Climate Change, Livelihoods, and Gender Norms: What Is Driving Changes in Women's Migration in Southwest Bangladesh?

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Abstract

The area of environment-migration and migration as an adaptation to climate change is of considerable interest to scholarship and development alike, yet women often are left out of analyses. Using Bangladesh as a case study, this study seeks to gain quantitative understanding of shifting social barriers to women's migration in the context of rapidly changing economic and environmental conditions and uses novel demographic data and modeling to capture and analyze the dynamism of this topic. Findings reveal increasing economic internal migration of women that is responsive to extreme weather and household social acceptance of women's migration. Agricultural status is found to change the relationship between extreme weather and economic migration, with heat waves, dry spells, and wet spells suppressing female migration in agricultural households. The intensity of the shock is also found to be important, and extreme drought years reverse this trend, increasing female migration in agricultural households. A measure of social acceptance of women's migration finds households with greater acceptance are more responsive to extreme weather, regardless of agricultural status. Individual and household demographics, measures of social capital, and economic opportunity are combined in analysis to investigate the connections between household and macro-level characteristics in predicting migration of women.

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I. Introduction

Women's migration is not a new phenomenon: many migrant streams are approaching or have already achieved gender balance in the last century (Donato & Gabaccia, 2015). Despite this, there is widespread exclusion of women in migration scholarship (S. R. Curran et al., 2006; Donato et al., 2006, 2017; Nawyn, 2010, 2019). In Bangladesh, migration is not gender balanced. In 2013, only 13% of international emigrants were women, while in the 2011 census, 60% of internal migrants were women (Barkat & Ahsan, 2014; BBS, 2015). The high level of internal migration of women in Bangladesh is consistently attributed to marriage migration, while internal migration of men is largely attributed to work (Afsar, 2003; M. Z. Alam & Mamun, 2022; BBS, 2015; Marshall & Rahman, 2013). The eighth-most populous country in the world, Bangladesh has experienced significant development and economic expansion in the last several decades, in large part due to the development of its export garment industry (CIA, 2020). And as the economy has expanded, simultaneously the impacts of climate change have mounted in Bangladesh's deltaic communities as extreme weather and climate variability increasingly disrupt communities and livelihoods (Dastagir, 2015; Sarwar & Islam, 2013). Despite this immense change, narratives about women's internal migration within Bangladesh have not much changed, even as women make up the majority of garment workers. This work aims to call into question that assumption of statis, and to do so, I differentiate migration that is related to family or marriage, which I refer to as familial migration, from economic migration. My research investigates how women's internal migration in Southwest Bangladesh has changed over the last thirty years, and especially how women's economic migration has changed in that time. I interpret the intersections of economic, environmental, and social changes, and ask these questions: First, has the *rate* of female internal migration out of rural Southwest Bangladesh communities increased over the last thirty years? Second, has the *type* of female migration changed during this period from being less familial in nature to being more economically motivated? Third, does environmental stress on households influence the rate of female migration? And if so, what are the processes that connect environmental change to women's migration (e.g., gender norms, livelihoods, labor opportunities), and *how* is intensifying environmental stress shifting migration risk?

The area of environment-migration and migration as an adaptation to climate change is of considerable interest to scholarship and development alike, yet women often are left out of analyses. This study seeks to gain quantitative understanding of shifting social barriers to women's migration in the context of rapidly changing economic and environmental conditions and uses novel demographic data and modeling to capture and analyze the dynamism and complexity of this topic. This thesis's approach focuses on women, centering the ways that women's migration is unique, making an original contribution to the scarcity of quantitative analysis on female internal migration in Bangladesh, as well as the common omission of females in studies examining environment and migration in Bangladesh. More generally, this study contributes to our understanding of how household, local, and macro contexts influence the ways women move and how climate change might alter those processes. The extreme nature of Bangladesh's context, its environmental stress, gender norms, rapid development, and femininization of its labor force, make connections clearer and more analyzable. Understanding these dynamics helps us to build a conceptual understanding that can be investigated in other contexts, a valuable contribution as global trends, such as escalating climate change, trade-oriented economic growth, and globalizing gender norms and labor opportunity (Benería et al., 2000; Seguino, 2007), continue.

II. Background

A. Theoretical foundations

I conceptually ground this work in the new economics of labor migration and cumulative causation theories of migration. I use the drivers of migration conceptual framework for environmental migration and the idea of social legitimacy of women's migration to modify and bridge those theories for understanding gendered realities and mobilities in the context of climate change.

New economics of labor migration

The new economics of labor migration framework, or NELM, has lent a cornerstone understanding to scholarship that looks at migration as a livelihood strategy. NELM was developed as an alternative to neoclassical migration theory, a paradigm that conceptualized migration as an individual-level decision based

on expected wage improvement and labor opportunity in a destination (Todaro, 1987). The NELM approach situates migration as a household or familial—not individual—strategy for income diversification and economic risk mitigation (Stark & Bloom, 1985). Remittances become a key instrument of household economic development as family members send money from their labor destinations back to their origin households. This money often supports family members remaining in place and bolsters the family's ability to weather local economic disruption where risk management institutions are more scarce, such as insurance mechanisms, credit, or government support (Massey et al., 1993; Taylor, 1999). Although environmental factors are not explicitly considered in this framework, they can become part of the 'risk' that a household mitigates through migration, and therefore NELM is a theoretical basis for many studies of environmental migration (de Sherbinin et al., 2022; Piguet, 2013). Environmental shocks and stressors contribute to what the framework would describe as local economic disruptions, and migrant remittances diversify household income to weather them. Feminist migration scholarship has criticized the new economics of labor migration framework for ignoring the discrepancies of power *within* a household and for its assumption that a household unit is rational and homogenous, rather than investigating the ways gender and social norms influence intra-household migration decision-making (Nawyn et al., 2009).

Cumulative causation theory

A complementing theory of migration is the cumulative causation of migration theory, which focuses on the social and economic contexts in which migration occurs, positing that the act of migration alters those contexts in ways that make further migration more likely (Massey, 1990; Myrdal, 1957). In Massey's treatment of cumulative causation theory, migration is analyzed as a household decision consistent with the new economics of labor framework but adds value by connecting this decision to local socioeconomic conditions and networks, which are, in turn, affected by conditions at larger scales. This becomes a feedback loop, where migration decisions stem from contexts of "personal characteristics, preferences, and the constraints imposed by the immediate socioeconomic environment," and then those migration decisions alter the contexts in ways to make further migration more likely (Massey, 1990, p. 9). Lindstrom and López-Ramírez develop this, examining the

'juncture point' between when migration is rare and driven by individual pioneers, the initial phase of migration, and migration takeoff, the second phase when the process shifts to being more socially driven (Lindstrom & López Ramírez, 2010). During this transition, social networks are built and subsequently the costs of migration are lowered in the community. As costs lower, migrations are more likely to be determined by migration aspirations or economic or other incentives to move, which leads to the final migration phase, the mature stage (Lindstrom & López Ramírez, 2010). The cumulative nature can also be a top-down process when growth in employment in a destination drives migration, which drives more employment growth, and so forth. (Massey, 1990). Cumulative causation theory has also been applied to environmental migration, adding environmental conditions to the socioeconomic contexts that drive a migration decision. Because there are many characteristics alongside environmental ones that contribute to migration, cumulative causation theoretically helps makes sense of environment migration findings that contradict, such as a hazard causing more migration in one locale and less in another (Faist & Schade, 2013). It is the interactions over time between environmental and other determinants that ultimately predict migration, as conceptualized by the drivers of migration conceptual framework presented by Black et al. (Black, Adger, et al., 2011b). Their framework allows for the analysis of complex relationships between migration and climate change and uncovers how households can use migration as an adaptive strategy to support environmentally stressed livelihoods (Black, Bennett, et al., 2011; Haan, 1999; Hunter et al., 2015; McLeman & Smit, 2006; Tacoli, 2009). However, the Black et al. framework does not treat the cumulative and circular feedback loops central to the theory of cumulative causation, lacking speculation on how environment might drive the creation of feedback loops.

Adding gender

Like NELM, cumulative causation theory is strengthened by avoiding a gender-neutral approach. Donato and Gabaccia argue that all migration occurs in gendered worlds in which the links and intersections among people, households, and societies are robust (Donato & Gabaccia, 2015). Gender serves as a key determinant of networks that facilitate migration, the socioeconomic context of migration, and motivation for migration (Boyd & Grieco, 2003; S. R. Curran & Saguy, 2001; Donato et al., 2017; Nawyn, 2019). Incorporating into the basis

of the cumulative causation theory the understanding that experiences of social networks, local socioeconomic conditions, and macroeconomic trends are deeply gendered offers a lens through which to analyze the migration of women. It is a natural extension of this to add the effects of climate change, which are also gendered, to the contexts influencing migration decisions of women. Hunter and David's 2009 review paper was one of the first calls to integrate gender in a nonsuperficial way into the emerging body of literature on environment and migration (Hunter & David, 2009). Gioli and Milan update the state of the field in 2018, finding that when gender is considered in quantitative research on environment and migration, it is usually done so as disaggregated data rather than with a nuanced gender lens (Gioli & Milan, 2018). Nuanced research would carefully treat the social norms and household and community characteristics that make up the context of a migration, in addition to more neoclassical drivers such as employment opportunities. Theoretical work of these reviews highlights that environmental change has gendered effects on migration through two primary pathways: a) increased severity and/or frequency of extreme weather, and b) changes in natural capital, such as agricultural potential or natural resources (Gioli & Milan, 2018; Hunter & David, 2009). Gender shapes how exposures are experienced and the livelihood options available to individuals that contribute to their ability to adapt to environmental stress and shocks (Adger et al., 2007; Arora-Jonsson, 2011; Carr & Thompson, 2014; Demetriades & Esplen, 2010; L. Jones & Boyd, 2011). A 2020 review article by Lama et al. furthers this foundation, advocating for a keen examination of how gender and gender norms influence the multitude of socioeconomic, political, and social processes that underlie migration and how climate change acts as a risk modifier to those processes (Lama et al., 2020). Chindarkar summarizes research at this nexus: "While research on climate change-induced migration in itself is scarce, its impact on women is under-explored" (Chindarkar, 2012, p. 1).

Consistent with the new economics of labor migration framework, this study will analyze the risk of individual migration by considering migration as a household decision and will view economic migration as a household strategy to diversify income. However, I will seek to address the shortcomings of NELM by considering the gender dynamics at the household level alongside environmental predictors. I use the theory of cumulative

causation to understand the change in women's migration over time, looking closely at the last thirty years and communities' transition from few 'pioneer' women migrants to takeoff stage and responsiveness to mobility incentives. With this lens, I consider a) how household social contexts might facilitate first-time economic migration of women, and b) how climate change is involved in these hypothesized feedback loops. To interpret socioeconomic contexts and their impact on migration, I center the idea of "social legitimacy" of women's migration as the key link between gender-neutral migration theory and the actual patterns of women's migration. Social legitimacy is a heuristic offered by Oishi, who posits that if female migration is not a socially legitimate choice, women's mobility will be lower than the new economics of migration framework predicts: Even if economic incentives exist to diversify livelihoods through migration, societal norms will limit this option (Oishi, 2005). For women, cultural and social norms at the societal level and government policy at the country level can outweigh the individual or household desire to diversify livelihoods: in other words, migration of women can be more "value driven" than "economically driven" (Nawyn, 2010; Oishi, 2002). Oishi centers the importance of social legitimacy as the link between individual agency and economic and policy macro-level forces influencing female mobility. If migration is not a socially legitimate choice determined by norms at the household, community, and even national levels, the barriers to mobility will be higher. Focused on women's international migration in Asia, Oishi claims that the social legitimacy of women's migration arises from (1) the history of female employment, (2) the feminization of the labor force, largely through export-oriented industry, (3) rural-urban migration flows stemming from the feminization of labor, and (4) gender equality in the society, namely educational attainment (Oishi, 2005, p. 145). Using proxies of these components at the family level in models that predict migration of women within Bangladesh, I adapt and operationalize the heuristic of social legitimacy to the household level—and recoin them as 'familial acceptance' of female migration—to connect changes in women's migration over time to household-level gender norms and macro-level changes of economic opportunity and environmental change. I investigate women's migration as both value-driven and economically and environmentally driven.

B. Bangladeshi context

The deltaic communities of Bangladesh are an ideal setting for studying environment-migration with a gender lens for three intersecting reasons. The first has to do with the environmental context of Bangladesh. The 2021 Long-Term Climate Risk Index rated Bangladesh as the seventh most affected country by extreme weather events in the last decade (Eckstein et al., 2021). Second, socially, there are strict, gendered structures that govern the social acceptability of male and female actions and have direct effects on women's mobility, labor participation, and adaptative capacity, making gender-sensitive analysis essential (Bridges et al., 2011). In the last forty years, gendered demands for women's labor have emerged, prompting increased female mobility (Kabeer & Mahmud, 2004). Lastly, Bangladesh is a highly mobile society and there is a substantial and growing scholarship on environmental migration in Bangladesh that sets the foundation for this work. These converging changes in Bangladesh create a valuable case study that can help scholars understand the links between climate change, gender norms, and the mobility of women.

Environment

The Ganges-Brahmaputra-Meghna, or GBM, low-lying delta of Bangladesh is considered one of the most vulnerable places in the world to climate change, representing both high physical exposure to natural hazards and low adaptive capacity, largely due to pervasive poverty and livelihood dependence on natural resources (MoEF, 2005; Wong et al., 2014). Bangladesh is exposed to both slow-onset environmental degradation and rapid-onset extreme weather and disasters, including cyclones, storm and tidal surges, erosion, heat waves, sea level rise, soil salinization, floods, and droughts (Dastagir, 2015; Sarwar & Islam, 2013). The predicted future impacts of climate change could be extremely disruptive to rural agriculture and natural resource-dependent livelihoods, and more than 60% of the population is rural (Ahmad et al., 1996; BBS, 2015; Sivakumar & Stefanski, 2011; World Bank, 2011, 2019b, 2019a). Bangladesh is the fourth-largest rice producer worldwide (USDA Economic Research Service, 2022). Especially in rainfed systems, rice cultivation in South Asia is vulnerable to increased drought, with simulations projecting an increase in yield loss as climate change affects seasonal rainfall and increases saltwater intrusion (Li et al., 2015; Schneider & Asch, 2020). On a global scale,

crop yields are generally simulated to be more sensitive to extreme events than changes in the mean growing conditions, and most sensitive to temperature extremes and irregularities compared to precipitation ones (Vogel et al., 2019; Zhu & Troy, 2018).

Gender norms and labor

In South Asia and Bangladesh, a central social structure has traditionally been purdah, a patriarchal moral system that defines gendered spaces through seclusion of females from males, enforcement of female modesty, and restriction of female mobility—and is closely tied to honor and status of a family (Amin, 1997; Dannecker, 2005; Papanek, 1973; Weiss, 1994). Purdah structures the access women in Bangladesh have to livelihoods, opportunities, and assets and therefore their livelihood strategies within and outside their family context. The Bangladeshi labor force is mostly male, but its growth is driven by women entering the labor force for the first time (ILO, 2020b; Mahmud, 2003). The ready-made garment, or RMG, industry emerged in the early 1980s, growing rapidly to employ 4 million workers in 2018 (ILO, 2020c). Seeking a flexible workforce, the industry specifically and strategically recruits women for the majority of its labor (F. E. Ahmed, 2004; Ali et al., 2008). It is important to acknowledge that the garment industry became an economic powerhouse in Bangladesh by providing low wages to its workers and that there are numerous and horrific abuses tied to garment factories: Though wages and conditions are improving, most are yet to be considered "decent" work for female workers (N. Ahmed & Nathan, 2016; Akhter et al., 2019; ILO, 2020a, 2020c). It is also important to note that garment work can be a unique and effective way for Bangladeshi women and their families to escape poverty. Afsar found that more than 80% of the garment workers she surveyed were able to earn enough to rise above poverty level, a noteworthy shift, especially considering nearly all were first-time income earners (Afsar, 2003). Rahman et al. highlight that while poverty is an expected push factor, social factors and attitudes are strong mediators in women's participation in the labor force and that marital status, age, and education can also be important predictors (Rahman & Islam, 2013). Bridges et al. find on a national level a positive relationship between extreme poverty and increased labor participation of women, likewise understood to be moderated by social norms (Bridges et al., 2011).

The intersections of purdah and poverty are key to understanding female labor migration in Bangladesh. Studies, primarily qualitative and focused on international migration, have examined the ways poverty challenges the practice of purdah, with a common framing that it is the poorer families that necessarily send female members to work outside the home. What these studies suggest is that the relationship between women's formal labor participation and purdah is two-way. Labor and mobility are restricted by purdah, *and* purdah is challenged by acts of female migration and formal economic contribution (Bélanger & Rahman, 2013; Dannecker, 2005, 2009; Rozario, 2007). For example, if a woman moves to work, it could be socially costly, but her act of moving for work works to reduce the social cost for the next woman. The recruitment of the RMG industry occurs in the context of changing social landscapes: the garment industry has developed as a largely female space through women's 'renegotiation' of purdah and patriarchal norms, the effect of which classified garment work as female work and therefore within the limits of socially permissible work for women (Kabeer, 2002; Udayagiri, 2002).

Rashid argues that in Bangladesh, female agency is primarily exercised within institutions of the family and household, rather than being defined by "liberal feminist models of 'empowerment'" (Rashid, 2013, p. 883). Change in norms can be generated by centering the family and household, the institutions at the heart of purdah (Hofmann & Buckley, 2013). By leveraging household livelihood stress and pursuing female labor options, social acceptability expands to encompass new behaviors. To use the language of cost-benefit analysis, findings of connections between poverty and labor participation suggest that when households face livelihood stress and poverty *and* there is the opportunity for women to participate in livelihood diversification, then the social costs might weigh less than the economic benefits. This could be happening through two intersecting mechanisms, both the expansion of the confines of purdah and the lessening of associated social costs, and/or that economic costs of women not working increase as rural livelihood stressors increase with climate change; both to the effect of prompting households to more readily send women when gendered pathways exist (Bridges et al., 2011; Rao, 2012). Another way to consider this is by analyzing the increase of drivers of migration

as a) the 'pull' of economic opportunity, b) the 'push' of stress on land-based livelihoods, and c) a decrease in the obstacles to migration set by social norms. It is important not to discount the autonomy women can exercise within the purdah system. For example, even in the early stages of women's entrance into the formal economy, when such choices were rare, one study of garment workers in 1990 found that the decision to go to work was overwhelmingly that of the woman, and often that decision was in opposition to their male household head (Zohir, 2001). The act of renegotiation of purdah to encompass more mobility and labor options is an act of agency. Rather than identifying women's migration as a challenge to purdah, this work seems to point to a reality where households are creating options for women to contribute to livelihood diversification *within* the purdah structure. That is, a woman's migration or entry into the labor force is not an independent decision that removes her from the context of her family, but that she participates in them by centering the need of her family.

Migration

Even with an increase in rural to urban labor migration for garment work, migration for marriage is the dominant flow for Bangladeshi women. As some government-produced migration data are considered inconsistently reliable, an important source of knowledge on internal migration demographics and motivation in Bangladesh comes from household surveys, which tend to disproportionately represent migrant men and hide migrant women (Afsar, 2011). Such surveys, however, lend conclusions that the migration of women is in large part internal, rural-to-rural, and marriage related (Afsar, 2003; N. Alam & Barkat-e-Khuda, 2011; G. W. Jones, 2020; Kuhn, 2005). Scholars and government reports generally express motivations for nonmarriage internal mobility in terms of urban economic opportunity and diversification of household income (Afsar, 1994, 2002, 2003; N. Alam & Barkat-e-Khuda, 2011; BBS, 2015; Hossain et al., 2003). The Bangladesh Bureau of Statistics defines a lifetime internal migrant as a person whose current district of residence is different than their place of birth, finding that around 38% enumerated in the 2011 census could be considered lifetime internal migrants (BBS, 2015). However, the census numbers would not show circular, temporary migration, nor much

of the short-distance moves taken within districts. This type of migration in Bangladesh is common, so the lack of data represents a significant gap in understanding.

International migration of women has been heavily moderated by government policies in addition to informal social norms and household-level power dynamics discussed previously. The Bangladeshi government has controlled the international migration of women through bans and other restrictions since the country was founded in 1971. Briefly, the government began to allow professional women workers to migrate in 1981, but this was soon reversed, and the ban on women's migration continued until 1988 until being reversed again to a strict ban in 1997—In 2003, the ban was lifted, and the official outflow of female migrants has steadily increased from 0% of total emigrants in 1990 to 13% in 2013 (Barkat & Ahsan, 2014; Bélanger & Rahman, 2013; Dannecker, 2005). The policies restricting female migration can be understood as being driven, even at this state level, by patriarchal values, in contrast to male migration, which is encouraged by the government as economically beneficial (Bélanger & Rahman, 2013; Dannecker, 2005; Oishi, 2002; Shamim, 2006). Internal migration has recently been approached from the same lens of economic benefit, but past government documents have tended to be vague or outright negative on internal migration, seeing rapid urbanization as a threat to city well-being, rural identity, and governance ability (Afsar, 2003; Barkat, 2020; Marshall & Rahman, 2013).

Martin et al. found scarce mention of the positive climate change adaptive ability of labor migration, though did find many policy and planning documents shifted in tone to be less anti-urbanization with the rise of the Awami League political party in 2008, which is still in power today (Martin et al., 2017). Meanwhile, migration generally, and international migration specifically, are viewed in an increasingly positive light (Martin et al., 2017). The IOM-driven Bangladesh Migration Governance Framework closely analyzes environmentally influenced migration, though the flow is framed more as climate displacement than an adaptive measure (Barkat, 2020). A recent national strategy paper focused on disaster management and climate-induced internal displacement (Siddiqui et al., 2015). As its description suggests, displacement rather than voluntary or labor

migration is its focus. Further, Bangladesh was featured as a case study in the high-profile Foresight report on migration and climate change (Black, Adger, et al., 2011a; MoEF, 2009). Despite the focus of these high-level documents on displacement, frequently studies on climate migration in Bangladesh report findings of complex, differential relationships. In other words, there is no single, linear relationship or effect of environment on migration, and the contexts of the environmental stressor, the community, household, and individual characteristics, and livelihoods are crucial pieces for understanding migratory responses that include, but are not exclusively, displacement. Many quantitative studies on environment and migration in Bangladesh find that mobility after environmental shocks and stressors is commonly temporary and short-distance—or significantly decreases—and is most often described by migrants in economic terms. This generalization is supported by quantitative studies in Bangladesh examining coastal and river flooding (Bernzen et al., 2019; Call et al., 2017; Chen & Mueller, 2018; Gray & Mueller, 2012; Hassani-Mahmooei & Parris, 2012; Pavel et al., 2022; Rayhan & Grote, 2007), drought and heat waves (Call et al., 2017; Carrico & Donato, 2019; Iqbal & Roy, 2015), and cyclones (Hassani-Mahmooei & Parris, 2012). Appendix Table A for selected summaries of climate-migration work in Bangladesh. A common rural-urban migration pathway springs in part from livelihood natural resource dependence: migrants and rarely whole families move to find work, propelled by the inadequacy of agricultural livelihoods due to crop failure, shortage of land, the seasonality of agricultural work, natural disaster, etc. (N. Alam & Barkat-e-Khuda, 2014; Falco et al., 2018; Maharjan et al., 2020, 2020, 2021; Mueller & Quisumbing, 2011).

Qualitative studies add detail to the complex relationships between mobility and environmental stress and emphasize livelihoods and social capital as key enablers and constraints of migration choices under environmental stress (Iqbal & Roy, 2015; Kartiki, 2011; Mallick et al., 2020; Martin et al., 2014). My hypotheses have been greatly influenced by the work of Evertsen and Geest, whose 2020 qualitative study focuses a gender lens on migration as an adaptation to environmental stress. Their research finds that "while social costs negatively affect the utilization and efficiency of female migration as an adaptation strategy to environmental stressors, it becomes clear that female migration is imperative to sustain livelihoods within the Bhola

community…" (Evertsen & Geest, 2020, p. 12). They call for quantitative analysis on women migrating independently as a climate change adaptation, a thread my work aims to pick up. This thesis is situated in climate-migration literature focused on agriculture as a key pathway that links the complex circumstances of a household with the choice to migrate. Mostly focused on international migration, this literature finds that agriculture dependence is a significant mediator of climate and environmental changes and migration throughout the world (Cai et al., 2016; Falco et al., 2018, 2019; Feng et al., 2010; Maharjan et al., 2020; Nawrotzki & Bakhtsiyarava, 2017). Using an earlier iteration of the Bangladesh Environment and Migration Survey used by this study, Carrico and Donato find evidence for this pathway for male migration, in which male migration is significantly predicted by the interactions between agricultural livelihood and extreme weather spells (2019). Joarder and Miller find evidence that short-term migration could serve as a survival strategy when poor agrarian households experience environmental shock (Joarder & Miller, 2013). Short-term migration of one family member could allow families who want to stay in their communities in the face of climate change to do so, and research shows that many families do want to stay (Mallick et al., 2020; Mallick & Schanze, 2020; Pemberton et al., 2021). Maharjan et al. undercover evidence for labor migration as a climate adaptation, finding that agricultural households with a migrant were 1.4 times more likely than nonagricultural households to take climate adaptation measures and that barriers were reported to be high for women to migrate when there were environmental stressors on their households, many citing safety concerns and family commitments (Maharjan et al., 2020, 2021).

Households are experiencing these national and global trends in economic growth, gender norm shifts, and climate change, and the decisions they make are the complex results of these drivers and the contexts of their relationships and communities. It is clear that Bangladesh is idiosyncratic and the ways that Bangladeshi families experience these drivers are context dependent and unique. Yet, and rather because of, the uniqueness of the Bangladesh case, it offers "hot spot" contexts that uniquely allow us to tease apart relationships. It presents relatively extreme experiences of environmental stress, gender norms, economic growth and the femininization of the labor force, and rapid development. Quantitatively examining household responses of women's

migration builds a case for how links could extend beyond local contexts. The extremity makes connections more clear and analyzable, and understanding these dynamics helps us build a conceptual map that can be applied to and investigated in many contexts, an essential contribution as global trends—escalating climate change, trade-oriented economic growth, and globalizing gender norms and labor opportunity (Benería et al., 2000; Seguino, 2007)—continue into the future.

III. Research Objectives and Hypotheses

My research uses rich survey data to uncover women's migration patterns in shifting environmental, macroeconomic, and livelihood contexts. To focus on how migrations could be linked to climate change adaptation and livelihood diversification versus the business-as-usual migrations linked to marriage and family, my analysis differentiates migration that is more familial in nature from those which could be more economically focused. I examine women's risk of migrating for the first time within Bangladesh, categorizing each first migration as either familial or economic. The outcome variable of interest is whether in a given year a migration was taken by a daughter, and this is sub-categorized into familial and economic migrations which are run in separate analyses. I use meteorological data to generate extreme weather indices giving yearly values for spells of extreme heat, dryness, and wetness that span the 1989-2017 survey dataset. Using the extreme weather indices as predictors for both familial and economic first migration migrations alongside a suite of social and economic controls on the individual, familial, and community levels, I seek quantitative understanding of the dynamics in play in Bangladeshi women's internal migration type and timing. Based on the literature that I have presented, I make the following predictions:

H1. Economic migrations of women are increasing over time both absolutely and vis-à-vis familial migrations.

H2. Women's economic migrations respond to extreme weather.

H2a. I expect agriculture and land-based livelihoods to modify the relationship between economic migration and extreme weather: I hypothesize that agricultural households are more likely to send a daughter on an economic migration after extreme weather.

H3. Women's economic migrations respond to the familial acceptance of women's migration.

H3a. I expect that familial acceptance modifies the relationship between economic migration and extreme weather. I hypothesize that households with greater familial acceptance of women's migration are more likely to send a daughter on an economic migration after extreme weather.

IV. Data and Methods

Bangladesh Environment and Migration Survey

I use the Bangladesh Environment and Migration Survey, or the BEMS. The second iteration of the BEMS used in this project gathered data in 2019. The survey covers 20 communities—small rural administrative units that together contain 30 total villages—each in southwest deltaic Bangladesh. The communities surveyed were chosen to capture the range of socioeconomic conditions and levels of vulnerability to coastal hazards that characterize the region. Within each, a complete census was conducted of all households, followed by random sampling of 200 of the households. The response rate was high at 95%, and the few households that refused or were not available were replaced by alternate randomly selected households. BEMS ethnosurvey methodology uses a flexible interview style to gather detailed information about households. Interviewers collect household histories of migration, livelihoods, land use, health, wealth indicators, perceived environmental conditions, and natural resources. To limit recall bias, the survey instrument collects data on the first, last, and second to last migration trips of all household members: In this thesis, only an individual's first migration is analyzed, aligned with findings that first migrations are more strongly associated with environmental stressors (Carrico & Donato, 2019; Nawrotzki et al., 2015). Daughters were selected as the sample to use the detailed data captured about the conditions of a daughter's natal household over time and to

hold constant the role within the household, which has shown to matter in migration decisions (S. R. Curran & Saguy, 2001). I expect first migrations of daughters to be more reliably reported, as generally daughters move to their spouse's household after marriage, possibly reducing the reliability of reported further migrations.

Analytical sample

The analyzed sample includes 1636 daughters from 889 households who were aged 15-39 years between 1989-2017, resulting in a total of 15,785 person-years. Analysis begins in 1989, when detailed weather data became available, and continues to 2017, the last year of full data collection. I limit the age period, despite significant numbers of first migrations before the age of 15, in order to capture the age of prime economic activity and when women are active on the marriage market; very few women migrate or marry after the age of 39. I exclude female-headed households, households without daughters, and individuals with incomplete demographic information from my dataset.

Variable definitions

Outcome variables

A migration is defined as a trip outside of the upazila—a subdistrict administrative district unit roughly equivalent to a county in the United States—that the individual lived and established a household for longer than three months. Upazila represents the second smallest administrative unit used in Bangladesh, so the use of this unit can capture relatively short distances while maintaining accuracy in recall. *Familial accompaniment* migrations are flagged by matching a daughter's first migration to any migration of a male household member above the age of 16, that is, migration that a woman presumably takes with a male guardian (Kabeer & Mahmud, 2004). *Familial marriage* migrations are identified if a first migration trip is taken in the same year of her marriage, aiming to capture the daughter moving to join her new spouse's household. The remaining first migrations are considered as those potentially economic in nature, and concisely referred to here as *economic*.

The dataset is a discrete-time person-year file and is analyzed using both logistic regression and survival analysis, predicting economic and familial migrations separately. See Appendix Table B for the list of variables and each's calculation and data source details, as well as descriptive statistics.

Individual-level predictor variables

Individual-level variables include the daughter's age, marital status—both time varying—and religion and level of education, which reflect the time of survey.

Household-level predictor variables

Household-level variables include an indicator of whether the mother works outside of the home and the level of education of the mother taken at the time of the survey. I have created an indicator of whether the father is the primary decision maker in the household, generated by asking the mother and father separately who makes decisions on health and house, or if those decisions are made equally. This variable indicates whether one or both partners listed the father as the sole primary decision maker over health and home decisions. This variable is used to proxy gender norms on the household level, expecting that if the father is the sole decision maker, that represents a household with stronger patriarchal practices. To understand dependency and specifically gendered dependencies, I calculated the ratio of male children to female children in the household. To assess household socioeconomic status, I calculated a wealth index that uses a household's belongings and transportation means, home materials, fuel use, and the education level of the father (to proxy human capital in the absence of salary data). This index is standardized across all surveyed households. I create a time-varying agricultural indicator to indicate that the household held—either by owning or renting—agricultural land in a person-year. A social capital variable indicates if a household has established social ties to a district with high associations with the ready-made garment industry. I define an established tie if the year is after the year of first migration by a daughter's grandparent, aunt, and/or uncle to an RMG-producing district. I use the variable to show familial links to areas with concentrated formal economic opportunities for women. Lastly on the household level, I generated an index of familial acceptance using indicators I expect to together proxy the

family's acceptance of women's migration, including the mother's education, if the mother works outside the home, whether the father is the primary decision maker, and if the household has female family members or female extended family and friends who have migrated domestically.

Community-level variables

The variables at the community level include the distance from the subdistrict to Dhaka, measuring the distance by road to the urban economic opportunity in the capital. It is important to note that distance does not necessarily mean accessibility in Bangladesh due to infrastructure disparity. To look at climate stress on livelihoods, I use annual extreme weather indices that cover the entire period from 1989 to 2017. I follow variable definitions reflecting recommendations by the Expert Team on Climate Change Detection and Indices (ETCCDI) to capture and characterize extreme climate events (Climdex, 2020; Donat et al., 2013; Dunn et al., 2020). The Warm Spell Duration Indicator, which I will refer to as heat waves, is calculated from the number of days per year that temperature exceeded the 90th percentile for six consecutive days compared to a baseline of 1961-1990. Consecutive Dry Days, which I will refer to as dry spells, is derived from the maximum number of days per year that received less than one millimeter of rainfall. Consecutive Wet Days, which I will refer to as wet spells, is derived from the maximum number of days per year that received more than one millimeter of rainfall. Lastly, an interaction between the Warm Spell and Dry Spell indicators, which I refer to as severe drought, is generated to capture years of intense agricultural stress. I apply these definitions by interpolating to the upazila level daily precipitation and temperature measurements using the Climdex R package (Bronaugh, 2013). Meteorological data was recorded at Jessore, a meteorological station that gives the most complete climate data for the sample region from 1961-2017 located in southwest Bangladesh. Each of these extreme weather variables is standardized by the mean and standard deviation of the community during the 1989-2017 period. This methodology and data have been used successfully in previous BEMS projects that associate demographic dynamics with extreme weather (Carrico et al., 2020; Carrico & Donato, 2019; Donato et al., 2016).

National-level variables

Using national estimates, I include female employment by the RMG industry to proxy gendered economic opportunity and connect growth in the industry to changes in migration risk. I also use this variable as a proxy for national social legitimacy of women's migration, drawing from the components of social legitimacy (Oishi, 2005). Another component of social legitimacy is gender equality, so I use national estimates of the gender parity index for primary and secondary school enrollment to look at gender equality on a national scale over time.

V. Results

Descriptive statistics

Migration

18.9% of the daughters included in the sample (n=468) have taken a first domestic migration classified as familial and 11.9% (n=295) have taken a first migration classified as economic. In Figure 1, controlling for year and community, the average probability of a daughter taking a first economic migration in a given year between the ages of 15 and 39 increases from 0.47% in 1989-1993 to 1.68% in 2009-2013 and 2.63% in 2014-2017. By contrast, the average annual probability of a daughter going on a first familial migration between the ages of 15 and 39 remains steady around 2.95% in 1989-1993 to 2.48% in 2009-2013 and 2.16% in 2014-2017, though year-to-year variation is high.

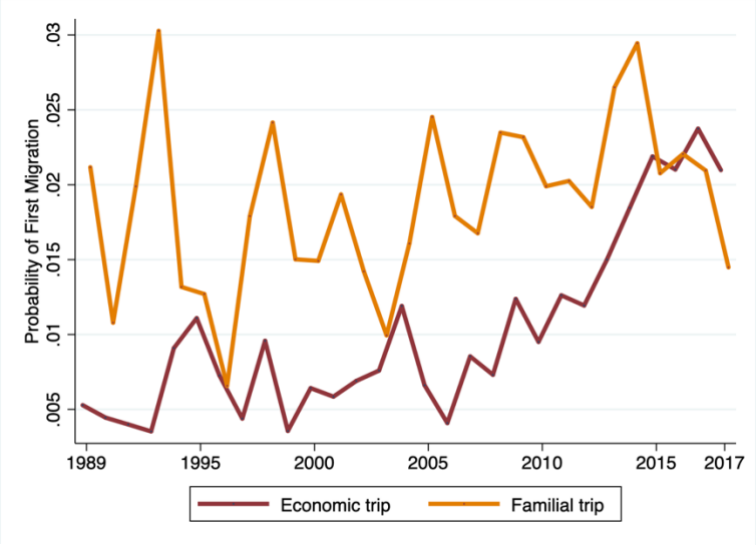

Figure 1: Yearly probability of migration over time

In Figure 2, Although the average annual risk of familial migration is higher, familial migration is highly concentrated in younger age groups. So, while familial migration rapidly decreases after age 25, the risk of economic migration continues through 39, though also concentrated at the younger age groupings. Over the entire 15-39 age range, the cumulative risk of familial migration is 5.4% and the cumulative risk of economic migration is 9.6%. Using stratified log-rank tests for equality of survivor functions, in the youngest age group, 15-19, risk of familial and economic migration is not statistically different. After age 20, the difference is significant ($p<0.001$). Note that this is limited to the time between ages 15 and 39, and the lifetime cumulative probability of a first migration is not represented in this figure. Using these data without age restriction (but following the same outcome variable definition, which is likely less reliable outside the 15-39 range), the cumulative probability of taking a first migration by age 49 is 9.09% for familial and 15.13% for economic migrations.

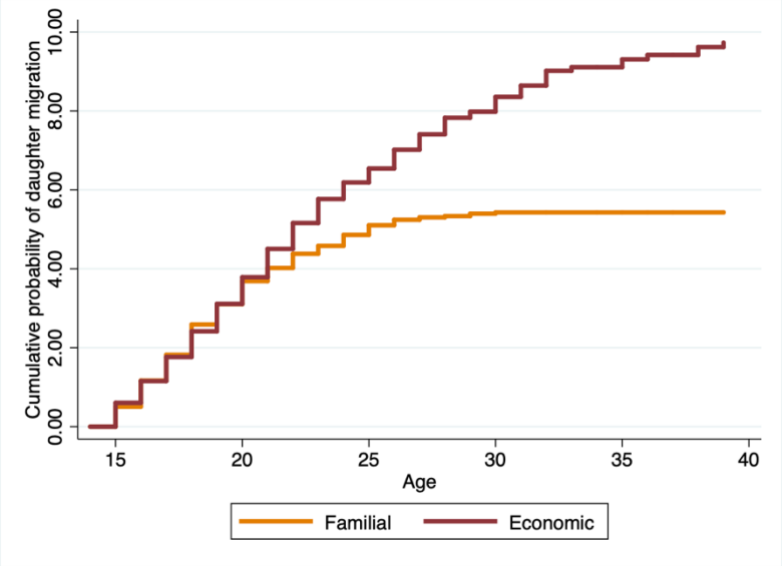

Figure 2: Cumulative probability of migration over ages 15-39

Extreme weather

Figure 3 shows extreme weather variables over time. Units are presented as yearly standard deviations from a given community's mean over the entire period. Community-years with large *positive* deviations represent years of substantial disruption. All four extreme weather indices are lagged one year to uncover time-delayed effects. Although negative deviations are shown for completeness, positive deviations, that is, years that have longer heat waves, dryness, both, or wetness, are considered more closely.

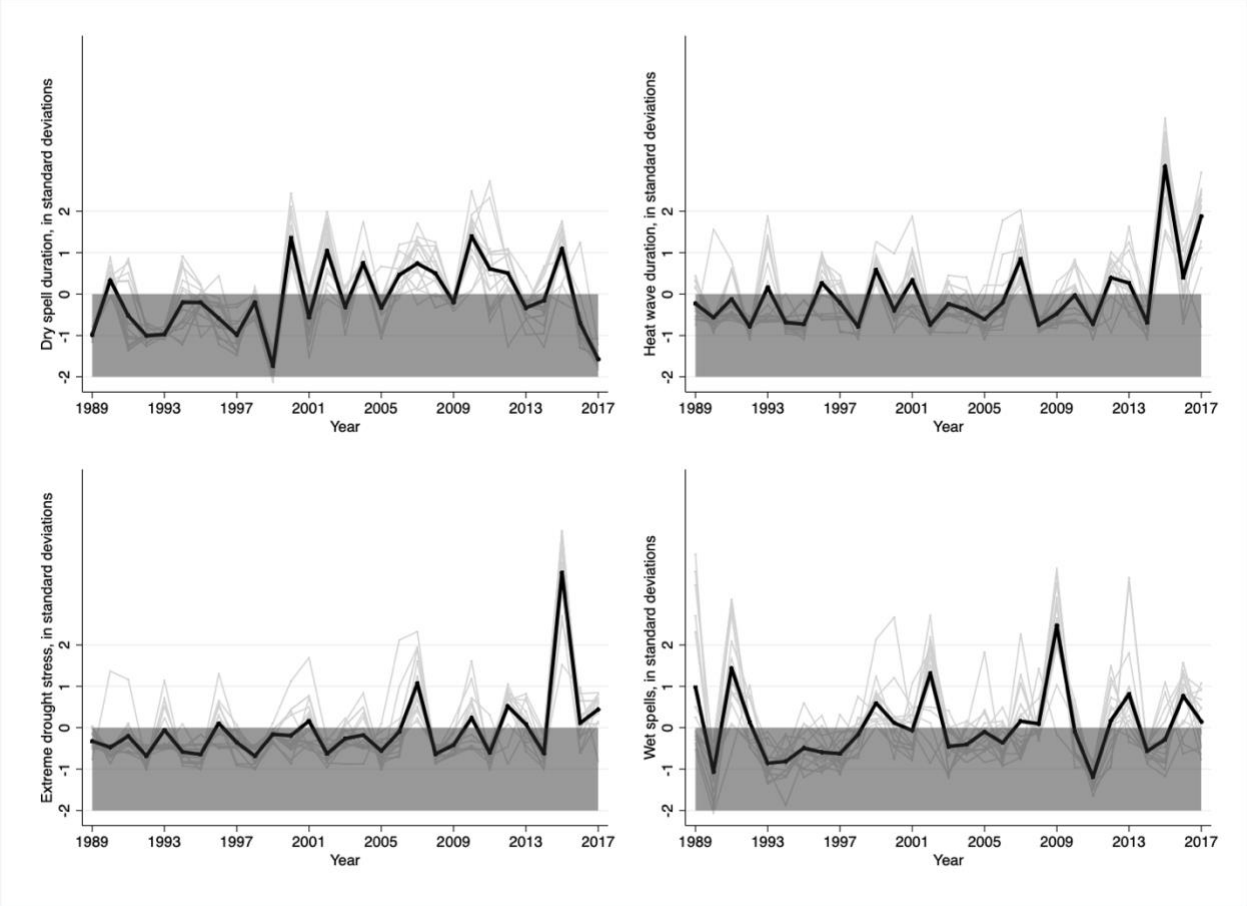

Figure 3: Extreme weather by community and year (individual community values in light gray, mean across communities in black, negative deviations are greyed out)

Regressing the indices by period of study, I find that all extreme weather variables have significantly increased over time. For each additional period after 1989-1994, dry spells have on average across communities increased 11% per period (or=1.112, p<0.001), heat waves 31% (or=1.307, p<0.001), severe drought 28% (or=1.278, p<0.001), and wet spells have on average across communities increased 8% per period (or=1.076, p<0.001). Table 1 shows that dry spells, heat waves, and severe drought have shown a more linear increase and with particular intensity after 2009, and wet spells have been less predictable.

Table 1: Extreme weather variables over study periods, units represent standard deviations

	Dry spell		Heat wave		Severe drought		Wet spell	
	or	se	or	se	or	se	or	se
ref: 1989-93	-	-	-	-	-	-	-	-

1994-98	1.252**	0.0900	0.890	0.0736	0.925	0.0596	0.537***	0.0754
1999-03	1.882***	0.152	1.186^	0.106	1.111	0.0764	1.245	0.191
2004-08	2.994***	0.292	1.100	0.0679	1.315***	0.0348	0.819	0.102
2009-13	2.906***	0.185	1.252*	0.131	1.418***	0.115	1.410**	0.153
2014-17	1.395***	0.0650	4.566***	0.702	3.634***	0.371	0.955	0.0819

Exponentiated coefficients; Standard errors in second column
^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Models A-C

I run six multivariate discrete-time logistic regression models to estimate the likelihood of a daughter making a first domestic migrant trip in a given person-year. Model A includes covariates for demographics and other characteristics at the individual, household, and community level, as well as community- and period- fixed effects. Model B adds extreme weather variables for dry spells, heat waves, severe drought, and wet spells. Model C interacts the extreme weather variables with a variable indicating whether the household held agricultural land in a given person-year. Models A-C are repeated to predict economic first migrations and familial first migrations. Table 2 presents results for economic migrations and Table 3 presents results for familial migrations.

See Appendix Table C for Model A predicting marriage and family accompaniment migration separately.

Table 2: Logistic regression models A-C predicting economic first daughter migration

Economic first migrations	Model A		Model B: + extreme weather main effects		Model C: + agriculture x extreme weather	
	or	*se*	*or*	*se*	*or*	*se*
ref: 15-19 years	-	-	-	-	-	-
20-24 years	1.181	0.218	1.087	0.208	1.092	0.210
25-39 years	0.419***	0.100	0.393***	0.0972	0.393***	0.0974
Married (L1)	1.375	0.292	1.552^	0.353	1.547^	0.352
Islam	0.448**	0.119	0.416**	0.119	0.407**	0.118
ref: Education=1, no schooling	-	-	-	-	-	-
Education=2, primary	1.957	1.410	2.020	1.468	2.011	1.461
Education=3, secondary	2.022	1.423	2.164	1.531	2.148	1.518
Education=4, higher	3.107	2.216	3.394^	2.445	3.424^	2.461
Mother works outside home	1.498*	0.297	1.362	0.300	1.342	0.295
ref: Mother's education=1, no schooling	-	-	-	-	-	-
Mother's education=2, primary	1.274	0.306	1.193	0.309	1.187	0.306
Mother's education=3, secondary	1.323	0.375	1.195	0.370	1.199	0.373
Mother's education=4, higher	3.333***	1.185	3.480**	1.321	3.414**	1.299
Father decision maker	0.705*	0.115	0.709^	0.126	0.705^	0.126
Ratio daughters: sons	1.130^	0.0804	1.124	0.0870	1.119	0.0871
Wealth (Z)	0.956	0.102	0.964	0.112	0.962	0.112
RMG district socap (L1)	1.570*	0.280	1.558*	0.295	1.542*	0.293
Dist. to Dhaka (Z)	0.665	0.238	0.666	0.241	0.639	0.232
ref: 1989-93	-	-	-	-	-	-
1994-98	1.266	0.672	1.628	0.970	1.640	0.989
1999-03	1.687	0.897	2.130	1.321	2.222	1.407
2004-08	1.545	0.774	1.914	1.115	2.065	1.228
2009-13	2.793*	1.323	3.362*	1.871	3.661*	2.081
2014-17	4.265**	2.079	5.419**	3.071	5.908**	3.420
Agricultural	1.206	0.195	1.221	0.208	1.418*	0.249
Dry spell			0.973	0.124	1.406*	0.220
Heat wave			0.927	0.172	1.568*	0.359
Severe drought			0.993	0.195	0.635^	0.156
Wet spell			0.946	0.0638	1.112	0.121
Agricultural x Dry spell					0.552**	0.113
Agricultural x Heat wave					0.430**	0.137
Agricultural x Severe drought					2.053*	0.697
Agricultural x Wet spell					0.765*	0.101
Constant	0.00291***	0.00294	0.00257***	0.00279	0.00228***	0.00249
Observations	17331		15785		15785	
Pseudo R^2	0.074		0.074		0.079	
AIC	2582.2		2334.5		2330.0	

Exponentiated coefficients; Standard errors in second column. Community fixed effects not shown.
^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Logistic regression models A-C predicting familial first daughter migrations

Familial first migrations	Model A		Model B: + extreme weather main effects		Model C: + agriculture x extreme weather	
	or	*se*	*or*	*se*	*or*	*se*
ref: 15-19 years	-	-	-	-	-	-
20-24 years	2.162***	0.309	2.292***	0.349	2.306***	0.349
25-39 years	1.369	0.459	1.538	0.533	1.526	0.528
15-19 years	1	.	1	.	1	.
Married (L1)	0.0118***	0.00460	0.0118***	0.00478	0.0118***	0.00478
Islam	0.880	0.211	0.973	0.276	0.972	0.279
ref: Education=1, no schooling	-	-	-	-	-	-
Education=2, primary	1.657	0.799	1.863	0.990	1.871	0.994
Education=3, secondary	1.512	0.738	1.756	0.943	1.765	0.948
Education=4, higher	0.722	0.368	0.878	0.490	0.883	0.494
Mother works outside home	0.926	0.147	0.933	0.157	0.933	0.157
ref: Mother's education=1, no schooling	-	-	-	-	-	-
Mother's education=2, primary	0.989	0.129	0.974	0.137	0.970	0.137
Mother's education=3, secondary	0.996	0.196	0.985	0.208	0.983	0.208
Mother's education=4, higher	0.499	0.309	0.731	0.448	0.740	0.452
Father decision maker	1.444**	0.168	1.481**	0.186	1.477**	0.186
Ratio daughters: sons	1.039	0.0469	1.083^	0.0502	1.084^	0.0505
Wealth (Z)	0.944	0.0799	0.888	0.0822	0.886	0.0822
RMG district socap (L1)	1.005	0.152	1.043	0.168	1.042	0.168
Dist. to Dhaka (Z)	0.616*	0.141	0.589*	0.136	0.589*	0.137
ref: 1989-93	-	-	-	-	-	-
1994-98	0.849	0.229	0.779	0.211	0.784	0.213
1999-03	0.645^	0.165	0.520*	0.142	0.521*	0.142
2004-08	0.974	0.236	0.756	0.190	0.762	0.191
2009-13	1.040	0.262	0.816	0.218	0.822	0.218
2014-17	0.919	0.243	0.702	0.199	0.709	0.199
Agricultural	0.859	0.102	0.925	0.115	0.945	0.121
Dry spell			1.040	0.104	1.056	0.152
Heat wave			0.983	0.171	1.143	0.297
Severe drought			1.096	0.194	0.996	0.266
Wet spell			1.014	0.0576	1.011	0.0839
Agricultural x Dry spell					0.976	0.177
Agricultural x Heat wave					0.750	0.246
Agricultural x Severe drought					1.201	0.414
Agricultural x Wet spell					1.008	0.109
Constant	0.0584***	0.0333	0.0496***	0.0311	0.0489***	0.0306
Observations	17331		15785		15785	
Pseudo R^2	0.221		0.219		0.220	
AIC	3035.6		2737.1		2743.3	

Exponentiated coefficients; Standard errors in second column. Community fixed effects not shown.

$^{\wedge}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Model A

Younger age groups are, on average, more likely to take a first migration trip. For economic migrations, the 15-19 and 20-24 age groups are the most likely to take a first migration, with the annual risk of a first migration dropping by 58% over age 25 (or=0.419, p<0.001). For familial migrations, the 20-24 age group has a likelihood of first migration 2.2 times higher than the 15-19 group (or=2.162, p<0.001), but this is driven by an imbalance in the data; the dominant subcategory of marriage migrations shows that the risk of marriage migration drops by more than half for 20-24 year-olds (or=0.457, p<0.001) and to nearly zero for those over 25 (or=0.0746, p<0.001). Marriage is not predictive of economic migration (or=1.375, p>0.10). Muslim women are half as likely as women of other religions to take a first economic migration (or=0.448, p<0.01). Although not significant, the effect sizes of daughter education suggest that more educated daughters are more likely to take a first economic migration than uneducated daughters.

The work and education of the mother significantly predict the migration of the daughter. If the mother reports that she works outside the home, the daughter is 50% more likely to take a first economic migration (or=1.498, p<0.05). If a daughter's mother is educated beyond secondary school, the daughter is 3.3 times more likely to take a first economic migration than those with mothers without education (or=3.333, p<0.001). Individual and maternal education were not predictive of familial migrations, nor was the mother's work status. The educational level of the father is not included because a) father is highly correlated with the education of the mother and b) it is a component of the wealth index and is therefore not duplicated as a covariate. The wealth index is nonsignificant for both economic and familial migrations. If parents reported that the father was the main decision maker for health and house- related decisions, the risk of the first economic migration of a daughter decreases by 30% (or=0.705, p<0.05) and increases by 40% for familial migrations (or=1.444, p<0.01). This effect is greater for family accompaniment migrations, and father primary decision making increases the risk of migration by 4.1 times (or=4.148, p<0.05). The social capital of the family in RMG-producing districts is predictive, with daughters with family members who have moved to districts producing

garments 1.5 times more likely to take a first economic migration than daughters without these connections (or=1.570, p<0.05). The distance to Dhaka, standardized by average community distance, is not a significant predictor of economic migration, but is of familial migration (or=0.616, p<0.05), driven by the marriage migrations (or=0.510, p<0.01). Lastly for the household-level covariates, the ratio of daughters to sons is marginally significantly predictive of economic migration; with each additional daughter than son, the risk increases by 13% (or=1.130, p<0.10).

For each 5-year period after the base period of 1989-1993, effect sizes suggest an increase, and the last two periods, 2009-13 and 2014-17, have significantly higher risk of economic migration than the base period. Risk of migration for 2009-13 is nearly 3 times greater (or=2.793, p<0.05) and 2014-17 is over 4 times greater than 1989-1993 (or=4.265, p<0.01). For familial migration, the period of 1999-2003 models a significantly lower risk of migration than the base period, but examination of familial migrations broken into marriage and family accompaniment shows that this is due to a very low number of accompaniment migrations in that period (n=20). Otherwise, as expected, while period-to-period variation is high, familial migrations have not trended over the analyzed time frame.

These period effects are co-explained almost entirely by the estimated size of female employment in the RMG industry. In Appendix Table D and Figure 4 (left), running Model A without period effects but with the number of women employed in the industry in a given year, an increase of employment by 1 million increases the risk of economic female migration by over 2 times (or=2.075, p<0.001). All period effects are insignificant if RMG size is added to the model, and effect sizes suggest contraction rather than expansion in economic migration over time. Export-oriented factory work and employment is one component of Oishi's social legitimacy, another is women's educational equality. To test whether the covariance of RMG employment and period is unique or if RMG could proxy social legitimacy, I ran the same regression using nationwide estimates of the gender parity index, or GPI, for primary and secondary school enrollment (World Bank, 2022). I find girls' educational attainment is an excellent predictor for economic migration, though RMG is a slightly better one

than the gender parity index: Above and beyond GPI, RMG is significantly predictive of economic migration in the absence of period effects, although the two variables are strongly correlated ($r = 0.939$, $p<0.001$).

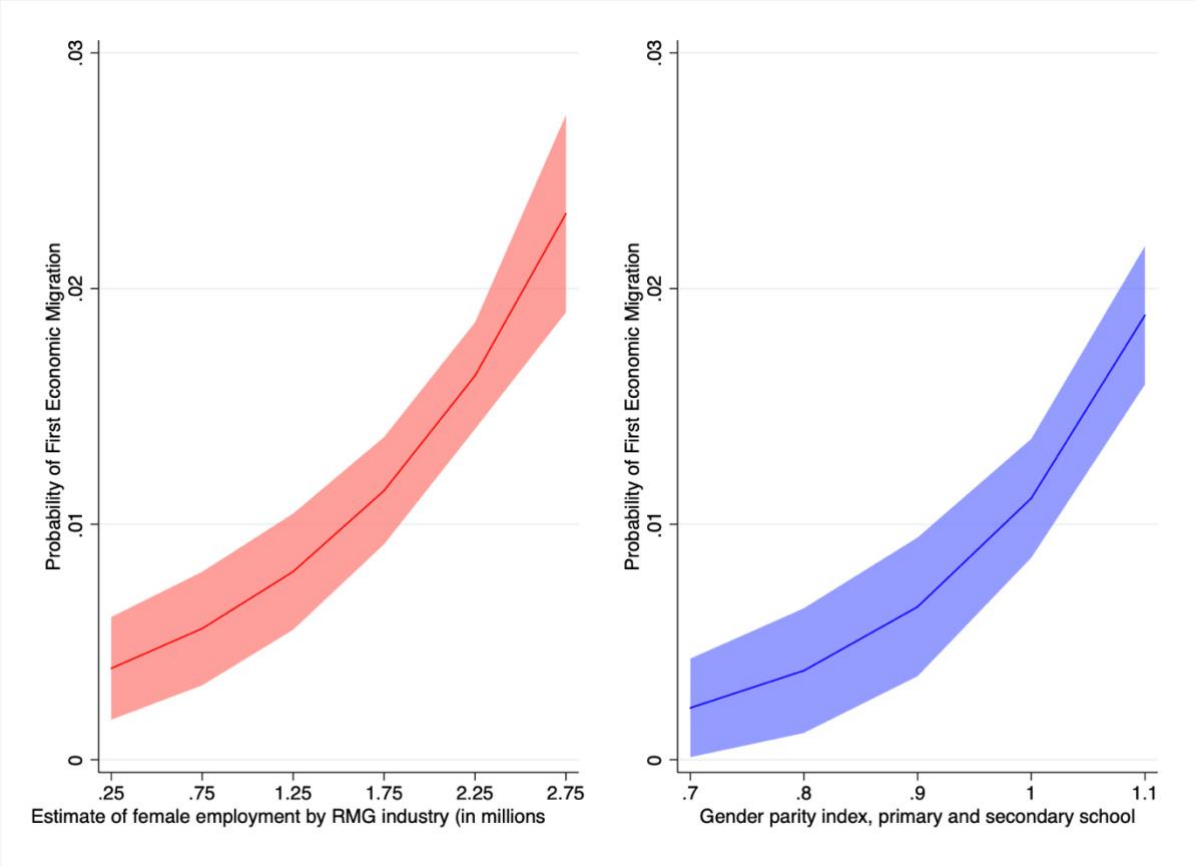

Figure 4: Probability of economic migration by RMG employment size, estimated using Model A (without period effects). Band shows 95% CI.

Models B and C

Model B adds one-year-lagged extreme weather variables. Extreme weather variables are the number of days in a maximum spell of extreme weather, standardized by community. As main effects, none of the lagged extreme weather variables are significantly predictive of first migrations. That is, the main effects of extreme weather do not significantly change the risk that a daughter migrates, and these variables do not improve on Model A.

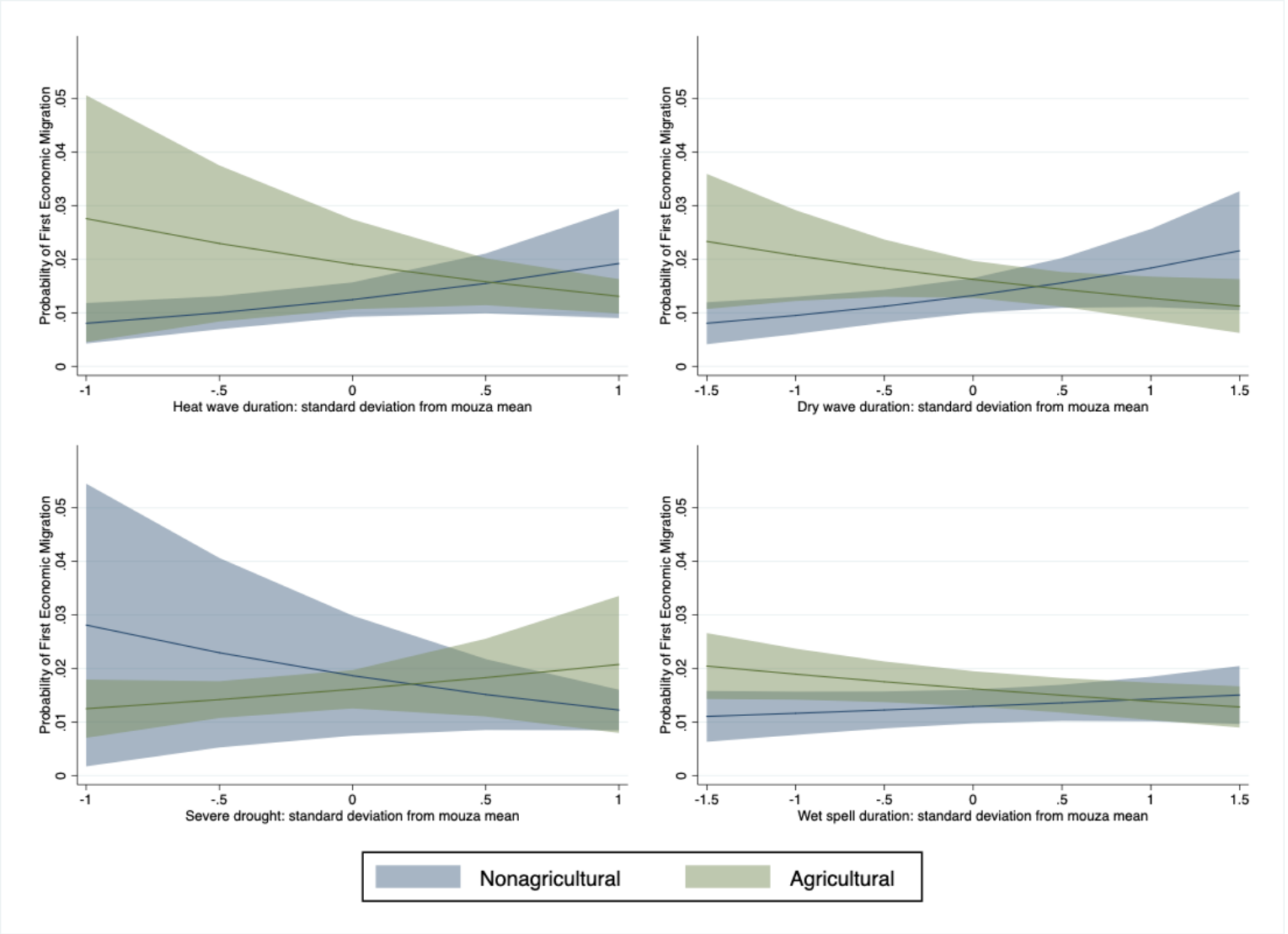

Figure 5: Average yearly probability of economic daughter migration by extreme weather

In Model C, I interact each extreme weather variable with a household's agricultural status, measured as whether the household held (owned or rented) cultivated land and likewise lagged by one year. In Figure 5, dry spells, heat waves, and wet spells all depress the likelihood that a daughter will take an economic migration in a given year for agricultural households. For each standard deviation above the mean number of dry days in the community, the risk of economic migration for agricultural households decreases by 45% (or=0.552, $p<0.01$). For each standard deviation above the mean duration of heat waves, economic migration risk for agricultural households decreases by 57% (or=0.430, $p<0.01$). For each standard deviation above the mean in the number of wet days, economic migration risk for agricultural households decreases by 23% (or=0.765, $p<0.05$). Severe drought is an interaction between dry spells and heat waves, generated to proxy agricultural stress in a given year. Divergently, this variable is significantly predictive of an increase in economic migration for agricultural households: As severe drought stress increases one standard deviation, economic migration increases by 105% (or=2.053, $p<0.05$). Another way to consider this variable is to go down the scale: As severe agricultural stress *decreases,* migration decreases for agricultural households.

In Table 4, calculating the simple slopes of these interactions for agricultural and nonagricultural households, I find different patterns of prediction for households that are *not* holders of cultivated land at the time of the extreme weather spell. For each standard deviation above the mean in the number of dry days, economic migration risk for nonagricultural households increases by 81% (or=1.811, $p<0.01$). For each standard deviation above the mean in the number of warm days, economic migration risk for agricultural households increases by 132% (or=2.324, $p<0.01$). For each standard deviation above the mean in the number of wet days, economic migration risk for agricultural households increases by 31% (or=1.307, $p<0.05$). Similarly to agricultural households, the severe drought indicator reverses the trend. As severe drought increases one standard deviation, economic migration decreases by 51% (or=0.487, $p<0.05$).

Table 4: Simple slopes derived from regression results presented in Table 2.

Economic first migration	Agricultural households		Nonagricultural households	
	or	se	or	se

Dry spell	0.552**	0.113	1.811**	0.372
Heat wave	0.430**	0.137	2.324**	0.738
Severe drought	2.053*	0.697	0.487*	0.165
Wet spell	0.765*	0.101	1.307*	0.173

Exponentiated coefficients; Standard errors in second column.
^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Odds ratios reflect the relationship between extreme weather and economic migration risk agricultural status and extreme weather, separately for agricultural and nonagricultural households

Investigating landholding further, I use stratified log-rank tests for equality of survivor functions and find that agriculture status does not significantly differentiate hazard of economic (p=0.898) and familial (p=0.981) migration. Furthermore, there are no age groups in which hazard of first economic migration is significantly different for agricultural and nonagricultural households. This suggests that while the overall yearly hazard of migration is similar for daughters in agricultural and nonagricultural households with no controls, the mechanisms predicting when a daughter in an agricultural household takes an economic migrant migration are unique from those predicting a migration for a daughter in a nonagricultural household. That is, agricultural status does not, on average, increase or suppress the annual migration risk, but it does matter for how extreme weather increases or suppresses the migration risk.

Models A2-C2: Familial acceptance

To test the effect of familial acceptance at the family level, I respecified the models above using an index generated through principal component analysis of binary variables in which 0 suggests lower familial acceptance for women's migration and 1 suggests higher familial acceptance for women's migration. See Appendix Table B for a full description. The variables already specified in models A-C were removed. In Figure 6, this indicator is severely right-skewed, with most households scoring low for familial acceptance. The factor is then median split into a below-median category, low, and above-median category, high. In Table 5, I run three new models, A2-C2.

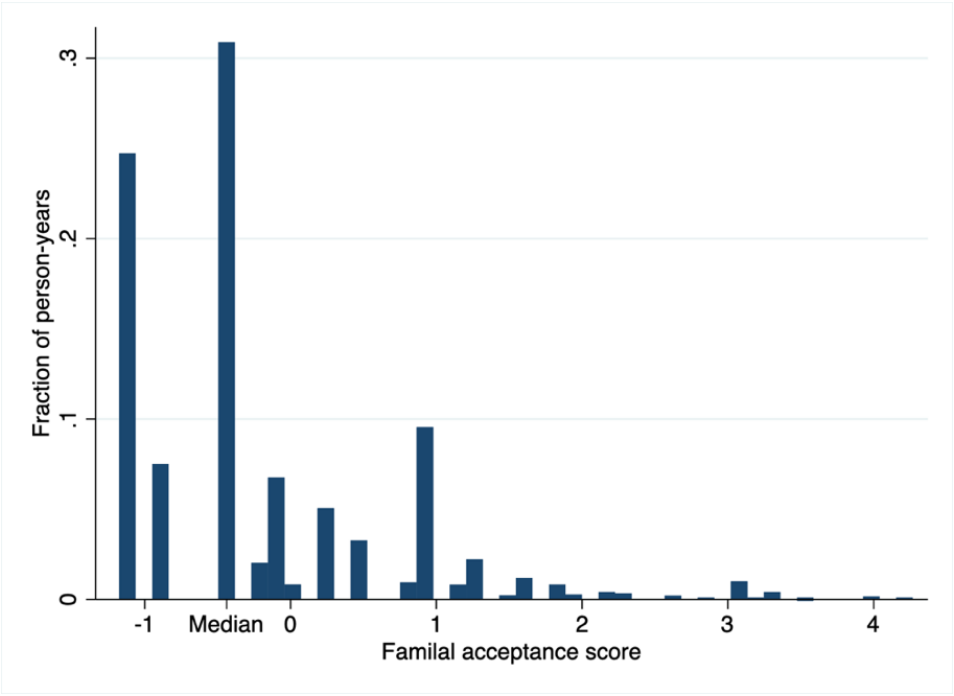

Figure 6: Histogram of familial acceptance scores (by % of person-years), median is indicated

Table 5: Logistic regression models A2-C2 predicting first economic daughter migrations using familial acceptance

Economic first migrations	Model A2: Incl. familial acceptance		Model B2: + Extreme weather main effects		Model C2: + Familial acceptance x extreme weather	
	or	se	or	se	or	se
ref: 15-19 years	-	-	-	-	-	-
20-24 years	1.125	0.203	1.020	0.192	1.012	0.191
25-39 years	0.396***	0.0921	0.367***	0.0887	0.367***	0.0890
15-19 years	1	.	1	.	1	.
Married (L1)	1.355	0.276	1.602*	0.350	1.606*	0.351
Islam	0.532*	0.145	0.500*	0.146	0.488*	0.143
ref: Education=1, no schooling	-	-	-	-	-	-
Education=2, primary	1.538	0.933	2.064	1.493	2.059	1.501
Education=3, secondary	1.543	0.918	2.219	1.539	2.205	1.538
Education=4, higher	2.477	1.516	3.743^	2.648	3.766^	2.684
RMG district socap (L1)	1.368	0.264	1.367	0.284	1.352	0.283
Ratio daughters: sons	1.155*	0.0843	1.151^	0.0925	1.151^	0.0926
Wealth (Z)	1.053	0.109	1.054	0.120	1.046	0.119
Familial acceptance	1.803***	0.289	1.824***	0.313	1.703**	0.307
Agricultural	1.267	0.207	1.337^	0.229	1.354^	0.231
Dist. to Dhaka (Z)	0.659	0.229	0.671	0.236	0.661	0.233
ref: 1989-93	-	-	-	-	-	-
1994-98	1.978	1.079	2.406	1.478	2.405	1.485
1999-03	1.982	1.053	2.499	1.532	2.550	1.566
2004-08	1.978	0.995	2.376	1.368	2.426	1.407
2009-13	3.518**	1.680	4.111*	2.265	4.204**	2.333
2014-17	5.540***	2.714	6.689***	3.758	6.836***	3.866
Dry spell			0.960	0.122	0.791	0.130
Heat wave			0.927	0.172	0.588*	0.142
Severe drought			1.017	0.199	1.606^	0.410
Wet spell			0.947	0.0640	0.893	0.0816
Familial acceptance x Dry spell					1.494^	0.339
Familial acceptance x Heat wave					2.467**	0.836
Familial acceptance x Severe drought					0.400*	0.143
Familial acceptance x Wet spell					1.141	0.150
Constant	0.00246***	0.00227	0.00142***	0.00154	0.00146***	0.00160
Observations	18399		16654		16654	
Pseudo R^2	0.068		0.071		0.074	
AIC	2682.6		2396.1		2396.7	
Exponentiated coefficients; Standard errors in second column. Community fixed effects not shown. ^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$						

Model A2

I find an 80% increase in probability of first economic migration as familial acceptance increases from low to high (or=1.803, p<0.001). Illustrated in Figure 7 and Figure 8, the resulting desperate outcomes over the 15-29 age range by acceptance level are distinct, with the yearly probability of first economic migration increasing as familial acceptance increases and survival analysis estimates of households with high familial acceptance scoring households having a 35.4% cumulative probability of a daughter migrating economically over 15-39 years, while households with the low level approaching only 19.2% over that age range. Using stratified log-rank tests of equality of survivor functions, the significant effect of familial acceptance on economic migration is significant (p<0.001) and robust over the 15-19 (p<0.001) and 25-39 (p=0.031) age groups, but not the 20-24 age group (p=0.621). The effect is also robust for agricultural households (p<0.001) and nonagricultural households (p=0.015).

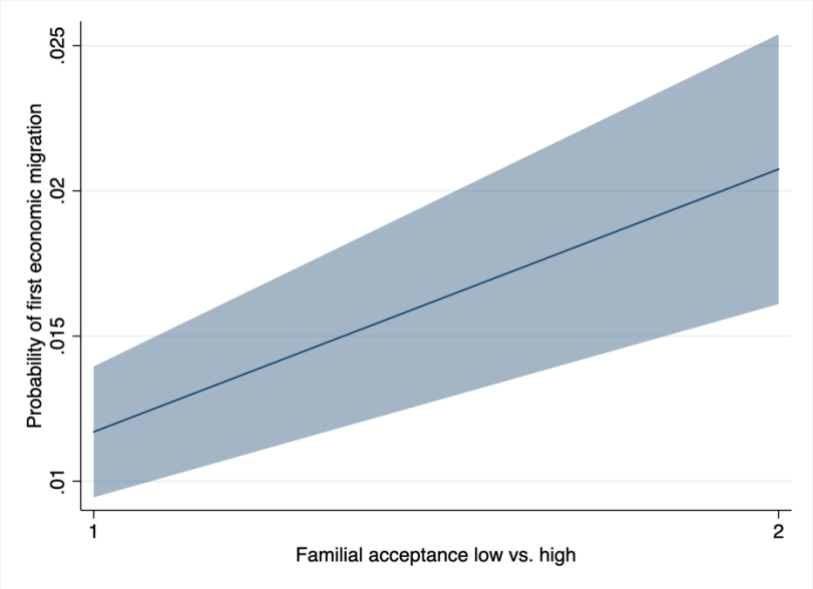

Figure 7: Probability of economic migration by social legitimacy (low and high, after median splitting), calculated using Model A2

Models B2 and C2

In Model B2, I test the main effects of extreme weather, expectedly not finding significance in those variables. In Model C2, I then tested the interaction between familial acceptance and extreme weather. I found that dry spell, heat wave, and severe drought have at least marginally significant interactions with familial acceptance. Like in Model C, dry spells and heat waves indicate opposite directionality as severe drought. As familial acceptance increases from low to high level, the effect of a standard deviation increase in dry spells increases risk of migration by 49% (or=1.494, p<0.10). In Figure 9, as familial acceptance increases, the effect of a standard deviation increase in heat waves increases risk of migration by 147% (or=2.467, p<0.01). In contrast, as familial acceptance increases, the effect of a standard deviation increase in severe drought suppresses the migration risk by 60% (or=0.400, p<0.01). There is no significant interaction between wet spells and familial acceptance.

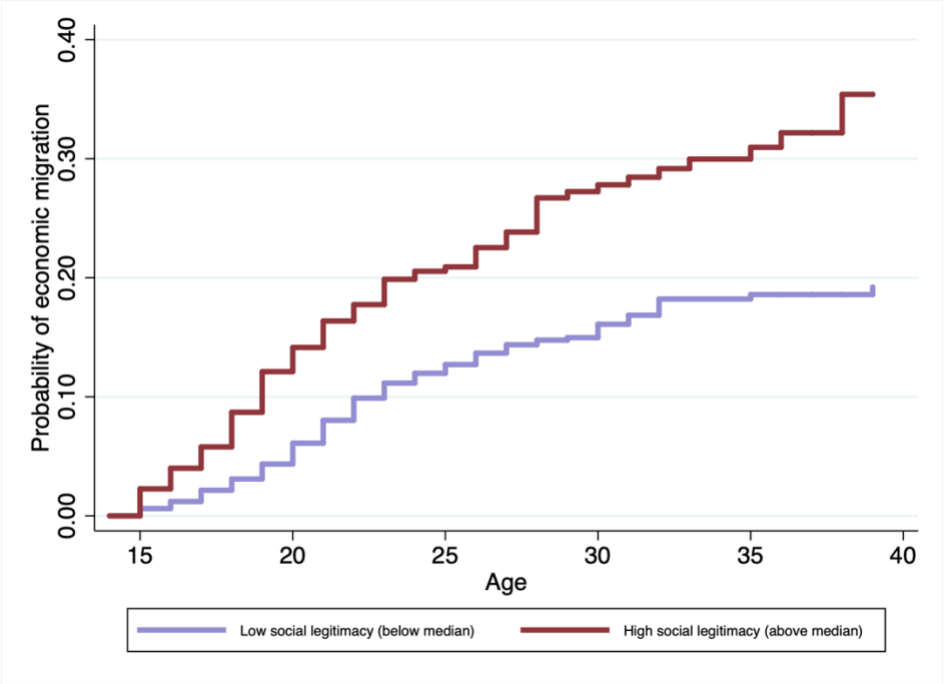

Figure 8: Cumulative probability of economic migration by family social legitimacy level

The interactions suggest that as familial acceptance increases, the effect of environmental stress on economic migration multiplies, while for severe drought, an increase in familial acceptance depresses the effect of stress on economic migration. However, it seems that the decrease in migration after severe drought is driven by households with greater family acceptance, which show a high risk of migration in years with low severe drought. Across extreme weather indicators, the migration risks for households with the lowest levels of familial

acceptance respond very little in the presence of *increases* in extreme weather and the higher familial acceptance group is generally more responsive groups to extreme weather spells.

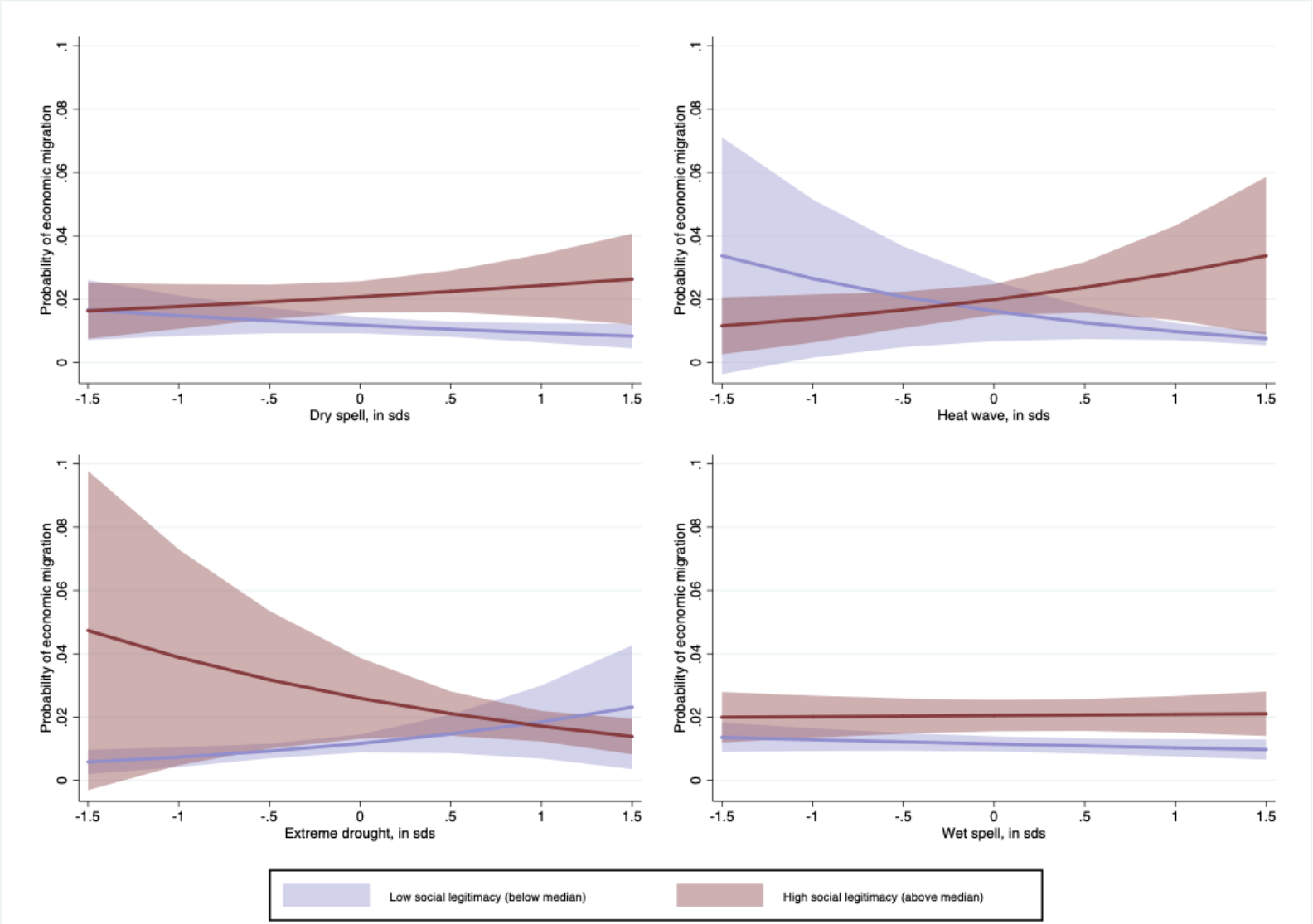

Figure 9: Probability of economic migration by extreme weather and familial acceptance

VI. Discussion

In this thesis, changes in type and risk of female migration are examined over time. Although a growing literature examines the relationships between environmental stress and migration in Bangladesh, this thesis focuses on the unique patterns of women's migration. Understanding the processes predicting marriage and family migration as unique from those leading to economic migration, I model the risk of a daughter's first migration, running separate models to predict familial first migration and economic first migration. I limit person-years to ages 15-39 to capture migrations during which the individual is most economically active and likely to marry. I use individual-, household-, and community-level predictors that capture gender norms, environmental conditions, and macroeconomic trends. Findings advance our understanding of how female migration relates to climate change and shifting socioeconomic factors.

First, these results support my first hypothesis that economic migrations are increasing over time and that they are increasing relative to familial migrations. Data support my second hypothesis that these economic migrations are sensitive to extreme weather, finding that agriculture indeed significantly moderates the relationship between the risk of a daughter's migration and the extreme weather that her family experiences. However, the relationship is opposite to what I predicted in H2a: agricultural households are only more likely to send a daughter on an economic migration after severe drought stress and are less likely after heat waves, dry spells, and wet spells. Lastly, I find evidence that economic migrations are responsive to the social legitimacy of women's migration, both as a measure of macrolevel indicators, women's employment and girls' education, and at the family level, supporting my third hypothesis. Bringing extreme weather and social legitimacy together, I uncover evidence to suggest that social legitimacy may enable the household to use women's migration as a response after an extreme weather spell, that households with higher levels of social legitimacy seem to send daughters more readily after environmental stressors, regardless of agricultural status. I find indications that the severity of event matters—extreme drought stress flips responses for all types of households (high and low social legitimacy, agricultural and nonagricultural). Female migration, like any migration, is complicated. My findings highlight the need for quantitative migration analysis that both includes women *and* strives to include

predictors that capture the culturally determined norms and situations that often differentiate women's migration risk from men's. This adds to the existing literature investigating women's internal migration in Bangladesh and environmental migration in Bangladesh and offers a conceptual roadmap for further investigation of women's migration in high-change environments. My study focuses on a period, 1989-2017, of extensive change for Bangladesh and Bangladeshi women. Macro-level changes are evident: a rapidly growing, industrialized economy, developmental progress reducing poverty and mortality and increasing health and educational opportunity, an intensification of rural to urban and international mobilities, climate changes. In modeling women's migration in this period, I sought to uncover evidence of these macrolevel changes in the migration patterns of Southwestern Bangladeshi women. What I found are clear indications that women's migration is significantly influenced by national industry, extreme weather, and individual and family level indicators that are directly or indirectly influenced by development and policy interventions.

The picture is one of recent and increasing change. It is not until the five-year period beginning in 2009 that women's economic migration takes off; probability of migration for 2009-13 was more than 3 times greater than 1989-1993 and 2014-17 is nearly 6 times greater than the same base period. This dramatic period effect, however, is co-explained by the rise in the ready-made garment industry. Female employment in the RMG industry and the period fixed effects are highly correlated ($r=0.942$, $p<0.001$). When RMG employment is added to the model, the once significant effects in 2009-13 and 2014-17 disappear. This could suggest that the temporal trends are nearly entirely driven by female labor opportunities in industry, and indeed running the base level Model A with RMG employment in place of period effects is a good predictor of economic migration. However, I interpret this as an indirect rather than direct connection, analyzing RMG employment as an input of another, more meaningful factor rather than the driver of migration itself. Social legitimacy of women's migration arises from four national-level components, including export-oriented industry growth such as the readymade garment industry (Oishi, 2005). What covariance of period effects and RMG employment could instead suggest is that as social legitimacy has increased over time, proxied by the increase in women's employment in the garment industry, economic migration has increased. To test this, I ran Model A again using

another component of social legitimacy, nationwide parity in the primary and secondary educational attainment over time. This model produced very similar results, lending credibility that macrolevel indicators of the social legitimacy of women's migration are excellent predictors of individual-level migration decisions, as it can be assumed that growth in the garment industry and increased education are reasonably exogenous.

In 2003, the Government of Bangladesh lifted its ban on women's international migration. Although this thesis focuses on internal migration, the policy change is another piece of evidence that national-level trends, norms, and policies are signals that social legitimacy and acceptance of women's migration are affecting individual mobilities. The opening of international migration to women by the government could be interpreted as a state-level indicator of the social legitimacy of women's labor migration. Five years later, the periods following 2009 show significant period-on-period increases in economic migration probability, possibly indicating a trickle-down effect on familial acceptance of women's migration.

To further examine the role of social norms, I generated an index of familial acceptance created from measures taken at the household level that together I intend to proxy the family's acceptance of women's migration. This index included the mother's education, if the mother works outside the home, if the father is the main decision maker, and if the household has female family members or female extended family and friends who have migrated. The index was median split into an indicator of low and high familial acceptance. I find familial acceptance to be an excellent predictor of economic migration of women above and beyond the period effects and individual- and household-level controls: as a daughter's familial acceptance increases, so does her chance of taking a first economic migration in a given year as well as her likelihood of migrating over the entire 15-39 age range. It is important to note that this index is not time-varying, and therefore is an imperfect test of the true familial acceptance of women's migration, which I would expect to be dynamic over time. Using a static indicator of familial acceptance means I cannot precisely test for evidence that the migrations are acting as cumulative causation theory coupled with the idea of social legitimacy and familial acceptance would predict: Over time, more migration means higher familial acceptance, which then leads to more migration. However, it

is useful to know that controlling for age, period, and individual and household characteristics, lower familial acceptance appears to be an obstacle to migration. Another strong predictor of a daughter's economic migration is whether parents have family members (defined as their parents or siblings) who have migrated to garment-producing districts. Daughters are far more likely to migrate in a year where these social ties exist than in a year without them. Together, these variables suggest two conclusions: first, the continued importance of the family as a site of decision-making and the nucleus of acceptance and legitimacy. Second is a likelihood of continuing expansion of female economic migration. As more family members live in economic centers, more rural members may join them. Similarly, if the familial acceptance of women's migration increases in households and communities, women could be increasingly likely to take economic trips.

The addition of extreme weather complicates the picture. I find that extreme weather events are highly predictive of migration—but only when differentiating between agricultural and nonagricultural households. The evidence suggests that for agricultural households, above-average heat waves and dry spells significantly *suppress* the likelihood that a daughter will take a first economic migration the year after. To a lesser extent, wet spells also suppress first migration for agricultural households. In contrast, severe drought *increases* the likelihood of the first economic migration for the same set of households. These findings contribute evidence to studies that examine agriculture as the mechanism that connects climate shocks to migration (Call et al., 2017; Carrico & Donato, 2019; Nawrotzki et al., 2015). Because migration is expensive, I would expect that additional stress on agricultural systems, presumably from extreme weather spells, decrease the resources a household has available to send a migrant by limiting crop productivity, etc. Heat waves and dry spells tend to have a greater impact on Bangladeshi farming, so it makes sense that these predictors have a greater effect than wet spells, which are common: One study estimated that during an average year, one-fifth of the country is covered in water by floods, which are considered an agricultural "necessity" rather than a threat (Mirza et al., 2003). Wet spells in this way serve as a robustness check, as they would not have been expected to predict migration as strongly. With heat and dryness, there appears to be a tipping point—when there is severe drought stress, proxied by the interaction between heat waves and dry spells, agricultural households could be finding

themselves without other options than to send female migrants on economic migrations. This flip could suggest that female migration is generally not used in the face of extreme weather because a) it is expensive and extreme weather reduces the ability to pay for migration, and/or b) the familial acceptance of female migration 'wins out' over the need of an agricultural household for income diversification, so that even when extreme weather affects the household, they choose to keep the daughter at home. Yet, when the stress on the agricultural household mounts, the calculus shifts, now, the social cost of sending a daughter on a migration is less than the benefit of gaining her income. Using data from an earlier iteration of BEMS, Carrico and Donato found that heat waves and dry spells *increase* the risk of migration for men engaged in agricultural livelihoods (2019). This might be because of difference in definition: I use the holding of agricultural land as an indicator of agricultural dependence rather than the livelihood status. This may indicate that either a) men have substantially different migration responses to extreme weather or b) that landlessness uniquely differentiates migration risk apart from livelihood.

Households that are nonagricultural are likely, however, to still be closely tied to the land and agriculturally based economies, and we expect many to be day laborers in agricultural settings. For the nonagricultural households—households that are not owners or renters of cultivated land—are significantly more likely to migrate after dry spells, heat waves, and wet spells, and are less likely to migrate after severe drought—the opposite of agricultural households. This mirrors findings in Bangladesh that find nonagricultural households or households not directly affected by shocks or stresses are more likely to migrate (G. M. M. Alam et al., 2020; Bernzen et al., 2019; Gray & Mueller, 2012). Agricultural status does not change the risk of economic migration in general, but rather it changes how extreme weather affects migration risk. Afsar compiled findings from studies in the early 2000s, finding that around 75% of women working in garment factories were landless (Afsar, 2003, p. 3). Since I control for wealth in each model, it is clear that landholding significantly modifies the relationship between extreme weather and female migration, above and beyond wealth. It is possible that because these households are not tied to the yields of their own land, they have the ability to move when conditions are severe but before conditions are desperate. It is illustrative to consider rice, a dominant crop in

the communities surveyed. Rice cultivation is highly labor intensive, so, for example, if a dry spell disrupts the harvest, the demand for labor will decrease. Nonagricultural households probably represent the labor supply, so when these jobs dry up, they are more likely to seek economic opportunities elsewhere by sending a female migrant while agricultural landholders have less economic mobility and might be more likely to carry on in situ.

I find evidence that familial acceptance affects a family's female migratory response when extreme weather occurs. Controlling for agricultural status, increased familial acceptance increases the positive effect of dry spells and heat waves. As dry spells or heat waves intensify, daughters of families with higher familial acceptance scores are more likely to take their first economic migrations. This could suggest that women's economic migration is being used as an adaptation to environmental stress only for households that are more likely to support women's migrations. Households with lower familial acceptance scores *are not as responsive to environmental stress*. This adaptive action does not seem to be as available to or utilized by them. Familial acceptance has a suppressive effect on the relationship between severe drought and migration. This could be interpreted by considering whether the reason higher familial acceptance scoring daughters are less likely to move after severe drought is that they moved earlier, when stress was high but not extreme. In other words, families with lower familial acceptance scores might be more likely to send a daughter only in the face of severe drought because they, like the agricultural households previously discussed, have reached a point of desperation. For both the models focused on agriculture's interaction with extreme weather as familial acceptance's interaction with the same, it seems that households in categories less prone to female migration—agricultural, low familial acceptance—still do experience an increase in female migration when confronted with extreme stress.

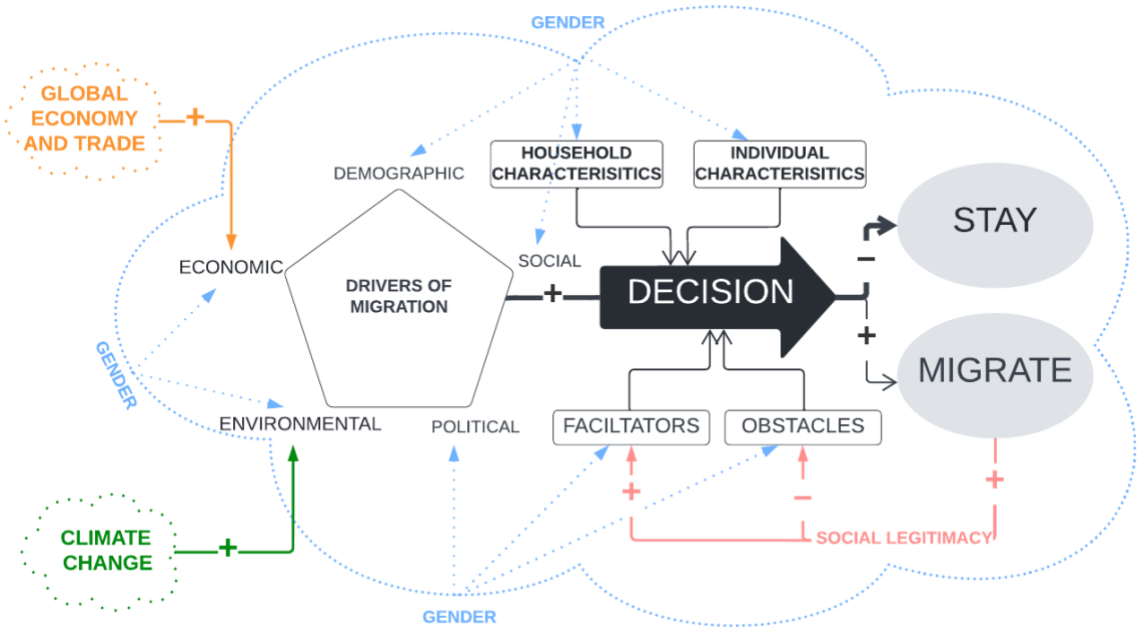

Figure 10: Gendered Drivers of Migration (adapted from (Black, Adger, et al., 2011a).

In Figure 10, I conceptually map the dynamics my findings suggest, using Black et. al's Drivers of Migration conceptual framework as a foundation (Black, Adger, et al., 2011a). What my analyses suggest is a situation where climate change is increasing the environmental drivers of migration and export-oriented industry labor opportunity is increasing the economic drivers of migration so that the decision point is being reached more often. Because of the constraints of social legitimacy and familial acceptance of women's migration, the obstacles are high, leading many of those decision points toward "Stay." But as households make decisions for daughters to migrate, the feedback loop of familial acceptance is strengthened, lowering the obstacles, which in turn leads more women to make the "Migrate" decision as the drivers continue to increase. My results suggest that familial acceptance serves as a facilitator to using women's migration to diversify household incomes when environmental stress strikes.

This thesis offers novel evidence of the importance of considering gender in studies of environment-migration and doing so in a way that investigates the value-driven *and* economically and/or environmental drivers and obstacles to migration. My findings have key implications for climate change adaptation in Bangladesh. I uncover evidence that the migration of women is both driven and suppressed by environmental stress in Bangladesh. The implication of environmental stress as a driver is that more women can be expected to migrate as climate change impacts intensify. The implication of environmental stress as a suppressor of migration is that more women will be immobile as climate change impacts intensify. Though seemingly contradictory, these realities, particularly the agencies and aspirations of women, need careful treatment by local and national policymakers and in further research focused on environment-migration in the region.

Limitations and Future Work

This project quantitatively investigates factors and contexts predicting women's migration and its findings are locally representative of the Southwest region of Bangladesh. Findings are not representative of Bangladesh as a whole, nor are they inclusive of very short distance trips. The research design of BEMS does not pick up very short distance moves for economic or familial trips, so if, for example, a daughter marries a person within her village, this would not be picked up by my analysis. Therefore, especially for marriage and family accompaniment migrations, which I expect are more likely to be local, especially in more rural villages, my findings will not fully reflect the sets of circumstances predicting *all* marriage and accompaniment migrations occurring for the sampled women, just those that are nonlocal. It is also necessary to re-emphasize that this analysis only considers first migration, and since familial first migration and economic first migration are likely to be competing risks, it means this thesis does not give full understanding to labor migration, as we expect married women to be a significant portion of those working in urban areas. This thesis, therefore, focuses on first-time entrants coming from their natal households. Future work considering the nature of how the probability of familial migration and risk of economic migration compete and whether that has changed over time would be a valuable insight. Testing whether the findings hold up when using complete longitudinal records and predicting all economic trips would likewise be valuable.

Several aspects of the findings presented would benefit from qualitative examination. First, to more precisely understand the mechanisms that connect a) extreme weather and migration via agriculture and b) extreme weather and migration via familial acceptance. Second, to investigate the nature of migration in the context of extreme weather: when and how is it more disruptive displacement and when and how is it more positive adaptation. The policy implications of this research rest upon that investigation. Further, it be beneficial to closely consider nonmigration in the context of extreme weather and livelihood stress, and whether it represents stuckness or desired status quo.

Planned further investigations and research direction

I will be adapting this thesis into a publication, aiming for submission during fall 2022. I plan two further papers directly stemming from this project. First, in November 2022, I will be traveling to Bangladesh to conduct qualitative work investigating the household-level decision making process around daughter migration. Using purposively chosen households to represent agricultural status, female migrant experience, social ties, and familial acceptance scores, I will conduct interviews to discuss why and how women's migration is occurring. This qualitative investigation will be treated as a 'ground truthing' exercise to test the validity of statistical findings and the Gendered Drivers of Migration conceptual map I have presented. I will adapt findings for a publication with a submission goal of 2023. Secondly, I will generate new analyses that run the models of this thesis to predict daughter *and* son migration. This paper will use multilevel modeling to consider community-level differences and the impact of local contexts and will delve into gendered differences in migration risk. This will be the third publication from this project, with a submission goal of summer 2023.

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VIII. Appendix

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Appendix Table A: Selected climate-migration work in Bangladesh and South Asia

Citation	Hazard(s)	Data & methodology	In short, climate-migration findings suggest…	Women specifics
(Pavel et al., 2022)	Short-term shocks (flooding, cyclones) and long-term (riverbank erosion)	Household Income and Expenditure Survey; Difference-in-difference analysis	Short term and long-term climate shocks force rural-to-urban migration. Migrant households have higher income and expenditures after shock than non-migrant households.	Female-headed households less likely to migrate to urban centers
(Ahsan et al., 2021)	Reported hazard impacts	Household survey; mixed method probabilistic modeling and qualitative analysis	Nonmigration is dominant trend, even in locales experiencing acute environmental stress, much of this is voluntary nonmigration.	
(Maharjan et al., 2021)	Perceived change and reported impact of climatic variables	Household survey, probabilistic modeling	Migrant households report higher agricultural adaptation measures.	Women increasingly participating in internal labor migration; female-headed households showed differing results

(Ayeb-Karlsson, 2020)	Cyclones	Discourse analysis	Gender is a determining factor in cyclone evacuation decisions, women's mobility more constrained.	<
(Evertsen & Geest, 2020)	Riverbank erosion	Qualitative	Women will migrate when environmental stress puts household in situation where male head of household cannot provide for family. There are real social costs of female migration on women themselves and their household (especially male heads). Economic benefits of migration can be outweighed by social costs.	<
(G. M. M. Alam et al., 2020)	Riverbank erosion	Household survey; focus groups	Households that have no/little agricultural land *and* limited employment more likely to migrate; households with land less likely to migrate.	
(Maharjan et al., 2020)	Climate sensitivity index	Household survey, descriptive statistics	Migration and remittance-sending serves as livelihood diversification, mitigating risks that include climate changes.	Women driven to migrate by livelihood disruption and extreme climate events but at lower rates than men; barriers to women's migration included sociocultural norms, domestic duties, lack of social and financial capitals
(Mallick et al., 2020)	Cyclone	Mixed methods; household survey, focus group, interview	Socioecological systems influence how households aspire to and complete migration in face of climate risk. Short-term migration supports long-term nonmigration.	
(Bernzen et al., 2019)	Flooding, riverbank erosion	Household survey; probabilistic modeling	Migration patterns are temporary, domestic, economic-focused. Non-agriculture more likely to migrate.	Gender roles of "breadwinning" promote migration; women's migration does not respond to variables that men's does
(Carrico & Donato, 2019)	Extreme weather	Retrospective household survey; probabilistic modeling	Dry spells most associated with increased migration, heavy rainfall less robust but suggested. Livelihood type, in particular agriculture, mediates relationship between climate shocks and migration. Social ties weakly associated with first domestic trips in presence of environmental stress.	
(Chen & Mueller, 2018)	Flooding, saltwater intrusion	Sample of Vital Registration	Flooding no effect, soil salinity has significant and heterogeneous (curvilinear) effect on migration,	

		System; probabilistic modeling	with migration more likely when soil slightly or extremely saline. Found that internal migration responded to different factors than international migration.	
(Paul & Ramekar, 2018)	Cyclone and flood events	Census; descriptive statistics	Coastal and districts categorized as "environmentally challenged" showed no statistical difference in internal migration rate than other districts or national average	
(Call et al., 2017)	Precipitation and temperature	High-frequency demographic surveillance data; probabilistic modeling	Flooding, precipitation, and temperature have varying effects on migration, and the effects vary in the short and medium term. Flooding, drought, and excess rainfall reduce migration risk. Increased temperature raises risk of migration. Wealthier households more likely to migrate in drought and less likely in excess rainfall. Livelihoods are key mediator between climate change and migration.	Men more likely than women to migrate in low rainfall times. Temperature increase decreases women's migration (opposite of men's)
(Islam & Shamsuddoha, 2017)	Disasters	Qualitative	Rapid-onset disasters cause displacement at large scale. Slow onset affect ecosystem services and opportunities, prompting more routine economic migration to diversify income.	Stuckness and Permanent migration has negative consequences, especially on women.
(Lu et al., 2016)	Cyclone	Trace mobile phone data; projections	Unlikely that there is casual link between cyclone and the short-term increased rate of migration to nearby urban center.	
(Stojanov et al., 2016)	General	Expert interviews	Migration is and will continue to be used as adaptation of climate change, but that the relationship is complex.	
(Iqbal & Roy, 2015)	Rainfall and temperature	Census; statistical modeling; projection	Reduced per capita revenue and rainfall variability could increase out-migration rates, but damaged crops are not found to.	
(Martin et al., 2014)	Perceived change and reported impacts	Qualitative, three case sites	Migration serves as adaptation to climate variability by diversifying land-based livelihoods; migration is mediated by sociocultural, behavioral factors. Social norms are a key element in predicting if/how migration used.	

(Joarder & Miller, 2013)	Perceived change and reported impact of climatic variables and hazards	Household survey; probabilistic modeling	Short-term migrations serve as a survival strategy when poor, agrarian households experience environmental shock.	Females more likely to be temporary migrants than males
(Gray & Mueller, 2012)	Flooding, crop failure	Longitudinal household survey	Flooding has moderate effects and crop failure has strong effects on mobility. Households not directly affected but living in affected area most likely to move. Disasters in some cases reduce mobility. Moves largely temporary, short-distance and poor not necessarily more affected than others.	Effects of flooding and crop failure on migration stronger for women than men
(Kartiki, 2011)	Cyclone	Qualitative	Mostly short-term migration, especially if households had limited social and financial capital; short-distance and temporary migration is not likely to enable households to adapt to climate change in the long-term nor increase resilience.	Gender inequality significant constraint on migration

Appendix Table B: Variable description and descriptive statistics

Variable	Description	Units	Min	Max	Mean by daughter	Sd	Lagged?	Time-varying?	Data source
Economic migration	DV: First migration, categorized as economic (not familial), trip taken in PY	0/1	0	1			N	Y	BEMS
Familial migration	DV: First migration, categorized as familial by being either marriage or family accompaniment migration, trip taken in PY	0/1	0	1			N	Y	BEMS
Marriage migration	DV: First migration, taken in PY of daughter's first year of marriage	0/1	0	1			N	Y	BEMS
Family accompaniment migration	DV: First migration in which daughter is traveling with a male family member above the age of 16	0/1	0	1			N	Y	BEMS
Age	Analyzed as three groups	Years	15	39	22.53	4.06	N	Y	BEMS
15-19	Reference age group	0/1	0	1	0.41	0.33	N	Y	BEMS

20-24		0/1	0	1	0.26	0.17	N	Y	BEMS
25-39		0/1	0	1	0.33	0.24	N	Y	BEMS
Married	Daughter is married in PY, starting in year of marriage	0/1	0	1	0.63	0.41	Y	Y	BEMS
Islam	Daughter is Muslim	0/1	0	1	0.94	0.25	N	N	BEMS
Education level	Daughter's education level, treated as categorical.	1	1	4	2.89	0.79	N	N	BEMS
Level=1	No schooling (reference category)	0/1	0	1	0.04	0.16			
Level=2	Some-completed primary school	0/1	0	1	0.29	0.42			
Level=3	Some-completed secondary school	0/1	0	1	0.41	0.50			
Level=4	Beyond secondary school	0/1	0	1	0.25	0.46			
Mother works	Mother works outside the home	0/1	0	1	0.17	0.40	N	N	BEMS
Mother's education level	Mother's education level, treated as categorical.	1	1	4	1.89	0.78	N	N	BEMS
Level=1	No schooling (reference category)	0/1	0	1	0.32	0.45			
Level=2	Some-completed primary school	0/1	0	1	0.50	0.50			
Level=3	Some-completed secondary school	0/1	0	1	0.17	0.40			
Level=4	Beyond secondary school	0/1	0	1	0.02	0.18			
Father decision maker	Father is primary decision maker; parents report that health and/or house decisions are not made equally or by mother	0/1	0	1	0.45	0.50	N	N	BEMS
Ratio daughters: sons	Ratio of number of daughters in household to number of sons	1	0.14	7	1.63	1.16	N	N	BEMS
Wealth	Standardized (by all sampled households) value of wealth; generated from factor score of principal component analysis of household belongings and transportation, home improvement fuel use, and education level of household head	sds	-1.67	2.67	-0.10	0.96	N	N	BEMS
Familial acceptance	Index proxying the family level of familial acceptance of women's migration; generated from factor score of principal component analysis of binary indicators of: mother having post-secondary	sds	-1.06	3.85	-0.20	0.93	N	N	BEMS

	education; primary decision maker is *not* father; mother works outside home; household has social ties to family members who are women migrants; household has social ties to extended family members and friends who are women migrants								
RMG district socap	Indicates whether individual has established social ties to RMG-producing districts. PY is 1 if a family member (mother, father, and/or sibling (in-law)) of the household head has migrated to Dhaka, Chittagong, Narayanganj, or Gazipur zilas.	0/1	0	1	0.19	0.39	Y	Y	BEMS
Distance to Dhaka	Standardized (by all sampled communities) distance in kilometers from center of community/subdistrict to center of Dhaka City along roads. Figures in paratheses are unstandardized data.	sd	-1.63 (61.6 km)	1.86 (283.9 km)	-0.01 (164.6 km)	1.01 (64.2 km)	N	N	OpenStreetMap
RMG female employment	Estimate of female employment by the RMG industry. Calculated by dividing total employment (in million workers) by estimated percentage of women employed in RMG, which is linearly extrapolated to decrease from 90% in 1990 to 60% in 2017. Descriptive stats by year, not individual	Millions of workers	0.27	2.72	1.61	0.78	N	Y	BGMEA, as cited by (ILO, 2020c)
GPI	Gender parity index for primary and secondary school enrollment, missing years are linearly interpolated. Descriptive stats by year, not individual		.73	1.11	0.97	0.13	N	Y	
Agricultural	Indicator that household holds agricultural land in PY	0/1	0	1	0.49	0.46	Y	Y	BEMS
Dry spell	Yearly maximum of consecutive days with less than 1mm of rainfall; as z-score standardized by community mean/sd over 1989-2017.	sd	-2.12	2.72	-0.01	0.40	Y	Y	BMD, calculated using methodology

									from (Dunn et al., 2020)
Heat waves [Warm spell]	Yearly maximum of consecutive days hotter than 90th percentile (compared to base period of 1961-1990) as z-score standardized by community mean/sd over 1989-2017.	sd	-1.09	4.24	0.06	0.53	Y	Y	BMD
Severe drought	Interaction between dry spell and heat wave; proxy for severe drought	sd	-1.01	4.75	0.03	0.36	Y	Y	BMD
Wet spell	Yearly maximum of consecutive days with more than 1mm of rainfall; as z-score standardized by community mean/sd over 1989-2017.	sd	-2.06	4.18	0.06	0.30	Y	Y	BMD
Period							N	Y	BEMS
1989-93	Reference category	0/1	0	1	0.10	0.21			
1994-98		0/1	0	1	0.13	0.16			
1999-03		0/1	0	1	0.16	0.15			
2004-08		0/1	0	1	0.20	0.17			
2009-13		0/1	0	1	0.22	0.18			
2014-17		0/1	0	1	0.19	0.29			

Appendix Table C: Logistic regression models predicting familial, marriage, and family accompaniment daughter migrations, Model A

Appendix Table C: Logistic regression models predicting familial, marriage, and family accompaniment daughter migrations, Model A

First daughter migration	Familial (all)		Marriage		Accompany family	
	or	se	or	or	se	or
ref: 15-19 years	-	-	-	-	-	-
20-24 years	2.162***	0.309	0.457***	0.0632	0.804	0.535
25-39 years	1.369	0.459	0.0746***	0.0192	1	.
15-19 years	1	.	1	.	1	.
Married (L1)	0.0118***	0.00460			0.632	0.472
Islam	0.880	0.211	0.511**	0.123	1	.
ref: Education=1, no schooling	-	-	-	-	-	-
Education=2, primary	1.657	0.799	1.519	0.648	0.118	0.168
Education=3, secondary	1.512	0.738	1.685	0.716	0.0768^	0.113
Education=4, higher	0.722	0.368	1.324	0.597	0.150	0.259
Mother works outside home	0.926	0.147	0.947	0.160	1.854	1.304
ref: Mother's education=1, no schooling	-	-	-	-	-	-
Mother's education=2, primary	0.989	0.129	1.051	0.150	1.307	1.114
Mother's education=3, secondary	0.996	0.196	1.073	0.220	1.740	1.788
Mother's education=4, higher	0.499	0.309	0.483	0.284	1	.
Father decision maker	1.444**	0.168	1.465**	0.180	4.148*	2.619
Ratio daughters: sons	1.039	0.0469	1.076	0.0510	1.213	0.313
Wealth (Z)	0.944	0.0799	1.004	0.0894	1.053	0.598
RMG district socap (L1)	1.005	0.152	0.993	0.160	1.398	0.981
Dist. to Dhaka (Z)	0.616*	0.141	0.510**	0.132	0.0128	0.0952
Agricultural	0.859	0.102	0.828	0.100	0.651	0.428
ref: 1989-93	-	-	-	-	-	-
1994-98	0.849	0.229	0.949	0.238	0.341	0.401
1999-03	0.645^	0.165	0.809	0.205	1	.
2004-08	0.974	0.236	1.201	0.291	0.472	0.289
2009-13	1.040	0.262	1.471	0.367	0.186*	0.150
2014-17	0.919	0.243	1.202	0.313	1	.
Constant	0.0584***	0.0333	0.0300***	0.0171	0.335	1.796
Observations	17331		17331		5536	
Pseudo R^2	0.221		0.091		0.117	
AIC	3035.6		3410.6		259.8	

Exponentiated coefficients; Standard errors in second column. Community fixed effects not shown.
^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix Table D: Logistic regression model A predicting economic using RMG and GPI

Economic first migration, Model A	Using RMG instead of period effects		Using GPI instead of period effects	
	or	se	or	se
ref: 15-19 years	-	-	-	-
20-24 years	1.179	0.219	1.184	0.220

25-39 years	0.433***	0.103	0.440***	0.105
15-19 years	1	.	1	.
Married (L1)	1.364	0.291	1.366	0.290
Islam	0.469**	0.124	0.478**	0.127
ref: Education=1, no schooling	-	-	-	-
Education=2, primary	1.928	1.408	1.890	1.379
Education=3, secondary	2.070	1.474	2.054	1.453
Education=4, higher	3.197	2.306	3.224	2.309
Mother works outside home	1.523*	0.301	1.510*	0.301
ref: Mother's education=1, no schooling	-	-	-	-
Mother's education=2, primary	1.290	0.310	1.286	0.310
Mother's education=3, secondary	1.356	0.382	1.346	0.382
Mother's education=4, higher	3.434***	1.202	3.356***	1.184
Father decisionmaker	0.704*	0.114	0.707*	0.114
Ratio daughters: sons	1.129^	0.0791	1.125^	0.0783
Wealth (Z)	0.937	0.100	0.930	0.0993
RMG district socap (L1)	1.599**	0.281	1.598**	0.281
Dist. to Dhaka (Z)	0.663	0.239	0.662	0.238
Agricultural	1.201	0.194	1.201	0.193
RMG female employ	2.075***	0.284		
Gender parity index			232.5***	300.7
Constant	0.00141***	0.00122	0.0000209***	0.0000345
Observations	17331		17331	
Pseudo R^2	0.070		0.069	
AIC	2584.0		2588.7	

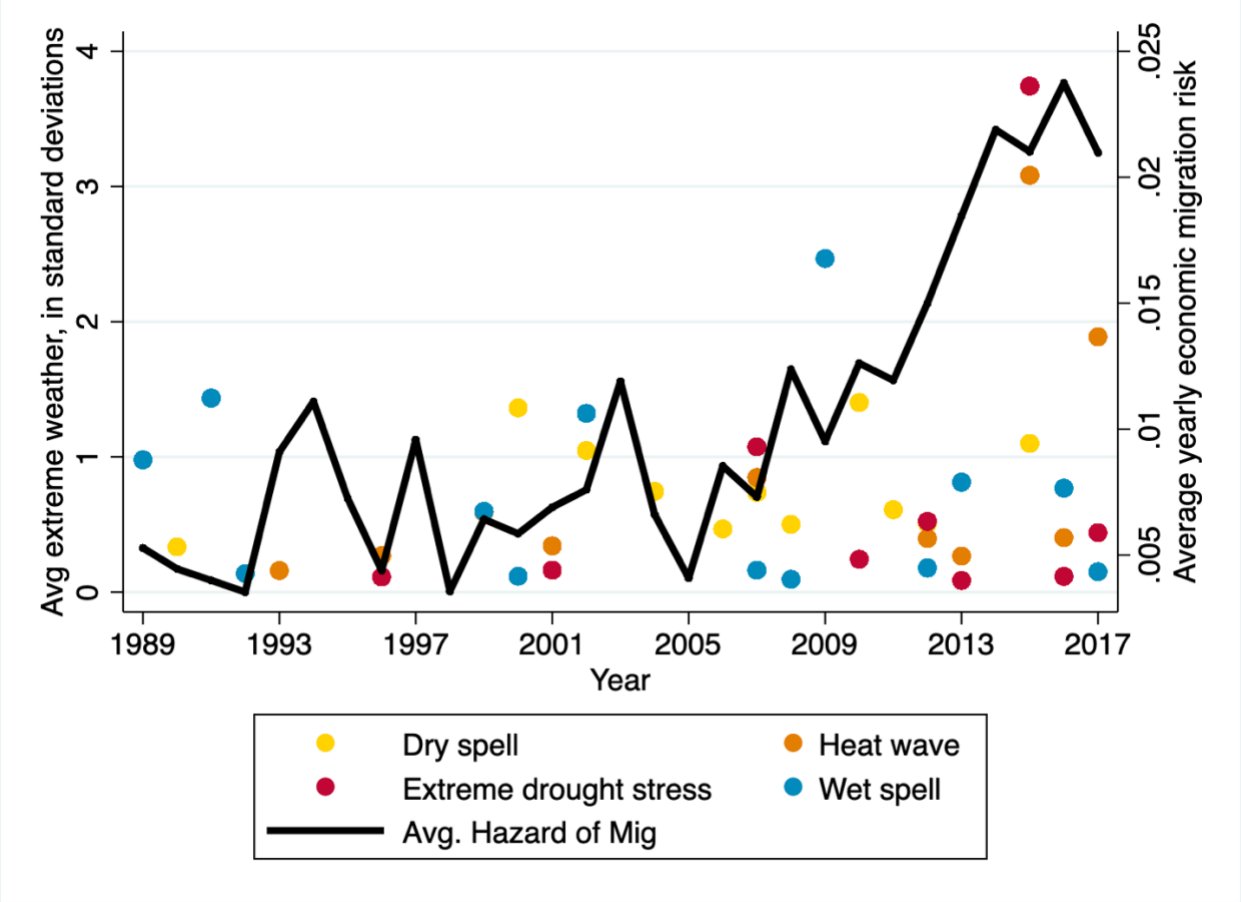
Exponentiated coefficients; Standard errors in second column. Community fixed effects not shown.
^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix Table E: Logistic regression models A-C predicting economic and familial first daughter migrations for nonagricultural households

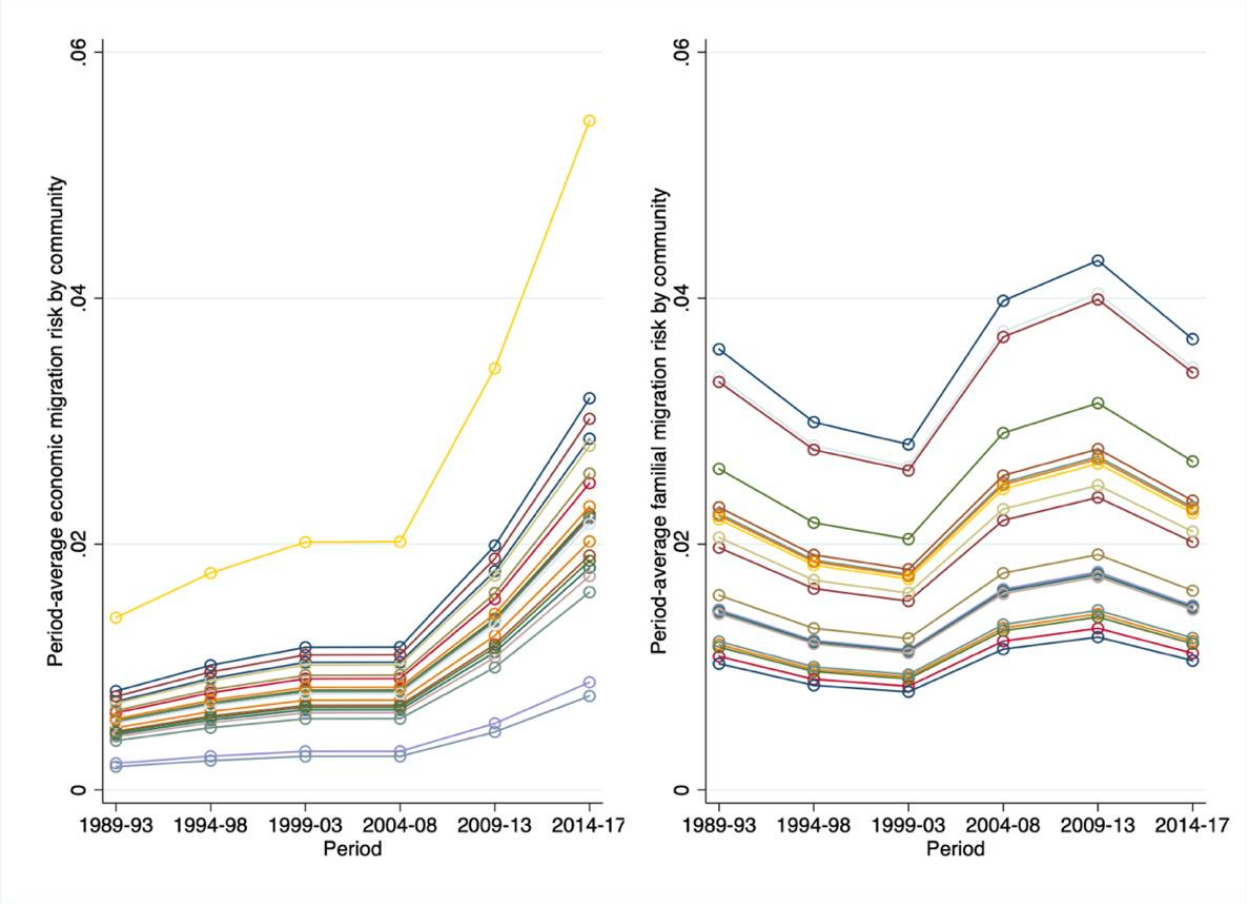
First migration for nonagricultural households	Economic		Familial	
	or	se	or	se
ref: 15-19 years	-	-	-	-
20-24 years	1.092	0.210	2.306***	0.349
25-39 years	0.393***	0.0974	1.526	0.528
15-19 years	1	.	1	.
Married (L1)	1.547^	0.352	0.0118***	0.00478
Islam	0.407**	0.118	0.972	0.279
ref: Education=1, no schooling	-	-	-	-
Education=2, primary	2.011	1.461	1.871	0.994
Education=3, secondary	2.148	1.518	1.765	0.948
Education=4, higher	3.424^	2.461	0.883	0.494
Female parent works	1.342	0.295	0.933	0.157

ref: Mother's education=1, no schooling	-	-	-	-
Mother's education=2, primary	1.187	0.306	0.970	0.137
Mother's education=3, secondary	1.199	0.373	0.983	0.208
Mother's education=4, higher	3.414**	1.299	0.740	0.452
Father decision maker	0.705^	0.126	1.477**	0.186
Ratio daughters: sons	1.119	0.0871	1.084^	0.0505
Wealth (Z)	0.962	0.112	0.886	0.0822
RMG district socap (L1)	1.542*	0.293	1.042	0.168
Dist. to Dhaka (Z)	0.639	0.232	0.589*	0.137
Nonagricultural	0.705*	0.124	1.059	0.136
Dry spell	0.777	0.124	1.031	0.130
Heat wave	0.674	0.166	0.857	0.188
Severe drought	1.303	0.340	1.196	0.271
Wet spell	0.851*	0.0669	1.019	0.0757
Nonag x Dry spell	1.811**	0.372	1.024	0.186
Nonag x Heat wave	2.324**	0.738	1.333	0.438
Nonag x Severe drought	0.487*	0.165	0.832	0.287
Nonag x Wet spell	1.307*	0.173	0.992	0.108
ref: 1989-93	-	-	-	-
1994-98	1.640	0.989	0.784	0.213
1999-03	2.222	1.407	0.521*	0.142
2004-08	2.065	1.228	0.762	0.191
2009-13	3.661*	2.081	0.822	0.218
2014-17	5.908**	3.420	0.709	0.199
Constant	0.00323***	0.00352	0.0462***	0.0295
Observations	15785		15785	
Pseudo R^2	0.079		0.220	
AIC	2330.0		2743.3	

Exponentiated coefficients; Standard errors in second column. Community fixed effects not shown.
^ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$



Appendix Figure A: Yearly average hazard of economic migration & above-mean extreme weather



Appendix Figure B: Period-community average risk of migration