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Optimizing Supply Chains for Improved Performance

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In Nigeria, a transport optimization analysis provided critical input into the design of a new vendor managed inventory distribution system. Here, workers complete the first delivery run of the new system.

Supply chain design and optimization is a powerful, practical tool that can improve performance now and position supply chains for the future.

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Effective supply chains must be flexible and responsive to the changing dynamics in the marketplace, in manufacturing and technology, and in consumer expectations. This is also true for public health supply chains, which must respond and adapt to dynamic environments. But, change must be planned and based on today's demands and tomorrow's opportunities and risks. Supply chain optimization is a powerful, practical tool that can improve performance now and position supply chains for the future.

Optimization is a commercial-sector approach to designing, strategic planning, and continuous improvement in supply chain operations. It can be used to design new supply chains, or to redesign existing supply chains. In public health, optimization helps address common policy questions, such as—

What would be the impact if a new vaccine was introduced in the supply chain?

Can I unify multiple distribution systems into one?

How many warehouses do I need and where should they be located?

What type of vehicles do I need and how many?

Using simulation software and routine data, the optimization process identifies flexible strategies for increasing the performance and cost effectiveness of each supply chain function. It can present a variety of options for supply chain leaders to consider, such as locating warehouses, setting inventory levels, creating or revising transport routes, removing distribution tiers, and reengineering business processes. The process also helps determine the resource requirements for each option; it can also help estimate what impact future changes may have on the system.

While often thought to be an academic exercise, private sector supply chains routinely use modeling in optimization analyses to help reduce cost and improve long-term supply chain performance. Supply chain optimization outputs are based on models and software simulations, but they are practical and easy to understand.

The USAID | DELIVER PROJECT has applied supply chain optimization analysis in a number of countries to answer design and improvement questions (USAID | DELIVER PROJECT 2013a), including—

- In Guatemala: What type of trucks, and how many, are needed for national distribution of HIV, malaria, and tuberculosis (TB) products?
- In Haiti: In a unified supply chain, what are the ideal warehouse locations, capacities, and—for delivering commodities—the distribution routes?
- In Nigeria: What are the optimal routes and resources needed for a new direct delivery top up system in Bauchi state?
- In Swaziland: What is the best approach for collecting expired commodities from multiple locations and transporting them to a central waste disposal facility?
- In Tanzania: What supply chain infrastructure does the country need to deliver public health commodities in 2020?

The Optimization Process

Common Applications

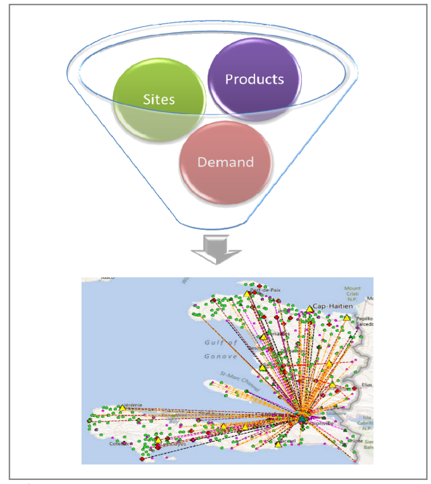
To answer these types of questions, optimization analysis is used in one of three ways: supply chain design, networking optimization, and transport optimization. The exact approach and scope are driven by the specific questions stakeholders need to answer; the various analyses can be used alone or with other analyses.

1. **Supply chain design** is a quantitative analysis in which partners build *working abstractions* for a real world supply chain. These analyses are typically used to support strategic and tactical decisionmaking by showing stakeholders real-world implications of management changes to the supply chain without actually piloting or implementing those changes.
2. **Network optimization** seeks to identify the lowest-cost network that meets stakeholders' performance objectives. The approach can compare potential networks—number of system tiers, number of facilities, location of facilities, service areas, and inventory policies. Different scenarios can then be run through a simulation exercise to estimate the potential impact of adverse shocks to the system, or gradual changes over time.
3. **Transport optimization** focuses on more operational transportation questions; it can be used to identify optimal routing, and the number and type of vehicles to serve expected demand. It can also compare potential transport options; for example, using different size vehicles, or changing routing length and number of vehicles. As with network optimization, various scenarios can also be run through a simulation exercise to estimate the potential impact of adverse shocks to the system, or gradual changes over time.

Data for Design and Optimization

The type of data needed for supply chain design and optimization depends on the objective of the exercise; but they fall into three basic categories: product data, site data, and demand data. Most supply chain organizations already have and routinely use these. To the extent possible, models are built using specific data, but many elements can comprise stakeholder-generated assumptions.

- Product data includes product name, value, pack size, unit volume (m^3), and unit weight.
- Site data includes facility type, global positioning system (GPS) coordinates, business hours, storage capacity (m^3), as well as costs.
- Demand data includes site-specific quantities, by product, requested over time.



Optimization modeling brings together various pieces of data to generate maps and other decisionmaking tools.

Other data that can be collected from stakeholders, or other sources, includes road network dataset; available vehicle assets by type, quantity, and capacity, including their operating costs; standard operating procedures; and policies related to delivery strategy, inventory control policies, and supply sourcing.

Steps in the Optimization Process

To design or improve the supply chain, the first step is to determine what questions need to be answered. After these questions are identified, you can determine if optimization analysis will help answer them. If so, it may be useful to engage a team of consultants, including the tools required to analyze the current situation and propose scenarios, based on your data and assumptions.

The next step is to organize and analyze the data from your supply chain described above. The data are entered into software, which links it to produce maps, charts, and other visual representations of the raw data. The software enables you to set the parameters for each scenario; for example, maximum load per truck, maximum time or distance per route, and maximum lead times to work with the existing schedules and resources. Optimization modeling uses this information to identify redundancies that can be eliminated, as well as gaps that must be filled.

In the third step, multiple possible scenarios are presented to stakeholders; these will answer some of the initial performance questions. To determine a way forward, the stakeholders can then consider the scenarios and assess the likely impact of different responses.

The final step is to adopt and implement the optimized supply chain design, based on the results of the modeling exercise; but, the process doesn't need to end here. Remember, optimization can be used for continuous improvement—as the system operates, data can be collected and fed back into the existing software model so the original predictions can be validated in real time. Adjustments may be needed; you can find them by rerunning the scenarios with new data and better assumptions, based on the experience of operating the optimized system.

Country Case Studies

The following short case studies are examples of how supply chain design and optimization has been used to address practical questions and real challenges in public health supply chain operations.

Zanzibar Network and Transport Optimization

The Zanzibar Central Medical Stores (ZCMS) in Tanzania operates a health commodities supply chain that serves the two major island groups that constitute Zanzibar: Ungjua and Pemba. ZCMS had been using a variety of channels to serve 146 facilities: monthly bulk push deliveries to four hospitals, standard kits pushed monthly to 44 primary health care (PHCs) facilities, and quarterly pulled orders through Zanzibar Integrated Logistics System (ZILS) to 98 PHC facilities. ZCMS wanted to transition all facilities to ZILS, but they needed assistance in selecting the best routes to serve the region from its main store on Unguja and its hub on Pemba. The network and transportation optimization analysis examined the three parallel supply chains, as well as the location of the Pemba hub, to help identify network and distribution strategies for cost savings. This was particularly important given the increase in the number of products moving through the ZILS system compared to the kits system.

Table 1 displays the number of routes, total distance, total time, and average duration of each route—all have cost or resource implications. This helped ZCMS examine the relative efficiency of the proposed routes (baseline) versus the optimized routes, and examine how the number and characteristics of the routes change under varying conditions.

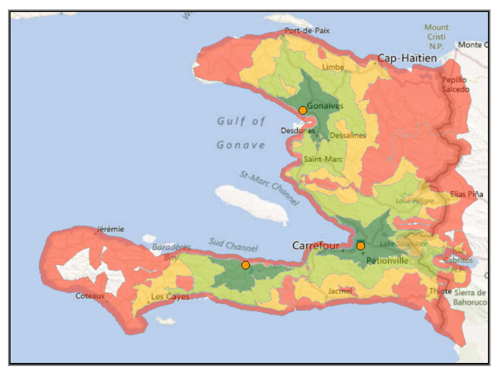
Table 1. Transport Modeling Analysis in Zanzibar

Scenario	Number of Routes	Total Distance (kilometers)	Total Time, all Routes (hours)	Average Route Duration
Baseline	29	1,751.75	160.2	5.5
Optimized	24	1,343.20	145.2	6.0
Optimized + 10% volume increase	28	1,439.68	156.1	5.6
Optimized + 20% volume increase	28	1,449.12	156.3	5.6
Optimized + 30% volume increase	29	1,452.76	157.4	5.4

Moving from the baseline to the optimized distribution reduces the number of routes needed to deliver all shipments from 29 to 24; a 400 kilometer decrease in distance traveled or a ~23 percent reduction. Optimized routes are shorter in total time, but the average route duration is longer, which maximizes a working day. ZCMS can increase shipment volume by 30 percent before reaching the 29 routes originally envisioned (USAID | DELIVER PROJECT 2013b).

Haiti Unified Supply Chain Design

In Haiti, seven separate donor-supported supply chains deliver health commodities from 13 storage locations to more than 500 service delivery points; they have overlapping delivery times, routes, and locations. To reduce costs and rationalize distribution, donors and the Ministry of Health (MOH) are trying to unify all supply chains into a single supply channel.



LLamasoft for the USAID | DELIVER PROJECT

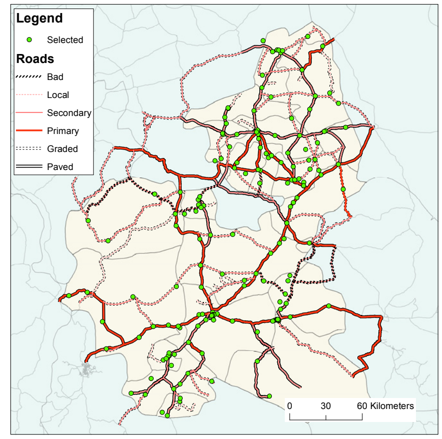
The proposed unified supply chain warehouse and distribution structure in Haiti

A supply chain analysis informed the design of the unified supply chain and enabled donors to make smart investments in supply chain infrastructure. The analysis recommended the most cost-effective warehouse locations to provide the greatest coverage; identified the most efficient distribution routes from the central warehouses to all health facilities; and recommended the minimum storage requirements for the proposed warehouse locations, given the projected population growth, disease patterns, and related trends. The map on this page, which was developed by the USAID | DELIVER PROJECT with the assistance of LLamasoft, shows the proposed warehouse locations: the dark green indicates areas within one hour of a warehouse; light green indicates areas within two hours; yellow, within three hours; and red, more than three hours. With this design, 78 percent of Haitians live within three hours of one of the three proposed warehouse locations. Implementation of the unified system will be phased-in to align with existing donor plans—such as investments in the Cap-Haitien region—and to mitigate risks. Because of their critical importance, HIV and TB commodities will remain outside the unified system until the system is fully functional (USAID | DELIVER PROJECT 2012).

Nigeria, Routing for New Vendor Managed Inventory System

In the Nigerian state of Bauchi, the state MOH is considering a new vendor managed inventory distribution system—13 different health commodities will be delivered directly to the health facilities. Under the design, stocks will be replenished from a *rolling warehouse,* based on inventory and consumption data collected onsite at the time of delivery. A transport optimization analysis has provided critical input into the design of the system, including the—

- resources needed to create a delivery truck logistics system
- capacity and cost for vehicles
- options for effective delivery routes.



Road network and accessible health facilities in Bauchi State, Nigeria

Because no historical shipment data is available, commodity forecasts and population distribution information were used to determine volume. Vehicle availability was a constraint, because only five trucks were available for the pilot. The initial design of the pilot assumed a bimonthly delivery, which limited the length of the possible routes. Another criterion was that facilities had to be accessible, defined as within 5 kilometers of paved or graded primary or secondary roads. The health facility locations were determined from the MOH datasets, as well as Health Systems 2020 data, the road network from the Survey General dataset, and expert knowledge on road conditions. From this, 164 sites were determined to be accessible. Table 2 presents two scenarios, based on the number of trucks available.

Table 2. Analysis Scenarios and Constraints

Scenario	A	B
Number of trucks	4	5
Maximum of 5 days out	✓	✓
70 kilometer per hour speed	✓	✓
Truck size	$5m^3$	$5m^3$
Percentage of shipments routed	88%	100%
Sensitivity to increase in volume	N/A	300%

In addition to providing guidance on the system design, the analysis also provided criteria that could be used to assess the bids from the transport services providers. Bidders whose cost proposals were low could be tested in the model to determine if they had proposed sufficient resources to meet service-level expectations; if they failed the test, their proposals were eliminated (Inglis 2013).

Conclusion

In recent applications of supply chain optimization analysis, initially, the stakeholders didn't think they had the data they needed, but they discovered that much of it could be exported from their existing warehouse management system. In other cases, the supply chain organization never knew their throughput volumes, or even the capacity of their warehouses. The optimization analysis presents staff with data they might already have, but in a more manageable, very visual framework. Furthermore, the analysis enables supply chain organizations to continue refining their processes and system designs. This is not a one-off exercise; after the initial design model is created, it can be updated with new data and the simulation rerun to check operational reality against the original predicted performance. New scenarios can be run when new opportunities and challenges arise.

Supply chain optimization analysis is a powerful tool that yields real results, with quantifiable savings and measurable performance improvements. It is a common tool and best practice in commercial supply chains; it should also be used in public health supply chains.

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John Snow, Inc.

1616 Fort Myer Drive, 16th Floor

Arlington, VA 22209 USA

Phone: 703-528-7474

Fax: 703-528-7480

Email: askdeliver@jsi.com

Internet: deliver.jsi.com