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**Background:** There are two prevalent supply management strategies for the Immediate Relief Period (IRP). The first is a **proactive** approach, where Humanitarian Organizations (HOs) procure relief items from suppliers, preposition this inventory (prepo stock) in strategically located distribution centers, and dispatch the items to affected areas only after a disaster occurs. The advantage of prepo stock lies in the ability of HOs to purchase and store selected relief items at a lower cost with assured quality. However, due to the unpredictable nature of disasters, accurately prepositioning the correct items in the right quantities is nearly impossible. Moreover, inventory holding costs, including obsolescence and the opportunity cost of capital, can be significant. To circumvent delays, HOs may resort to air transport if ground transportation exceeds a two-day transit to the affected area, incurring substantial costs. Additionally, donors are generally less inclined to fund inventory procurement in anticipation of a disaster, forcing HOs to use their limited reserves with the hope of reimbursement from donor contributions post-emergency.

The second strategy is **reactive**, wherein HOs purchase inventory (known as reactive stock) after a disaster has occurred from suppliers located in or near the affected area, distributing it to beneficiaries via more cost-effective transportation methods, such as trucking. Reactive stock offers several benefits. Firstly, demand assessments for purchases are significantly more accurate at the time of the disaster. Secondly, while purchasing from local suppliers may face competitive bidding due to the presence of multiple HOs, leading to higher prices, the overall landed cost of items acquired locally is generally lower than that of prepo stock due to reduced transportation costs. Additionally, the unit cost for items such as kitchen sets, cleanup supplies, and hygiene products is often lower when purchased locally or regionally. However, a disaster may lead to collapse of the local banking system or destroy the local supply base, or items quality may be substandard.

Between 1980 and 2019, over 22,800 natural disasters were documented globally that affected more than 14 billion people in need of immediate assistance such as medical services, shelter, food, and water.

**Question:** Assuming the priority is to procure from the local market, with prepo stock acting as a *backup* option, what should be the optimal level of prepo?

**Setting:** We address the challenge of optimizing the stock for a single relief item (or a kit of essential items) under several key assumptions: demand uncertainty, unreliable local supply, unpredictable timing of the next disaster, and stochastic total budget (which may include emergency funds received post-disaster). It is noteworthy that the emergency fund could correlate with the disaster's magnitude, potentially influenced by media attention. In our setting, a cycle is defined as the period from the response to one disaster (end of IRP) to the occurrence of the next. At the beginning of the cycle, the decision-maker determines the prepo level and then waits the next disaster.

(We also consider a scenario where the decision-maker has the flexibility to *adjust* the prepo level within a cycle–initially setting it at the cycle's start and later amending it before the subsequent disaster strikes. This scenario is discussed in Section 5 of the paper. In summary, the practical difference in outcomes due to this flexibility is negligible.)

**Insights:** The aim of this paper is to create an analytical framework that incorporates various uncertainties, assisting humanitarian decision-makers in their planning processes. We identify and detail the optimal level of prepo stock and provide an in-depth characterization of it. The table presented below succinctly explains how the optimal prepo level adjusts in reaction to alterations in the parameters listed in the first column,

using straightforward language for clarity.

| Directional impact of [variable, if increasing] | **Reactive** (Local supply is cheaper) | | **Proactive** (Prepo is cheaper) | |
|---|---|---|---|---|
| | Sufficient budget | Insufficient budget | Sufficient budget | Insufficient budget |
| Disaster frequency | ↗ | ↗ ↘ | ↗ | ↗ ↘ |
| Shortage cost | ↗ | ↗ | ↗ | ↗ |
| Holding cost | ↘ | ↘ | ↘ | ↘ |
| Average local supply | ↘ | ↘ | ↘ | ↘ |
| Uncertainty of emergency funds | Unaffected | ↗ ↘ | Unaffected | ↗ ↘ |
| Average emergency funds | Unaffected | ↗ ↘ | Unaffected | ↗ ↘ |
| Volatility of disaster frequency | Unaffected | ↗ ↘ | Unaffected | ↗ ↘ |
| Cash inflow | Unaffected | ↗ | Unaffected | ↗ ↘ |
| Cost of local supply | Unaffected | ↗ ↘ | ↗ | ↗ ↘ |
| Initial budget | ↗ | ↗ | ↗ | ↗ ↘ |
| Cost per unit of prepo | ↘ | ↘ | ↘ | ↗ ↘ |
| Demand or supply uncertainty | If critical ↗ | ↗ ↘ | ↗ | ↗ ↘ |
| Effective **approximate solution** | We found simple approximate solution. | | We have not been able to find it. | |

This table illustrates how the optimal prepositioning (prepo) level adjusts in reaction to changes in the variables listed in the first column. For instance, when local supply is preferred and a sufficient budget is available, an increase in disaster frequency will result in a rise in the prepo level (as indicated by the direction of the arrow in the second column). However, with an insufficient budget (third column), an increase in disaster frequency could either raise or lower the prepo level. Under these circumstances, the decision-maker requires further information, such as cash flow details or the probability of receiving a substantial emergency fund.

We also compare our results with those coming from a simple Newsvendor Model and discuss in what situations (e.g., if budget is unlimited and local supply is nonexistence) our optimization problem is the classic model without the constraint.

The findings indicate that HOs are able to strategically set the prepo level. For instance, a basic decision tree could be developed by initially posing the following questions:

- What is your organization's internal preference: proactive or reactive? (For instance, European HOs are often encouraged to procure from local markets.)
- Narrow down the list of items your organization plans to deliver.
- For each region, categorize items based on their comparative prices, criticality, and the likelihood of a shortage in the local market.
- Historical data can significantly aid in tailoring policies with reduced error.
- Leveraging insights from this study, decision-makers should be able to establish a "good" level of prepo stock. For example, if there is flexibility between reactive and proactive approaches but access to the budget is limited, allocate emergency funds to less critical items.