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Deciding between cash-based and in-kind distributions during humanitarian emergencies

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Abstract

Purpose – The purpose of this paper is to provide an analytical model to decide between cash-based and in-kind distributions during emergency responses considering the needs of beneficiaries and market conditions. To allow the switch between modalities, a preparedness framework for humanitarian organizations (HOs) is provided.

Design/methodology/approach – A mathematical model is proposed to help humanitarian responders make quantitative decisions on the type of programs to implement in emergency responses. The model was applied to a field response by an international HO during the COVID-19 emergency in Colombia.

Findings – Cash-based and in-kind distributions are not mutually exclusive response modalities during emergencies, and the real needs of beneficiaries and market effects should be included in the modality selection decision to improve program effectiveness.

Research limitations/implications – The research is focused on short-term immediate response to emergencies; the proposed model assumes favorable market conditions and limits the aid options to direct in-kind and multipurpose cash assistance, excluding other types of cash transfers.

Practical implications – The research outlines practical preconditions to operationalize switching between programs during an emergency. The study provides evidence that HOs should consider dynamics decision tools to select aid modalities and evaluate their response depending on market conditions.

Social implications – Considering aid modality as a dynamic decision and including the needs from beneficiaries in the choice can have profound impact in the dignifying of humanitarian response to emergencies.

Originality/value – The quantitative model to decide between aid modalities is a novel approach to include beneficiaries' needs and market dynamics into humanitarian supply chain research. The preparedness framework closes the gap between the emergency preparedness literature and the operational constraints that organizations face for fast program implementation.

Keywords Humanitarian supply chain, Emergency logistics, Not-for-profit supply chain

Paper type Research paper

1. Introduction

Sudden on-set emergencies threat large amounts of population with losing their livelihoods and failing to cover their basic needs. During acute emergencies, humanitarian organizations (HOs) request funds to donors to respond to unexpected events. The preferences of donors and the availability of resources can restrict the response modality for humanitarian agencies. Moreover, the lack of flexibility generates additional externalities in the markets where events take place. Constrained modality selection produces late delivery of aid, poor decisions by HOs (Donovan *et al.*, 2005) and impedes a dignifying response to beneficiaries. Cash transfers and in-kind aid represent two generalized options to attend the basic needs of vulnerable population affected by emergencies. However, there are increasing doubts whether which one of the two modalities is the most effective relief option by itself (Oxfam, 2005; OECD, 2017).

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Cash transfers consist in providing beneficiaries aid in the form of cash, vouchers, cards or tokens to access goods and services (ICRC, 2018). Cash increases the spending power and transfers to the receivers the decision to access the markets and satisfy their needs how they prefer. Aid in the form of cash exposes recipients to market dynamics, meaning that an increase in prices reduces their effective purchase power and covered needs. This market feedback from aid is seldom considered in the modality selection phase. In-kind aid focuses on a single need to cover such as food or sanitation, providing beneficiaries directly with the items to satisfy their needs. Deciding for the beneficiaries what they need or what food they consume can generate mismatches between the supplied goods and the real demand (Gelan, 2006). Whether to provide cash or in-kind aid is not a question with clear answers (Heaslip *et al.*, 2016).

The tools employed by mayor humanitarian actors consider the selection of aid modality as static, involving feasibility parameters such as security, logistics preparedness or market readiness and efficiency considerations on the use of funds. After the onset of a crisis these parameters evolve and, without the appropriate preparedness frameworks, aid agencies may be unable to modify their response. Qualitative tools such as decision trees are a common options to select the modality response in emergencies (Barret *et al.*, 2009). These models take multivariate decision problems and discretize the relationships between them to arrive at a binary decision: whether to apply an aid modality or not.

Several authors have studied the relative economic relationship between the amount of aid provided through cash or in-kind (Basu, 1996; Harvey, 2005; Aker, 2013). These studies analyze the economic impact of giving cash or food aid during medium to long periods of time, such as months or years. During acute emergencies, where the most vulnerable face severe needs, decisions must be made in terms of weeks or even days. Such a short time frame to set up humanitarian operations requires flexible organizations and supply chain preparedness to execute these programs. In addition to the time constraint, budget availability is a major factor that influences the criticality of the decisions taken.

The recent literature based on field studies has emphasized that humanitarian actors prefer to switch between cash or in-kind aid depending on market circumstances such as seasonality, product availability and budget effectiveness compared to the total population in need (Peters *et al.*, 2016). Supply chains have profound implications on the responsiveness and speed to which programmatic decisions can be implemented. During acute crisis, funds availability is a recurrent constraint that limits the scope of the response (L'Hermitte *et al.*, 2016). The efficient use of funds implies a greater outreach, but this efficiency must be accompanied by a measure of effectiveness, where the real needs of the population are satisfied. Another constraint to effectiveness is that humanitarian agencies often decide in advance the type of response to implement and then search for target population that fits their programs (Levine and Chastre, 2004).

This paper aims to provide a decision model to adjust the emergency response according to external market dynamics. The model contributes to the literature including the market feedback from the humanitarian response and the satisfaction of the real needs from beneficiaries as an objective. We also create a framework with a set of preconditions for an agile supply chain that can switch between the main modalities in a short period of time. Furthermore, we describe the field perspective of the implementation of the model and the measures taken by an HO during the COVID-19 pandemic in Colombia to scale its operations for the response.

The paper structure is as follows. First, in section 2 we provide the background and context of cash transfers and in-kind aid with a review of the modality selection tools available. In section 3, we describe a framework of preparedness to create the capacity to switch between cash and in-kind aid. In section 4, we define the model and make a quantitative analysis of the sensitivity of its parameters. In section 5, we show the application of the decision model and preparedness framework to the emergency response in Colombia to

the COVID-19 crisis in 2020. Finally, in section 6 we discuss the theoretical and practical contributions of the work and outline future paths for the research.

2. Context and selection of cash and in-kind

Cash transfers and in-kind aid are deeply established modalities of humanitarian aid. The trade-offs between each option have been studied in the humanitarian research literature and in the programmatic standards of HOs. The following literature review describes the market effects of humanitarian intervention and the current tools available to decide between each modality.

2.1 Background on response modalities

Cash programs have increased rapidly since 2015. UNHCR spent 2.4 billion dollars between 2016 and 2020 in cash assistance, where 95% was multipurpose cash assistance (UNHCR, 2019). For WFP, in 2018 cash accounted for 45% of the distributions compared to 27% in 2016 (WFP, 2019). Cash is often considered to be more cost-efficient, to encourage production, more dignifying for beneficiaries (DRC, 2020) and a stronger incentive for the markets where it is deployed (Devereux, 2002). However, the use of cash also exposes beneficiaries to complex market dynamics such as inflation, product availability and security during the delivery.

In-kind aid directly addresses specific needs, increases the availability of products and tends to favor women, children and older persons. The main disadvantages of in-kind aid are higher logistics costs, less choices for the beneficiaries, losses due to spoilage and theft and direct competition with local markets (Sabates-Wheeler and Devereux, 2010).

The preparedness and operational requirements differ for each response modality. Donors and HOs have established explicit checklists that markets and social customs must fulfill for the successful implementation of each modality (ECHO, 2017). Targeting is often more complex in cash programs due to the diverse characteristics of families receiving aid, while in-kind targeting tends to focus on the main need addressed. Donors also require traceability of the aid delivered in different manners for each modality. In cash transfers HOs have to show the payment to the beneficiary but not the use of the aid, while in in-kind distributions must prove the complete product flow of aid. Cash programs require the existence of financial systems in the country, or established means of payment and secure cash outlay for beneficiaries. Successful in-kind programs are based on flexible supply chains and agile logistics able to respond to uncertainties in demand. Flexibility strategies vary from stock prepositioning to framework agreements (FAs) with suppliers to ensure product availability. The comparison of each modality requirements is shown in Table 1.

From a budgetary point of view, cash transfers experience less overhead than in-kind aid and more efficient use of the donor funds. This efficiency can be measured as the total cost to

Table 1. Requirements for in-kind and cash-based interventions

	Cash-based response	In-kind response
Targeting	Individualized with complex methodologies	Localized, based on market conditions and surveyed information
Audit requirements	Audit trail of payment to beneficiaries and financial service provider contract	Audit trail of beneficiaries receipt and the complete supply chain product flow
Market preconditions	Supply expandability De Matteis (2010) and financial infrastructure for cash delivery	Vendors' adaptability, market accessibility and items availability
Core HO capabilities	Finance, accountancy and customer service	Warehousing, distribution and/or network orchestration
Security	Ensuring safety at the moment of registry and when delivering means of payment	Overall network security from storage to distribution

transfer ratio, defined as the proportion of funds that beneficiaries receive to the total budget for the program (ECHO, 2017). ECHO mentions a value of 85:15 for the efficiency ratio as a target to reach between needs assessment and distribution. This indicator can be misleading when considering the effective satisfaction of needs from beneficiaries if prices rise or product availability is low. Thus, we cannot assume that once the funds are distributed to beneficiaries their demand is met (Aker, 2013; Heaslip *et al.*, 2016). As a consequence, a more evidence-based approach is needed to ensure that the goods or services delivered satisfy the true demand of the beneficiaries.

Cash transfers focus on the needs that beneficiaries can satisfy by themselves through functioning markets. We can consider cash-based programming as a pull-based response that minimizes the assumptions on the specific services to be provided and generates a minimum overhead on the funds. In contrast, in-kind aid can be regarded as a push strategy to satisfy the demand from the people in need. Frequently, not all beneficiaries require the amount or type of food received from HOs, reducing the effectiveness of the humanitarian goal. Additionally, the nature of humanitarian responses produces exogenous effects in markets that must be considered jointly with the satisfaction of demand to avoid further disruptions once the emergency ends.

2.2 Market effects of cash-based and in-kind aid

Local markets operate as complex systems with dynamics that are affected by humanitarian responses. Humanitarian interventions are a causal factor that influence demand and supply and so decision makers must consider the feedback of their actions in their planning. There exists evidence that markets in developing countries tend to be loosely integrated, prone to arbitrage and vulnerable to the effects of disasters and disruptions (Harvey, 2005). The effects of cash-based and in-kind aid have been modeled ex-post and *ex ante* and measured in detail for multiple operations over the years.

Introducing cash in a market has the theoretical foreseen effect of inflation due to a rise in demand with a fixed amount of supply (Basu, 1996). Increases in prices reduce the effectiveness of the cash received by beneficiaries and move non-beneficiaries to lower poverty thresholds (Bailey *et al.*, 2008). The impact of inflation should be measured including the time that markets take to adjust to changes in demand but is rarely included as a variable to select the aid modality. De Matteis (2010) proposes a market analysis model that takes into account market functionality to determine intervention strategies where market functioning is defined as *"the extent to which supply manages to make demanded goods and services available at affordable prices"*.

The effect that cash programs have in the price of commodities is not clear based on the present evidences. In the case of Ethiopia, several authors mention that cash has been safely implemented with inflation having a minor effect (Harvey, 2005; Kedebe, 2006). Large humanitarian cash programs have shown modest increase in prices, like the UNHCR cash program in Jordan where a 5% increase was measured (UNHCR, 2017). Other authors mention that the effect of inflation is underestimated and cash programs should be linked to external indexes to avoid the reduction in purchase power of beneficiaries (Sabates-Wheeler and Devereux, 2010).

While cash programs increase demand, in-kind aid produces the opposite effect of rising supply of products. Studies have shown that the theoretical reduction in prices due to food aid is not always present (Harvey, 2005). Other studies showed that when food aid is introduced in functioning markets the effects of price reduction are more prominent, as it occurred in the eruption in Goma in 2002 (Sesnan, 2004). The uncertainty surrounding the purchasing power of beneficiaries is a deciding factor to include inflation as a key parameter when deciding between modalities.

Another relevant effect caused by the mismatch between demand and items delivered is the reselling of aid in the market. It is common for beneficiaries to sell part of the food received at a lower price than its cost. In Afghanistan, the reselling of aid can be done at a price up to six times lower than the cost to deliver (Development Researchers Network, 2003) and in the Kakuma refugee camp in northern Kenya, 12% of the income of the refugees comes from reselling WFP food rations (IFC, 2018). In the proposed model we overcome the common assumption in the literature of complete acceptance of aid by the receiving population (Peters *et al.*, 2016).

The externalities of humanitarian aid should not deter the delivery of programs, but be included as feedback effects to consider during response design. One clear result evidenced by research is that context affects the functioning of markets (De Matteis, 2010). Because emergencies operate with complex interrelated dynamics between markets and agendas from donors, we cannot assume that cash or in-kind aid is more or less efficient or preferred by populations. The reviewed literature suggests that tools to decide between aid modalities should include the market and context uncertainties to produce robust and adaptable programs.

2.3 Modality selection tools

The humanitarian ecosystem has developed extensive policy papers and tools to assist respondents on the ground make fast decisions in volatile environments. Sudden on-set events are characterized by high levels of uncertainty, low availability of resources and short time-frames to decide and implement programs. The main objective under these conditions should be to maximize the outreach of the response and ensure attention to the most vulnerable. In contrast, many of the procedures found in the public documents of HOs propose decision models based on feasibility as a goal instead of efficiency or dignity in the response.

Decision trees are a recurrent tool applied by NGOs (Oxfam, 2005; WFP, 2009; ICRC, 2018; DRC, 2020). Trees are based on general questions gathered from needs assessment and translated into binary decisions to choose between modalities. Creti and Jaspars (2006) propose a decision tree that analyzes the possible failures of supply and demand and their structure. These models enable fast decision making processes using complex economic variables and qualitative evaluations as an input. The main concerns with decision trees are the static nature of the decisions, the variability of the input parameters and the lack of quantitative analysis regarding program objectives. Figure 1 shows an example of a decision tree for modality selection in the cross border response from Turkey into Northern Syria (OCHA, 2020). The tree should be read vertically, where answers are "Yes" move down the column and where answers are "No" move horizontally to the final column to select the modality.

Organizations also use multivariate indicators to select the type of response. AREU (2004) considers the accessibility of markets, the frequency of aid delivery, the time span of the response and the preferences of beneficiaries between food aid and cash. WFP proposes market indicators, the customs of beneficiaries, seasonal accessibility to markets, delivery insecurity and possible impact on prices (Hofmann, 2004). Scoring matrixes are also used to weight different factors to decide on response modality. ICRC employs a questionnaire to fill the information from a scoring matrix (ICRC, 2014). Table 2 shows an example of the scoring matrix employed by ICRC for modality selection. On practical basis some of the questions are too dynamic to resume to a single value or difficult to evaluate.

Optimization models have also been studied as emergency preparedness and response tools. The supply chain optimization literature for emergencies is focused on facility location, distribution and stock prepositioning (Manopiniwes and Irohara, 2014). Recent studies have been proposed to embed supply chain optimization within modality selection decisions. Peters *et al.* (2016) developed a mixed integer linear program that optimizes food aid content, procurement and distribution considering in-kind transfers and commodity vouchers. The

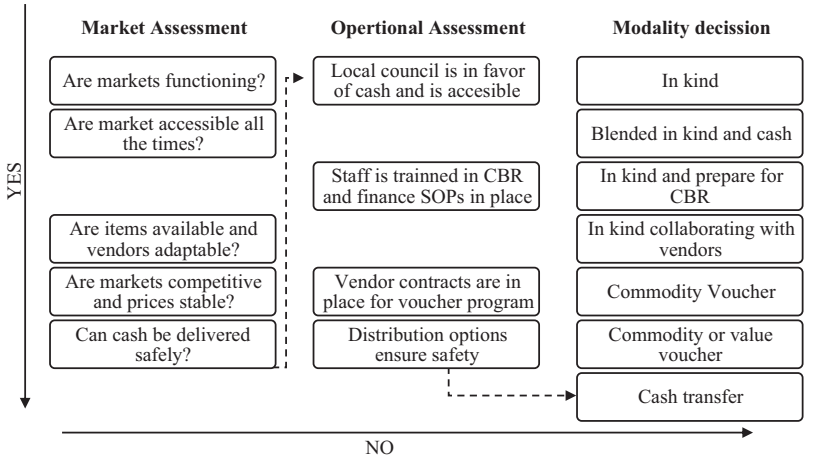

Figure 1.
Northern Syria assistance modality decision tree (cash-based responses technical working group)

Criteria	Weight	Response option A	Response option B	Justification
Cost effectiveness	3	$3 \times 4 = 12$	$3 \times 1 = 3$	
Risk of inflation	2	$2 \times 1 = 2$	$2 \times 2 = 4$	
Potential market distortions	3	$3 \times 1 = 3$	$3 \times 3 = 9$	
Secondary impacts on markets	1	$1 \times 5 = 5$	$1 \times 2 = 2$	
Total scores		22	18	

Table 2.
Modality selection scoring matrix
ICRC (2018)

authors suggest possible extensions to cash transfers but they are not included explicitly in the model. Sahinyazan *et al.* (2019) propose a model to determine the modality and quantity of aid. The model is focused on nutrition improvement and combines the consumption of beneficiaries and the HO decision in a bi-level optimization model. Although modality selection has been approached for specific contexts, the literature does not provide input on how to prepare operations to switch between modalities.

The reviewed literature has not found evidence on the use of the pull-based needs from beneficiaries to dynamically choose the response modality during emergencies. The main decision models have a strong focus on feasibility in terms of security and market failure to avoid wasted funds and unmet demand. The author finds that flexibility and efficiency in humanitarian responses have been deeply studied, but modality selection studies do not provide the necessary conditions to implement the proposed decisions.

The model described in this paper directly includes the needs expressed by beneficiaries and the market impact of the response to do *ex ante* and *in situ* effectiveness analysis. We also extend the common objectives of the models in the literature: cost, time effectiveness and amount of unmet demand (Manopiniwes and Irohara, 2014). These objectives differ from reality where the most efficient and timely response to an emergency can bring the wrong items to a population that has different needs.

3. Adjusting aid modality through agile supply chain preparedness

The main assumption for providing a decision model to alternate aid modalities is that ground conditions can change rapidly and affect the effectiveness of humanitarian programs. To adjust the implemented programs, we describe a framework of supply chain preparedness

that sets the preconditions to make the decisions proposed in section 4 actionable. We use the definition of flexibility from L'Hermitte *et al.* (2015) as the ability to change what is being done at the operational level. The framework addresses the support functions of HOs and suggest flexibility measures to be taken that do not increase the operational overhead of the program. Figure 2 shows the components of the framework.

The adaptability of humanitarian actors to different environments can be summarized as the requirement to be *agile organizations* (L'Hermitte *et al.*, 2015). Humanitarian supply chains face the great challenge of forecasting volatile needs in sudden-onset or slow-onset events with constrained resources. Under high uncertainty and short time requirements, push strategies such as inventory prepositioning and resource pre-allocation are common measures. In contrast, when pull-based responses represent the only option, the mismatch between resources and needs between locations is a common result (Kwon and Kim, 2018). We argue that more collaborative and less resource-intense strategies can be chosen to prepare agile responses to several modalities based on external conditions.

Cash and in-kind require different type of preparedness. However, a grounded theory study with interviews to HOs and UN agencies in Palestine, showed that similar supply strategies were being used for cash and in-kind despite their different nature (Heaslip *et al.*, 2018). Agile supply chains are characterized by a focus on service level, flexibility and responsiveness to uncertain and changing environment (Shafiq and Soratana, 2019). In cash distributions, flexibility can be anticipated working with financial service providers (FSPs) with extensive service networks and adaptable requirements to provide cash to population in need. Agile in-kind distributions require stronger planning and network development to ensure that relief items are available. In addition, having flexible agreements with service providers allows for fast operational set ups and higher cost certainty.

FAs are a common tool in the humanitarian sector for fast response to emergencies that comply with donor procurement requirements in advance. HOs use FAs to establish contractual terms of future purchases such as price, delivery times, payment terms and service levels. FA differ from purchase agreements (PAs) in that they do not agree to a complete consumption of the contract. FAs are preferred to PAs because they do not require

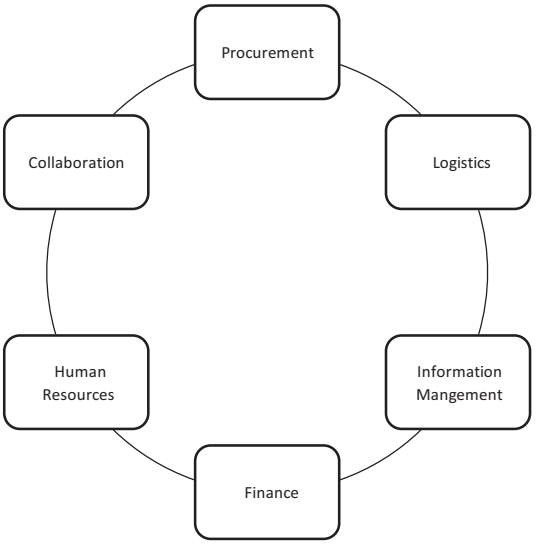

Figure 2.
Agile emergency supply chain preparedness components

budget commitments, which pose financial risks for HOs when donor funding stops. Local FAs are a viable supply chain option to speed delivery as long as products are available in the markets (Piotrovich, 2018). Establishing FAs require tender periods of weeks in advance and, most importantly, they mitigate the effects of inflation and market dynamics in the procurement processes. Additionally, logistics services are necessary to transport and distribute the product to affected regions.

Transportation and warehousing are essential processes tied to in-kind distributions and critical to deliver in emergencies. To enable a proper switch between modalities, logistics networks should already be available to utilize. However, creating logistics networks requires extensive amount of funds to position and move assets and resources not available before a crisis unfolds. Due to uncertainty in the location and type of demand, managing logistics as a service in the humanitarian response can increase flexibility and minimize set up costs. Specialized supply chain teams are required to analyze and develop the agreements weeks in advance so they can cover the geographical scope and timeliness of an emergency. Having service oriented FAs with logistics providers allows organizations to respond with low levels of investment leveraging deeper market knowledge.

As much as logistics habilitate the product flow in emergencies, information is the base for decision making. Available information is essential to be able to ensure the effectiveness of the response and react accordingly. After making data available, information should be integrated into the different processes of the operation. In this sense, there is a trade-off between the amount available and the resources and time to obtain it. During emergencies, the lack of necessary information is a foreseeable situation (Donovan *et al.*, 2005). For this reason, having available and open data related to suppliers and the logistic context can fasten the response. Cloud-based repositories enable the operationalization of shared information regarding suppliers, market dynamics and the development of the response.

Cash-based programs require information systems to develop the complex targeting parameters that they entail and to monitor the financial flows between FSPs and beneficiaries. While modality switching requires targeting processes to be ready, comprehensive information systems reach costs over the hundreds of thousands of dollars. When the scale of the response is not appropriate to this type of systems, carefully created and integrated spreadsheets serve the purpose to trace targeting to delivery and help finding corruption cases. The targeting parameters of in-kind responses are no less complex than cash programs (Harvey, 2005), but additionally require monitoring of the inventory flow and internal transparency when organizations operate logistics directly. This level of transparency can be provided through enterprise planning systems or clear inventory management processes.

Besides product and information flows, financial capabilities are instrumental to provide flexibility in the response. HOs have cash-flows different from for-profit organizations as they receive income from donors and the only end to these funds is to spend them in the response. A critical financial constraint during an emergency is the payment capacity of finance teams. To overcome this constraint and increase financial throughput, having bank accounts per location of operation allows more flexible resource spending. Besides payment transfers, financial derivatives are overlooked by HOs and perceived as speculative products, but is in the countries where emergencies occur that currencies have the highest scarcity and volatility. Futures contracts can allow responders to focus more on needs and impact and less on financial volatility.

Emergencies not only require product, financial and information flows to function properly but also to be able to scale rapidly. Scaling up operations by humanitarian actors requires hiring new staff and training them into the standard processes of the organization. Clear processes and summarized operational handbooks are important to reduce the learning curve of newly hired personnel. Crisis do not always allow the time to go through all the

Table 3.
Preparedness strategy per aid modality

	Cash-based response	In-kind response
Procurement	Anticipated FAs with FSPs	Local FAs or PAs ensuring product availability
Logistics	Communication and reach to beneficiaries after targeting	Available logistics networks and agreements with logistics providers
Finance	Flexibility for scale up of payments	Contracts to mitigate currency fluctuation
Information management	Targeting systems and financial transfers follow-up	Standardized product flow traceability and visibility
Human resources	Staff trained in cash-based response and flexible SOPs	Staff trained in logistics and orchestration
Collaboration	Interagency collaboration for market and indicators visibility	Collaboration for resource pooling and accessibility

standards of an organization in depth, so operations require qualified staff leading and monitoring the implemented programs. Additionally, standard emergency procedures should allow the speeding of the procurement and contracting processes. Some examples of this procedural flexibility are reducing tender periods, reducing the required number of suppliers to perform open tendering and widening the approval threshold for purchases.

Another source of agility in the supply chain processes of HOs is collaborating with other organizations at the operational and informational level. Collaboration is a valuable tool to ensure a global view of the emergency and enable accurate decisions. Collaboration is operationalized through regular formal spaces such as UN clusters. For example, weekly UN Logistics Clusters are instrumental for HOs in certain contexts to obtain transportation to remote areas and to help with the national import and export regulations. Bilateral collaboration between HOs is also helpful to validate data and avoid biases on the parameters of modality selection. Synergies should also exist with the private sector and strategic partnerships with commercial organizations can generate a stronger network for both cash and in-kind (Heaslip *et al.*, 2018).

The preparedness framework described aims to close the gap between the model proposed in the following section and the practical conditions that HOs face. The financial, collaborative and procedural components of the framework are not included explicitly in the model, but considered as preconditions to implement the modality switching during an emergency. The options outlined are not intended to be a comprehensive list, but the basis of an agile operation with low investment required and capacity to adapt to changes in beneficiaries needs or market conditions. Table 3 summarizes the agile preparedness options for each modality.

4. Model to decide between cash and in-kind distributions

This section describes the problem addressed in section 4.1, outlines the model in section 4.2 and gives general numerical analysis in section 4.3.

4.1 Problem description

A humanitarian responder has developed a rapid needs assessment in multiple regions of a country after the outbreak of a crisis. The emergency team has concluded that both multipurpose cash assistance and in-kind programs are feasible in terms of security, appropriateness and market capacity and adequate to serve the needs of the affected population. Multiple surveys performed in the immediate onset have offered information about the humanitarian needs and allowed to quantify the type of requirements such as food,

sanitation, health, livelihood, shelter or security. Of the set of needs, the organization could only attend a fraction as in-kind aid due to limited resources and expertise. In consultation with national authorities, the HO has defined the amount of cash to deliver per beneficiary. Finally, it has to decide in which regions to set up cash transfers and in which to deliver in-kind goods. In order to implement a consistent response and limit excessive overhead, the HO has decided to use only one type of aid modality in each region, be it cash or in-kind.

The objective is to maximize the properly satisfied demand from beneficiaries based on the surveyed basic needs. We assume that, at the planning stage of the emergency, the amount of cash delivered to a beneficiary covers 100% of its basic needs. A certain percentage of the needs is subject to inflation, which reduces the purchase power of beneficiaries and the satisfaction of their real demand. We do not argue that price increases are caused by the intervention, but consider inflation as an environmental effect during the response. If aid is delivered in-kind, beneficiaries then get satisfied only a percentage of their needs and an extra additional quantity obtained by selling part of the goods at a discounted price. The organization is assumed to operate with a fixed budget given by donors to optimize by maximizing the effective coverage of the needs generated by the crisis.

We consider that the cash-based program is implemented via a FSP which charges a fee as a percentage of the amount distributed to each beneficiary. The cash program has also an administrative cost to operate the financial transactions and monitor the operation. We assume that the cost of the in-kind program is completely variable and divided between the procurement cost of the goods and the logistics cost of transporting them to the affected areas. Fixed costs on in-kind delivery are not considered because logistics are regarded to be operated either through a third party or accounted to the project on an activity basis. The logistics cost can vary for each region. We suppose that the availability of in-kind goods is not a constraint because either local markets function effectively or the organization has stock ensured by FAs with suppliers as described in the previous section.

The following notation is used to model the problem:

Sets:

N: Set of regions; $i \in N$

Parameters:

α_c	Fixed administrative cost of the cash transfer program per region
α_f	Fixed administrative cost of the in-kind program per region
f	Transfer fee charged by the financial service provider
θ_i	Inflation rate in region $i \in N$
σ	Discount rate at which beneficiaries sell the excess of in-kind aid received
p_i	Percentage of total in-kind needs of beneficiaries in region $i \in N$
δ	Fixed amount of cash to deliver to each beneficiary
c_p	Purchase cost to suppliers of the in-kind base amount of goods
c_t	Transportation cost of the in-kind base amount of goods
u_i	Maximum number of beneficiaries reachable in region
l_i	Minimum number of beneficiaries to attend in region $i \in N$
M	Total budget for the response
n_{c_i}	Total number of beneficiaries covered by cash transfers in region $i \in N$

Variables:

n_{k_i}	Total number of beneficiaries covered by in-kind distributions in region $i \in N$
$\widehat{n_i}$	Amount of effective beneficiaries needs covered in region $i \in N$

m_i	Budget spent in the response in region $i \in N$
$x_i = 1$	If cash transfers are chosen for region $i \in N$, 0 if in-kind aid is chosen

4.2 Model

We develop a quadratic mixed-integer model to select the most effective modality for each region in an emergency response maximizing the real needs covered of the beneficiaries. Accordingly, the HO implements the program for a period of time and is able to reevaluate the conditions in the next period and switch between programs. The uncertainty in the parameters of the model, such as the demand in each region and the type of needs of the beneficiaries, is resolved periodically via monitoring and evaluation by the responder. This approach shows a combination between the classical equilibrium models from the economics literature (Basu, 1996; Coate, 1989) and the product flow based literature of humanitarian supply chain management.

To simplify the model, we consider a single period decision process that can be iterated over the response. We exclude multiperiod modeling due to the complexity of forecasting the future values of parameters such as inflation, more specifically, we regard that organizational flexibility and preparedness counteract the lack of medium-term forecast.

The formulation of the model is presented below:

$$\text{maximize} \sum_{i \in N} \widehat{n}_i \tag{1}$$

$$\text{s.t.} \quad n_{c_i} \leq x_i * \frac{(m_i - \alpha_c) * (1 - f)}{\delta}, \ \forall i \in N \tag{2}$$

$$n_{k_i} \leq (1 - x_i) * \frac{(m_i - \alpha_f)}{c_p + c_t}, \ \forall i \in N \tag{3}$$

$$\widehat{n}_i = \frac{n_{c_i}}{1 - p_i + p_i * \theta_i} + p_i * n_{k_i} + \sigma * (1 - p_i) * n_{k_i}, \ \forall i \in N \tag{4}$$

$$n_{c_i} + n_{k_i} \geq l_i, \ \ \forall i \in N \tag{5}$$

$$n_{c_i} + n_{k_i} \leq u_i, \ \ \forall i \in N \tag{6}$$

$$\sum_{i \in N} m_i \leq M \tag{7}$$

$$x_i \epsilon \{0, 1\}, \ \ \forall i \in N \tag{8}$$

$$m_i, n_i \geq 0, \ \ \forall i \in N. \tag{9}$$

The objective function (1) maximizes the sum of the effective needs of beneficiaries for each region. Constraint (2) defines the upper bound on the number of beneficiaries reached with cash-based distributions in region $i \in N$. The right-hand side has positive value if $x_i = 1$ and $m_i > 0$. In this case, the upper bound is the ratio between the net funds available to beneficiaries and the fixed amount of cash delivered per beneficiary. The net amount of funds is obtained subtracting to m_i the fixed administrative cost of the HO α_c and the fee f charged by the FSP. Constraint (3) models the upper bound of beneficiaries aided by in-kind distribution in region $i \in N$. The upper bound of in-kind aid is obtained as the ratio between the net funds available and the total delivery cost of the goods per beneficiary. The net amount of funds for in-kind programs is computed as the funds spent m_i minus the fixed administrative cost α_f. The total delivery cost includes the procurement cost c_p and the transportation cost c_t. Due to the relationship with variable x_i, only one of the two

constraints (2) and (3) will have a right-hand side greater than 0. This relationship ensures that only cash-based or in-kind distribution is selected in each region i.

Constraint (4) is an auxiliary constraint to adjust the number of beneficiaries reached to the real needs covered. For cash distributions, inflation θ_i in each region reduces the effectiveness of the program to the p_i percentage of in-kind needs that beneficiaries purchase in the market. In-kind distributions only attend p_i in-kind needs of beneficiaries. The other $1-p_i$ of in-kind goods is resold by the recipients at a discount rate σ generating them extra income. Constraints (5) and (6) set the lower and upper bounds of reachable beneficiaries per region. Constraint (7) ensures that the sum of the budget allocated to each region does not exceed the total budget from the donor. The budget M is assumed to not to include the fixed overhead from the HO. Constraints (8) and (9) define the type of decision variables.

The model can be formulated more compactly by substituting constraints (2) and (3) into the objective function and rearranging the coefficients multiplying the variable m_i in the auxiliary constraint (4). By the structure of the model, constraints (2) and (3) are summed and the variable $\widehat{n}_i$ substituted into the objective function. Constraints (5) to (9) remain equal in the compact formulation.

$$\text{maximize} \sum_{i \in N} x_i*(m_i*a+b)+(1-x_i)*(m_i*c+d) \tag{1a}$$

$$a=\frac{1-f}{(1-p_i+\theta_i*p_i)*\delta} \tag{2a}$$

$$b=-\frac{\alpha_c*(1-f)}{(1-p_i+\theta_i*p_i)*\delta} \tag{2b}$$

$$c=\frac{p_i+\sigma*(1-p_i)}{c_p+c_t} \tag{3a}$$

$$d=-\frac{\alpha_f*(p_i+(1-p_i)*\sigma)}{c_p+c_t} \tag{3b}$$

The compact version of the model offers an economic interpretation where the modality selection is based on the trade-off between the fixed and variable costs of each program including the indirect effects of the market environment. The following section shows the numerical properties and the sensitivity of the model to its parameters.

4.3 Numerical analysis

To provide intuition about the model, in this section we analyze the sensitivity to changes in the environmental parameters and the net result of the needs covered to the beneficiaries. Particularly, we show the impact of changes in (1) procurement and logistics cost, (2) inflation, (3) percentage of in-kind needs of beneficiaries and (4) discount rate at which beneficiaries can resell the aid. We used four locations for the analysis to prove the effects of variability between several locations. Each location had the same upper bound of beneficiaries u_i and inflation θ_i, but different values for the minimum number of beneficiaries and the percentage of in-kind needs. Figure 3 shows the variation in beneficiaries and net needs covered and the ranges within which all locations implement cash transfers or in-kind distributions.

We built the model using JuMP/Cbc (Dunning *et al.*, 2017) in a regular laptop with Intel i7 and 16GB of RAM. The computational complexity of the stated model is bounded by the number of regions and it is solvable using open source solvers or spreadsheet modeling.

4.3.1 Procurement and logistics cost. We analyze the variation of net needs covered by changes in procurement and logistics cost as a percentage of the total amount of cash to

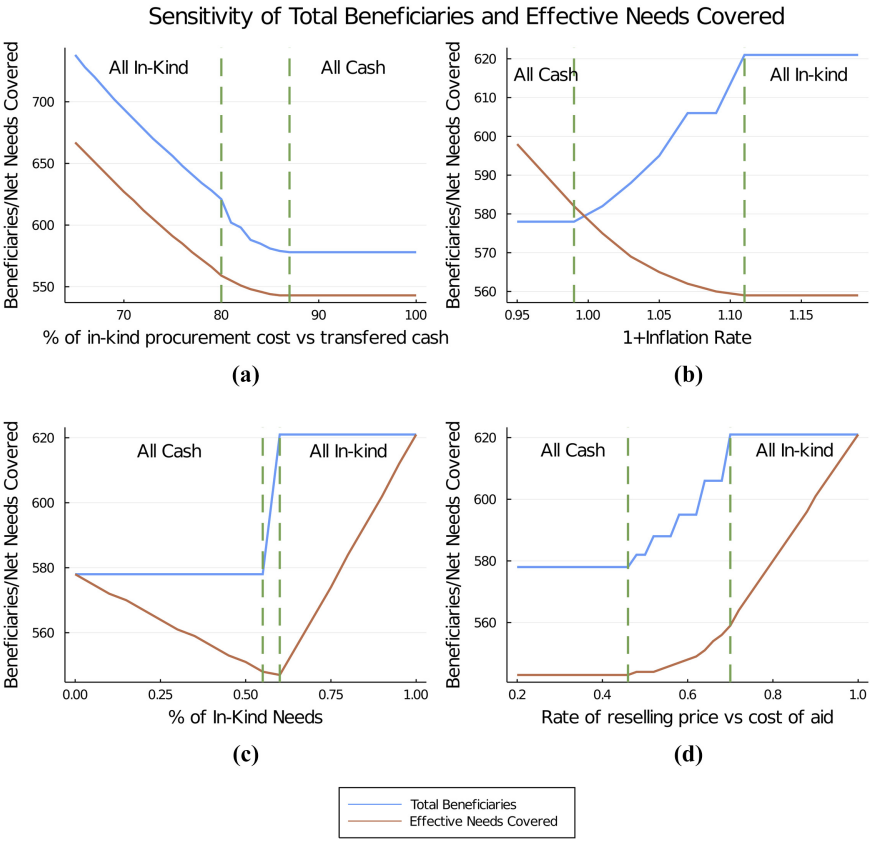

Figure 3.
Total beneficiaries and net needs covered with varying (a) procurement cost, (b) inflation, (c) % of in-kind needs and (d) discount rate of resold aid

deliver. Figure 3a shows that when the procurement costs are small compared to the amount of cash, the number of beneficiaries is strictly higher than with a pure cash-transfer program. For fixed values of the rest of the parameters, there is a linear relationship between the procurement cost and the total number of beneficiaries. Up to a certain ratio of beneficiaries reached, cash programs start being more effective to cover the needs and increase outreach. The length of the transition phase, where some regions deliver cash and others deliver in-kind, depends directly on the percentage of in-kind needs in each location. After a certain increase in procurement cost, the number of beneficiaries stays constant meaning that all the locations should switch to cash transfers and the needs covered are no longer dependent on the cost of in-kind aid.

Results show that the total number of beneficiaries is an upper bound for the effective needs covered when only the logistics costs change. The constant gap between beneficiaries and needs is caused due to the constant in-kind needs of beneficiaries in this analysis.

4.3.2 Inflation. In this subsection we analyze how inflation affects the needs covered by the response. Inflation is understood to happen in the retail market where beneficiaries spend the cash received. Price increases do not affect the HOs procurement cost as the preparedness strategy is assumed to have established a FA to get a fixed price of in-kind items.

In Figure 3b we observe that for negative values of inflation the actual needs covered are higher than the net amount of beneficiaries. We interpret this result as attending population

beyond their basic needs. This reduction in retail prices may occur in emergencies that keep the retail market demand but reduce the industrial consumption. A pandemic that quarantines population can produce price reduction at the beginning of the outbreak due to excess of supply derived from economic shutdown. As shown in Figure 3b, the net needs covered have an inverse relationship with inflation. For low levels of inflation, cash transfers increase the spending power. However, the amount of in-kind goods obtained is reduced if the margin earned by retailers is higher than the logistic and administrative cost of the HO. We observe this condition after the point in which the number of beneficiaries reaches a maximum and the net needs covered a minimum. This occurs when all locations implement in-kind transfers and the beneficiaries are protected from inflation at the expense of less accurate coverage of their needs.

4.3.3 Percentage of in-kind needs. We also demonstrate how the percentage of in-kind needs of the population affects the net needs covered and the decision from the HO. The differentiation between in-kind and non-in-kind refers to the needs that could be supplied by a HO versus the ones where direct purchasing in the market is the only viable mean. Examples of non-in-kind needs are educational services or the rent of living spaces.

In Figure 3c we show how it is theoretically possible to reach a perfect match between beneficiaries attended and needs covered. We observe this phenomenon at the first and a last point of the chart where the total beneficiaries and the needs covered coincide. The absence of in-kind needs is not a realistic assumption as beneficiaries always have a wider set of needs that money can acquire, such as for example hygiene items.

The gap between both curves provides a theoretical reference on the distance between what HOs try to deliver and the effectiveness of their programs. When the percentage of in-kind needs is low enough, cash-based response is the most effective modality because beneficiaries have a relevant percentage of needs to cover by their own means. After a certain threshold, in-kind programs prevail because the HO starts serving the affected population more accurately. Here we observe how the change from complete cash to complete in-kind modality is abrupt and has a relevant impact in both efficiency and effectiveness of the response. Moreover, sudden modality changes suggest that the responding organization should monitor the type of needs closely to ensure an effective response.

4.3.4 Discount rate of reselling aid. In this subsection we illustrate the impact of the reselling discount of in-kind aid in the objective of the model. When beneficiaries receive a different type of aid than what they want, it is a natural response to obtain liquidity to cover their real needs. Additionally, if people receiving in-kind aid resell the goods at their full price, they obtain an amount of cash equivalent to cover the rest of their basic needs. We observe in Figure 3d that for highly discounted reselling price, cash-based distributions are the preferred modality. The reason for this result is that beneficiaries selling humanitarian aid for a value lower than its cost means a demand mismatch to resolve giving the beneficiaries the cost of those goods in-cash. Although economically optimal, this last option is impractical because it is not possible to know in advance the reselling price and quantity of the received aid.

With increasing value obtained by the goods sold, in-kind transfers balance the cost of assuming the delivery of in-kind goods. Consequently, for fixed values of the rest of the parameters, the transition of modality between locations occurs depending solely on the percentage of in-kind needs in each region. The higher the percentage of in-kind needs the lower the excess in aid and the lower the effect of the discount rate of reselling aid.

In summary, the sensitivity analysis on the model showed how under certain conditions of inflation, percentage of in-kind needs and reselling price of aid, in-kind aid becomes a more effective modality than cash. The result is observed in Figure 3b-c-d where all locations implement in-kind aid as a mean to protect people in need from unfavorable market conditions. The sensitivity analysis on logistics costs concurs with the perception that when

the HO supply chain cost is high, is preferable to deliver cash to beneficiaries. As the model allows only one modality per location, the transition phase between "all cash" and "all in-kind", shows individual locations switching aid modality. In the following section, we apply the model to a response to the COVID-19 crisis during 2020 and show the preparedness framework in a HO.

5. Case study: COVID-19 emergency response in Colombia

In this section we apply the model to a real emergency to evaluate the effectiveness of the modality selected by an HO. We describe the background and context of the COVID-19 emergency in Colombia in section 5.1 and depict the results in terms of preparedness and application of the model in section 5.2. The case is based on the work of the author with the Danish Refugee Council (DRC) in the emergency response. DRC is a major international HO with presence in 40 countries and more than 9,000 employees. DRC had presence in Colombia since 2011 and the size of the operation had grown three-fold in 2020 since the previous year. The author worked as a responder in the emergency which allowed better understanding and primary information gathering.

5.1 Case description

By 2020, Colombia had received the biggest amount of displaced population from the economic crisis in Venezuela. Between 2018 and 2020 1.2 million people had fled Venezuela reaching 5.5 million according to UN projections. In 2015 the number of Venezuelans hosted in Colombia was 40,000. In February 2020 the number of migrant and refugee population in Colombia from Venezuela had risen to 1.8 million (RMRP, 2020). The consequences for Colombia were an increase in the amount of vulnerable population adding to the 5.5 million internally displaced people in the country, the second largest in the world after Syria (IDMC, 2020). The majority of the Venezuelan population who crossed the borders by land were in need of food security, health and protection (RMRP, 2020). As a result, the crisis called the attention of international donors and generated the response of international actors to mitigate the emergency.

The COVID-19 pandemic arrived in Colombia by the beginning of March 2020 and generated a crisis within a crisis in the country. In Colombia more than 48% of the economy is informal (Dane, 2020a, b) and vulnerable population had limited access to basic services. The quarantine measures imposed in the country produced a lock-down that resulted in the loss of income for a large percentage of the population. Access to food and payment of rent were a major concern for migrant and refugees. Consequently, several NGOs made global appeals of funds to respond to the crisis.

By January 2020, DRC had presence in Colombia with six offices and a multipurpose cash assistance (MPCA) program for refugees and migrants in the cities of Bogotá and Barranquilla. The amount delivered in cash to beneficiaries as part of the cash program was negotiated with the government and set at a fixed amount. Due to the pandemic impact, DRC scaled up the MPCA program into two more regions where it already had presence. The food and financial supply chain operated with normality after the lock-down impacting only the price of food. 74.3% of the respondents from the DRC rapid needs assessment mentioned an increase in the price of food (R4V, 2020). The reported inflation raised concerns about the effectiveness of the scaled operation and the model described in the previous section was applied to provide *ex ante* analysis of the effectiveness of cash transfers and alternative aid modalities.

5.2 Case results and analysis

The emergency response to the COVID-19 crisis started in April 2020 when medium term confinement had been established by the Colombian government. After an assessment of the

severity of the situation and the immediate needs generated by confinement, donor funds were obtained and the decision to scale up operations was taken. The following subsections describe the results of the case study as the preparedness measures to scale up the response by DRC and the application of the model to the emergency cash program implemented in four regions of the country. Figure 4 shows the presence of DRC in Colombia and the regions where the operation was escalated.

The information to feed the model was obtained from several primary and secondary sources. Through the supply chain stablished contracts, DRC provided the procurement and delivery costs of a standard kit defined by WFP and the FSP transfer costs from the emergency MPCA program. Beneficiaries needs were obtained through a rapid needs and protection assessment conducted in April with Venezuelan migrants and refugees and Colombian returnees in 4 cities of the country. A total of 227 heads of households and 32 key informant interviews were conducted. Inflation values for basic basket products were obtained through the WFP led Cash Working Group and the national department of statistics in the country (Dane, 2020a, b). The lower and upper bounds of beneficiaries were obtained through the target of assisted beneficiaries from the result contract with the donor.

5.2.1 Preparedness. The primary measures taken to scale operations were: the development of the supply chain capabilities, hiring new staff, reinforcing the financial operation and creating the security protocols to guarantee the safety of the program.

The means to develop supply chain capabilities were to create FAs on critical procurement goods and services and increase the logistic capacity to mobilize humanitarian teams. The main FA was for financial services to deliver the cash-based aid without the need to provide physical cards to beneficiaries and reduce the risk of COVID-19 infection. The rapid needs assessment showed how only 18% of the surveyed population managed to eat three meals a day, which made the timeline to begin delivering a critical factor. The procurement procedure to generate a sizable agreement required a three weeks tender process. To accelerate the process, the organization approved an emergency procedure reducing the tendering time to one week. DRC had an outsourced logistic operation apart from a rented fleet of 22 vehicles. As a result and thanks to an existing FA, the fleet size was able to increase by 50% to 34 vehicles in less than 3 weeks.

The mandate of DRC during the pandemic was "to remain and deliver", which required hiring of additional staff to scale the emergency operation. Still, preserving the programmatic

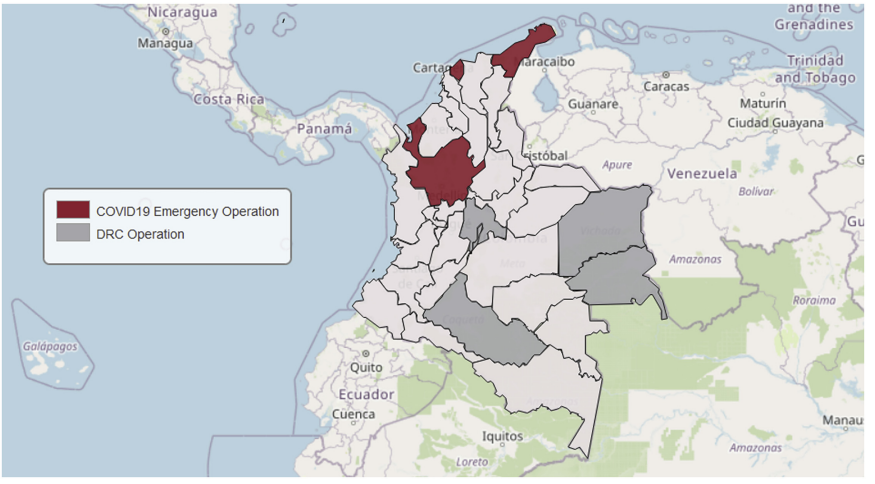

Figure 4.
COVID-19 emergency operation and Danish refugee council presence in Colombia

quality standards was mandatory due to the response. This was ensured by intensive training to new personnel and the flexibility to mobilize managers and coordinators by road to places with scaled operation. The information management and monitoring capabilities and procedures from previous programs were adapted to the response to allow fast information flow between operations and decision-makers.

Financial flows were needed to be scaled up as much as operational ones. There was an economy of scale for those purchases under FAs due to negotiated payment conditions with suppliers. For those goods and services for which an agreement was infeasible due to price volatility or product availability, fast and often immediate payment was to be ensured. Personal protection equipment was one of these products that required agile procurement and payment to receive the necessary stock to start the operations.

Ensuring the safety of the operation while being able to deliver was the major constraint to respond to the emergency. Therefore, safety supplies such as face masks where highly demanded and difficult to obtain at reasonable prices. The solution to market visibility and product availability was to reinforce collaboration between partner NGOs and communication in open spaces such as the Logistic Working Group led by WFP in Colombia.

5.2.2 Cash to in-kind decisions. The model presented in section 4 was used to evaluate the effectiveness of the selected aid modality and to analyze the market variables that could influence the emergency cash-based response. The model suggested cash-based responses in every region. Due to data limitation, the discount reselling price was assumed to be 0 to depict the condition where the quarantine impeded beneficiaries to go out and resell freely any excess. The first result we see in Figure 5 is the difference between the amount of beneficiaries

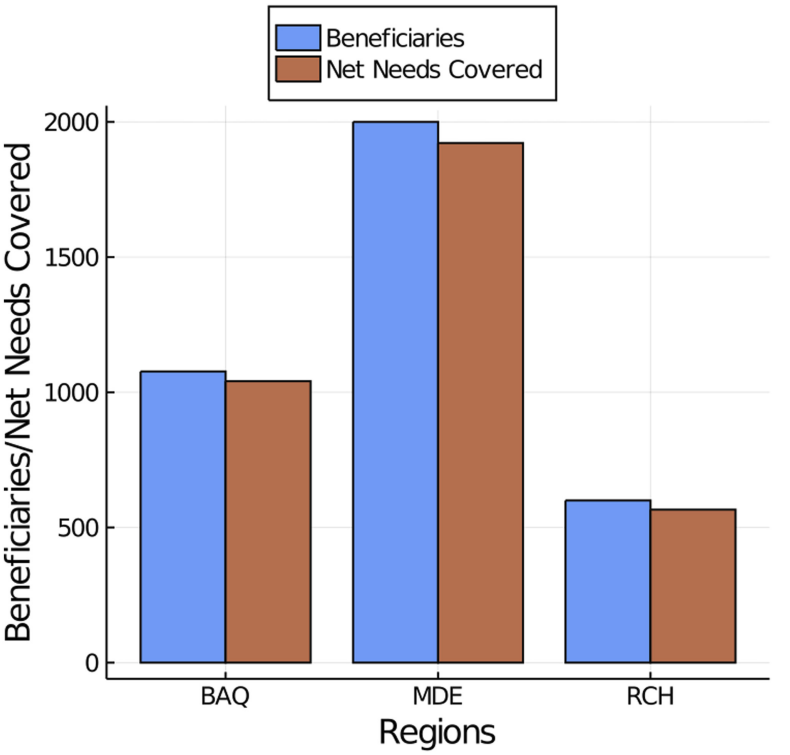

Figure 5.
Beneficiaries and needs covered from cash-based response

attended and the net needs covered for each of the three regions. The difference reflects the inflation between the moment when the government fixed the size of the cash transfers and the response time. It is due to this government decision that increasing the amount delivered in cash was not an option to counteract inflation.

In Figure 6 we observe that the inflation threshold to switch from cash transfers to in-kind is close to 5%. This is a small margin considering that weighted annual inflation in Colombia for 2019 was 3.86% and certain basic products like rice had a price increase of 41% by May 2020, in the middle of the crisis (Dane, 2020a, b). The baseline for inflation is based on the moment when the response commenced and the HO was suggested to perform a close follow up due to the impact on the effectiveness of cash transfers. Another relevant aspect is that cash transfers were selected as a mean to cover the needs of beneficiaries, but not due to more efficient logistics as in-kind aid would reach 13.4% more population.

The results shown in Figures 7 and 8 contain the total number of beneficiaries and effective needs covered for several percentages of resold aid and discount prices. We used a range of values at which beneficiaries may sell the in-kind aid received in case the in-kind distribution were implemented. Furthermore, we observe how, for a narrow range between 50 and 65%, the selected program changes completely for all the regions. This sensitivity remarks the importance of understanding the liquidity of markets and including the impact of reselling aid into the results expected from the program. The exact value of the discount

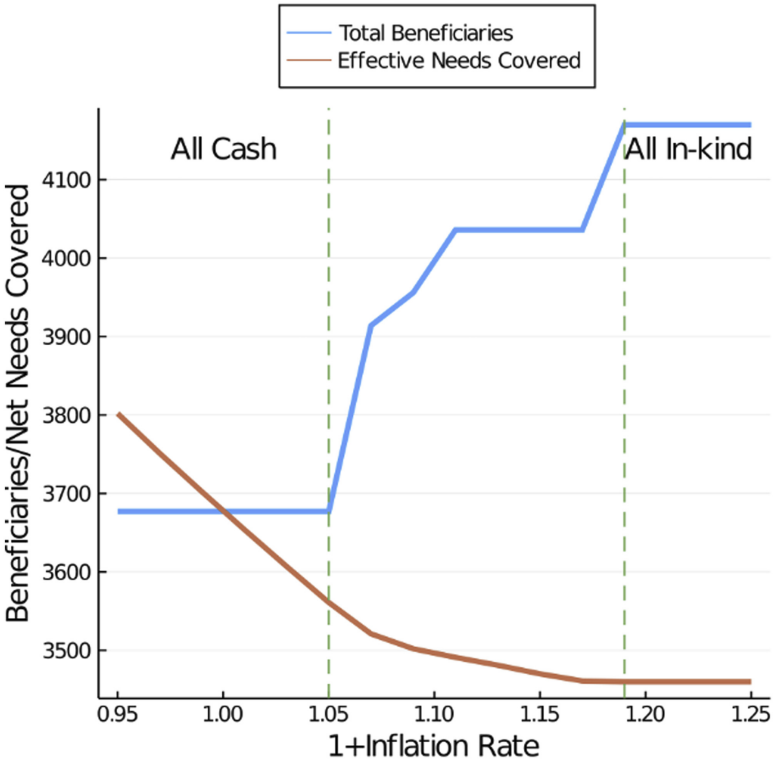

Figure 6.
Change in beneficiaries according to changes in inflation

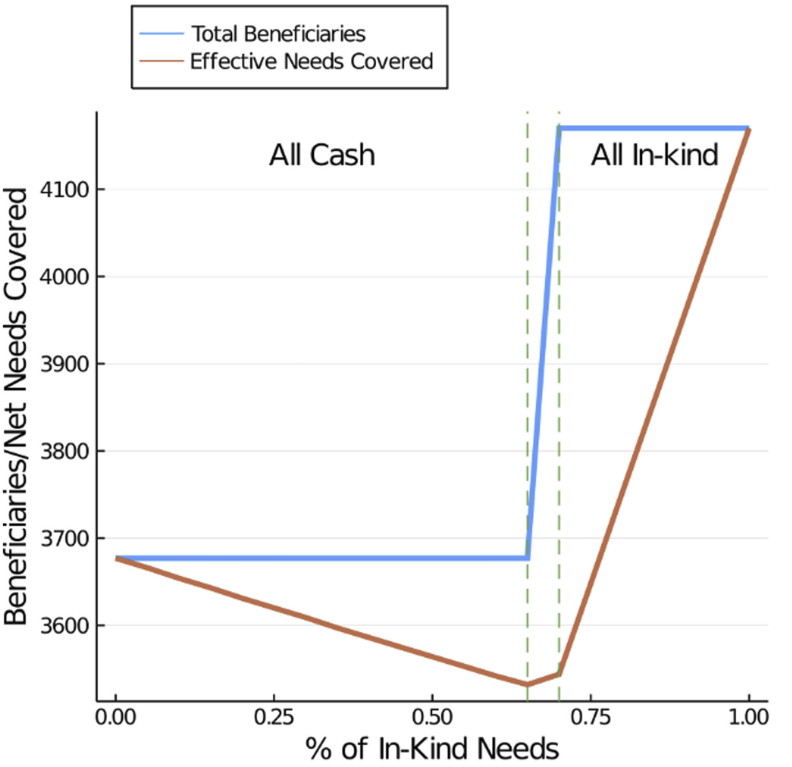

Figure 7.
Change in beneficiaries according to % of in-kind needs served by DRC

was unknown during the response but it could be estimated as lower than 50% due to the lockdown measures implemented to contain the spread of the COVID-19 virus.

According to the results, the cash-based program initially planned to maximize the effective needs covered but not the maximum number of beneficiaries as in-kind produces a higher value by 13.4%. The results also highlighted the high sensitivity of the modality decision regarding the percentage of in-kind needs. After discussing the results with the organization, cash was confirmed as a proper modality as it was able to serve a critical need for migrants and refugees in urban areas: paying rent and avoiding eviction in the middle of the pandemic. Although the model allows for dynamics evaluation of the response, only one iteration of the decision process was done due to the timed scope of the research. In parallel of the analysis done to the effectiveness of pure cash transfers, DRC started delivering emergency kits for hand-washing, which was considered a critical need during the pandemic. The combination of modalities was not part of the model but remained as a relevant next step.

One conclusion after the application of the model was that its objective is to decide between cash-based and in-kind responses during an emergency and not to analyze the root cause of the changes in the parameters. Inflation should be analyzed in terms of the products that the target population purchase with cash and can also be procured by the HO. In the Colombian case, migrants and refugees from Venezuela always have the possibility to change their consumption habits due to inflation. As a consequence, it is important to survey the post-distribution effect of aid before deciding to change between one modality or another.

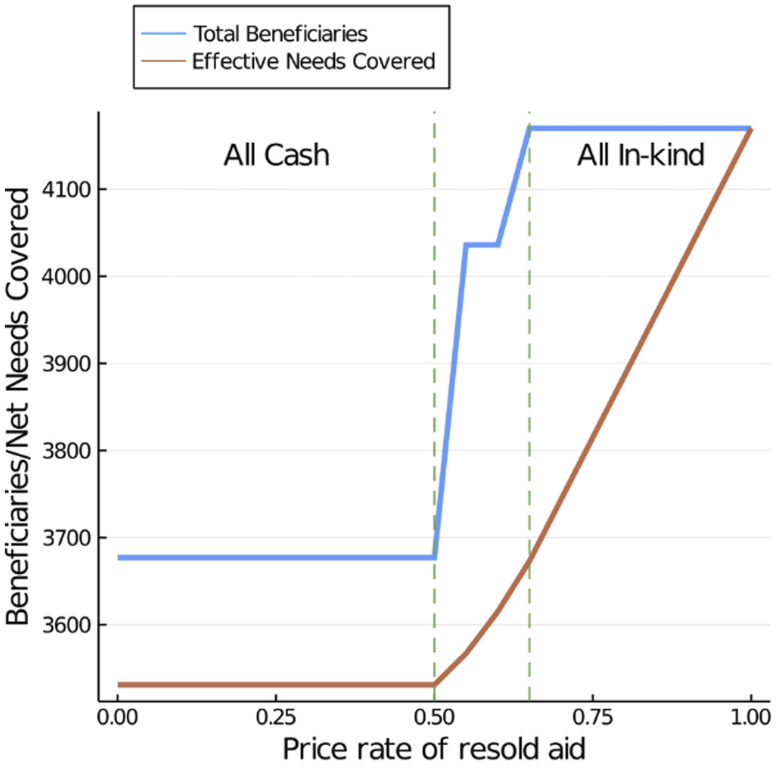

Figure 8.
Change in beneficiaries according to changes in the price rate of resold aid

6. Conclusions

This paper provides a novel decision model that combines the needs from beneficiaries, market dynamics and supply chain costs to select the response modality with highest effectiveness during emergencies. To ensure the operability of the decisions suggested, we describe a set of preparedness measures to implement and develop the agility required to switch between response modalities. The preparedness framework and the model were shown into functioning through a case study of the COVID-19 emergency response in Colombia. The results show how including the needs and decisions of beneficiaries into the aid modality selection improves the effectiveness of the response.

The research provides theoretical evidence that aid modality selection should not be considered as a static decision as given by the decision tools employed by HOs. The results from the sensitivity analysis challenge the accepted conception in the literature that cash-based programs are more efficient due to the cost reduction in transportation and warehousing (Heaslip *et al.*, 2016). We show that considering the effectiveness of each modality in terms of providing what beneficiaries actually need and protecting them from market externalities can make either cash or in-kind aid the most adequate option. We also encourage emergency responders to include quantitative market feedback into the planning of a humanitarian response. In practice, this requires a constant monitoring of external parameters such as inflation and beneficiaries use of aid.

The second theoretical contribution is the consideration of the imperfect satisfaction of needs from beneficiaries after receiving aid. We relax the common assumption in the

literature that demand from beneficiaries is immediately satisfied when receiving aid. The model considers the capacity of reselling aid if it does not match the beneficiary needs. We also show that cash transfers can be less effective because beneficiaries spend the resources in the retail market. The retail cost of products is subject to inflation and contains the margin charged by the retailer and additional taxes imposed by governments. Because HOs are frequently tax exempt, they have the capacity to mitigate these costs and yield larger outreach than cash-programs if the appropriate conditions are met.

The preparedness framework outlined and applied in the case study is a practical contribution for HOs as it gives an explicit set of preconditions for flexible aid modality implementation during an emergency. The framework has a novel focus on agility without the frequent emphasis from the literature on asset allocation. Although prepositioning of assets is a useful option, this research makes emphasis on strategic options that can adapt to uncertainty reducing the commitment of resources and increasing the speed of the response. Additionally, the model provides a tool to make *ex ante* analysis based on one of the critical parameters for responders and donors: the effectiveness of aid covering needs. The model is a practical tool with low complexity that can be employed by HOs to decide and evaluate the selected response modality during an emergency.

Including the preferences and use of aid from beneficiaries directly in the decision making tools of emergency response helps dignifying the process of helping the most vulnerable. Furthermore, dignifying and human-centered programs have higher chances of meeting correctly the demand from beneficiaries and produce a better use of the funds given by donors. Considering external factors of the product flow of humanitarian aid also helps closing a literature gap that has been suggested as useful for linking the impact of aid into other sectors of the economy (Gelan, 2006).

The research has several limitations in terms of scope and assumptions. First, the model focuses on the short-term impacts of sudden emergencies and is not applicable without deeper analysis for longer-term and macroeconomic conclusions. Second, the researcher makes strong assumptions on favorable market conditions that may not hold in the most severe and conflict affected emergencies such as the existence of third-party logistic providers and the capacity to establish FAs. Third, the model assumes that only one modality is implemented per location and excludes modalities like commodity voucher assistance and point-based in-kind distribution. Lastly, the availability of certain model parameters such as beneficiaries' true demand and effective use of aid requires surveying the population and are prone to be biased without the proper survey methodology.

The model and the response dynamics analyzed have a potential number of extensions useful for practitioners and academics. Adding other modalities such as vouchers or point-based systems to distribute aid would generate different effects in the market and would require different preparedness measures worth the analysis. Future work could also explore including the framework to adjust the modality of aid in the optimization model extending its use from response to preparedness. Finally, a system dynamics approach to the causal relationships between the type of aid provided and its effect on the beneficiaries and the market could further the understanding of the impact of emergency response.

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