To Remain or to Return:

A Post-Conflict Analysis of Iraqi Popular Mobilization Forces

Security Impacts on the Return of Iraqi Internally Displaced Persons

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February 23, 2020

Abstract

The Iraqi Popular Mobilization Forces (PMF) is a recognized, permanent state security force (Blanchard 2020, July 17; 12) of mostly Shia-based militias assembled to defeat the Islamic State (IS) threat during the Iraqi Civil War (2013-2017). Their participation in Iraqi liberation efforts were vital to the eventual defeat of IS by December 9, 2017 (Paktian 2019, 1). The PMF continues to operate as a security actor despite concerns of past human rights atrocities and being a source of sectarian tensions in the post-conflict environment.

This project seeks to explore the post-conflict interactions between IS and PMF, and their impacts on internally displaced person (IDP) movements and returns. Exploratory spatial data analysis, cartographic visualization analysis, and spatial regression analysis were applied to determine the conflict events impacts on IDP-returnee movements. The coronavirus (Covid-19) pandemic limits the post-conflict period study to two years from the first available record of Iraqi returnees (February 28, 2018 to February 28, 2020).

The PMF, with its problematic sectarian orientation and questionable legitimacy, was expected to have a negative impact on IDP movements and returns to their districts of origin. The literature suggests geospatial variation of displacement and returns relative to conflict areas, and that living condition severity variables are more prominent. The project identifies a first-year return exodus phenomena despite increased violence while other IDPs migrate further away from PMF-IS conflict zones. The spatial error and lag dependence testing suggest living condition severity and other security actors as potential explanatory variables.

Introduction

The post-conflict environment of the Iraqi Civil War (2013-2017) presents the apparent and immediate problems of Iraqi internally displaced persons (IDP) attempting to return to their areas of home origin, and the continued presence of the Iraqi Popular Mobilization Forces (PMF) throughout conflict-affected areas once held by the Islamic State (IS). The main objective of this project is to evaluate and determine the impact and relationship between PMF presence and IDP movements at the Iraqi district level. The IS threat is a continued driver of increased violence, displacement, and the PMF response. Increased PMF-IS violence is expected to have negative impact on IDP flows and return movements.

The Iraqi Popular Mobilization Forces is an Iraqi "umbrella organization" (Paktian 2019, 1) of mostly Shia militias formed to combat the Islamic State (IS) after the collapse of the Iraqi Security Forces (International Crisis Group 2018, 2) during the Iraqi Civil War. The PMF has participated in Iraqi liberation efforts and continues to provide security in the post-conflict environment (Blanchard 2020, July 17; 12). The post-conflict Iraqi reconstruction period has also been left with the problem of IS remnant resurgence, sectarianism, and IDPs still in displacement. Islamic State violence was the initial driver of displacement during the Iraqi Civil War while the PMF continues to play a critical part in post-conflict security efforts.

The PMF has carried out counterinsurgency operations against IS remnants in cooperation with Iraqi government security forces (Iraqi Security Forces – ISF) while providing essential needs and services to affected populations (International Crisis Group 2018). PMF-ISF counterinsurgency efforts against IS have resulted in the effective neutralization of IS remnant facilities, weapons seizures, and the disposal of explosives materials. The PMF presence in Iraq has also been cited for continued displacement attributed to human rights atrocities (Riordan 2016, 1), but Guiu and Siddiqui suggest severity in living conditions at district of origin as the greater factor in their return index (2020, 5).

Literature Review

Bradley (2017) and Carrillo (2009) acknowledge that conflict is the major driver impacting the economic and social situations of those displaced. Colombia ranks as the leading country with the highest number of conflict-affected displaced persons in the world (Shultz 2014, 2) with a displaced population ranging between 2.6 to 4.3 million (Carrillo 2009, 527). Various illegal, armed groups are the source of conflicts in areas where groups fight for territorial control and local populations are directly subjected to extreme violence (Carrillo 2009).

Lischer's (2008, 105) term of "demographic engineering", in which Iraqi militant groups carry out violent displacement strategies to discourage future return, can be applied to Colombian armed groups' deliberate violence to depopulate areas and to change or destroy social networks to establish control of the population in their areas of interest (Carrillo 2009). However, Bradley (2017) states that even "two equally violent conflicts" do not have the same level of displacement impact, and that not all populations flee in high-violence environments. The Colombian internal displacement situation is characterized by rural-to-urban displacement flows (Shultz et. al. 2014) while the Iraqi displacement situation is characterized by both internal displacements and departures from conflict-affected environments. Both Iraqi and Colombian armed groups share the natural commonality of asserting territorial dominance through the application of force.

The International Organization of Migration – Iraq Mission (IOM-Iraq) of the United Nations Migration Agency published a series of Integrated Location Assessments (ILA) that provide detailed information on IDPs and returnees in Iraq. IDPs are those displaced from their homes of origin due to conflict (IOM-Iraq 2018). ILA III and IV published reports are the most in-depth and provide key IDP-returnee information on the eighteen provinces of the Republic of Iraq (IOM-Iraq 2020). The Displacement Tracking Matrix (DTM) employed a system of rapid assessment and response team (RARTs) composed of over 100 field staff personnel throughout Iraq to conduct data collection and qualitative surveys on IDPs and returnees (IOM-Iraq, 2019). DTM maintains updated records of IDP and returnee registration estimates throughout Iraq (IOM-Iraq, 2020).

The IDP and returnee spatial flows vary at the district levels based on push and pull factors to return to location of origin from displacement. Security and safety were the most prominent reasons for displacement and delayed return, followed by housing and services availability (IOM-Iraq 2018, 72). Security, safety, available housing, services, and employment at location of origin would serve as positive, pull factors that would influence IDPs to return to origin, while poor conditions of the same would serve as push factors for IDPs to depart to another location. In addition, PMF presence, blocked returns by security forces, explosive remnants of war (ERW) contamination, and changed ethno-religious composition in areas of origin are also related negative, push factors (IOM-Iraq 2018, 71 and IOM-Iraq 2019, 53-54).

The uncleared ERW contamination and the contributing IS remnant actor (estimated at 20,000-30,000) present the most risks to nationwide recovery and return of IDPs (Wilkinson 2019). The clearance of mostly "victim-operated IEDs" (improvised explosive devices) emplaced by IS throughout a contaminated urban environment for territorial control is the most prominent ERW clearance challenge (Wilkinson 2019, 2). Various humanitarian organizations and security actors, to include the ISF and PMF, have continued contributing to Iraqi stability and security efforts to neutralize IS remnants by eliminating insurgents, facilities, and materials that support attacks and IED employment.

The Iraqi PMF is a collective network of mostly Shia Arab militias subordinated to the Iraqi government's Popular Mobilization Committee (PMC), which was created in the summer of 2014 to combat the IS threat (El-Dessouki 2017). The formation of the PMF was inspired by Iraq's most influential Shia cleric, Grand Ayatollah Al-Sistani, through a *fatwa* issued on June 13, 2014 for all "Iraqi men to take up arms" by joining the Iraqi Security Forces (International Crisis Group 2018, 2); however, the *fatwa* was interpreted by responders to join long-standing Shia militia groups associated with Iraqi political parties (Parry and Burlinghaus 2019). Some of these PMF associations are designated by the U.S. State Department as terrorist groups with ties to Iran and Hezbollah (Blanchard 2020).

Lack of Iraqi government accountability, human rights abuses, and sectarian tensions exacerbated by the IS threat are concerns surrounding the PMF structure, despite being a legitimate organization supported through the Iraqi national security establishment (El-Dessouki 2017 & Blanchard 2020, 21-22). IS resurgence and Iranian influence (Vice News 2019; 2020; & PBS NewsHour 2017) make the possibility of PMF demobilization and reintegration unlikely (Paktian 2019). The International Crisis Group (2018) contends the PMF has become increasingly involved in both formal and informal economic sector activities as well as employing fighters to provide services for reconstruction (Paktian 2019, 10). This contrasts with O'Driscoll's assessment and suggestion that PMF fighters in demobilization and reintegration phases may struggle in the long-term to settle as laborers within the Iraqi domestic market (O'Driscoll and Van Zoonen 2017). Yeung's coverage of the PMF, the illicit drug trade, and the circulation of Iranian currency in the Najaf city markets provide examples of the reality of Iran's proximity and influence in Iraq's economy and reconstruction efforts (Vice News 2020).

The Iran-Iraq Khosravi border terminal near Iraq's Khanaqin District of Diyala Province, is a strategic example of the real proximity and implications of spatial dependencies of regional interactions and economic growth spillovers (Amidi et. al. 2020). Spatial dependencies often call for the application of spatial regression model methods (Chi & Zhu 2020) used in spatial econometrics (Amidi et. al. 2020). Spatial dependencies typically have either a spreading effect (positive spatial lag) or a backwash effect (negative spatial lag), and the impacts of PMF-IS violence, Iran-Iraq trade, or conflict spillovers from regional neighbor countries will impact the population and situational response variables (Chi & Zhu 2020, 68).

The Iraqi sectarian tensions and violence are characteristic of the dynamics of civil war. The PMF activity and their security impacts are geospatially expressed and indicated through conflict events maintained by the Armed Conflict Location Event & Data Project (ACLED) distributed on a geospatial point layer over corresponding Iraqi administrative boundary vector shapefiles (2020). Post-conflict PMF activities consist mostly of attacks on IS along with supporting combined ISF activities that result in destruction of IS haven locations and defusals of explosives materials (ACLED 2020). Additionally, geospatial techniques and methods for counterterrorism applications described by Alharith (2018) and Can/Leipnik (2010) begin with crime incident data. Crime data is normally used by law enforcement agencies to determine any trends, patterns, indicators, and even potential hotspot zones of insurgent/terrorist and criminal activity.

Salvi utilizes observed, incident-based Second Congo War conflict data (1998-2000) to note that 62% of combatant events took place within 5 km of a major roadway despite the road network buffer space comprising less than 14% of Congo's total land area (Salvi et al 2019, 187). The common hypothesis to challenge was the positive, "road-intensive" correlation between violence-against-civilians and armed conflict along a spatial-temporal framework model (Salvi et al. 2017). The results were overall positive, but the increase of VAC incidents was delayed after the initial battle event incidents (Salvi et al. 2017, 194). The Armed Conflict Locations & Events Data Project (ACLED) tracks the same conflict event variables with Iraq.

Project Goals and Objectives:

The project will focus on the post-conflict geospatial distribution of PMF and IS conflict events, and their surrounding spatial autocorrelation or dependence effects (Chi & Zhu 2020, 69) on Iraqi IDP returns and departures. The primary objective is to evaluate correlative relationships and spatial dependence between PMF-IS conflict zones and Iraqi IDP-returnee movement flows. A secondary goal of this project is to determine if there are any indications of sectarian tensions between the PMF and IDPs-returnees based on available datasets. Furthermore, this study on spatial dependence between armed group conflict violence and IDP-returnee flows is limited to the post-conflict period prior to the global outbreak of the coronavirus crisis (first confirmed Iraqi case of Covid-19 was February 22, 2020). The project will cover two yearly time-periods between February 28, 2018, February 28, 2019, and February 28, 2020.

Methodology:

This project began with an extended period of literature and data review on the PMF-IS conflict events and the situation of Iraqi IDPs during the Iraqi Civil War. The application analysis of conflict events and displacement data are both theory-driven and data-driven approaches (Chi & Zhu 2020, 210). The theory-driven approach derived from the literature review will provide the substantive basis and context for the inferential interpretation of the linear regression and spatial dependence model results.

Data Review:

PMF and IS conflict event datasets are part of the conflict events data covering the Iraqi Civil War period (2016-present) and is published by the ACLED (Raleigh et al. 2010) through the Humanitarian Data Exchange website (ACLED 2020). Post-conflict PMF and IS armed conflict events dates for this project will align with the first available record of returns published on February 28, 2018 (UN IOM-Iraq 2020). The first post-conflict year spans from February 28, 2018 to February 28, 2019, while the second-year spans from February 28, 2019 to February 28, 2020. The IDP and returnee flows for each year are two separate response (dependent) variables for this project. PMF and IS events are two separate explanatory variables. IS has been commonly recognized as the initial driver of displacement during the Iraqi Civil War while the PMF is an interactive variable to IS.

Post-conflict PMF-IS event datasets were aggregated from all event types into a single geospatial point layer for each armed group. All PMF conflict events consist of those carried out by the various PMF militias and those supporting Iraqi government security forces. Aggregation of each armed group's conflict events produces each group's conflict zones through a Kernel Density Estimate raster layer that is visually more relatable to IDP-returnee flows.

The IOM-Iraq DTM maintains available Iraqi returnee and IDP estimates tracked from the sub-district, district, and governorate/province levels. Iraqi IDP and returnee estimate datasets are field-collected by the UN IOM's RART, and maintained as IDP and Returnee Master Lists at the DTM website (IOM-Iraq 2020, August 31). The first record of available returns is Returnee Master List 90 (February 28, 2018), and the corresponding IDP record is IDP Master List 90 (February 28, 2018). IDP and Returnee Master List 108 are dated and published on February 2019, and Master List 114 are dated February 2020. IDP and returnee flow datasets were obtained by calculating the count differences between 2018-2019 estimates and 2019-2020 estimates. Iraqi IDP-returnee flows provide a more dynamic response variable for the ESDA.

Almost all geospatial data processed is vector-based and expressed through Iraqi district and province boundary shapefiles. Currently, kernel density estimation (KDE) layers created from PMF-IS events point pattern analysis are the only raster data used in this project. The Iraqi administrative boundary shapefile data can be accessed from the Humanitarian Data Exchange website (UNOCHA 2019).

Analytical Methods:

The ESDA descriptive statistics analysis entailed an in-depth review of PMF and IS conflict events for the 2018-2019 and 2019-2020 time periods to develop an understanding between post-conflict violence and IDP-return flows. The ESDA descriptive and comparative review products for the PMF-IS conflict events and IDP-returnee district flows provide preliminary linear, graphic analysis plots. In addition to graphic outputs, the ESDA on both groups will produce KDE layers (PMF-IS conflict zones) for IDP-returnee flow distributions per district on a cartographic visualization.

Establishing the standard linear regression models for IDP flow response variables and the conflict events explanatory variables was the initial part of the spatial dependence process (Chi & Zhu 2020, 56). The matrix notation expression of the IDP flows response variables are as follows:

$$Y_{\Delta IDP\,`18-`19} = X\beta_{PMF\,`18-`19} + X\beta_{IS\,`18-`19} + X\beta_{IDP\,`18} + \varepsilon$$
$$Y_{\Delta IDP\,`19-`20} = X\beta_{PMF\,`19-`20} + X\beta_{IS\,`19-`20} + X\beta_{IDP\,`19} + \varepsilon$$

where $Y_{\Delta IDP\,`18-`19}$ and $Y_{\Delta IDP\,`19-`20}$ are calculated Iraqi IDP flows within their yearly time-periods. $X\beta_{PMF\,`18-`19}$ and $X\beta_{PMF\,`19-`20}$ represent the coefficient (β) and explanatory variable of PMF events ($X_{PMF\,`YR-`YR}$) per year. $X\beta_{IS\,`18-`19}$ and $X\beta_{IS\,`19-`20}$ represent the coefficient and explanatory variable of IS events ($X_{IS\,`YR-`YR}$) per year. The regression coefficients (β) represent the correlative effects or impacts per change of each unit of the explanatory variable (X). ε is the "vector of error terms independently and identically distributed as normal distribution with a mean of 0 and a constant variance" (Chi & Zhu 2020, 56).

The matrix notation expression for standard linear regression models of returnee flows are as follows:

$$Y_{\Delta Returns\,`18-`19} = X\beta_{PMF\,`18-`19} + X\beta_{IS\,`18-`19} + X\beta_{\Delta IDP\,`18-`19} + X\beta_{IDP\,`18} + \varepsilon$$
$$Y_{\Delta Returns\,`19-`20} = X\beta_{PMF\,`19-`20} + X\beta_{IS\,`19-`20} + X\beta_{\Delta IDP\,`18-`19} + X\beta_{IDP\,`19} + \varepsilon$$

The return flow regression models include the same coefficient and explanatory variables of PMF-IS conflict events and IDP estimates per district ($X\beta_{PMF\,`YR-`YR} + X\beta_{IS\,`YR-`YR} + X\beta_{IDP\,`YR}$), but also factor IDP flows as an explanatory variable ($X\beta_{\Delta IDP\,`YR-`YR}$). Negative IDP flow values are indications of return or departure movements. Positive IDP flow values are indications of IDP arrivals. ε is the "vector of error terms independently and identically distributed as normal distribution with a mean of 0 and a constant variance" (Chi & Zhu 2020, 56).

The spatial error model (SEM) is applied to the IDP and returnee flow response variables pending the diagnostics for spatial error dependence results through the Lagrange multiplier diagnostics testing. The SEM for IDP and returnee flows are as follows:

$$Y_{\Delta IDP\,`18-`19} = X\beta_{PMF\,`18-`19} + X\beta_{IS\,`18-`19} + X\beta_{IDP\,`18} + u, (u = \rho W_Q u + \varepsilon)$$
$$Y_{\Delta IDP\,`19-`20} = X\beta_{PMF\,`19-`20} + X\beta_{IS\,`19-`20} + X\beta_{IDP\,`19} + u, (u = \rho W_Q u + \varepsilon)$$
$$Y_{\Delta Returns\,`18-`19} = X\beta_{PMF\,`18-`19} + X\beta_{IS\,`18-`19} + X\beta_{\Delta IDP\,`18-`19} + X\beta_{IDP\,`18} + u,$$

$$(u = \rho W_Q u + \varepsilon)$$

$$Y_{\Delta Returns\,`19-`20} = X\beta_{PMF\,`19-`20} + X\beta_{IS\,`19-`20} + X\beta_{\Delta IDP\,`19-`20} + X\beta_{IDP\,`19} + u,$$

$$(u = \rho W_Q u + \varepsilon)$$

The IDP and returnee flow SEM consist of the same explanatory variables as their corresponding linear regression models, but are differentiated by their respective spatial weight and error term parameter ($u = \rho W_Q u + \varepsilon$). The spatial weight matrix has been defined and established to queen-contiguity to account for all possible adjacent, surrounding districts in which spatial dependence may occur.

If Lagrange Multiplier (LM) diagnostics indicate greater significance for 'LMlag' (spatial lag), then the spatial lag model (SLM) for IDP and returnee flows will be applied to determine if there is a significant spatially weighted average of the flow variables in the adjacent neighborhoods of districts (Chi & Zhu 2020, 67). The SLM for IDP and returnee flows are as follows:

$$Y_{\Delta IDP\,`18-`19} = X\beta_{PMF\,`18-`19} + X\beta_{IS\,`18-`19} + X\beta_{IDP\,`18} + \rho W_Q Y_{\Delta IDP\,`18-`19} + \varepsilon$$

$$Y_{\Delta IDP\,`19-`20} = X\beta_{PMF\,`19-`20} + X\beta_{IS\,`19-`20} + X\beta_{IDP\,`19} + \rho W_Q Y_{\Delta IDP\,`19-`20} + \varepsilon$$

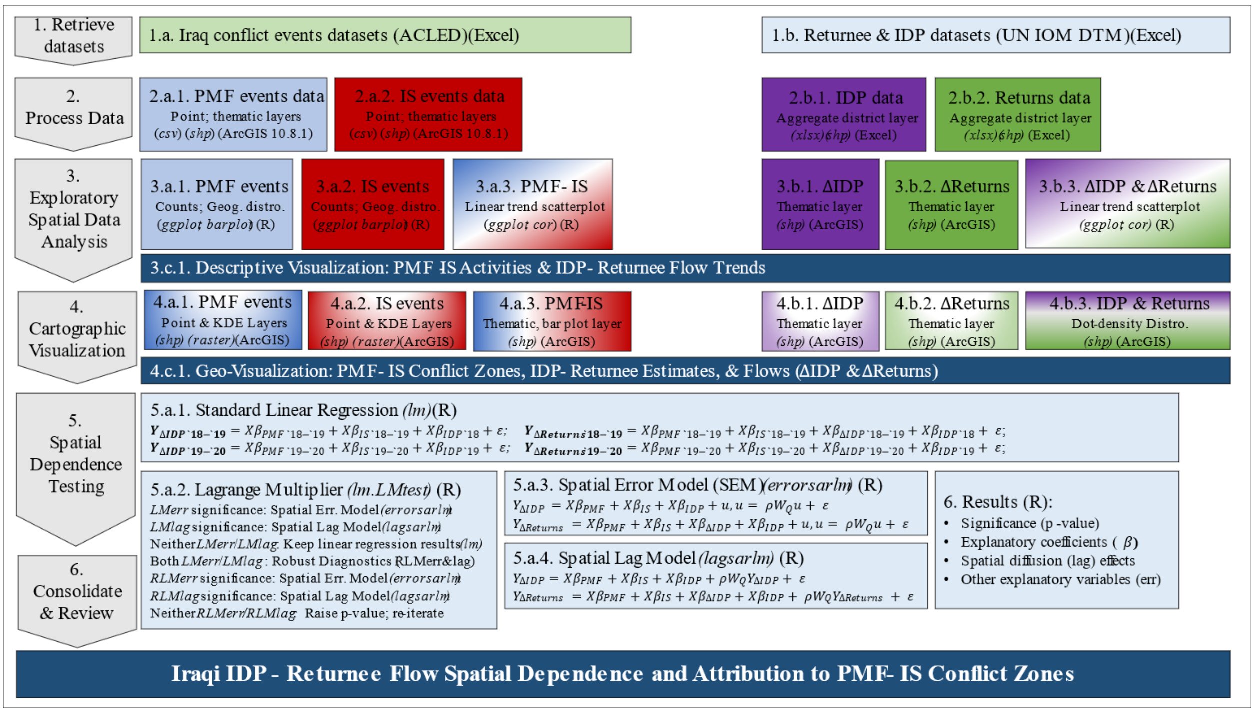
$$Y_{\Delta Returns\,`18-`19} = X\beta_{PMF\,`18-`19} + X\beta_{IS\,`18-`19} + X\beta_{\Delta IDP\,`18-`19} + X\beta_{IDP\,`18} + \rho W_Q Y_{\Delta Returns\,`18-`19} + \varepsilon$$

$$Y_{\Delta Returns\,`19-`20} = X\beta_{PMF\,`19-`20} + X\beta_{IS\,`19-`20} + X\beta_{\Delta IDP\,`19-`20} + X\beta_{IDP\,`19} + \rho W_Q Y_{\Delta Returns\,`19-`20} + \varepsilon$$

The SLM for all IDP-returnee flows consist of the same explanatory variable sets as their corresponding linear regression models except for its autocovariate-spatial lag parameters ($\rho W_Q Y_{\Delta IDP\,`YR-`YR}$; $\rho W_Q Y_{\Delta Returns\,`YR-`YR}$) (Chi & Zhu 2020, 65). The same queen-contiguity spatial weight (W_Q) applies, while respective spatial lag parameter (ρ) and auto-covariates (WY) to the IDP and returnee flow response variables factor whether or not spatial lag dependence exists between explanatory and response variables (Chi & Zhu 2020, 65).

Software Applications and Data Processing Techniques:

The flowchart in Figure 1 below, defines the phases and steps towards processing retrieved datasets into geospatial data outputs in preparation for the geospatial visualization of the data. From data retrieval through data processing, ArcGIS (version 10.8.1) was used to review the Iraq conflict events spreadsheet *(csv)* dataset and to extract and export PMF and IS conflict events within the defined post-conflict timeframes into point layer shapefiles *(shp)*. The PMF and IS events spreadsheet *(csv)* were used as the input of the exploratory spatial data analysis (ESDA) to produce a linear trend scatter plot of correlating PMF and IS with the previously aggregated and created PMF and IS point layer shapefiles *(shp)*. R was used to process the conflict events dataset.



(Figure 1. Analytical Process Workflow for Iraqi Post-Conflict IDP-Return Flow Attributions to PMF-IS Events)

Excel was used to review and aggregate IDP and returnee estimate datasets *(xlsx)* per Iraqi districts in the defined time-periods and joined to the district shapefile *(shp)* with ArcGIS. The inputs of the IDP-return ESDA are defined in Steps '3.b.1. ΔIDP' *(shp)* and '3.b.2. $\Delta Returns$' *(shp)*. '3.b.3. ΔIDP & $\Delta Returns$' is the IDP-returnee linear scatterplot output from the ESDA shapefile inputs in R. The IDP-returnee flow and estimate counts (by district) shapefiles are used as inputs to the geospatial visualization that is still part of the ESDA.

The PMF and IS conflict event point layers for 2018-2019 and 2019-2020 were converted into their own KDE conflict zone layers. The PMF-IS conflict zones are ESDA outputs, and geospatial visualization inputs, which further includes IDP-returnee flows (*shp*) and total estimate counts per district (*shp*). The estimate counts are depicted in dot-density distribution on

ArcGIS while the dynamic flows are depicted thematically to display and reveal any spatial distribution patterns suggesting spatial dependence with PMF-IS conflict zones.

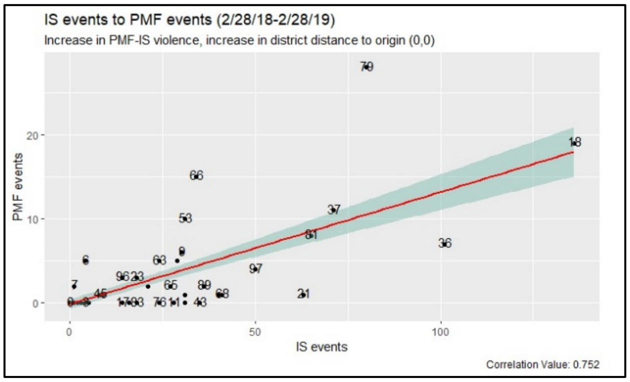
R was used to establish the linear regression model functions for the LM testing model selection between the IDP-returnee spatial error and SLM. The LM testing model selection criteria are outlined in Fig. 1 within Step '5.a.2. Lagrange Multiplier' block. Chi & Zhu (2020; 67-69, 77) reference Anselin and apply the Lagrange multiplier diagnostics test for spatial dependence (R function *'lm.LMtest()'*). The significance in either lag or error would call for their respective model, while lack of any significance results in keeping the linear regression residuals and coefficients.

A dual lag and error significance calls for robust testing, and a failure of both robust lag and error residuals calls for LM testing reiteration with a higher significance value (p-value), or an eventual acceptance of previous linear regression or spatial dependence testing residuals. The spatial dependence models and their R functions have been provided for reference in Figure 1. The results will provide the explanatory coefficients to the response variable, significance determination, spatial diffusion effects, and the existence of other explanatory variables.

Considerations and Limitations:

ACLED and DTM datasets will always be sample datasets against an entire population located throughout a vast plane of space and terrain perpetually changing throughout the passage of time. Additionally, ACLED's Iraq conflict events dataset is only as accurate and correct as the sources that report on the events. UN IOM RART sample surveys indicate that safety-security, living conditions, and economic well-being were factors in the IDP returns, departures, or continued displacement, but they may not be the only factors and obstacles for all IDP populations. A data-driven approach to test for spatial error dependence may determine the existence of other explanatory variables, but sample data may not be available or obtainable due to area accessibility. The IDP-returnee flows derived from initial estimate datasets indicate changes and movements of IDPs and returnees of each district, but IDP flows are not distinguished between departures of continued displacement and departures to return.

Descriptive Statistics Analysis of PMF and IS Conflict Events Per District



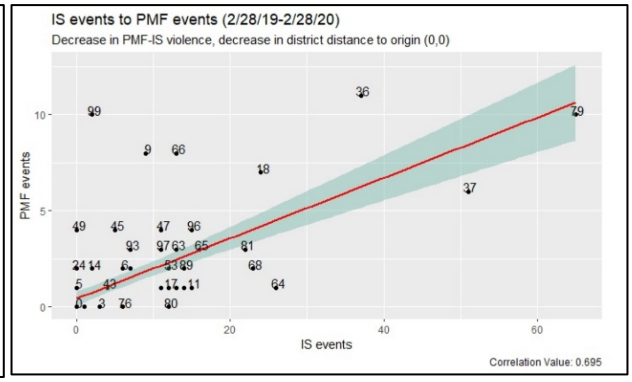
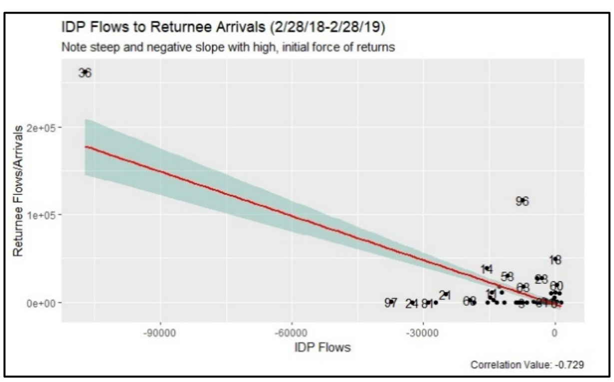


Figure 2 (left). Linear Trend Scatterplot of PMF-IS Conflict Events Per Iraqi District, 2018-2019
Figure 3 (right). Linear Trend Scatterplot of PMF-IS Conflict Events Per Iraqi District, 2019-2020

The conflict events ESDA yielded a linear trend scatterplot indicating the correlation between PMF and IS events for each defined year. The Fig. 2 plot depicts the number of PMF and IS events between 2018 and 2019 for each district. Note the higher, positive linear correlation (0.752), and the high number of IS events for that year. Districts furthest from the plot origin are identified as outliers for their high conflict events counts, and displacement patterns may be more prominent in those districts. The linear scatterplot of PMF-IS slope for Fig. 3 depicts a slighter positive correlation due to decreased IS violence. Lower PMF and IS violence for all districts are reflected by shorter distance to plot origin, which can be used to determine improved security and stability.

Descriptive Statistics Analysis of IDP Flows and Returnee Arrivals Per District



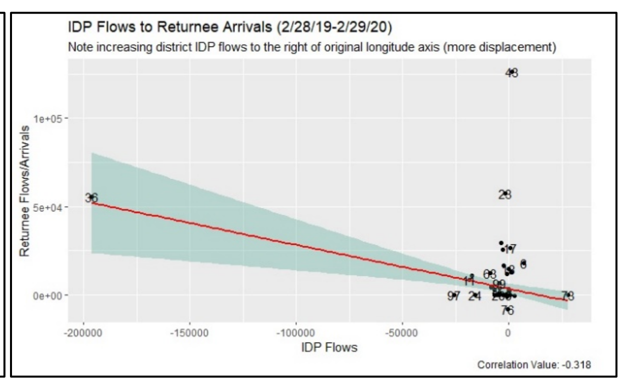


Figure 4 (left). Linear Trend Scatterplot of IDP-Returnee Flows, 2018-2019
Figure 5 (right). Linear Trend Scatterplot of IDP-Returnee Flows, 2019-2020

A steep, negative correlation (-0.729) exists between post-conflict IDP and returnee flows during the 2018-2019 period (Fig. 4), mostly due to the Mosul outlier (District no. 36 on Fig. 4) of highest returns and IDP out-flows. A potential backwash effect in districts with high returns and IDP out-flows from surrounding areas would exist for major population areas and strategic centers like Mosul and Tal Afar (No. 96 on Fig. 4) districts. Districts with IDP out-flows, but marginal (or none) returnee arrivals (In Fig. 5 linear graph, sitting along the original, latitude axis; y = 0) may be among the outer, surrounding districts contributing to the backwash effect into districts of high returns – as IDPs are returning to their original districts or departing to settle in others.

A slight, negative correlative relationship (-0.318) exists in the IDP and returnee flows for the 2019-2020 period (Fig. 5) due to passage of the post-conflict, initial wave of returns; however, Mosul (District no. 36 on Fig. 5) maintains high returnee arrivals, and a greater number of IDP out-flows which may be attributed to departures. Al-Ramadi (District no. 46 on Fig. 5) indicates a potential backwash location with high returns, but non-existent IDP flows. Districts of gaining IDP in-flows (to the right of the original, longitude axis on Fig. 5) may be a part of the spreading, spatial diffusion (lag) effect. A tighter grouping of districts towards the origin in Fig. 5 may be caused by an unidentified explanatory variable that can be addressed through spatial error dependence testing (Chi & Zhu 2020, 79).

Geospatial Visualization Analysis of Conflict and IDP-Return Flows

Figure 6 (below) displays the Iraqi IDP flow and returnee arrival maps for 2018-2019. Only the Iraqi provinces have been labeled, but districts within the provinces depict the IDP flow and returnee arrival values for visualization purposes. A clustering pattern of returnee arrivals is evident towards the northern districts of Ninewa and Salah Al-Din, which are also covered by PMF-IS conflict zones. A backwash effect between the northern district returnee arrivals and departing IDP flows is evident through the conflict zones.

Outward IDP flows from the conflict zones exhibit an observed spreading effect, and the outermost districts and provinces are observed gaining IDP arrivals. The lack of returnee arrivals in the Kurdistan region provinces of Duhok, Erbil, and Al-Sulaymaniyah reveals that IDPs migrated to Kurdistan to avoid violence while conflict-affected displacement is not observed to originate from Kurdistan. The first two, dark-colored bars on the conflict events bar graphs provide that 2018-2019 has a higher PMF-IS conflict violence count than 2019-2020.

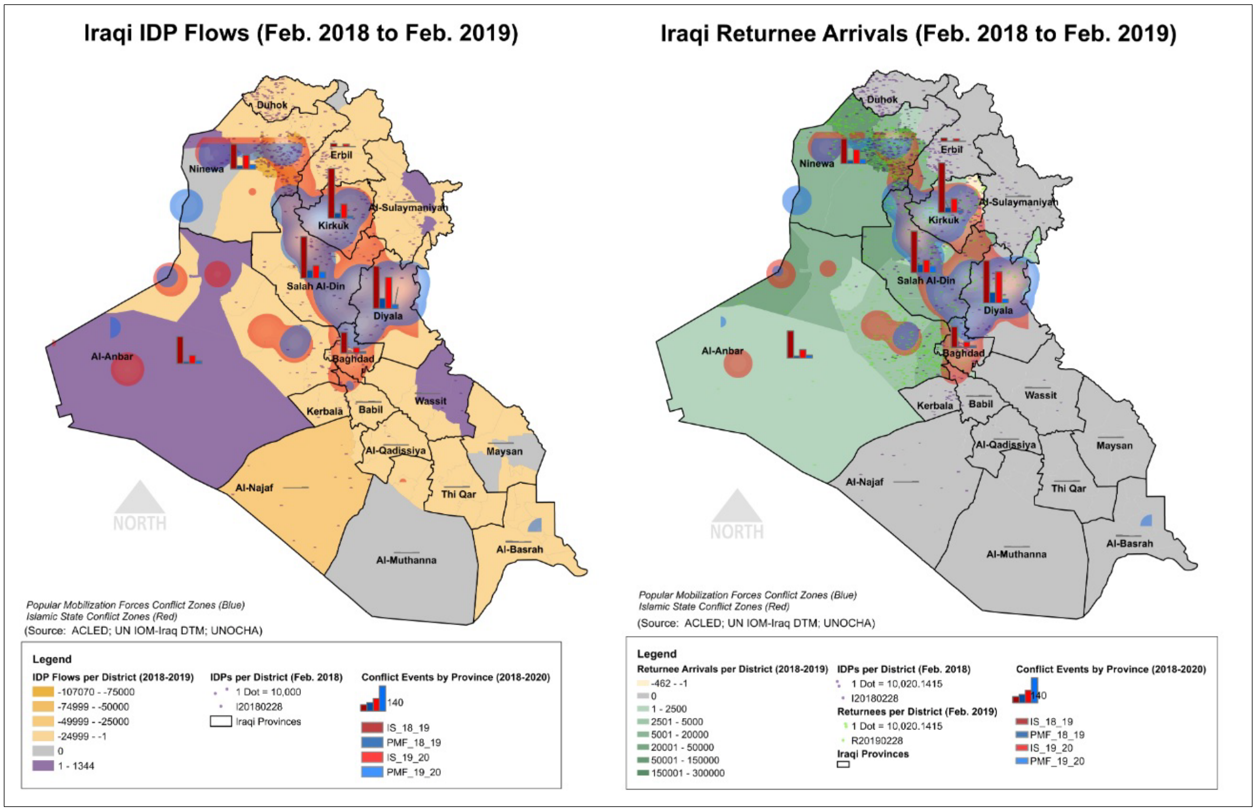


Figure 6. (Left) Iraqi IDP Flows from February 2018 to February 2019. (Right) Iraqi Returnee Arrivals from February 2018 to February 2019.
Note: Islamic State conflict zones (KDE raster layer) are in red, and Iraqi Popular Mobilization Forces conflict zones (KDE raster layer) are depicted in blue.

The conflict events bar graph layer indicates that Diyala, Kirkuk, and Salah Al-Din provinces have the highest, collective concentration of PMF-IS conflict events and violence during the two-year period of this project. Outward IDP flows away from the conflict zones are observable while an increased returnee arrival flow takes place in the districts within the conflict zones. The increased returns in areas within the conflict zones can be attributed to the post-conflict initial exodus of returns. The negative returnee values can be attributed to administrative situation changes, or closures of displacement sites, or discrepancies from a rapidly changing, and even unstable, post-conflict period.

Figure 7 (below) exhibits continued return arrivals from February 2019 to February 2020. Despite the increased PMF-IS conflict violence in 2018-2019 and continued conflict events of 2019-2020, return arrivals increase towards major population areas such as Baghdad, Fallujah (Al-Anbar Province), Ramadi (Al-Anbar Province), and Mosul (Ninewa Province). IDPs displaced and remaining in their districts of origin would make up most returnee arrivals in conflict areas. IDP flows have increased nearly two-fold in some areas during 2018-2019. An observable sprawling effect of IDP arrivals and displacement is depicted in Fig. 7, which can be attributed to the increased post-conflict insurgency violence.

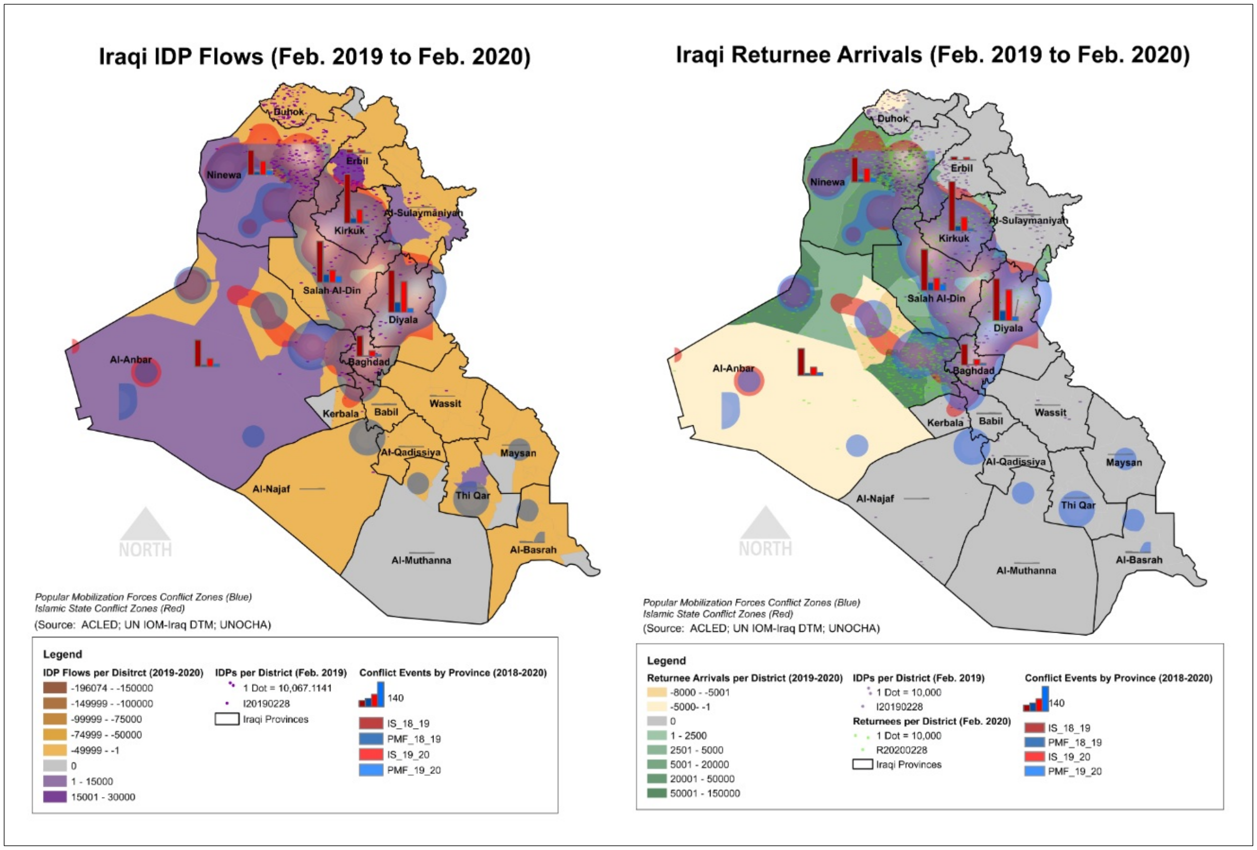


Figure 7. (Left) Iraqi IDP Flows from February 2019 to February 2020. (Right) Iraqi Returnee Arrivals from February 2019 to February 2020.
Note: Islamic State conflict zones (KDE raster layer) are in red, and Iraqi Popular Mobilization Forces conflict zones (KDE raster layer) are depicted in blue.

Continued, post-conflict IDP departures in the Kurdistan provinces (Duhok, Erbil, and Al Sulaymaniyah) contribute to return arrivals in Ninewa Province to the south along with an increasing IDP arrival concentration in the Erbil (Erbil Province), Chamchamal (Al-Sulaymaniyah Province), and Halabcha districts (Al-Sulaymaniyah Province). IDP dot-density distributions and adjacent conflict zones appear to contribute to the IDP arrivals in those Kurdistan-administered areas. Figure 7 depicts an IS conflict zone creep from Baghdad Province through Al-Ramadi, Heet, Haditha, and Ana districts of Al-Anbar Province with responsive PMF events. The linear shape of the IS conflict zone creep through Al-Anbar Province suggests distribution of violence along major road networks and a series of population centers, which is characteristic of attacks on checkpoints, patrols, and IED attacks.

Spatial Regression Analysis Results

After reviewing the linear regression residuals and spatial dependence diagnostics testing with Global Moran's I and Lagrange Multiplier testing, the key results for IDP and returnee flows for both years are defined by their respective matrix notation formulas defined in the Analytical Methods Section. Four sets of linear regression residuals and spatial dependence diagnostics results were generated, of which Returns Flows, 2018-2019 (Table 2) exhibited spatial dependence that called for further testing.

IDP Flows, 2018-2019	**Linear Regression Residuals**		
Variable	**Coefficient**	**Significance**	**Standard Error**
Intercept	-434.1	0.5367	700.23
PMF Events, 2018-2019	661.81**	0.0061	236.04
IS Events, 2018-2019	-196.6***	2.35e-05	44.23
IDP Estimates, 2018	-0.17***	<2e-16	0.01209
Diagnostics for Spatial Dependence			
Moran's I for residuals	0.1012	0.05027	Not Reject Null of Random
LM test for error *(Lmerr)*	2.625	0.1052	Keep Linear Regression Results
LM test for lag *(Lmlag)*	0.5745	0.4485	Keep Linear Regression Results
Robust LM test for error *(RLMerr)*	2.051	0.1521	Keep Linear Regression Results
Robust LM test for lag *(RLMlag)*	0.0002118	0.9884	Keep Linear Regression Results

Table 1. (above) Linear Regression Residuals for IDP Flows between February 2018 to February 2019.
*Significance at α = 0.05 level. **Significance at α = 0.01 level. ***Significance at α = 0.001 level.

The coefficients and standard error values for the explanatory variables of IS conflict events (2018-2019) and IDP estimates (2018) appear consistent with the expected negative relationship they have with IDP flows (2018-2019). Significance values at α = 0.001 for IS events (2018-2019) and IDP estimates (2018) suggest very strong evidence of a negative relationship with IDP flows (Chi and Zhu 2020, 61). From 2018 to 2019, the increase in IS conflict events is negatively related to IDP flows, which means an increase in IS violence increases IDP out-flows (departures to other locations or attempts to return). The PMF coefficient at 661.81 IDP increases per PMF event has a dual interpretation of allowing IDPs to depart and arrive at destination districts as well as blocking IDPs from returning to their original districts which leaves IDPs in continued displacement. There is strong evidence of a positive relationship between PMF events and IDP flows (2018-2019) at α = 0.01.

The Global Moran's I for residuals for IDP flows in 2018-2019 is not significant and is diagnostic of failure in Lagrange Multiplier testing residuals. There is no spatial dependence between explanatory and response variables for 2018-2019 IDP flows. Neither spatial dependence model would be applied after LM testing failures for 2018-2019 IDP flows. As a result, the explanatory variables' significance values are kept in relation to the IDP flow response variable.

Returns Flows, 2018-2019	**Linear Regression Residuals**		
Variable	**Coefficient**	**Significance**	**Standard Error**
Intercept	-4577*	0.0415	2215
PMF Events, 2018-2019	744.5	0.339	774.9
IS Events, 2018-2019	126.2	0.412	153.2
IDP Estimates, 2018	-0.1338*	0.0397	0.06656
IDP Flows, 2018-2019	-1.022**	0.00193	0.3206
Diagnostics for Spatial Dependence			
Moran's I for residuals	0.165**	0.002364	Spatial Dependence
LM test for error *(Lmerr)*	6.968**	0.008297	Try for Spatial Error
LM test for lag *(Lmlag)*	5.911*	0.01504	Try for Spatial Lag
Robust LM test for error *(RLMerr)*	1.835	0.1754	Keep Previous Error Results
Robust LM test for lag *(RLMlag)*	0.7792	0.3774	Keep Previous Lag Results

Table 2. (above) Linear Regression Residuals for Return Flows between February 2018 to February 2019. *Significance at $\alpha = 0.05$ level. **Significance at $\alpha = 0.01$ level. ***Significance at $\alpha = 0.001$ level.

From Table 2, the high coefficient and standard error values of PMF and IS events during 2018-2019 indicate increases in violence and returns were not consistent with the expectation and hypothesis that they have a negative relationship with return flows. Both groups' conflict events also lack significance for any evidence of positive relationships with the return flow response variable. IDP estimates and IDP flows of 2018-2019 were included as explanatory variables because they contribute to returnee flows as all returnees had to be displaced to return to their origins.

The negative coefficient of IDP estimates (2018) is consistent with the gradual post-conflict decrease of IDPs while a near one-to-one person negative relationship between IDP and return flows indicates an initial exodus of returns, which means all departing IDPs (negative IDP flow values) are returnees. The marginal difference of -0.022 in the IDP flow coefficient can be attributed to estimation and accounting errors and latency on DTM during the constantly changing Iraqi displacement situation. At $\alpha = 0.05$, there is moderate evidence that declining IDP estimates are related to increased return flows in the 2018-2019 period. At $\alpha = 0.001$, there is strong evidence of a negative relationship between the IDP flows (2018-2019) and return flows (2018-2019) – and that negative IDP flow values contribute to positive return flow values.

The Global Moran's I for residuals of returnee flows (2018-2019) suggests spatial dependence at $\alpha = 0.01$. The Lagrange Multiplier testing residuals diagnose the existence of spatial error dependence and spatial lag dependence through the *LMerr* and *LMlag* significance values. Dual significance and robust LM testing that resulted in insignificant *RLMerr* and *RLMlag* residuals, which means previous LM and spatial dependence model testing results are kept. The LM error diagnostics is significant at $\alpha = 0.01$ while the LM lag diagnostics is significant at $\alpha = 0.05$, which means spatial error dependence is more prevalent than spatial lag dependence.

The existence of spatial error dependence between the returnee flows (2018-2019) response variable and the conflict-IDP explanatory variables suggest that previous linear regression residuals (Table 2) become inefficient yet unbiased; however, the additional existence of spatial lag dependence suggests that linear regression estimates are inconsistent and biased (Chi and Zhu 2020, 77-78). Post-conflict IS resurgence, PMF response, and the phenomenal wave of post-conflict returns can be attributed to the bias and inconsistency of spatial lag dependence. The near one-to-one negative IDP flow coefficient to return flows (with very strong evidence of relationship) is reflective of the post-conflict return exodus factor, and PMF and IS coefficients at 744.56 and 126.2 may still reflect the backwashing returns of IDPs displaced within adjacent and original districts but are inconsistent with the outward IDP flow patterns from PMF-IS conflict zones observed in the ESDA.

Return Flows, 2018-2019	Spatial Error Model (SEM)			Spatial Lag Model (SLM)		
Variable	**Coefficient**	**Significance**	**Standard Error**	**Coefficient**	**Significance**	**Standard Error**
Intercept	-5416.9	0.0954	3248.9	592.6	0.0064	2176.5
PMF Events, 2018-2019	567.27*	0.0416	697.38	672.4	0.3589	733.05
IS Events, 2018-2019	275.08	0.0615	147.1	128.12	0.3754	144.57
IDP Estimates, 2018	0.06684	0.299	0.0644	0.1213	0.0558	0.0634
IDP Flows, 2018-2019	-1.143***	0.000171	0.304	-1.029***	0.0007	0.3036
	Spatial Error Model Results			**Spatial Lag Model Results**		
	Spatial Error Model p-value:		0.00539**	Spatial Lag Model p-value:		0.0248*
	Monte-Carlo sim. Moran's I (nsim=999) - Residuals			**Monte-Carlo sim. Moran's I (nsim=999) - Residuals**		
	Obs. Moran's I Test Statistic:		-0.0092744	*Obs. Moran's I Test Statistic:*		0.05997
	p-value: (1-0.492) x 2 =		0.508	*p-value: (1-0.11) x 2 =*		1.78
	No spatial error dependence in residuals			**No spatial lag dependence in residuals**		

Table 3. (above) Spatial Dependence Residuals for Return Flows between February 2018 to February 2019.
*Significance at $\alpha = 0.05$ level. **Significance at $\alpha = 0.01$ level. ***Significance at $\alpha = 0.001$ level.

The spatial dependence residuals for returnee flows (2018-2019) suggest greater prevalence of spatial error dependence than spatial lag dependence. The PMF coefficient of the SEM is significant at $\alpha = 0.05$ while the linear regression and SLM PMF coefficients are insignificant at that level. The IS coefficient of the SEM increases nearly two-fold from the linear regression coefficient at 126.2 (Table 2) to IS coefficient 275.08 (Table 3). IDP estimates also change coefficients from linear regression coefficient of -0.1338 to spatial error coefficient of +0.06684 (but drops in significance from linear regression coefficient 0.0397 at $\alpha = 0.05$ to 0.299 spatial error significance). The variation between IDP flow coefficients in the linear regression residuals, SEM, and SLM are stable and consistent, and maintain the same negative relationship with returns within the one-to-one tolerance.

Moderate evidence of a positive relationship between PMF and return flows suggest that IDPs displaced and remaining within their districts of origin make up most of the returns during the initial returns period within the SEM. Very strong evidence of a negative relationship between IDP flows and return flows (2018-2019) indicate the existence of the initial, post-conflict return exodus in both SEM and SLM (significance level of $\alpha = 0.001$). The evidence of IS conflict violence having a positive effect on return flows is not significant or consistent with the theory of it being the initial and primary driver of displacement. The evidence of positive relationship between IDP estimates and return flows is not significant enough nor is it consistent with the accountability balance of IDPs.

Return flow spatial error dependence (p-value = 0.00539) and spatial lag dependence (p-value = 0.0248) indicate inconsistency and bias of its linear regression residuals (Chi and Zhu 2020, 77-78). The theory of initial returns exodus, and possible shifts in PMF activities against IS and area security, could be attributed to the spatial dependence. A more rigorous Monte-Carlo Simulation of Global Moran's I test for residuals was applied to the spatial dependence models with the same linear regression formula parameters, and the results of non-significance reinforce the non-significant robust LM testing residuals. No further spatial dependence exists beyond the coefficients and significance of explanatory variables in Tables 2 and 3 for return flows of 2018-2019.

IDP Flows, 2019-2020	**Linear Regression Residuals**		
Variable	**Coefficient**	**Significance**	**Standard Error**
Intercept	3908*	0.0147 (<0.05)	1574
PMF Events, 2019-2020	-2001*	0.0175 (< 0.05)	828
IS Events, 2019-2020	-22.36	0.9029	182.8
IDP Estimates, 2019	-0.2769***	4.39e-14 (<0.001)	0.03135
Diagnostics for Spatial Dependence			
Moran's I for residuals	0.04331	0.3228	Not Reject Null of Random
LM test for error *(Lmerr)*	0.48	0.4884	Keep Linear Regression Results
LM test for lag *(Lmlag)*	0.08123	0.7731	Keep Linear Regression Results
Robust LM test for error *(RLMerr)*	1.366	0.2424	Keep Linear Regression Results
Robust LM test for lag *(RLMlag)*	0.9695	0.3248	Keep Linear Regression Results

Table 4. (above) Linear Regression Residuals for IDP Flows between February 2019 to February 2020.
*Significance at $\alpha = 0.05$ level. **Significance at $\alpha = 0.01$ level. ***Significance at $\alpha = 0.001$ level.

IDP flows of 2019-2020 (Table 4) have tested insignificant on both Global Moran's I test for residuals and LM testing, which means there is no spatial dependence (error or lag) for the IDP flow response variable. Based on the explanatory variables' coefficients and significance values of Table 4, there is moderate evidence of a negative relationship between PMF events and IDP flows (at $\alpha = 0.05$) while very strong evidence of a negative relationship exists between IDP estimates and IDP flows (at $\alpha = 0.001$). Evidence of negative IDP estimates and flows relationship suggests IDP migrations continue to take place, but at a much steeper rate than that observed in Table 1 possibly due to previous movement delays caused by increased violence

(2018-2019), and then an increase of IDP movements following decreased violence (2019-2020). The lack of spatial dependence suggests there may not be other potential explanatory variables affecting IDP flow, and that significant coefficients are generally consistent, efficient, and unbiased.

Return Flows, 2019-2020	**Linear Regression Residuals**		
Variable	**Coefficient**	**Significance**	**Standard Error**
Intercept	2328	0.1908	1767
PMF Events, 2019-2020	1262	0.1769	927.9
IS Events, 2019-2020	8.434	0.9663	198.9
IDP Estimates, 2019	-0.007605	0.8686	0.04583
IDP Flows, 2019-2020	-0.1941	0.0822	0.1105
Diagnostics for Spatial Dependence			
Moran's I for residuals	0.04194	0.3302	Not Reject Null of Random
LM test for error *(Lmerr)*	0.4501	0.5022	Keep Linear Regression Results
LM test for lag *(Lmlag)*	1.347	0.2457	Keep Linear Regression Results
Robust LM test for error *(RLMerr)*	2.023	0.1549	Keep Linear Regression Results
Robust LM test for lag *(RLMlag)*	2.921	0.08745	Keep Linear Regression Results

Table 5. (above) Linear Regression Residuals for Return Flows between February 2019 to February 2020.
*Significance at $\alpha = 0.05$ level. **Significance at $\alpha = 0.01$ level. ***Significance at $\alpha = 0.001$ level.

All explanatory variable coefficients and their significance values indicate weak evidence of their respective relationships with 2019-2020 return flows (Table 5). IDP estimates and flows below significance of $\alpha = 0.05$ and $\alpha = 0.001$ indicate the passage of the post-conflict initial returns exodus. This is indicated by the slight, negative coefficient relationship between IDP out-flows and return in-flows for 2019-2020. The decrease in IS violence can be deduced from the low coefficient values and lack of significance. Both the Global Moran's I for residuals and LM testing diagnostics show no significance in spatial dependence testing, hence not rejecting the null of random distribution.

Discussion

Areas most heavily affected by conflict and displacement are also major population centers and prominent statistical outliers identified through exploratory and geospatial visualization analysis. The visualization analysis reveals observable spatial patterns of IDPs returning to their original districts (return flows) even during increased post-conflict violence and PMF territorial control, and other IDPs migrating and remaining in the outer district and province areas away from the PMF and IS conflict zones. The post-conflict IDP return-to-urban origin areas like Mosul and Fallujah are somewhat characteristic of Shultz's rural-to-urban displacement flows (Schultz et. al. 2014) and is consistent with the impact variations between those that flee or stay in conflict-affected environments (Bradley 2017). From a geospatial visualization perspective, the spatial diffusion of IDPs and the effects of conflict violence are observable.

The spatial regression analysis for spatial dependence of IDP-return flows for the 2018-2019 and 2019-2020 post-conflict years indicate shifting relationships between PMF activity and presence to IDP and return flows. The linear regression residuals indicate lack of spatial dependence for IDP flows, and a distorting spatial dependence effect on return flows. There is strong evidence for PMF activity facilitating IDP flows during the post-conflict, initial return exodus period (2018-2019), but moderate evidence of blocking IDP flows during the second year (2019-2020). The increased PMF territorial control and blocked IDP movements during the second year can be attributed to the delayed effect (Salvi et. al. 2017) of increased of IS conflict violence during the first year.

The spatial error and lag dependence found in the first year of return flows, and the moderate evidence of PMF facilitation of returns, suggests that additional security actor interactions are factors in IDP-return flows for both years. Additionally, the high PMF coefficients suggest inefficiency and bias (spatial lag dependence), and that moderate PMF significance in spatial error dependence reinforces coefficient inefficiency and the possibility of other security actors and explanatory variables. The lack of evidence and significance for the explanatory variables of 2019-2020 return flows linear regression is an indication of other effective security actors and possible living conditions severity affecting the ability of remaining IDPs to return – and that the PMF and IS conflict events no longer carry as much significance in the second year of the post-conflict period.

Furthermore, IDP-return flow and interactions between adjacent districts within conflict zones, and those outside conflict zones can contribute to the spatial error and lag dependence. Interactions driven by ethno-religious differences and sectarian tensions between IDPs, returnees, PMF, and IS would currently be substantiated by other ancillary socio-demographic data that supports movements of ethno-religious groups between districts, but complete nation-wide datasets are currently not available. Ethno-religious classification within IDP and returnee estimate datasets for both years could potentially detect effective returns and continued displacements based on ethnicity or religious affiliation, but such data is currently not available.

Conclusion

The increased PMF-IS violence and continued PMF presence in the post-conflict environment was expected to decrease IDP in-flows and returns due to security and safety conditions. The actual findings and results of the spatial regression analysis results support the cartographic visualization patterns of IDP out-flows spreading away from PMF-IS conflict zones, but the overwhelming effect of first-year initial wave of returns was not expected. The spatial dependence of first year returns indicates that the PMF presence may not have facilitated returns but only affected continued displacement for IDPs, which explains the moderate evidence of a negative relationship between PMF and IDP flow in the second year. The consistent significance of first year IDP flows and returns coefficient in the first year returns spatial dependence models may be an indication of a comparative explanatory indicator of the initial wave of returns.

The exploratory-visualization and spatial regression analyses on IDP-return flows and PMF-IS conflict zones reveal the relationships, significance, and evidence between the explanatory and response variables. The analyses indicate potential errors and additional explanatory variables to factor for future studies on conflict-affected displacement, and the impact of quality demographic datasets on displaced populations and data-driven dispositions of armed group actors involved. Future analytical studies on the post-conflict Iraqi displacement situation will call for data collection and implementation of explanatory variables related to reconstruction, severity in living conditions, and even administered governance.

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