Transit monitoring capacity expansion: Analytics for combating human trafficking

Kezban Yagci Sokat  
*San Jose State University, kezban.yagcisokat@sjsu.edu*

Melissa Chi  
*Northwestern University*

Jonathan Hudlow  
*BioMarin Pharmaceutical Inc.*

Follow this and additional works at: [https://scholarworks.sjsu.edu/faculty_rsc](https://scholarworks.sjsu.edu/faculty_rsc)

**Recommended Citation**

https://doi.org/10.1016/j.trip.2024.101032

This Article is brought to you for free and open access by SJSU ScholarWorks. It has been accepted for inclusion in Faculty Research, Scholarly, and Creative Activity by an authorized administrator of SJSU ScholarWorks. For more information, please contact scholarworks@sjsu.edu.
Transit monitoring capacity expansion: Analytics for combating human trafficking

Kezban Yagci Sokat a,b,⁎, Melissa Chi c, Jonathan Hudlow d

a Marketing and Business Analytics Department, Lucas College and Graduate School of Business, San Jose State University, One Washington Square, San Jose, CA 95192, United States
b Mineta Transportation Institute, 210 N 4th St #400, San Jose, CA 95112, United States
c Northwestern University, United States
d BioMarin Pharmaceutical Inc., United States

⁎ Corresponding author at: Department of Marketing and Business Analytics, Lucas College and Graduate School of Business, San Jose State University, One Washington Square, San Jose, CA 95192-0069, United States.
E-mail address: kezban.yagcisokat@sjsu.edu (K. Yagci Sokat).

Contents lists available at ScienceDirect
Transportation Research Interdisciplinary Perspectives
journal homepage: www.sciencedirect.com/journal/transportation-research-interdisciplinary-perspectives

ARTICLE INFO

Keywords:
Human trafficking
Transit monitoring
Crime
Safety
Security

ABSTRACT

Human trafficking is a rising complex global problem, and effective anti-trafficking programs can address the problem through four objectives: prevention, prosecution, protection, and partnership, known as the 4Ps. The transportation industry plays a critical role in preventing and disrupting human trafficking. Research shows that transit points are crucial for recruiting and transporting victims of human trafficking between source and destination locations. Motivated by transit monitoring, a strategy that aims to identify and intercept potential human trafficking victims while they are in transit and before exploitation, this research demonstrates one of the first examples of transportation efforts to combat human trafficking. Through an academic and practitioner partnership, we develop field data-driven capacity expansion strategies for transit monitoring that integrates the 4Ps. This research utilizes a new multi-target metric to evaluate the impact of anti-trafficking operations, which amalgamates the prevention, protection, prosecution goals, and program cost. It also incorporates organizational factors to understand the success of potential interventions and demonstrates an early example of predictive analytics for combating human trafficking.

Introduction

Human trafficking, the recruitment, transport, and transfer of persons using force, fraud, or coercion to exploit them for acts of labor or sex, is a pressing global humanitarian issue (United Nations, 2000). According to the International Labor Organization, human trafficking is the second fastest-growing organized crime, with approximately $150 billion in annual profits. While it is hard to assess the full scope of human trafficking due to the clandestine nature of the crime and limited data (Gozdiak, 2011), there are 27.6 million people trapped for labor and sex (ILO, 2021). Moreover, the 2016 United Nations Office on Drugs and Crime’s (UNODC) Global Report on Trafficking in Persons reports 79% of the trafficked individuals to be women and children. The report also shows the vulnerability of migrants to human trafficking, especially female migrants (United Nations Office on Drug and Crime (UNODC), 2016).

Efforts to combat human trafficking have increased substantially since adopting the United Nations Protocol to Prevent, Suppress and Punish Trafficking in Persons, Especially Women and Children (2000). Also known as the UN Anti-Trafficking Protocol or the Palermo Protocol, it is one of the most critical global anti-trafficking efforts composed of 4Ps: prevention, prosecution, protection, and partnership. The 4Ps serve as global, national, and international cooperation strategies to take action in countries of origin, transit, and destination for human trafficking, including 1) prevention of human trafficking by identifying and reducing the vulnerability of people, 2) prosecution of the perpetrator, 3) protection of survivors and services to rebuild their lives, and 4) partnership (sometimes also referred as policy) in the local, national and international level for cooperation and coordination (U.S. State Department, 2011).

Transportation is vital in combating human trafficking, as traffickers rely on transportation to recruit and move victims (Yagci Sokat, 2022a). While transportations is not always required, traffickers often do transport a person from one location to another, either within the same...
country or across international borders. One of the main reasons this is common is that, within economies of human trafficking, locations of supply and demand tend to be geographically separate from one another. Moving a victim to an area where they are socially, culturally, or linguistically isolated from their home environment also allows perpetrators to more easily maintain control over their victims. The Trafficking in Persons (TIP) report, an annual report developed by the United States Department of State since 2001 to evaluate countries for their efforts on prevention, protection, and prosecution, often highlights the critical role played by transportation in its discussion of trends for each country as primarily a place of origin, destination or transit.

Many different modalities are used by traffickers to transport their victims, including air, marine, and most commonly many different types of land transportation. The particular type of transportation used is highly context specific, and is constrained by local availability, cost, and likelihood of avoiding suspicion. While source areas in particular tend to be spread out over wide geographic regions, and destinations tend to be more concentrated though still spread out in many clusters, transit points for major forms of transportation often present even more concentrated bottlenecks which provide strategic opportunities for intervention. While most pre-trafficking prevention programs lack the tangibility of measurable impact (being counterfactual), and while most post-trafficking interventions such as rescues fail to prevent the damage done to victims, intervening at the transit stage can provide a balance of tangible prevention unlike other approaches.

Intercepting victims while in transit is an established anti-trafficking strategy, though, outside the work of a few NGOs, it has mainly been implemented by immigration officers at national borders (Miller & Baumeister, 2013). Recent research also shows the importance, suggestions and examples of how data analytics could help the transportation industry to combat human trafficking (Yagci Sokat, 2022a; Yagci Sokat, 2022b, Yagci Sokat et al., 2024). Like many other anti-trafficking efforts, it is hard to obtain reliable data on the impact of these efforts (Hudlow, 2015). To fill this gap in rigorously addressing the transportation and transit stage of human trafficking, Love Justice International (LJI), a nongovernmental organization (NGO) focused on data-driven decision-making, employs an innovative transit monitoring strategy to identify and intercept potential human trafficking victims in transit and before being exploited. For effective transit monitoring, LJI collects data for each country on various factors, such as border openness, security, civil society engagement, cost, and traditional determinants of human trafficking. Using these data and data from field operations, LJI aims to identify potential countries for conducting feasibility assessments to expand their operations to different countries.

Motivated by LJI’s on-the-ground operations for anti-trafficking and recent transportation-related anti-trafficking work, this research focuses on the intersection of transportation, human trafficking and analytics. It incorporates the 4Ps in the anti-trafficking protocol: prevention, protection, prosecution, and partnership. Through an academic and practitioner partnership, we develop field data-driven capacity expansion strategies for transit monitoring. This research utilizes a new multi-target metric to evaluate the impact of anti-trafficking operations, which amalgamates the prevention and prosecution goals and the cost of intervention. It also incorporates organizational factors to understand the success of a potential intervention. This study demonstrates an early example of how transportation can aid anti-trafficking efforts through predictive analytics and can be valuable in limited data environments.

The rest of the paper is organized as follows. In Section 2, we review the relevant literature. Section 3 explains the methods regarding data collection, target and variable selection, and modeling. In Section 4, we discuss the results of our analysis. Section 5 concludes the paper with a discussion about the limitations of our study and identifies future research directions.

Background and literature review

Transportation and human trafficking

While transportation plays a crucial role in combating human trafficking, there is limited academic literature on the intersection of human trafficking and transportation. Yagci Sokat (2022a) presents the role of transportation in combating human trafficking in California through multi-disciplinary input from anti-trafficking practitioners. She mentions the crucial role of transit and transit operators in identifying victims and supporting a safe exit strategy for them as the “eyes and ears of the community.” Yagci Sokat (2022a) also highlights the need for data and analysis for combating human trafficking and provides multiple examples of data and analysis that the transportation industry could utilize. Yagci Sokat (2022b) shows the importance of transit availability for labor violations, which can lead to labor trafficking, a specialized population. Hill et al. (2022) discuss the impact of socio-spatial immobility on increasing the vulnerability to human trafficking in another special population, missing and murdered indigenous women in North America.

Yagci Sokat et al. (2024) presents the findings from a large national survey, National Outreach Survey for Transportation (NOST), on the intersection of forced labor and transportation. Authors identify the challenges, best practices and recommendations on the frontlines of the counter human trafficking efforts through the survey of transportation personnel, victim service providers and human trafficking survivors. For example, only 26% feel slightly or very confident about labor trafficking in their work environment.

Green et al. (2023) study the relationship between human trafficking and high-volume transport corridors in Tanzania and Uganda. They investigate the role of vehicle operators and communities in facilitating and preventing human trafficking, identifying those at risk of being trafficked, and outlining their experiences through a survey of over 1500 individuals (780 vehicle operators and 769 community members) and interviews with 55 key informants. The operators include drivers, conductors and drivers’ assistants who operate buses, coaches, heavy goods vehicles (HGVs), mini buses and taxis. The study shows that a small but significant proportion of operators and communities were involved in human trafficking in both countries. The research also points out the need for human trafficking for vehicle operations, poor knowledge of human trafficking in communities and low confidence in the officials’ capacity to address human trafficking.

The academic research is supplemented by invaluable reports. The 2019 United States Department of Transportation (USDOT) (U.S. Department of Transportation, 2019) Advisory Committee on Human Trafficking provides extensive content on the efforts to combat human trafficking in the transportation industry. The report lays out the efforts from the department as well as the partners and recommendations by modality along with the access to the materials for different stakeholders. The 2020 synthesis report on transit security provides some statistics with regards to human trafficking awareness and anti-trafficking efforts in the agencies (National Academies of Sciences, Engineering, and Medicine, 2020). For example, 45% of the agencies collaborate with law enforcement for addressing human trafficking.

Wigle and Baglin (2023) share the general knowledge, recommendation and challenges in counter-trafficking efforts through the NOST report. 48% of the participants state that they were concerned about misidentifying the signs of human trafficking. 60% of the service providers mention that it is difficult to obtain transportation in their area.

Much of the current research focuses on laying the groundwork in the United States, which has potentially different transportation networks and governmental approach to combating human trafficking, especially the involvement of transportation industry and the governmental transportation entities. For example, the United States Department of Transportation (USDOT) launched the Transportation Leaders Against Human Trafficking (TLAHT) program, which is a partnership.
with representatives of aviation, buses, ports, rail, transit, trucking, and other transportation stakeholders to optimize the impact of transportation sector’s anti-trafficking efforts. To the best of our knowledge TLAHT is the first ever collective effort of a government and within the transportation industry around the world to combat human trafficking. Since then, the department has continued countless efforts including forming an advisory committee on human trafficking, which also integrates researchers and research.

This research focuses on the transit monitoring operations in low or middle-income countries. When we look at the Trafficking in Persons Report, all the countries that LJI operates in are listed at Tier 2 or below, meaning the government does not fully meet the minimum standards for the elimination of trafficking in prevention, prosecution, and protection.

Transit monitoring

Safety and security are essential criteria for ensuring quality public transport (Cozens & van der Linde, 2015). Litman (2014) suggests that transit can reduce crime by improving surveillance. This study builds on the findings from an earlier application of transit monitoring for anti-trafficking in South Asia by LJI (Hudlow, 2015). LJI started its anti-trafficking work in 2006 and has now implemented transit monitoring in more than 20 countries. Transit monitoring evolved out of the related strategy of border monitoring, developed in the 1990s by NGOs in Nepal to combat trafficking across the open border with India (Evans et al., 2000). For this purpose, NGOs place their personnel at unofficial checkpoints to monitor the border and intercept potential victims.

LJI expanded upon border monitoring by incorporating its organizational values and changing the strategy of the monitoring model also to target non-border transit locations. LJI relies on local churches’ partnership to understand the local context and recruit local staff and volunteers. Moreover, rather than setting up the operations close to the booths of other organizations on the border, they utilized the transportation structure of the geography. They set their stations at the transit hubs near the border. They strategically target major travel points like busy railway or bus stations to cover as many cases as possible. This strategy also helps with the covert nature of the traffickers, who might learn the various stations at the borders and change routes.

Transit monitoring involves three key steps: (a) visual identification of suspicious signs that may indicate trafficking, (b) conversations with possible victims or traffickers using a questioning protocol to determine whether trafficking is present, and (c) verification of the responses given through independent sources (Hudlow, 2015).

Transit monitoring is a process involving multiple parties. When NGO personnel move into a country, they partner with local citizens and municipalities. The NGO trains these partners to help identify potential trafficking victims. If trafficking is suspected, the NGO-trained staff will typically go through a series of questions to determine whether there is evidence or a high risk of human trafficking. The local municipality will prosecute the perpetrator according to local laws if there is sufficient evidence and the suspect can be apprehended. Fig. 1 shows the transit monitoring process (based on Hudlow, 2015).

While the main modality of the data for this manuscript is from the monitoring around the transit locations, such as bus and train, the concept of transit monitoring can be applied in different modalities, such as airlines and ports. For example, LJI started their transit monitoring work in Indonesia, which is a combination of various islands and requires alternative modes. Thus, LJI’s work in Indonesia focuses on monitoring the ports of Manado and Bitung (Love Justice International, 2023).

Monitoring human trafficking and reporting is challenging for all modalities. Since the crime is of hidden nature, there is limited knowledge across the different forms of modalities. Additionally, victims are generally scared or emotionally attached to the trafficker - making it hard for them to remember the ways they were transported. Moreover, there can be privacy issues or fear of retaliation which would prevent transportation personnel intercepting a case. Thus, collaboration with local entities is highly crucial.

Analytical decision making

Through expert input, Yagci Sokat (2022b) shows that anti-trafficking work should have a systems and economic model approach. Assessing the impact and effectiveness of anti-trafficking interventions is a complex issue. Like understanding human trafficking, most research on this topic comes from social sciences concerning evaluation and impact assessment studies. Anti-trafficking evaluations are generally process evaluations based on a qualitative review of documents, interviews, and case studies (Bryant & Landman, 2020). Many of these evaluations provide descriptive statistics of the individuals and populations approached, such as demographics and country of origin, and whether the program was implemented according to the plans rather than the result of the program objectives.

Limited studies incorporate costs and budgets in understanding the value of different anti-trafficking interventions (Davy, 2015). Konrad (2019) develops an analytical approach for optimizing pre-trafficking
awareness campaigns, which maximizes the number of people aware of human trafficking, given a limited budget. Maass et al. (2020) develop an optimization model for locating residential shelters in the United States to maximize societal impact under a limited budget constraint. Our model differs from these researches with the objective and incorporation of cost. The definition of “success” for an anti-trafficking intervention highly depends on the stakeholder group interested in the intervention, as well as the target group for the intervention (Gallagher & Surtees, 2012; van Dyke, 2017). For example, when measuring success, many evaluations neglect the prosecution aspect, one of the critical pillars of the Palermo Protocol (Davy, 2015). This project combines the impact on the victim (prevention and protection) and the consequences for the trafficker (prosecution) with a multi-target model using a weighted sum model (the simplest multi-criteria decision-making model). To the best of our knowledge, this is one of the first applications of analytics in human trafficking through transportation to predict potential impact on prevention, protection, and prosecution.

One stream of literature related to this objective is the evaluation and estimation methodologies based on indexes, rating, and ranking development. To this extent, our work is related to the Global Slavery Index (GSI), which ranks each country based on the number of estimated people in modern slavery. Their methodology combines prevalence, vulnerability, government response, and importing risk to measure the extent of slavery in each country and the government’s responses to the issue. GSI, prevalence estimation studies, and other traditional studies, which investigate the determinants of human trafficking using statistical models, are precious for understanding the push and pull factors fueling human trafficking (Cho, 2015). In this project, we approach this issue from an organizational perspective. Thus, we incorporate the critical organizational indicator factors important in nonprofit operating structure. Furthermore, we consider variables that influence the feasibility of the NGO’s intervention, such as border or transit area security and local municipality cooperation with NGOs. Thus, we extend variable selection in the literature for push and pull factors fueling human trafficking.

We should note that a closely related study by Dimas et al. (2023), which is also based on and uses LJI’s transit monitoring data, demonstrates a system for LJI to evaluate the effectiveness of their stations using data envelopment analysis. Authors analyze the 7 stations over 13 quarters using the number of suspected trafficking occurrences, number of potential victims and completeness of LJI forms in the Nepal - India border. In this paper, we focus on LJI’s global operations and work in all countries. Moreover, we develop a predictive model for expansion, which incorporates prosecution and cost effectiveness.

Methods

In this section, we describe the steps for the predictive model to identify the best candidates for transit monitoring motivated by the LJI’s operations as well as the availability of the data. As discussed above, there is limited data regarding human trafficking. Previous research shows that simpler models work better with limited data, especially when there is not enough data to spare for learning (Yagci Sokat et al., 2018; Yagci Sokat & Altay, 2023). We describe the targets selected, the variable selected, and the model development. Fig. 2 shows the general representation of the capacity expansion model.

Response selection

This project assesses the success of an intervention from the organizational lens of LJI. Thus, it has two objectives, representing the prevention, protection, and prosecution aspects of the 4Ps. The first objective of prevention/protection is to understand the potential impact of transit monitoring on the victim. The second objective of prosecution is to understand the impact of transit monitoring on traffickers.

We calculate the expected impact from the prevention/protection target for country i using the verification weighted (\(\alpha_i\)) percentage of intercepts (\(\text{int}_i\)) (equation (1)). The verification weight aims to measure the correctly identified intercepts for country i. As a result, equation (1) gives the percentage of all correctly identified intercepts for country i.
among all the total correctly identified intercepts as a normalized measure.

$$\sum_{i,n} n_{int, \text{all}}$$

(1)

We calculated the expected impact from the prosecution objective for country $i$ using the percentage of arrests ($arr$) that resulted in convictions (equation (2)). We multiply the convictions by the average length of stay for each conviction per country ($los$) to find the total length of stay for country $i$. In order to normalize, we divide this by the total length of stay for all the countries. As a result, the numerator gives the percentage of the total length of stay for convicted traffickers in country $i$ among all the convicted traffickers in all countries of operation.

$$\sum_{i,n} \frac{\beta_{\text{arr,los}} \cdot \text{los}}{\sum_{i,n} \text{los}}$$

(2)

We obtain the total expected impact of transit monitoring by the equally weighted sum of the objectives in Equation (1) and Equation (2). We then divide this sum by the allocated budget per country $i$ ($c_i$) to find the effectiveness of transit monitoring for each country where LJI currently operates, referred to as impact budget ratio ($ibr$) (equation (3)).

$$ibr_i = \frac{\sum_{i,n} \frac{\beta_{\text{arr,los}} \cdot \text{los}}{\sum_{i,n} \text{los}}}{c_i}$$

(3)

The selection of $ibr$ as the response variable is based on the easiness of understanding for the NGO and the availability of data. We should note that in the period of this study, LJI was operating in a total of 17 countries, mainly in Asia and Africa. The years that data available for a country range from less than a year to 8 years. Among these, only five countries have non-zero prosecution values. Additionally, LJI partners with local organizations and law enforcement, which are considered the last P (partnership) of the 4Ps. While we do not directly embed partnership into the target selection as an outcome, we indirectly include it in both targets, especially in the prosecution aspect.

### Variable selection

Human trafficking is a complex problem that can be fueled by social, economic, cultural, geographical, political, law, and health-related factors. In selecting potential variables, we start with LJI experts’ previous research on countries and previous literature reviews on determinants of human trafficking (Bales, 2007; Cho, 2015; Perry & McEwing, 2013). LJI’s previous country research provides unique elements to investigating the potential variables as it includes the core values of the organization and the operating structure of the transit monitoring system, such as NGO Registration Ease, Total Percentage of Christian Population, Annual Growth of Christianity, and Border Openness. We then investigate the most commonly cited determinants of human trafficking and add variables addressing these, such as GDP per capita, Gender Inequality Index, and Network Readiness Index.

In addition, we include factors that might be related to public health, which can explain a country’s human trafficking-related trends (Gufraind and Yagci Sokat, 2023; Zimmerman and Kiss, 2017). Previous research linking social vulnerability and the effects of disease outbreaks inspired us to look at common worldwide epidemics (Worsnop, 2019; Stanturf et al., 2015; Yagci Sokat & Alay, 2021). The HIV epidemic can show a country’s vulnerability, and studies have shown the association between sex trafficking and HIV prevalence (Silverman et al., 2006; Wirthe et al., 2013). Furthermore, as our second target is for prosecution, we integrate variables that might demonstrate law enforcement’s relationship with transit monitoring success. The most commonly known law-related factor included in the previous models is the prostitution law, which was shown to be inconclusive. Instead, we use the number of anti-trafficking legislations to represent the potential relationship between laws and human trafficking prosecutions. Additionally, in the enforcement part, we include the number of convictions reported per country in the Trafficking In Persons Report (TIP).

As a result, we include variables in our initial set that represent several categories: social, economic, political, law and enforcement, cultural, geographic, and health. Many of the variables are interconnected and belong to more than one category. For example, the Gender Inequality Index measures health and participation in the labor force; thus, it could fall into health and economic. Table A1 in Appendix describes all the variables considered for the model.

### Variable reduction

We use Principal Component Analysis (PCA) and Factor Analysis in atypical ways to narrow down the variables. Although they are used in dimension reduction, PCA and Factor Analysis typically create new latent variables encompassing several other variables. Instead of using the methods mentioned above to create new variables, we use them to identify the number of components for factor analysis and reduce singular variables that may have no impact on the latent components present (Miller, 2014).

We first start with PCA to see how components impact the variance. Utilizing the mean of different methods outlined in Table A2 in the Appendix, we chose five components to retain. Using those five components, we use Factor Analysis to see the variables’ effect on these latent components. We implement a cutoff of 0.49 (Miller, 2014) to ensure that our factors had practical significance. As a result, we remove the factors (Disease Outbreak in the Past Five Years) that have little to no effect on the components.

In order to find the optimal number of variables for our model, we next run feature selection on the remaining 15 variables. We run recursive feature selection on the data and consistently find that three variables result in the lowest root mean squared error from cross-validation (see Figure A1).

### Model steps

Our model aims to predict different countries’ impact budget ratio ($ibr$). During model creation, we use the log of the outcome variable; in this case the. The logarithmic transformation helps to symmetrize a skewed distribution and bring it closer to normality. The benefit of symmetrization is that it results in fewer outliers. Estimates of regression coefficients are sensitive to outliers as well, so the estimation of regression equations becomes more stable after logarithmic transformation. The benefit of normality is that the t-test confidence intervals assume the normality of the dependent variable, which is more closely satisfied. The predictions are on the log scale and were raised as the exponent of 10 to bring it to the original scale.

In order to find the best three variables to put into the model, we use the best subsets. Best subsets give us the variables “Border Openness,” “Human Development Index,” and “NGO Registration Ease” to include. We run a linear regression to develop a final model with an adjusted R-squared of about 80 %. This model will be used to predict countries where LJI will be able to have the most beneficial impact. Using the linear model, we fit predictions to about 71 other countries.

The regression equation summary is.

$$Y = -0.5381 \times \text{Border Openness} - 12.0031 \times \text{Human Development Index} + 0.3207 \times \text{NGO Registration Ease} + 6.9405$$

(4)

The majority of the significant variables incorporate the organizational lens, which differs from previous research. “Border Openness” influences transit monitoring, as the easier it is for people to move between country borders, the easier it is for human trafficking victims to be in transit. “NGO Registration Ease” gives an administration view on the
feasibility of expanding operations by partnering with local law enforcement. We should note that Border Openness is inversely related to choosing a location for transit monitoring, which is counterintuitive.

We should note that although "Border Openness" and "NGO Registration Ease" are not continuous variables, they are categorical variables put on an ordinal scale. Both scales range from 1 to 5. However, putting the categorical variables was reasonable to understand the relationships better (Anderson, 1984). We test this with other models and get similar answers.

Results and discussion

Using the regression model developed in Section 3.3., we predict the impact budget ratio for the remaining 71 countries. Table 1 shows the top 5 candidates for LJI to consider expanding. Gambia, Haiti, Liberia, Ethiopia, and Mozambique are the best locations for the LJI to send crew for on-ground feasibility checks. Four of these five countries are in Africa, which signals that Africa as a continent would be a beneficial selection to expand transit monitoring operations. Additionally, among the countries are Gambia and Liberia, which are the countries where LJI has current operations in a bordering country.

Since data is limited and prosecution is rare, we conduct a similar analysis with a different response metric to check the model’s sensitivity. We follow similar steps in Sections 3.3 and 3.4 using the interceptions as the new response. We find that the model with three variables is the best fit, which is again "Border Openness," Human Development Index,” and “NGO Registration Ease.” Table 2 shows the top 5 countries for LJI to expand its transit monitoring stations. Haiti, Gambia, and Ethiopia are among the top 5 countries with intercepts, similar to the impact budget ratio, and Africa is the most frequently observed continent. As a result, we observe that the model is not sensitive to the response variable. Since the prosecution depends on the intercepts, we expect this result.

Having transit monitoring stations in African and Asian countries is intuitive since human trafficking still exists on a large scale in Asia and Africa (Wondu, 2018). Public transportation in the country, cross-border public transportation, and crime in cross-border are generally expected in these areas (Pirie et al., 2014; Pophiwa et al., 2020). As African countries are moving more towards rapid bus systems (Andrew et al., 2022), transit monitoring is more crucial for these regions with a higher risk of human trafficking. On the other hand, having Haiti consistently towards the top is unexpected. However, looking at the explanatory variables (such as NGO Registration Ease and Border Openness), we can see why Haiti has excellent potential for transit monitoring. For example, Haiti is well-known for working with NGOs post-2010 Haiti earthquake. Thus, they have a higher NGO Registration Ease, which positively influences the impact. Buses and mini-buses are Haiti’s most common transportation tools, so public transport must pay attention to safety measures on and around the transit stations.

These results also inform us about potential extensions of transit monitoring strategies to other locations or transit areas in addition to the buses or trains. For example, paratransit systems, especially motorcycles, are highly used in Southeast Asia, Latin America, West and East Africa (Mwale et al., 2022). However, motorcycles are less regulated. Thus, there might be other indications or risk factors to look for transit monitoring for these vehicle types.

Table 2
Top 5 Expansion Candidates Based on Intercepts.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Country Name</th>
<th>Geography</th>
<th>Intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Haiti</td>
<td>North America</td>
<td>2.34</td>
</tr>
<tr>
<td>2</td>
<td>Nigeria</td>
<td>Africa</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>Philippines</td>
<td>Asia</td>
<td>2.18</td>
</tr>
<tr>
<td>4</td>
<td>Gambia</td>
<td>Africa</td>
<td>2.15</td>
</tr>
<tr>
<td>5</td>
<td>Ethiopia</td>
<td>Africa</td>
<td>2.09</td>
</tr>
</tbody>
</table>

Conclusion

Transportation plays a critical role in combating human trafficking. Through an academic-practitioner partnership, we demonstrate efforts for using transportation for anti-trafficking efforts. We present an early example of using predictive analytics to combat human trafficking for a non-governmental organization that utilizes transit monitoring. Through an organizational lens, we develop a new multi-target metric to evaluate the impact of anti-trafficking operations using the 4Ps of the anti-trafficking protocol: prevention, prosecution, protection, and partnership. We incorporate organizational factors and the cost of intervention in determining and predicting success. This partnership and research will encourage others to utilize critical organizational data, no matter how limited, to make better and more informed decisions.

The methods and results discussed in this paper are in progress, and readers must approach them cautiously. A more detailed analysis could follow when more data emerge, especially on response variables with limited observations. We believe that when there are more prosecutions, the model could change and provide more insightful results. We hope to continue a similar analysis for different modalities as more data emerges.

Implications

This research has implications for multiple stakeholders within and outside the transportation industry, especially for the 4P discussed: prevention, prosecution, protection and partnership. In this section, we summarize these implications for several stakeholders.

- Lawmakers and policymakers: This model builds upon successful prosecution, which is a key performance indicator that depends on various legislative efforts for combating human trafficking. Legislations for combating human trafficking differ from country to country, which might not necessarily align with the 2000 UN TIP Protocol. Successful implementation of this model requires alignment of human trafficking definition internationally for effective prosecution. For example, the Human Trafficking and Transportation (Control) Act in Nepal does not criminalize all forms of human sex trafficking and human trafficking.

- Moreover, there are various legislation to increase awareness and adopt proactive measures in the transportation industry. In the United States, for example, California has legislation AB 2034, which mandates transportation organizations to train their employees on human trafficking. There is also federal legislation for training airline employees. If there were to be standardized training for transportation employees internationally, there would be an increase not only in intervention cases but also prosecution as well.

- Industry: There is significant open source information about how different modalities and industries could work together to combat human trafficking in the United States. For instance, an ongoing research by the Airport Cooperative Research Program (ACRP) aims to investigate the use of existing and emerging technologies to identify and mitigate human trafficking at airports (ACRP). In another case, there are security alerts apps to track and monitor human trafficking in certain modalities within the United States (ACHT, 2019; Yagci Sokat, 2022a). Industry should work on
increasing access to information as well as these applications to help combat human trafficking.

- Operators: Operators play a key role in the success of transit monitoring. Increased access to training for the operators should come as the first step for combating human trafficking in transportation and effective transit monitoring strategies. Modality specific operator training and awareness materials can help with identification and reporting of human trafficking. For example, there are transit indicators for identifying victims of human trafficking in (Ruiz et al., 2019; USDOT, 2019)

- Border operations: Border openness is selected as one of the key variables for identifying the success of anti-trafficking efforts. Thus, this research implies that monitoring border operations is a significant task for combating human trafficking. Training on awareness and reporting suspicious cases are must for intercepting potential human trafficking cases.

- Migrants: Education of migrants about their vulnerabilities and their rights should be a key step. For example, it is illegal to hire migrants through debt and expect them to pay back through their salaries, which is known as debt bondage. However, most migrants would not know that. Moreover, in specific countries, when migrants are hired for certain jobs, the company has to pay for or provide transportation. However, migrants are generally not aware of these stipulations when accepting job offers. PAXU, a workforce development app geared towards migrants by Pacific Links Foundation, provides access to trusted information about costs across different locations and easy comparisons for informed decision making.

Key takeaways and future directions

In this section we list a few key takeaways and future directions for regulators, operators and researchers.

Regulators: Regulators could learn from different monitoring techniques and current legislation across the world in order to create an international standard regarding human trafficking laws. With synched legislations and cooperative agreements between bordering countries, there can be an increase in the success of transit monitoring, prevention and intercepting of trafficked victims.

Operators: Our research identifies countries that LJI would have the biggest impact expanding into with their transit monitoring operations. These countries should examine their prevalent modes of transportation and train operators to identify signs of human trafficking cases in these specific modalities. Heightened awareness and proactive training is key in operators, as they are within the first steps of observing human trafficking victims in transit. The training should include how to safely report and track potential cases of human trafficking to ensure cases are also followed in the legal system for successful prosecution efforts.

Researchers: This is only an initial example for researchers to show how data analytics can help decision making in the intersection of human trafficking and transportation. Different methods and analyses could evolve with other data availability. For instance, future transit monitoring research could utilize image processing in transportation stations with security cameras. This model can also be applied for transit safety and security using the data from transportation public safety apps for finding locations prone to human trafficking. Additionally, understanding the environment is key for successful and high impact modeling. This model is developed based on the decision makers’ (LJI) organizational goals and operating environment for human trafficking prevention and prosecution. Further models can have different success measures and variables not only for combating human trafficking but also similar crimes. To exemplify, some transportation companies collaborate with NGOs on sexual harassment and gender-based violence. A variation of this model can help identify and track different crimes and points of intervention for increasing the safety of all, including operators.

CRediT authorship contribution statement

Kezban Yagci Sokat: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. Melissa Chi: Formal analysis, Methodology, Visualization, Writing – review & editing. Jonathan Hudlow: Conceptualization, Data curation, Project administration, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Jonathan Hudlow reports financial support was provided by Love Justice International.

Data availability

The authors do not have permission to share data.

Acknowledgements

This research is partially supported by SJSU RSCA Grant 70031. We are thankful to students Anatolia Sayed, Yibo Pan, Michael Bump and Paula Assis for their hard work in the initial stages of this work during the Northwestern University Client Challenge. We are also thankful to Love Justice International for data access.

Appendix

Table A1
Variable Descriptions and Data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Inspiration and Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Openness</td>
<td>The measurement of ease of passing through a country’s border</td>
<td>LJI</td>
</tr>
<tr>
<td>GDP per Capita</td>
<td>The value of all goods and services produced in the economy divided by the population</td>
<td>Bales (World Pocketbook of Statistics)</td>
</tr>
<tr>
<td>Average Wage per Month</td>
<td>Average annual income for individuals in the country divided into a monthly basis</td>
<td>Bales (International Labor Organization)</td>
</tr>
<tr>
<td>Economy: Agriculture(% of Gross Value Added)</td>
<td>The shares of the components of Gross Value Added (GVA) at current prices by kind of economic activity; agriculture, industry and in services and other sectors</td>
<td>Bales (2007) (World Pocketbook of Statistics)</td>
</tr>
<tr>
<td>Infant Mortality Rate per 1000 live births</td>
<td>The ratio of infant deaths (the deaths of children under one year of age) in a given year to the total number of live births in the same year, expressed as a rate per 1000 live births</td>
<td>Bales (2007) World Pocketbook of Statistics</td>
</tr>
</tbody>
</table>

(continued on next page)
Table A1 (continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Inspiration and Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV Population Percentage</td>
<td>Percentage of the population diagnosed with HIV</td>
<td>Health care/we came up with this (World Health Organization)</td>
</tr>
<tr>
<td>Number of Convictions</td>
<td>Number of trafficking convictions</td>
<td>Prosecution (TIP report)</td>
</tr>
<tr>
<td>Immigration</td>
<td>Number of immigrants</td>
<td>LJI (Pew Research Center)</td>
</tr>
<tr>
<td>Slaves per 1000 people</td>
<td>Estimated proportion of people living in modern Slavery per 1000 people</td>
<td>LJI (Global Slavery Index)</td>
</tr>
<tr>
<td>CIVICUS</td>
<td>Measurement of civil society, including civil society networks and organisations; trade unions; faith-based networks; professional associations; NGO capacity development organisations; philanthropic foundations and other funding bodies</td>
<td>LJI (CIVICUS)</td>
</tr>
<tr>
<td>Agricultural Production Index</td>
<td>Calculation based on the sum of price-weighted quantities of different agricultural commodities produced. The commodities covered in the computation of indices of agricultural production are all crops and livestock products originating in each country. Practically all products are covered, with the main exception of fodder crops. Production quantities of each commodity are weighted by the average international commodity prices in the base period and summed for each year. To obtain the index, the aggregate for a given year is divided by the average aggregate for the base period 2004-2006.</td>
<td>Bales (World Pocketbook of Statistics)</td>
</tr>
<tr>
<td>Networked Readiness Index</td>
<td>Measurement reflecting how technology and people need to be integrated within an effective governance structure in order to have the right impact on our economy, society and the environment</td>
<td>Cho (2015) (Network Readiness Index)</td>
</tr>
<tr>
<td>NGO Registration Ease</td>
<td>Ease of NGO registering and setting up</td>
<td>LJI (Pew Research Center)</td>
</tr>
<tr>
<td>Emigration</td>
<td>Number of people emigrating</td>
<td>LJI (Pew Research Center)</td>
</tr>
<tr>
<td>Political Stability</td>
<td>Stability of the government</td>
<td>LJI (Global Peace Index)</td>
</tr>
<tr>
<td>Total Percentage of Christian Population</td>
<td>Percentage of the Christian population in the country</td>
<td>LJI (Pew Research Center)</td>
</tr>
<tr>
<td>Population Ages 0-14</td>
<td>Percentage of the population ages 0-14</td>
<td>Bales (2007) (World Pocketbook of Statistics)</td>
</tr>
<tr>
<td>Unemployment Rate (% of labour force)</td>
<td>Individuals above a specified age who during a specified reference period were: “without work”, “currently available for work”, and “seeking work.” The data refer to the 15 years and over age group and are based on ILO’s modelled estimates, unless otherwise stated in a footnote.</td>
<td>Bales (2007) (World Pocketbook of Statistics)</td>
</tr>
<tr>
<td>HIV Incident Cases</td>
<td>Number of new HIV cases per year</td>
<td>Health care perspective (World Health Organization)</td>
</tr>
<tr>
<td>Number of Trafficking Legislation</td>
<td>Number of legislation in the country pertaining to trafficking</td>
<td>Prosecution perspective (Counter Trafficking Data Collective)</td>
</tr>
<tr>
<td>Total Migration</td>
<td>Summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions.</td>
<td>Cho (2015) (United Nations Development Programme)</td>
</tr>
<tr>
<td>Human Development Index</td>
<td>Annual percentage growth of Christianity</td>
<td>LJI (Pew Research Center)</td>
</tr>
<tr>
<td>Annual Percentage Growth of Christianity</td>
<td>Percentage of the population ages 60 and over</td>
<td>Bales (2007) (World Pocketbook of Statistics)</td>
</tr>
<tr>
<td>Population Ages 60+</td>
<td>Measurement of gender inequalities in three important aspects of human development—reproductive health, empowerment, and economic status, expressed as labour market participation and measured by labour force participation rate of female and male populations aged 15 years and older.</td>
<td>Cho (2015) (United Nations Development Programme)</td>
</tr>
<tr>
<td>Gender Inequality Index</td>
<td>Disease Outbreak in the Past Five Years</td>
<td>Health care perspective (World Health Organization)</td>
</tr>
</tbody>
</table>

Table A2

Principal Component Analysis Results.

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of Principal Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scree Plot</td>
<td>5 or 6</td>
</tr>
<tr>
<td>Parallel Analysis</td>
<td>4</td>
</tr>
<tr>
<td>80 % of Variance Explained</td>
<td>5</td>
</tr>
<tr>
<td>90 % of Variance Explained</td>
<td>7</td>
</tr>
<tr>
<td>Mean</td>
<td>5.4</td>
</tr>
</tbody>
</table>
K. Yagci Sokat et al.

Transportation Research Interdisciplinary Perspectives 24 (2024) 101032

References


