Is Climate Change Likely to Lead to Higher Net Internal Migration? The Republic of Yemen's Case

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Abstract

Concerns abound about the potential impact of climate change on future migration, especially in the Middle East and North Africa, one of the regions that is likely to suffer the most from climate change. Yet it is not clear whether so far climate patterns have been a key driver of internal migration in countries such as Yemen, despite the pressures created by water scarcity. By combining data from Yemen's latest census and a weather database as well as other geographic information, we analyze the determinants of past net internal migration rates. Next, using future climate change scenarios, we predict the potential impact of rising temperatures on future net internal migration rates. The results suggest that while climate does have an impact on net internal migration rates, this impact is limited, so that on the basis of past patterns of climate and migration, rising temperature may not have a large impact on future net internal migration.

1. Introduction

Climate change is likely to lead to substantial migration flows (for a recent review of the evidence to-date, see Foresight, 2011). Jakobeit and Methmann (2007) suggested some years back that there may be up to 150 to 200 million environmental refuges in 30 years, but this estimate was considered as conservative by the Stern Review on the Economics of Climate Change (2006) and the Foresight report notes that 42 million people were displaced by natural hazards just in 2010. It is also clear that the impact of climate change may be very different on different types of households depending on their coping mechanisms (see Meze-Hausken, 2004, on Ethiopia) and that the magnitude of migration flows will depend on country conditions. For example, fast onset disasters such as hurricanes and floods, as well as droughts or decreasing agricultural yields may lead to only temporary displacement (for country case studies, see Paul, 2005; Findley, 1994; Haug, 2002; Henry et al., 2004; Shuaizhang et al., forthcoming; see also Barrios et al., 2006), while slow onset events such as desertification or rising sea levels may take longer to occur but may also have longer lasting effects on net migration flows.

The Middle East and North Africa (MENA) is likely to be one of the most vulnerable regions to climate change, both due to a number of cities threatened by rising sea levels and the vulnerability of agricultural production given water scarcity which is expected to increase further. Average temperatures in many MENA countries may increase by two degrees Celsius by the end of the century, including in Yemen, a country where the depletion of groundwater resources is likely to reduce agricultural output by 40 percent (World Bank, 2010; for a review of the literature which informs this chapter, see the introduction of chapter 2 by Wodon et al. (2014) and chapter 3 on the focus countries for this work by Burger et al. (2014a) in this study).

In a country like Yemen, climate change is likely lead to higher migration principally due to the need for households to improve their livelihoods. But many households also tend to be fairly attached to their area of origin, and when they move, this is typically driven more by socio-economic factors than climate variables, as shown by Joseph and Wodon (2014) using a gravity-type model with census data on internal migration rates combined with data on weather patterns at the district level. Building on Joseph and Wodon (2013), we consider in this chapter net migration rates (as opposed to bi-directional flows) and predict to what extent changes in climate are likely to affect such net internal migration flows. We focus on net migration rates because from a policy point of view, these are likely to be more important than overall bi-directional flows.

The results suggest that controlling for other factors that may affect net internal migration rates, these rates tend to be lower towards areas with higher temperatures, but the impact of temperature on net migration rates, while statistically significant, is small. Using predicted values for future temperatures under alternative climate change scenarios, out-of-sample predictions of expected net international migration rates suggest limited changes in patterns of migration due to rising temperatures. It should be emphasized however that because we rely on past patterns of migration and climate, our results can only be considered as suggesting (in an imperfect and indicative way) that slowly changing climate patterns may affect migration in the not too distant future in a limited way only, but they should not be relied upon to assess how structural breaks such as dramatic changes in climate patterns may affect long-term migration.

The chapter is organized as follows. Section two presents our data and methodology. Section three describes our results. A brief conclusion follows.

2. Data and Methodology

Net internal migration rates are obtained at the district level from the latest Yemen census implemented in 2004. The census has information on 2,752,629 households with 19,708,760 individuals living in 333 districts. It provides information on the current residence, previous residence and place of birth of all individuals living in Yemen at the time of the census. Information is also available on the number of years each individual has been living in the current residence, which along with age enables us to compute net internal migration rates for different age cohorts. For each cohort, we have 333 observations corresponding to the 333 districts in Yemen (as of the administrative structure in 2004). Considering seven cohorts corresponding to age groups defined at five years of interval for the population aged 20 to 54, this provides us with 2331 observations. The census also provides demographic and socio-economic information including the level of education of the population, its occupation and employment characteristics, and the extent of urbanization. Finally, we also have at our disposal poverty estimates at the district level that were obtained through the combination of household and survey data through the poverty mapping technique (see Elbers et al., 2004).

In addition, information on the distance between major cities in each district is calculated from the highest population center in each district to all other districts using an Euclidean distance function in ESRI ArcGIS 9.3 software, and the same procedure is used for distance to the coast. Travel time to the nearest city with 100,000 populations uses a methodology developed from Nelson (2008) with regionally specific information (World Bank, 2011). The road data provide kilometers of asphalt roads. The mean slope of district land is derived from a global dataset by Verdin et al. (2007). The percentage of irrigated land is taken from Global Map of Irrigated Areas version 4 (Siebert et al., 2005; Siebert et al., 2006). Weather data on annual mean temperature and rainfall and their variability are collected from BIOCLIM (Busby, 1991).

Denoting by Y_i the net internal migration rate to district i to as a proportion of the population of the district, and by X_i the characteristics of the district, we estimate a standard regression using a fractional logit model:

$$Y_i = \alpha + \beta' X_i + \varepsilon_i \quad (1)$$

We also use a decomposition proposed by Fields (2004) to assess how much of the variation in net internal migration rates between districts is accounted for by each of the independent variables. The weights from the decomposition are constructed to sum to the total percentage of the explained variance (i.e., the R^2). Denote by s_k the share of the variation in the dependent variable attributed to the k^{th} explanatory variable, by $\beta_k$is the multiple regression coefficient for that variable, and by $\sigma_k$is the standard deviation of the k^{th} explanatory variable. $Cov(X_k\beta_{k,}Y)$ is the correlation between the k^{th} explanatory variable and the dependent variable Y and σ_Y is the standard deviation of the dependent variable. We have:

$$s_k = \frac{Cov(X_k\beta_k,Y)}{Var(Y)} = Cor(X_k, Y)\frac{\sigma_k}{\sigma_Y}\beta_k \quad (2)$$

Normalized weights p_k are obtained by dividing s_k by R^2 so that each weight is expressed as fraction of the percentage of total explained variance and the weights sum to 100. Five slightly different specifications are used to test for the robustness of the coefficient estimates. The first model or baseline specification does not include dummy variables for the governorates (the administrative level immediately above the district), and it includes the climate variables in both levels and squared values. In the second model, governorate dummy variables are added (although not shown in the regression table – these estimates are available upon request). Next, in the third specification we keep the governorate dummies, but do not include the quadratic terms for the climate variables.

In the last two specifications, we also keep the governorate dummies, but we replace the climate variables that measure seasonality by three intervals each including one third of the districts, with the "low" interval (in terms of temperature or rainfall) being the excluded reference category in the regression, and the other two intervals being included as dummy variables. The reason to do so is that for the predictive analysis, while we do have estimates of future temperature and rainfall from climate change models, we do not have estimates of future seasonality in temperature and rainfall that are as reliable. At the same time, it is unlikely that for most districts changes in seasonality would be so dramatic as to shift the interval of seasonality to which a district belongs. Then the last two models can then be considered as the best models for out-of-sample predictions of the potential impact of higher temperatures and lower rainfall on future net internal migration rates. The difference between the last two models is that one includes squared values for mean temperature and rainfall, while the other does not.

For the predictions of future migration under likely future climate patterns, we rely on data from Strzepek and Schlosser (2010). These data provide expected percent changes in temperature and precipitation for the years 2030 (defined as the average for the period 2026 to 2035) and 2050 (defined as the average for the period 2046 to 2055) on a monthly basis in comparison to the model baseline (1961-1990) which are historical data from the CRU TS 2.1 (Mitchell and Jones 2005). Strzepek and Schlosser define three scenarios (Wet, Mid, and Dry) using a Climate Moisture Index (CMI), which is an indicator of the aridity of a region. The CMI depends on the average annual precipitation and average annual potential evapotranspiration (PET). The Wet scenario is defined as the global climate model (GCM) that has the largest increase in average CMI over the baseline period, while the Dry scenario is defined as the GCM that has the largest decrease in average CMI over the baseline period. The Mid scenario is defined as the GCM closest to the mid-point between the Wet and Dry scenarios. Since GCMs vary in spatial resolution, the results are coerced to the CRU half degree by half degree resolution and then summarized by district.

3. Results

Table 1 provides basic statistics on the main variables of interest. Net internal migration rates are not very large. They range from -2.86 percent to 0.37 percent. The fact that the rates are larger in negative values suggest that net internal migration on average tends to take place from districts with smaller populations to districts with larger populations, as expected. Table 1 also provides summary statistics for the independent variables used in the regression. The summary statistics show that Yemen's population still lives predominantly in rural areas with an average urban population across districts of about 20 percent. Trade and services provide employment to 42 percent of the employed. Education levels tend to be low, with 17 percent of the population above 40 years of age being literate. The share of irrigated land is also low, at only four percent. Mean temperatures are relatively high, but not excessive at 22 degrees Celsius. Precipitations are low, at 200 mm per year on average. Temperature and precipitation seasonality are high. Many districts are located far from the nearest city with more than 100,000 inhabitants. Most districts also have limited water, public lighting, and road infrastructure.

Regression results are provided in table 2. Net migration rates are smaller in districts with a large population, but this is a stock effect – even if migrants tend to go to more populated districts, given that rates are expressed in proportion to existing populations, larger districts tend to have smaller rates controlling for other factors. Poverty does not seem to be correlated with net migration in a statistically significant way, even though the sign is negative as expected in almost all cases. Districts with a higher share of urban population have lower net migration rates – this could be seen as surprising, but the raw data suggests indeed that migration does not necessarily take place towards the largest cities, at least within Yemen (there is apparently substantial international migration towards cities in Saudi Arabia, but this is not captured here).

Migration tends to be directed towards districts with a higher share of employment in trade and services, which does make sense, given that many migrants may be leaving agricultural occupations. Migration is higher towards areas with higher access to piped water supply, although the impact of public lighting is negative in a few cases (but also smaller and only marginally statistically significant). Migration is higher in areas with a higher share of the population above 40 having secondary education, with a negative correlation in the case of tertiary education – this might capture areas where migrants have a reasonable expectation of finding good employment, given that many migrants will not have tertiary education. Migration tends to take place in areas with less irrigated land – maybe because areas with irrigated land are already well occupied. Travel time to the nearest large city is in many cases positively related to migration rates but this is partly offset by the squared term, and in some cases, the impact is not statistically significant, including for the preferred specifications (4) and (5). The same can be said for distance to the coast. Finally, migration rates are higher for the age groups 20-24 and then 25-29 (the reference category is 15-19) than for any other age group, as expected.

As for climate variables, there is a clear negative effect of higher temperatures on net migration rates, which is important for our out-of-sample predictions of future migration. The sign and the magnitude of the coefficients tend to be stable across specifications (taking into account the squared term when included). By contrast the impact of the level of rainfall is not statistically significant. Seasonality also does matter, and this is easiest to see in specifications (4) and (5) which suggest higher net migration rates to areas with lower temperature variability, with a smaller impact again for rainfall which is not always statistically significant.

Table 1: Basic Statistics on Key Variables of Interest, Yemen 2004-2006

	Mean	Std. Dev.	Min	Max
Dependent variables				
Net migration rate for youth (age 20-24)	-0.001	0.247	-1.710	0.359
Net migration rate for older cohort (age 25-54)	-0.038	0.338	-2.861	0.370
Net migration rate - total	-0.033	0.327	-2.861	0.370
Independent variables				
Log of total population in the district	10.63	0.92	7.32	12.65
Squared poverty gap in the district	0.05	0.05	0.00	0.31
Share of urban population in the district	0.20	0.30	0.00	1.00
Share of employed in manufacturing, construction	0.15	0.09	0.00	0.60
Share of employed in trade and services	0.46	0.20	0.05	0.91
Share of population with public water supply	0.18	0.26	0.00	0.95
Share of population with public lighting	0.32	0.34	0.00	0.97
Average slope of terrain in the district (%)	15.35	12.30	0.00	49.33
Share of literate population above 40	0.17	0.12	0.01	0.61
Share of primary educated population above 40	0.14	0.13	0.00	0.51
Share of secondary educated population above 40	0.02	0.03	0.00	0.17
Share of tertiary educated population above 40	0.02	0.03	0.00	0.22
Percentage of irrigated land in the district	3.28	5.97	0.00	44.73
Annual mean temperature (°C)	21.95	4.16	13.93	30.45
Annual mean temperature squared	500.88	187.19	196.57	927.45
Annual precipitation	20.42	12.37	2.61	50.97
Annual precipitation squared	577.29	611.00	7.23	2600.47
Temperature seasonality (standard deviation *100)	28.83	3.32	18.79	40.61
Temperature seasonality squared	842.67	203.13	353.45	1656.13
Precipitation seasonality (coefficient of variation)	8.47	1.82	4.69	13.34
Precipitation seasonality squared	75.28	32.00	21.99	179.40
Travel time to nearest city with 100,000 population (hours)	3.68	3.20	0.02	20.35
Travel time to nearest city squared	23.77	50.77	0.00	414.30
Distance to coast/100 (only Yemen)	0.96	0.53	0.00	2.51
Distance to coast squared/100 (only Yemen)	1.20	1.20	0.00	6.30
Km of asphalt roads /100	0.16	0.30	0.00	3.23
Km of asphalt roads squared /100	0.12	0.76	0.00	10.43
Medium temperature level (tercile)	0.33	0.47	0.00	1.00
High temperature level (tercile)	0.33	0.47	0.00	1.00
Medium rain level (tercile)	0.33	0.47	0.00	1.00
High rain level (tercile)	0.33	0.47	0.00	1.00

Source: Authors' estimation.

The fact that temperature – in levels and variability – affects net migration rates is an important result, but this does not mean that the effect is large. As shown in table 3 which provides the results of a decomposition of the explained variance proposed by Fields (2004), these variables account only for a limited share of the explained differences in net migration rates between districts (Fields decomposition shares can also be computed for regional governorate effects in the regressions, but these shares are small and therefore are not included in the Table). The share of the difference in migration rates explained by temperature levels is only at about three to four percent when considering linear and quadratic terms, and it is lower when quadratic terms are omitted. This is small in comparison to the role of urbanization, education, infrastructure, employment, and even population size. This suggests that changes in future temperature levels might have only a limited impact on future net migration rates.

Table 2: District-Level Correlates of Net Migration Rates, District Level

	(1) Base	(2) With regional dummies, squared terms	(3) With regional dummies, no squared terms	(4) With climate variability brackets, squared terms	(5) With climate variability brackets, no squared terms
Log total population	-0.060***	-0.054***	-0.054***	-0.050***	-0.048***
Squared poverty gap	-0.134	-0.143	-0.158	-0.031	0.005
Urban population (%)	-0.603***	-0.562***	-0.571***	-0.541***	-0.534***
Manuf./construction employment (%)	0.137***	0.035	0.025	0.047	0.078*
Trade/services employment (%)	-0.018	0.117***	0.121***	0.113***	0.133***
Population with public water supply (%)	0.198***	0.147***	0.175***	0.139***	0.151***
Population with public lighting (%)	-0.019	-0.038**	-0.025	-0.034*	-0.039**
Mean slope (%)	0.002***	0.001	-0.000	0.001*	0.000
Literate population above 40 (%)	-0.259*	-0.056	-0.061	-0.098	-0.114
Primary educ. population above 40 (%)	-1.139***	-0.940*	-1.153**	-0.875*	-0.743
Secondary educ. pop. above 40 (%)	11.570***	7.839***	7.178***	8.072***	7.252***
Tertiary educ. population above 40 (%)	-8.764***	-5.885***	-5.768***	-6.121***	-6.004***
Irrigated land (%)	0.000	-0.003***	-0.003***	-0.002**	-0.002***
Annual mean temperature	-0.115***	-0.098***	-0.011***	-0.104***	-0.009***
Annual mean temperature squared	0.002***	0.002***		0.002***	
Annual precipitation	-0.003	-0.002	-0.001	0.001	-0.001
Annual precipitation squared	0.000**	0.000		-0.000	
Temperature seasonality	-0.071***	-0.042***	-0.025***		
Temperature seasonality squared	0.001***	0.000*			
Precipitation seasonality	0.022	0.123***	0.011***		
Precipitation seasonality squared	-0.002	-0.007***			
Travel time to nearest large city	0.038***	0.037***	0.012***	0.031***	0.000
Travel time to nearest large city squared	-0.003***	-0.002***		-0.002***	
Distance to coast/100 (only Yemen)	-0.080*	0.054	-0.054***	0.029	-0.070***
Distance to coast squared	-0.004	-0.046***		-0.028*	
Km of asphalt roads /100	0.006	-0.020	0.007	-0.014	0.018*
Km of asphalt roads squared/100	-0.010	0.008		0.007	
Age group (20-24)	0.050***	0.050***	0.050***	0.050***	0.050***
Age group (25-29)	0.031**	0.031**	0.031**	0.031**	0.031**
Age group (30-34)	0.023	0.023	0.023	0.023	0.023
Age group (35-39)	0.013	0.013	0.013	0.013	0.013
Age group (40-44)	0.007	0.007	0.007	0.007	0.007
Age group (45-49)	0.003	0.003	0.003	0.003	0.003
Temperature variability - medium				-0.069***	-0.079***
Temperature variability - high				-0.158***	-0.180***
Rainfall variability - medium				0.012	0.023***
Rainfall variability - high				-0.007	0.035***
Constant	3.140***	2.030***	1.525***	1.689***	0.862***
Number of observations	2331	2331	2331	2331	2331
R-squared	0.623	0.691	0.685	0.692	0.685

Source: Authors' estimation.

Table 3: Fields Decomposition of Explained Variance in Migration Rates

	(1) Base	(2) With regional dummies, squared terms	(3) With regional dummies, no squared terms	(4) Climate variability levels, squared terms	(5) Climate variability levels, no squared terms
Log of total population	6.4	5.1	5.2	4.8	4.6
Squared poverty gap	-0.6	-0.6	-0.7	-0.1	0.0
Share of urban population	56.0	47.0	48.2	45.2	45.1
Share of employed in manufacturing, construction	-0.3	-0.1	0.0	-0.1	-0.2
Share of employed in trade and services	0.6	-3.5	-3.6	-3.3	-4.0
Share of population with public water supply	-11.5	-7.7	-9.3	-7.3	-8.0
Share of population with public lighting	1.4	2.5	1.6	2.2	2.6
Mean slope (%)	4.4	1.0	-0.7	2.2	0.4
Share of literate population above 40	6.4	1.2	1.4	2.2	2.6
Share of primary educated population above 40	7.6	5.7	7.0	5.3	4.5
Share of secondary educated population above 40	-51.1	-31.2	-28.8	-32.1	-29.1
Share of tertiary educated population above 40	76.2	46.1	45.6	47.9	47.5
Percentage of irrigated land	-0.2	1.1	1.2	0.9	1.1
Annual mean temperature	-13.9	-10.7	-1.2	-11.3	-1.0
Annual mean temperature squared	10.0	7.6		8.2	
Annual precipitation	-0.7	-0.5	-0.2	0.2	-0.2
Annual precipitation squared	1.0	0.5		-0.2	
Temperature seasonality (standard dev. *100)	-3.9	-2.1	-1.2		
Temperature seasonality squared	3.1	1.0			
Precipitation seasonality (coeff. of variation)	-0.7	-3.6	-0.3		
Precipitation seasonality squared	1.3	4.0			
Travel time to nearest city with 100,000 pop.	6.7	5.8	1.9	4.9	0.0
Travel time to the nearest city squared	-0.6	-0.3		-0.4	
Distance to coast/100 in Yemen	1.9	-1.1		-0.6	1.5
Distance to coast squared	0.3	2.9	1.1	1.8	
Km of asphalt roads /100	0.1	-0.3		-0.2	0.3
Km of asphalt roads squared /100	-0.2	0.1	0.1	0.1	
Temperature variability-medium				-1.1	-1.3
Temperature variability-high				-0.7	-0.8
Rainfall variability-medium				0.3	0.6
Rainfall variability-high				0.2	-1.1
Age group (20-24)	0.3	0.3	0.3	0.3	0.3
Age group (25-29)	0.1	0.1	0.1	0.1	0.1
Age group (30-34)	0.0	0.0	0.0	0.0	0.0
Age group (35-39)	0.0	0.0	0.0	0.0	0.0
Age group (40-44)	0.0	0.0	0.0	0.0	0.0
Age group (45-49)	0.0	0.0	0.0	0.0	0.0

Source: Authors' estimation.

Table 4 provides the results of the estimation of future migration rates obtained with estimates of future temperature levels (given that rainfall does not have a statistically significant impact on net migration rates, the out-of-sample predictions were computed only for expected changes in temperature). For easier reading, the districts were grouped into three intervals, each accounting for one third of the districts, and labeled as low, medium, and high temperature districts. Because migration rates are higher for the age group 20-24, we present statistics for that group, as well as for older individuals. The table suggests that net migration rates are lower for low and high temperature districts. Predicted migration rates are obtained under higher temperatures under the mild, dry, and wet scenarios, and considering both expected temperatures in 2030 and 2050, but the differences versus the predicted migration rates today are very small, and the differences between the three scenarios, as well as between 2030 and 2050 are also small. In other words, at least based on patterns of past migration, expected changes in temperature might not affect net internal migration rates to a significant extent.

Table 4: Actual and predicted net migration rates

	Model (4)							
	Youth (age 20-24)				Others (age 25-54)			
	Cold	Medium	Hot	All	Cold	Medium	Hot	All
2004 data								
Actual	-0.02461	0.03595	-0.01306	-0.00057	-0.09771	0.01867	-0.0356	-0.03821
Predicted	-0.05101	0.05462	-0.00533	-0.00057	-0.08865	0.01698	-0.04297	-0.03821
2030 predicted								
Mid scenario	-0.06134	0.04844	-0.0033	-0.0054	-0.09898	0.0108	-0.04094	-0.04304
Dry scenario	-0.06204	0.04824	-0.00222	-0.00534	-0.09968	0.0106	-0.03986	-0.04298
Wet scenario	-0.06181	0.04827	-0.00312	-0.00555	-0.09945	0.01063	-0.04076	-0.04319
2050 predicted								
Mid scenario	-0.06618	0.04725	0.00156	-0.00579	-0.10381	0.00961	-0.03608	-0.04343
Dry scenario	-0.06775	0.04694	0.00365	-0.00572	-0.10539	0.0093	-0.03399	-0.04336
Wet scenario	-0.06457	0.04755	-0.0004	-0.00581	-0.10221	0.00991	-0.03804	-0.04345
	Model (5)							
	Youth (age 20-24)				Others (age 25-54)			
	Cold	Medium	Hot	All	Cold	Medium	Hot	All
2004 data								
Actual	-0.02461	0.03595	-0.01306	-0.00057	-0.09771	0.01867	-0.0356	-0.03821
Predicted	-0.05696	0.06444	-0.0092	-0.00057	-0.0946	0.0268	-0.04684	-0.03821
2030 predicted								
Mid scenario	-0.05565	0.06613	-0.00741	0.00102	-0.09329	0.02849	-0.04505	-0.03662
Dry scenario	-0.05593	0.06574	-0.00797	0.00061	-0.09357	0.0281	-0.04561	-0.03703
Wet scenario	-0.05584	0.06586	-0.00761	0.0008	-0.09348	0.02822	-0.04525	-0.03684
2050 predicted								
Mid scenario	-0.05761	0.06373	-0.01015	-0.00134	-0.09525	0.0261	-0.04778	-0.03898
Dry scenario	-0.05825	0.06299	-0.01107	-0.00211	-0.09589	0.02535	-0.04871	-0.03975
Wet scenario	-0.05696	0.06444	-0.0092	-0.00057	-0.0946	0.0268	-0.04684	-0.03821

Source: Authors' estimation.

4. Conclusion

Is climate change expected to generate larger net internal migration flows in Yemen away from areas with higher expected temperatures? Using census and weather data, this chapter has tried to answer this question. We found that although higher temperatures and higher variability in temperatures are associated in a statistically significant way with lower net migration rates, the effects are not large. Out-of-sample predictions suggest that with the increase in temperatures that are to be expected under various climate change scenarios, the impact of climate change on net migration rates is not likely to be large. It should be strongly cautioned however that these results are based on past patterns of migration and climate in Yemen, and "business as usual" extrapolations of past patterns. Therefore the simulation may not capture what might happen in the future under more drastic changes in climate, including much more severe weather shocks.

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