference) prices, which in turn is reflected in a decreasing NRPx. Likewise, reduction or elimination of import tariffs, as well as price control mechanisms, aim at mitigating the effects of international price increases, which is in fact observed in the negative variation of the gap between monthly domestic and international prices.

However, it should also be noted that the high heterogeneity in NRPx variations within the sample and the analyzed groups signals that policy responses were not as widespread nor sustainedly introduced by countries as during the 2007–2008 crisis. Moreover, the fact that LMICs are often not fully integrated in international trade may have further contributed to the delayed response of domestic prices to international price increases. This aligns with previous empirical evidence which suggests that price transmission from international to domestic markets after a shock in the international agricultural commodity markets is often quite slow (Greb et al., 2016, Baquedano and Liefert, 2014). Regardless of this, the consistency of the results from this study with

²⁰ When the international price for rice reached its historical minimum (Vos et al., 2022).

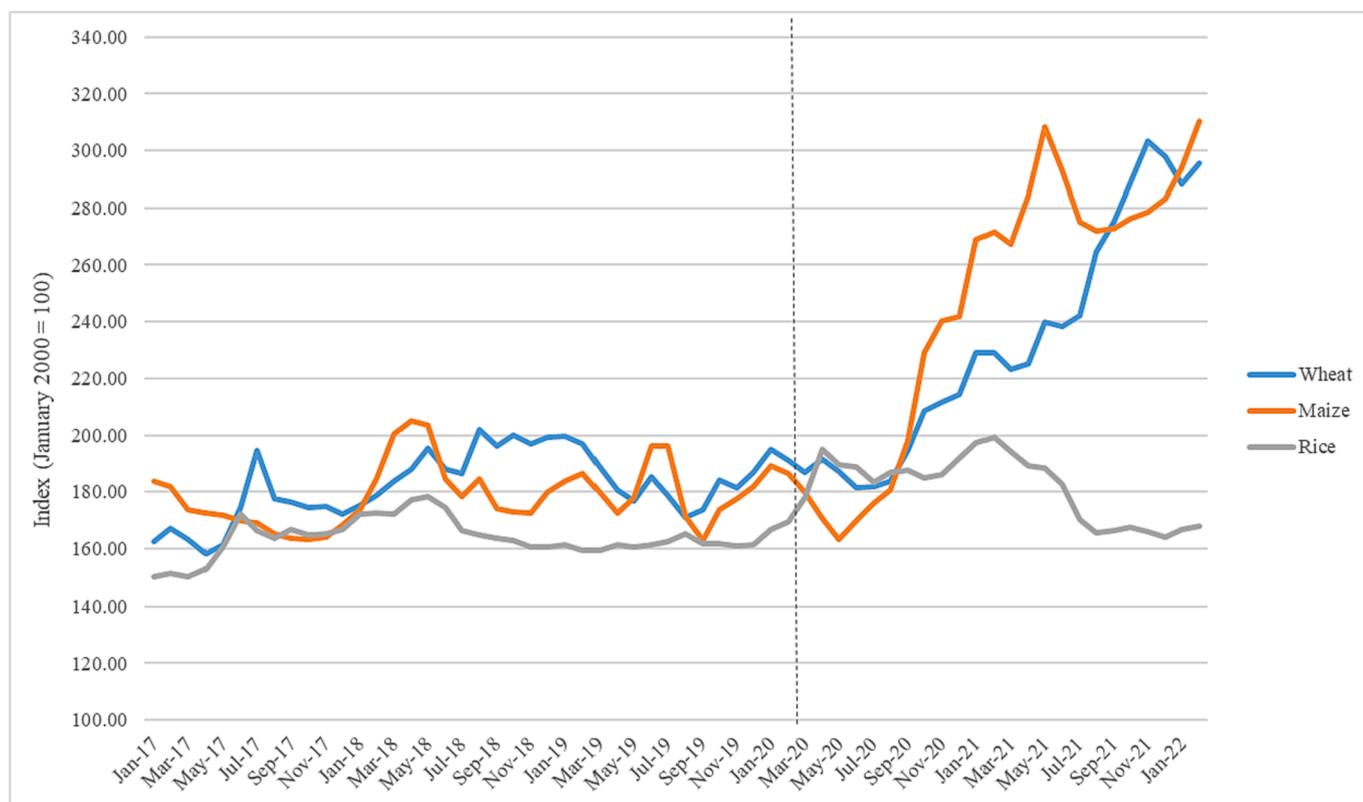


Fig. 4. World price sub-index (January 2000 = 100) changes for wheat, maize and rice – IGC sub-indices, January 2017 to February 2022. Data: International Grains Council, 2022.

predicted outcomes and with other empirical evidence from current and previous food crises may be promising for the use of the NRPx as a tool to measure differences between international and domestic prices and as a way to provide analytical inputs for policy debates in the context of current and future price shocks.

Examining specific drivers behind changes to price incentives for every case study is beyond the scope of this paper, and could be conducted in the form of country-specific analysis that can synthesise monthly NRPx data with information from policy trackers, such as those provided in Laborde et al. (2020b), FAO (2021e), IMF (2021), and WTO (2021). For example, this could potentially be an additional tool embedded in a website such as that of the Agricultural Incentives Consortium (IFPRI, 2020) or FAO's GIEWS (FAO, 2021d) and updated as monthly price data becomes available.

6. Conclusions

The median decline in NRPx levels for staple cereals in LMICs during the first two years of COVID-19 highlights that, as the pandemic and its impacts on international prices evolve, and in light of other recent shocks in agricultural markets, governments should carefully consider how to promote food security for poor consumers without consequently generating disincentives to local production and risking tightening the local supply of staples, especially if the trend is sustained. Moreover, abrupt implementation of export restrictions not only can exacerbate international price increases, but it can also introduce instability, uncertainty, and volatility in both domestic and world markets (Glauber and Martin, 2020), distorting prices and leading to a reduction of economic welfare. While arguments have been made in favor of policy interventions in agricultural markets for the purpose of avoiding price volatility, Pieters and Swinnen (2016) conclude that interventions in staple food markets of LMICs either have been ineffective at reducing volatility or have done so at a high distortionary cost relative to the level

of volatility reduction, leaving “much room for policy improvement.”.

Although changes to trade policies can be successful in mitigating domestic price increases in individual countries in the short run, and despite the fact that little progress has been made in efforts of the World Trade Organization (WTO) to effectively bind, discipline and regulate the use of variable trade restrictions, alternatives should be strongly prioritized (Glauber and Martin, 2020; Anderson and Jensen, 2017). As mentioned previously, empirical evidence suggests that trade policy responses to the COVID-19 shock have had a more limited effect on international prices, and this can provide the opportunity for governments to reconsider how to strengthen food availability, accessibility, and resilience of food systems, and how to adapt policy environments to be better equipped to respond to market shocks and trends in a comprehensive way that takes into account the potentially adverse effects of trade-insulating measures. As noted in Brooks (2014), initiatives to help farmers manage risk, targeted cash transfer programmes, and increased investments in long-term improvements to agricultural productivity can help achieve food security in place of a reliance on trade-distorting instruments.

Finally, by providing a mechanism to signal how policies enacted are affecting prices domestically on a monthly basis, the new monthly NRPx indicator can contribute to the monitoring of price deviations, especially for cases where distortionary policies are prevalent, and help identify where policy realignments need to be focused. Ideally, it will continue to enable rapid policy monitoring during current and future shocks to the global food system. The monthly NRPx can be beneficial as a quantitative tool when a timely analysis is needed and access to data is limited. However, extended use of the monthly NRPx indicator is dependent on the ability to strengthen available information on trade values and volumes in many countries. For future work, individual country analysis should be conducted in order to understand the exact causes for domestic price deviations from international prices, and how countries cope with shocks at the international level.

With this, the ability to measure price gap changes on a monthly basis can help provide technical support for the development policy recommendations that can facilitate economic recovery in the post-COVID-19 era and ensure food security and nutrition for the world's poorest consumers. Moreover, extending the NRPx coverage to big exporters might help address questions on how policy shifts or shocks in those countries may affect world prices. For instance, future applications could be to monitor the effects of climate shocks or wars affecting big exporters on low-income net importer countries' food security.

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CRedit authorship contribution statement

Sarah Consoli: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Juan José Egas Yerovi:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing. **Matteo Machiorlatti:** Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – review & editing, Visualization. **Cristian Morales Opazo:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.foodpol.2023.102405>.

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