The Effects of Immigration Policy on Migration Systems

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Declaration of Originality

I, Miranda Soledad Simon, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

This thesis examines the unintended effects of immigration policy. It develops a new theoretical framework to examine how aspiring migrants respond to immigration policy restrictions and the role social ties play in this process. It formalises this framework as an agent-based computational model (ABM) embedded with a range of experimental and other empirical designs that purposefully target different challenges in causal identification and measurement. This combination of methods allows us to examine policy scenarios and their counterfactuals and clandestine populations.

To help researchers combine empirical instruments with ABM, this thesis develops a general "Proactive Approach to Empirical Embeddedness," which relies on the co-evolution of empirical and ABM designs to generate targetted data collection strategies. The 'proactive' approach guides the research process of this thesis. The thesis is informed by an original nation-wide survey of Jamaica, a country with rich history of migration, designed with the primary aim of informing the model. Issues of endogeneity in measuring the effects of policy are addressed through the design of an audiovisual experiment, which showed that policy affects individuals' perceived ability but not their desire to move. Theory expects these feelings of 'involuntary immobility' will drive unauthorised migration. Issues of social desirability bias

in asking about this sensitive topic are mitigated through the design of a list experiment, which finds support for these expectations. The ABM, with these and other analyses embedded, shows that barriers to family and low-skilled migration produce the most unauthorised migration and that border enforcement is an inefficient solution. In the last chapter, this thesis examines another response to policy: reorientation to alternative countries. Theory expects robust spatial corridors to emerge from path-dependent network migration. Using ABM, this chapter shows policy restrictions can break path-dependence under dynamic conditions.

Impact Statement

Examining the causal effects of macro-level factors, such as a policy change or the introduction of a new technology is extremely important for social scientists. However, when we observe these types of changes in the real world, we cannot easily infer what would have occurred in their absence. In an agent-based computational model (ABM), we can simulate macro-level conditions and their counterfactuals, allowing us to isolate their causal effects. This thesis tailors an origin country survey to inform and feed data into an ABM of migration. Aside from examining policy scenarios and their counterfactuals, this combination of methods allows us to examine policy targets' adaptive and unexpected responses, simulate difficult to observe populations (such as unauthorised migrants) and examine the nonlinear effects that may emerge when policy information spreads across networks. These aspects are impossible or impractical to observe using statistical methods on their own.

ABM is a flexible method, which can integrate information from many types of qualitative or quantitative instruments. The synergy between agent-based modelling and empirical methods is vast and, as of yet, insufficiently explored. For example, it is difficult to observe the causal effects of a policy change. However, policy change may affect individuals through signals reflecting the new status quo and it is relatively easy to construct an experiment that exposes a randomly selected group of respondents to these signals. In an ABM framework, researchers can piece together this and other micro-level designs and simulate the macro-level conditions that trigger them. In so doing, researchers can develop simulation tools that model macro-level effects we cannot observe or isolate in the real world. These capabilities not only benefit scholars interested in the effects of immigration policy, but also those seeking to understand the full impact of a wide range of macro-level factors on a population. Furthermore, by allowing us to simulate scenarios that we cannot observe in the real world, ABM allows empirical researchers to access a wealth of new questions.

Empirically-driven ABM can also help practitioners, in any policy arena, develop expectations on policy outcomes. By allowing us to test hypothetical scenarios, ABM can also help us design smarter policies that limit its unintended effects. This thesis has had an impact on the way the UK government thinks about the effects of immigration policy. The main findings of this thesis were presented to the Migration and Border Analysis Unit in the UK Home Office. They said they believe it is the first time they have seen credible estimates of the extent of the 'substitution effect,' whereby otherwise legal migrants decide to migrate through unauthorised means due to changes in policy, and were interested in using a model such as the one presented in this thesis to estimate the efficiency of their enforcement efforts as a function of expenditure. Given the amount of data they have access to in-house analysis they carry out, this opinion shows that, in addition to its academic impact, the thesis can also have an important policy impact.

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Chapter 1

Introduction

1.1 Motivation

All countries have the same basic aims when it comes to borders: Allowing movement that is beneficial to their national interest, while keeping the rest out of the country. As such, entry policies consist of a multifaceted regulatory arm – a set of categories with different quotas and conditions – and an enforcement arm to deter and dampen illegal movement. This combination of interdependent components creates the legal environment within which aspiring migrants make plans and adapt to change. As I will discuss in Chapter 2, interpersonal ties between migrants and would-be migrants facilitate the circulation of information. Over time, these repeated local-level interactions become a system with its own internal momentum. As policy conditions change, the system adapts in ways that are difficult for governments to predict (Massey, 1990; Rosenblum and Brick, 2011).[1] Imposing

[1] Migration scholars have often used the term migration system to denote systems of countries which are connected by trade and migration (e.g. Mabogunje, 1970). In this

these complicated policy structures on adaptive social systems means that a change in one policy component can have "perverse, regrettable, and often unintended, consequences and feedbacks" (Hansen and Papademetriou, 2014, p. 1).[2]

In regards to security, a particularly costly form of adaptation is the reorientation of migrants to unauthorised channels when legal entry is restricted. Historical evidence has shown that unauthorised migration tends to coincide with visa restrictions (Clemens and Gough, 2018). Levels of unauthorised migration around the world are high and on the rise (GCIM, 2005). Estimates show that over 11 million migrants lived in the United States without legal documentation in 2016 (Krogstad et al., 2017) – a more than three-fold increase from 1990 levels (Passel et al., 2009; Hoefer et al., 2009). In the European Union, the size of the irregular migrant stock in 2008 was measured to be between 1.9 and 3.8 million. The recent refugee crisis led to a significant surge in irregular migration, with arrivals to Greece by land and sea surpassing 900,000 in 2015 (IOM, 2015). These high levels of undocumented movement are often perceived to threaten national security, the economy, and national identity (Hood and Morris, 1998; Cohen, 2001; Brader et al., 2008; Malhotra et al., 2013; Hainmueller and Hangartner, 2013; Hainmueller and Hopkins, 2014). For migrants themselves, the choice to migrate illegally is risky and can lead to precarious living conditions. Unauthorised migrants have limited access to services and protections from the state, they often work for sub-market wages, and they must accept conditions of extreme

thesis, I define a system to be a collection of individuals connected by social relationships.

[2]While many policies affect migration (Czaika and De Haas, 2013), this thesis refers specifically to restrictions on entry.

uncertainty (Eschbach et al., 2001; Donato et al., 2005). The cycle of risk perpetuates itself as restrictive, complicated immigration policies increase demand for intermediaries and create a market for organised criminal groups (Hernández-León, 2013).

Policy restrictions can also have knock-on effects by reorienting migrant flows to other countries. With developed economies being difficult to access for many of the world's population, citizens of developing countries often migrate to other developing countries (Castles, 2004a; Bakewell, 2009). The extent of the so-called 'South-South' migration is vast and growing; in 2017, more than one-third of international migrants moved from one developing country to another (UNDESA, 2017). Despite its size and importance, we understand very little about the processes driving South-South migration due, in part, to a lack of reliable data (IOM, 2013). Immigration into developing countries can boost economic development at both the origin and destination, but it can also be a burden on developing countries, which may not have the resources or infrastructure to absorb a large number of new migrants (Hujo and Piper, 2007; IOM, 2013; Lesser et al., 2006; Bakewell, 2009), and subject migrants to vulnerable situations. In many developing countries, social policies addressing migrant integration or human rights are weak and may lead to ethnic tensions and conflict (Hujo and Piper, 2007; Bakewell, 2009; Lesser et al., 2006). Developing countries that are geographically close to industrialised nations can become temporary stops or even turn into permanent destinations for migrants who wish(ed) to settle in the industrialised nation. These transit countries and the migrants that pass through them face particularly difficult challenges. In Mexico, for example, undocumented migrants from Central America who may be travelling to the US are extremely vulnerable and experience violence and abuse by gangs and the government, including arbitrary detentions, assaults, beatings and sexual violence. These migrants also lack access to legal help or healthcare (Infante et al., 2012). In the Caribbean this reorientation of migrants is often associated with irregular migration, migrant smuggling, human trafficking and the spread of HIV/ AIDS (Lesser et al., 2006).[3]

Despite these severe externalities, no systematic empirical research exists to assess migrant reorientation given policy restriction, or what De Haas (2011) terms "substitution effects." Existing studies tend to focus on total migrant inflows or on the effect of a policy on its target category (e.g. Mayda, 2010; Ortega and Peri, 2009; Hatton, 2004) and can, therefore, not capture the diversion of flows to other channels (Czaika and De Haas, 2013, p. 504). This is an important shortcoming because if we are unable to observe the reorientation of flows, we are also unable to assess the *full* impact of immigration policy. A clear example is reorientation towards unauthorised channels, which are difficult to observe empirically. Researchers estimating the effects of immigration policy restriction in the presence of this substitution effect will, likely, be overestimating its effects. This is simply because restriction can lead a larger portion of inflows to become clandestine and, therefore, absent from the data. Similarly, neighbouring countries like Mexico or Canada may be interested in estimating the impact of US policies, recently imple-

[3]Mobile populations and individuals living in transit areas are considered at higher risk of HIV/ AIDS contagion. This is due to many factors including the separation of individuals from their families, the exploitation and vulnerability of migrants en route, particularly among young women, and the prevalence of sex trafficking (IOM, 2006)

mented by the Trump administration, curtailing rights and opportunities for legal and unauthorised migrants (Kim, 2017; Batalova et al., 2018) on immigration into their own countries.[4] However, any significant increase in immigration into these countries may be due to a variety of factors – domestic policy or macro-economic shifts, for example – and may be difficult to attribute exclusively to US immigration policies.

These examples illustrate two of several methodological challenges to assessing the full effects of immigration policy. In this thesis, I identify three: (1) the problem of substantial unobservable populations, particularly when the effect we seek to estimate, in itself, is likely to affect the size of these unobservable populations; (2) the challenge of attributing changes in overall migrant flow or composition to immigration policy change and, (3) the difficulties in estimating the scale of migrant flows in the presence of network effects. I expand on each of these points in turn. First, unauthorised migration is difficult to measure because data, if available, is often problematic. Some countries measure unauthorised migration using estimates of individuals caught, detained or deported (Thomas-hope, 2003; Heckmann, 2004). The United States estimates this population by applying the 'residual method' on census data. Briefly, the residual method consists of subtracting the number of immigrants residing legally in the country from the total number of immigrants as measured by the American Community Survey or the Current Population Survey carried out by the U.S. Census. The difference is assumed to be the number of unauthorised immigrants in the survey (Passel

[4]The reorientation of migrants from the US to Canada has been documented in media reports (e.g. Craig, 2018)

and Cohn, 2014). The number of legal residents is estimated through a series of indirect questions in the survey. Migration scholars have conceded that the residual estimates are of "limited scope," and "the quality of the data and assumptions underlying the residual method are becoming more tenuous each year" (Warren, 2014, p. 307). One source of bias stems from the fact that it is based on self-reported responses on items relating to legal status, which may suffer from under-reporting; and another is that the data being used is often severely outdated (Warren, 2014).

The likely impact of policy on unobservable populations – the second consideration in problem 1 – is related to problem 2: the measurement of immigration policy. Quantitative researchers measure immigration policy change using two types of models. The first is to use a binary immigration policy variable in an econometric model, marking the years in which a policy change occurred (e.g. Karemera et al., 2000; Vogler and Rotte, 2000), and the second is to construct an index that can measure the intensity of policy restrictiveness (e.g. Mayda, 2010; Ortega and Peri, 2009). Most of these studies use written policy measures because measuring policy implementation is incredibly difficult, if at all possible. However, the problem with using written policy measures is that intended policy changes can differ substantially from those actually implemented (Czaika and De Haas, 2013, p. 498). Policy implementation deficiencies are common and may arise due to practical or budgetary constraints or as a consequence of corruption or subversion and may, in practice, significantly water down the policy change intended (Hollifield and Wong, 2000; Hollifield et al., 2014). Isolating the causal effect of immigration policy change is also extremely difficult, for various reasons.

First, policies often interact with other variables, which hampers our ability to measure its unique effect; for example, Mayda (2010) finds that when immigration policies are more restrictive, factors such as distance and the relative number of young people in origin countries have larger effects. Second, if immigration policy responds to changes in migration inflows, as was the case in many European countries in response to the refugee crisis (UNHCR, 2017), we cannot easily determine the direction of causality. Third, policy may drive migrants outside the purview of available datasets, not only by reorienting individuals towards unauthorised channels, but also through reorientation to countries not be captured in the data (Czaika and De Haas, 2013). Experiments that randomly assign individuals to be subject to an immigration policy "treatment" provide a good solution to the problems of confoundedness and reverse-causality – the first two points mentioned in this paragraph. Such an experiment can be carried out through the use of visa lotteries, which exogeneously treat random respondents with the receipt of a visa. McKenzie et al. (2010), for example, examine the economic impact of migrating for Tongans receiving a lottery visa to migrate to New Zealand. However, such an experiment is costly, difficult to carry out and requires establishing government collaborations. As such, few of these kinds of studies have been carried out.

A third challenge I identified involves forming expectations about migrant flows in the presence of network effects. The 'multiplier effect' in legal family-based migration has long been documented. Jasso and Rosenzweig (1986, p. 291), for example, write,

> *The potential for growth in excess visa entitlements is high given provisions rendering siblings, parents, spouses, and adult children of U.S. citizens eligible for visas... Indeed, the multiplier effect can, in principle, be infinite through "chaining." As in a genealogical table, a new link is forged each time that an "original" immigrant sponsors a new immigrant; the set of all new immigrants brought to the United States by the original immigrant constitutes that immigrant's direct "progeny," a second generation. Each member of that second generation may, in turn, sponsor the immigration of a third generation, and so on... the potential explosiveness of this hypothetical multiple-strand chain depicting the reproduction of immigrants has not gone unnoticed.*

Recently, US President Donald Trump has said that his country's current immigration system allows a single immigrant to "bring in virtually unlimited numbers of distant relatives" and called for limiting migrants' ability to sponsor family members to spouses and minor children (Bennett, 2018). This statement is, of course, an exaggeration, but it does indicate that this effect is gaining political relevance. The exponential effects of migrant networks is, however, not isolated to family reunification. As I will discuss in Chapter 2, networks are essential to perpetuating most forms of migration including unauthorised migration (Boyd, 1989, p. 649). The modulating effect of networks makes migration and, by extension, the effects of immigration policies difficult to anticipate (Klabunde and Willekens, 2016).

Our lack of understanding of immigration policy effects does not stem purely from lack of evidence or unsuitable methods: The mechanisms driving migrant reorientation are also weakly *theorised*. I delve into theoretical shortcomings at length in Chapter 2, but I make three general points here. First, students of migration have until recently, paid little attention to the effects of immigration policy on population movements (Massey, 1999). Indeed, most migration theory attempts to explain what would occur *in the absence* of legal or political barriers (Arango, 2000; Massey et al., 1998; Carling, 2002). This is an important omission given the role of immigration policy in shaping migration flows. As Massey et al. (1998) suggest, considering global disparities in wealth, the actual size of migration flows is "only a fraction of what might potentially result" if migration systems were left "to operate without state interference" (p. 7).

Second, theories of migration have often focused overly on structural drivers of migration (for example, labour demand in destination countries) or have adopted an individual focus that conceives of migrants as atomistic utility maximisers with perfect knowledge of their environment (Castles et al., 2003). According to the latter perspective, which is couched in expected utility theory, it is easy and effective to deter unauthorised migration by intensifying sanctions that increase the costs and risks of migration. Yet, increased enforcement have been largely unsuccessful (Donato et al., 1992; Espenshade, 1994; Ryo, 2013). The fact that migration flows continue to rise despite restrictive immigration policies (UNDESA, 2017) has led several scholars to question whether labour-importing states can effectively control their borders in a globalised post-industrial world (Sassen, 1999; Castles, 2004b; Cornelius et al., 2004). According to Bhagwati (2003, p. 1), "... the ability to control migration has shrunk as the desire to do so increased." Individuals do not respond to policy in exactly the way governments might want them to because they are *not* atomistic utility maximisers. As I will discuss in Chapter 2, potential migrants are reflexive and creative, and use these qualities to try to overcome structural constraints such as immigration policy (Giddens, 1984). Specifically, individuals actively search for information that can allow them to adapt to restrictive policies (Gigerenzer and Selten, 2002; Simon, 1957). As I will argue in Chapter 2, the tendency of individuals to actively search for information to solve problems (as opposed to being passively all-knowing as assumed in expected utility theory) is an essential aspect of what makes individuals agents.

Furthermore, migration theory is highly fragmented and often focuses on processes occurring at one or two levels of aggregation (i.e. micro-, meso- or macro-level). Therefore, a single theory cannot explain migration in all its dimensions, rather, different theories must be drawn upon to explain different parts (Massey et al., 1998; Castles, 2010). This is a significant shortcoming because, in real life, migration processes taking place at different levels of aggregation interact with each other; that is, they are not entirely amenable to being examined independently. Immigration policies, for instance, operate at a macro level, yet we cannot assume individuals react directly to macro-level measures. Instead they form perceptions (Carling, 2002) by considering their experiences and others' experiences with immigration policy, processes that occur at the micro- and meso- levels (Hagen-Zanker and Mallett, 2016; Gigerenzer and Selten, 2002; Sabates-Wheeler et al., 2009). Theoretical integration would allow us to describe migration and the effects of immigration policy in a more natural and realistic way (Brettell and Hollifield, 2000; Massey et al., 1998; Castles, 2010; Haug, 2008).

1.2 Aim

The purpose of this thesis is to examine how migrants respond to changing immigration policies, the role that social ties play in this process, and how this behaviour plays out on an international level.[5] I argue that, to understand the full impact of immigration policy, we must: (1) consider the externalities of immigration policy, namely the reorientation of migrants, and (2) we need to adopt an agency-centred approach to migration that connects migration processes occurring at multiple levels of aggregation. Specifically, I ask: *To what extent do migrants adapt to immigration policy restrictions by adopting illegal routes or alternative spatial corridors, and what role do social networks play in this process?* This thesis focuses primarily on unauthorised migration and begins to explore spatial reorientation (with a focus on theory) in the last chapter.

This thesis aims to advance the study of migration and immigration policy by addressing the theoretical and methodological shortcomings described above. To address these theoretical gaps – as well as others – this thesis develops a new agency-centred theoretical framework to examine the effects of immigration policy on individuals and their social context. This framework, which draws on theory across the social and behavioural sciences, will guide

[5]To be clear, this thesis does not aim to examine the *determinants* of migration (i.e. what drives people to migrate); it focuses exclusively on the effects of immigration policy on migration decisions and how these effects are propagated across networks.

the empirical work presented in my thesis. This framework aims to address: the conceptualisation of migration; the heterogeneous effects of immigration policy and the diverse migration outcomes it can produce across a population; the manner in which perceptions about immigration policy are formed and the role that social context plays in this process; how migrants assess policy on normative and rational levels; and the kinds of behaviour that are expected to arise from this process.

I aim to, then, formalise this theoretical framework in the form of an agent-based computational model (ABM). Agent-based modelling, which I detail in Section 1.3 below, consists of building a theoretical or inductively derived mechanism in the form of a computer program. The researcher will generally identify an observed pattern in the real world and a hypothesised mechanism thought to generate it. She will then formalise and program this mechanism explicitly into the ABM and observe, through simulation, whether this mechanism indeed gives rise to the observed pattern (Macy and Willer, 2002; Epstein, 1999). In order to make inferences about the real world, agent-based modellers often embed data and empirical estimates into their models and agent-based models are flexible enough to integrate a wide range of empirical designs, including experiments (Boero and Squazzoni, 2005; Tubaro and Casilli, 2010).[6] In this thesis, I aim to construct and implement an original nation-wide survey of Jamaica (the *Migration Decisions and Policy* survey) – a country with a rich emigration history and a large number of aspiring migrants (Thomas-Hope, 2003) – with the explicit

[6]All ABMs in this thesis are implemented in NetLogo, a state of the art multi-agent programmable modelling environment (Wilensky, 1999).

intention of informing and setting numerical parameters in the simulation model.

In Section 1.1, I identified three methodological challenges to measuring the full impact of immigration policies: (1) the problem of unobservable or unauthorised populations, (2) the difficulties in attributing changes in migration to immigration policy change and, (3) the challenges of estimating the scale of migrant flows in the presence of network effects. This thesis aims to address these challenges by combining simulation and experimental designs implemented in an origin country. Agent-based models allow us to incorporate a range of different empirical instruments. Therefore, I aim to leverage ABM's flexibility with data types and implement designs that can allow us to draw causal inferences about how individual-level decisions and strategies respond to changes in immigration policy and provide us with reliable measures for sensitive issues such as unauthorised migration – addressing the first and second point. Agent-based models are the only form of simulation that can allow us to explicitly model the effects of social interaction and observe the nonlinear effects that emerge at the macro-level. As such, this thesis aims to incorporate the effects of networks into its estimates of unauthorised migration using this platform.

The following section provides a brief background on agent-based modelling, why it is a useful method for examining the effects of immigration policy on migration, and how data is embedded into these kinds of models. This is necessary to understand the specific methodological contributions of this thesis, which will be detailed in Section 1.5 below. It will also serve as a background to the literature review presented in Chapter 3, which focuses on the use of data in ABMs of migration.

1.3 Methodological Background: Agent-based Modelling

Agent-based modelling is a relatively novel analytical method; it is a form of computer simulation where the programmer creates a artificial society of agents, generally, based on theory. They allow us to generate a "natural" depiction of a system, which is very difficult to achieve using other analytical methods (Bonabeau, 2002; Gilbert, 2008). ABM is a generative approach (Epstein, 1999). Its goal is to construct a mechanism from the bottom up to explain the emergence of macroscopic regularities, such as non-random crime hotspots (Pitcher and Johnson, 2011; Malleson et al., 2009); the formation of schools fish or flocks of birds (Tang and Bennett, 2010) or, as done in this thesis, patterns of unauthorised migration (Chapter 7), or the spatial clustering of migrants from one origin country in a given destination country (Chapter 9). A generativist often seeks to ask two questions: First, what mechanism produces a given pattern or regularity that we observe in the real world (Epstein, 1999) and can we replicate this mechanism in a 'natural' or realistic way? Second, what outcomes do we get if we systematically change certain conditions (i.e. immigration policies, amount of rainfall, or the number of police patrols on a street). The second question usually is dependent on an affirmative answer to the first, as I will explain in Section 1.3.2 below.

Agent-based models can serve different functions. They may aim to develop theory: agent-based models are an ideal platform for what Cederman (1997) has called "complex thought experiments," allowing us to introduce or relax assumptions and test the boundaries of theoretical expectations (Epstein, 1999). I present a model of this type in Chapter 9. Others researchers may use agent-based models to produce more realistic outcomes, as is done in Chapter 7. Regardless of modellers' intentions, according to Gilbert (2008), agent-based models have six key features: (1) ontological correspondence, (2) heterogeneous agents, (3) a representation of the environment, (4) agent interactions, (5) bounded rationality and (6) learning. I expand on each point in turn.

In an ABM, autonomous individuals or entities – for example, nations or people – are generally represented with correspondence to the real world (Gilbert, 2008). Like real nations or people, agents have a clear goal, they are independent or autonomous in making decisions to reach a certain goal, and they adapt their decisions to changing situations (Grimm et al., 2005). While social science theories often assume individuals are similar and act similar in key respects, agents in an ABM may act according to heterogeneous preferences or even follow different sets of rules, according to the theory tested. For example, agents may be classified as migrants and non-migrants, or they may display a higher degree of individual difference, such as possessing different demographic characteristics (age or gender, for example). Agents need not be different to each other, but modellers usually take advantage of ABM's flexibility for producing agents that can vary on a seemingly endless set of dimensions – as in the real world.

Agents exist in an environment, which may be entirely abstract or display different degrees of realism. For example, agents may live in an abstract representation of an area (e.g. a simple grid) or a spatially explicit geography, where locations are identified with real coordinates. Agent-based modelling affords the flexibility of incorporating data from Geographic Information Systems (GIS), which store and analyse data about phenomena with a spatial location (Brown et al., 2005). Incorporating some sort of geographic realism is relatively popular among modellers in different disciplines. According to a systematic review of agent-based models of urban crime, more than 80% of articles reviewed use some form of spatially explicit model, with 34% of modellers using GIS with varying levels of detail (Groff et al., 2018). In Chapter 3, I review ABMs that examine migration (as the main behaviour or one of many) and find that these models follow a very similar trend with more than 80% using spatially explicit models and 33% using GIS.

Models may also contain social networks, which may be as abstract or realistic as the researcher wants them to be and may serve different purposes. They may connect geographic locations to one another (e.g. Hassani-Mahmooei and Parris, 2012), to map movement trajectories for agents. They may also connect individuals and enable them to exchange information or resources. These network representations may be stylised, like a random-network (Erdős, 1959) or a small-world network (Watts and Strogatz, 1998). They may be fixed or evolving over time as agents interact with one another and form friendships (Klabunde and Willekens, 2016). They may also be data driven. Agent-based models allow us to easily import adjacency matrices – for example, the sexual or friendship networks collected in the National

Longitudinal Study of Adolescent Health (Harris et al., 2009) – and connect agents using a real network topology.

Agent-based modelling allows agents to be boundedly rational – that is, they may have limited knowledge about their environment or situation and limited cognitive abilities for processing information (Simon, 1957). Rather than assuming that individuals have perfect knowledge, agents can be given the capacity to accumulate knowledge from a variety of sources – such as their physical environment or their networks – and evaluate their situation inter-temporally. In general the rules guiding agent decision-making are simple and do not involve unrealistic sequences of complex reasoning (Gilbert, 2008, p. 15). Programmers may also choose to incorporate cognitive biases by weighting information signals differentially, as this thesis does in Chapter 8. ABMs sometimes incorporate evolutionary algorithms, neural networks or other learning techniques to make agents learn and adapt to change realistically (Bonabeau, 2002). Modellers may also design their agents as having perfect information and to act in a deterministic manner, or to have no information at all. The degree of knowledge a programmer endows their agents with is completely up to their discretion.

The main benefit of ABM is often considered to be the ability to observe emergence: system dynamics that arise from the interactions between agents (Railsback and Grimm, 2011, p. 10). Emergence is a behaviour that is difficult to predict from observing individual components in a system because the interactions between these different components can, itself, cause behaviours to arise. For example, we could consider a simple model where 50% of agents wish to migrate to location A and the remaining 50% wishes to migrate to destination B – and they have no impediments in doing so. From observing individual components, the outcome is clear: agents will be distributed equally amongst locations A and B. However, if we connect agents to one another through networks and allow them to distribute information about this location, we may see a very different sort of behaviour. If the first individual who migrates moves to destination A and transmits positive feedback to her network connections, she may be the start of a new path-dependent behaviour that causes *all* agents to end up in location A, rather than just half. Because emergent behaviour is difficult to predict, it can explain why policies or interventions often lead to unintended consequences in the real world (Room, 2011). Agent-based modelling is the only method that allows us to explicitly model interactions and generate emergent dynamics that are "out of the reach of pure mathematical methods" (Bonabeau, 2002, p. 7280).

As mentioned in the beginning of this section agent-based modellers seek to generate observed patterns and also examine what may occur if conditions change. Generally, if a model is able to replicate a real-life pattern, the mechanism formalised in the model is a good candidate for the real-life mechanism underlying this pattern. This is often referred to as model validation and will be discussed further in Section 1.3.2 as well as Chapter 3. If the model is a good candidate, modellers will often also want to experiment with alternative scenarios. Specifically, agent-based models generate results by way of in-silico experimentation. Modellers apply some 'treatment' or condition to the system and compare it to a baseline model. The baseline model is the same in all respects, except that the condition of interest is 'turned off.' An in-silico experiment is usually repeated several times to observe variation that may occur due to randomness and compute a measure of uncertainty across simulation runs (Railsback and Grimm, 2011). In this way, in-silico experimentation allows us to infer the cause of a particular phenomenon and can be a highly advantageous way to explore causality in situations where human-subject experiments are impractical or unethical (Gilbert, 2008). However, unlike human-subject experiments, in-silico experiments do not generate new data about the real world (Morton et al., 2010) and depend on whether the model is a true approximation of the real mechanism at play. To address this issue, modellers often use a combination of theory and empirics, as will be discussed in Section 1.3.2 and in Chapter 3.

1.3.1 ABMs, Migration and Agency

The theoretical framework for this thesis was developed in tandem with an exploration of ABM's capacity to model processes in a natural way. Because the method allows us to test theories explicitly (Johnson and Groff, 2014), this framework could take seriously details of human cognition and behaviour that researchers may consider extraneous simply because they are unable to test them. In short, an agency-centred, multilevel theoretical framework is facilitated by a method that allows us to depict agents and multiple levels of aggregation. Without presenting the theory that it draws on, I am unable to discuss this theoretical framework. Therefore, in this section, I describe the general correspondence between real migration systems and the type of behaviour that is often depicted in ABMs. All references to the characteristics of migration are discussed in Chapter 2, and the attributes of ABM are discussed in the section above.

1. *ABMs are driven by agents.* Agents are autonomous individuals who are thoughtful and adapt to change by learning about their environment. This is not only a more realistic way of depicting individuals, but it is also the ideal perspective through which to examine potential migrants' response to immigration policy change. The reorientation of migrants to alternative (illegal) channels or destinations is an adaptive response resulting from experiential learning of the policy environment (Gigerenzer and Gaissmaier, 2011; Simon, 1972).

2. *Individuals in an ABM generally interact,*[7] *most often through networks, with no global entity controlling the system.* Migrants and would-be migrants also exchange information and resources locally through social ties (Haug, 2008).

3. *Processes can occur in stages, whereby the previous stage will affect the next.* Decisions in econometric models, for example discrete choice models, are taken in a single step. Agent-based models are dynamic and changing conditions or the prior actions of other agents may affect the decision at a given point in time. This can cause systems to evolve. As in the simple migration example presented in the above section, some agents had an initial preference to behave in a certain way but changed due to feedback being sent through the system. Their migration decision then affected those who would migrate in the future,

[7]This is what sets ABM apart from similar methods such as microsimulation (Gilbert, 2008)

producing path-dependent behaviour. This is another essential feature of migration, made most explicit in the theory of cumulative causation, which will be discussed in Chapter 2.

4. *ABMs allow us to observe emergence.* As mentioned above, emergence is the presence of a behaviour, unexpected given the individual components of the system, which comes about through interaction. Policy failures or unintended consequences are often due to the unpredictable nature of emergent behaviour (Room, 2011). As such, being able to depict migration systems using a method that allows us to observe emergence is extremely important to this thesis' research question.

As these points illustrate, ABMs are very useful for the study of migration. However, as I will show in Chapter 3, literature using this method in migration is scarce and this thesis contributes to this nascent field. This thesis also contributes a new approach for the use of empirics in ABM. The following section provides a background on general practices to contextualise this contribution.

1.3.2 Types of Models and Use of Empirics in ABMs

Modellers can use empirics in three main processes: model calibration, validation and specification. Model calibration is the use of numerical evidence to set the features of a model component. Modellers may, for instance, set agent characteristics such as age or aspiration to migrate, by inputting values from a survey dataset. They may also employ data more sparingly by using stylised distributions (e.g. a normal or exponential distribution), with measures of centrality and dispersion derived from empirical data to assign numerical values to model characteristics (Gilbert, 2008). Empirical validation is the qualitative or quantitative comparison of computational outputs with empirical patterns (i.e. migration stocks or flows over time) to assess whether the model is sufficient to explain a particular natural process (Axtell and Epstein, 1994). Model specification refers to the selection of appropriate model components (e.g. types of agents, micro decision processes) and the relationship between them. This aspect is often guided by theory. However, modellers have used a wide range of quantitative and qualitative data sources (first- or second-hand) to obtain evidence that certain relationships are present in their selected case. Whether or how modellers use data in these processes or if they employ these processes at all, usually depends on the class of model in question and available resources, among other factors. However, as will be shown in Chapter 3, migration studies that do use data or empirics to calibrate, validate or specify model processes, rarely use data in all model components. This is also the case for ABMs in other fields, such as crime (Groff et al., 2018). This thesis develops an approach to facilitate a more thorough use of data in the ABMs (see Chapter 3).

According to Gilbert (2008), there are three broad classes of models: abstract, middle range and facsimile models. These types of modes differ in the degree of realism with which the researcher aims to depict a phenomenon. Abstract models are not intended to represent a specific empirical case, rather a simple mechanism that need not perfectly correspond to observable reality. One of the most cited abstract agent-based models is the Schelling model, which aims to explain racial segregation in cities within the United States.

The model is a very simple one. It is based on a regular rectangular grid of cells representing an urban area. Agents – who belong to one of two (ethnic) groups – are initially positioned in separate cells selected at random from across the grid, leaving some cells empty. Every time step, agents evaluate the eight cells surrounding theirs and compute the ratio of neighbours belonging to the other group to the neighbours belonging to their own group. They compare the resulting fraction to a constant "tolerance" threshold. If the them-to-us ratio is above the tolerance threshold, the agent relocates to a random empty cell. Schelling found that, at tolerance values equal to or above 0.3, agents naturally segregate into uniform clusters. Schelling concludes, then, that even low values of racial prejudice can lead to segregation. These types of models are generally used for theory development and are not intended to approximate the characteristics of the system under study in an empirical sense. Therefore, they often do not make use of empirical data to set parameter values. Instead, they use simple assumptions to substantiate model rules and do not validate the model beyond demonstrating it can generate the phenomenon in question (i.e. segregation in Schelling, 1978 or cooperation in Axelrod and Hamilton, 1981).

Facsimile models are at the other extreme of the spectrum. These models look to reproduce a specific case as precisely as possible, often to predict future scenarios. One of the most well known examples of a facsimile ABM is the Artificial Long House Valley agent-based modeling project (Dean et al., 2000; Axtell et al., 2002), which aimed to explain, in precise detail, the rise and fall of the Anasazi civilisation of Native Americans in the southwestern United States between AD 800 to AD 1350. This model made use of extensive archeological, anthropological, and ecological data to specify, calibrate and validate the model, in an effort to credibly replicate the trajectory of this civilization. As I show in Chapter 3, many agent-based models of migration are of the facsimile type. The authors collect extensive evidence on a very limited geographical area and attempt to replicate behaviour in that area.

Between abstract and facsimile ABMs are middle-range models or what Bruch and Atwell (2013) call low-dimensional realism models. These are more generic models, which aim to depict the characteristics of a real social phenomenon, but do not compare exactly to a particular observable case. They generally aim to reproduce stylised facts, or simple empirical findings that are consistent across a range of different cases such that they can be generalisable. For example, Epstein et al. (2008) takes a traditional mathematical model of contagion and adds a simple behavioural component to it. Specifically, in this model agents do not simply contract a disease based on a rate of contagion, as in traditional mathematical models, they also actively hide and flee to a safer area. This sort of adaptive behaviour has been documented in historical cases and the authors show that the inclusion of this behaviour more closely approximates patterns observed in historical epidemics in a *qualitative* sense. The authors compare how long disease takes to spread when agents are able to hide and when they are not but do not compare outcomes to numerical figures from historical accounts. This model is middle-range because the model itself is relatively stylised – it is derived from a classic mathematical model – but is adapted to include a more realistic behavioural feature. Furthermore, it does not aim to produce patterns that can be compared to a specific case in a quantitative sense. It just aims to show that flight, a documented behaviour, can actually improve how we represent contagion. The use of data in a middle-range model varies. Researchers may not use any data, they may calibrate the model by assuming stylised distributions and anchoring measures of centrality and dispersion to empirical data, or they may populate agent characteristics by importing data directly from a survey dataset, for example. Validation is often qualitative. That is, empirical stylised patterns may be compared to model outputs by, for example, comparing the distributional properties of the agent population in simulated and empirical data (Axtell and Epstein, 1994).

1.4 Modelling Process

After having established the research aims, the ABM of unauthorised migration was developed in the following stages:

Stage 1: Conceptualization of ABM

The first stage of development consisted of the following three steps, which were iterated through multiple times: (a) reviewing existing theory and building a theoretical framework, (b) finding gaps in the literature that needed to be investigated (c) developing a sketch of the ABM architecture.

The theoretical framework was developed incrementally. The overarching set of theories that built the basis of the ABM concerned the effects of immigration policy on migration decisions (Carling, 2002; Czaika and De Haas, 2013). As parts of the model were further refined, theories on migrant decision-making, migration networks and the law were explored and incorporated (see **Chapter 2**). This was needed in order to substantiate the modelling choices made. In this way, agent-based modelling was a conduit to a wide repertoire of complementary theories.

Theory was then formalised as an agent-based model. In other words, theory was transformed into to rules telling the ABM what operations to perform. For example, theory maintains that policy affects agents' perceived ability to migrate (Carling, 2002; Castles et al., 2013a). This is translated into a rule whereby whenever agents receive a signal reflecting immigration policy, their perceived ability to migrate will be either incremented or reduced. The full set of rules, contained within components or modules (shown as boxes in Figure 1.1), form the ABM's architecture.

In the process of formalisation, certain gaps in the literature became evident (Johnson and Groff, 2014) and became empirical questions which needed to be investigated. These are summarised in Table 2.1 (Chapter 2). Returning to the previous example, while literature maintains that immigration policies lower individuals' perceived ability to migrate, it is unclear whether they lower individuals' aspiration to migrate as well. As such, when defining the rule that guides how learning about immigration policy affects agents, it was necessary to gather data on the relationship between policy and perceived ability and the relationship between policy and aspiration to migrate.

Formalisation also highlighted the parameters in the model that needed to be quantified. For example, given that a signal about immigration policy affects agents' perceived ability, it was also necessary to know by how much. In this stage, I identified the survey data needed to conduct the appropriate statistical test and any empirical challenges that would arise in doing so (e.g. causal identification or gathering truthful responses).

Stage 2: Data Collection, Analysis and Embeddedness

The survey was designed to address the items listed in the previous stage. Guided by ABM rules and overall architecture, the survey design consisted of experimental and non-experimental items on perceptions, attitudes and preferences, migration history and migrant networks, demographics and an experiment on immigration policy. These items were designed to address the empirical challenges identified in the previous stage. Further details are described in **Chapter 4**. For instance, it was necessary to disentangle the effects of an exogeneous influence (information about immigration policy) from pre-existing attitudes, which were in and of themselves affected by the policy environment. This was tackled through the design of a policy experiment where the only difference between the treatment and control group was exposure to an audiovisual cue regarding the immigration policy environment. A difference-in-means test would then identify the unique effect of receiving immigration policy information on attitudes.

Once data was obtained, analyses were used to substantiate assumptions and answer the questions identified and quantify parameters in model functions, (e.g. the effect of policy on perceived ability to migrate) and agent characteristics. I expand on these in turn.

By addressing theoretical gaps, empirical evidence from the field helped refine ABM rules. The analysis of the policy experiment, for example, identified a statistically significant relationship between receiving policy information and perceived ability to migrate but not a statistically significant relationship between policy information and aspiration. This informed agent rules: when receiving feedback, agents' perceived ability to migrate would be altered, but not their aspiration.

The survey data was also used to calibrate the model. First, a slice of the MDP survey dataset containing the relevant variables was input into the program. Agents, equal in number to the survey respondents, were given the characteristics of a randomly selected respondent. Second, the numerical output of statistical tests were used to quantify model parameters. Specifically, I used the parameters of a curve of best fit resulting from an inferential statistical model to quantify a relationship of the same form within the ABM. For example, parameter π, which guides the amount that an agent alters their perceived ability to migrate when exposed to policy information, was set to the Average Treatment Effect of the policy (or audiovisual) experiment. When immigration policy is restricted in an in-silico experiment, aspiring migrant agents' odds of success decreased (I expand on this in the next stage). Successes and failures were operationalised as signals. When receiving a failure signal, an agents' ability to migrate was lowered by quantity π.

Stage 3: Analysis of ABM

The first step in the analysis of the ABM consisted of examining its quality. This was done by comparing ABM outputs to independent data sources (this is described in **Chapter 7, Section 7.3**). This involved evaluating metrics such as the proportion of migrants that are unauthorized in relation to real-life estimates on unauthorized migration, for example. Once evidence for the quality of the model was found, the next step involved running several in-silico experiments on different immigration policies (**Chapter 7, Section 7.4**). These experiments consisted of changing the number and type (in terms of sociodemographic characteristics) of migrants admitted into the destination country in a variety of different ways. For example, the low-skilled labor migration was restricted by reducing the quota of low-skilled agents admitted into the country.

A series of sensitivity tests were also carried out, examining parameters that I was not able to collect data on, for example, biases in decision-making. The purpose of these sensitivity tests was to examine the full range of the unknown parameter and its impact on results. These sensitivity tests can be found in **Chapter 8** and in **Appendix A**.

1.5 Structure of Thesis and Contributions

My thesis is organised around the design, implementation and results of an agent-based model of unauthorised migration. Part 1 (Chapters 2 to 4) discusses the general background of the model, Part 2 (Chapters 5 and 6) relates to the empirical specification and calibration of specific portions of the model. Part 3 (Chapters 7 and 8) presents the full description and results of the agent-based model of unauthorised migration, bringing together the work shown in all previous chapters. Part 4 of the thesis examines spatial reorientation.

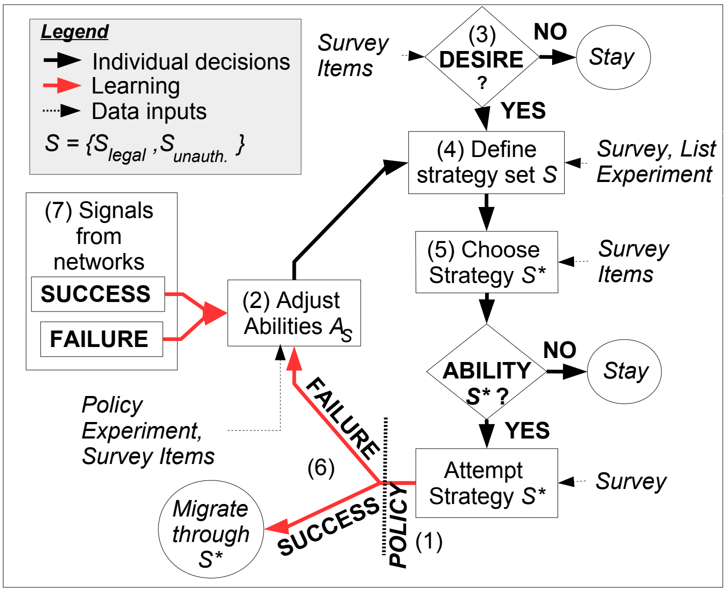
The first two chapters of my thesis set out its theoretical and methodological framework. Chapter 2 critically reviews theory across the social sciences with a view to understanding the effects of immigration policy on migration systems. It, then, introduces a new agency-centred theoretical framework for the study of immigration policy on multi-level migration systems. This theoretical framework helps us think systematically about the effects of immigration policy on systems of adaptive individuals. It consists of the following elements, which, in Chapter 2, are subdivided into eight premises. First, migration must be conceptualised as non-binary. Immigration policies create different modes of legal (i.e. family reunification, low-skilled or high-skilled work) and unauthorised migration (i.e. complying with some aspects of immigration law or bypassing it entirely). Each mode consists of a different migration experience, with different levels of security and risk, and these differences matter in the decision to migrate (Carling, 2002; Ruhs, 2010). Second, immigration policy constraints affect individuals differently depending on their individual characteristics (i.e. wealth, skills or family members abroad). This explains why some individuals succeed and others fail in their migration plans (Carling, 2002). Third, to understand how individuals *act* when their options are constrained, we must understand their reflexive process; that is, the process by which they form normative and rational perceptions. Individuals are boundedly rational (Simon, 1972) and may display cognitive biases (Hattle et al., 2016) when learning and deciding to migrate under different policies. The manner in which individuals send and process information will have some bearing on individuals' decision to migrate and within which mode, thereby distorting the effects of immigration policy through differential weighting of information or through the boundedness of network relationships. Fourth, social context – the 'crucial meso-level' (Faist, 1997) – can shape and reshape the options individuals consider and the decisions they ultimately take. This theoretical framework contributes to migration theory by (1) conceptualising the migrant as an *agent* that is responsive to changes in immigration policy, (2) conceptualising the heterogeneous effects of immigration policy, and (3) systematically laying out how immigration policy effects trickle down from the macro-level to the individual and their social context, addressing the theoretical gaps identified in Section 1.1.

Chapter 3 reviews the nascent literature using data-driven agent-based modelling to study migration, focusing on the use of empirics in model specification, calibration and validation. Based on this review, I propose a "proactive approach to empirical embeddedness." This approach consists of making survey data collection an intrinsic aspect of the ABM design process and, thereby, anticipating data needs. This process consists of three steps that combine an ABM design process with a data collection process: (1) a conceptualisation of the data collection project and an initial sketch of the ABM, (2) an operationalisation of concepts and an identification of ABM calibration needs, and (3) a plan for data analysis and an identification of ABM validation needs. Aside from making sure that the adequate data is collected (particularly as data collection is often costly and errors can often not be remediated), this framework for data collection allows us to elicit data that can be analysed in a dynamic setting. This is done by visualising survey respondents in a similar fashion to simulation agents who may change their perception and behaviour under different states of the world (or simulation settings). It also allows us to identify junctures where particular kinds of empirical instruments may be needed or desired. For example, if we want to exogeneously vary immigration policy in the ABM, we can use the results of a human-subject experiment, which similarly assigns respondents an exogeneous treatment to calibrate this part of the model. This novel approach to data embeddedness can help extend the explanatory power of individual empirical instruments by integrating several designs that target specific aspects of decision-making (i.e. aspirations, attitudes, perceptions) and simulating future behaviour, which is often impossible to observe. This can make agent-based models useful to researchers accustomed to more mainstream methods. In sum, it presents a methodological advance on the current way in which data is used in ABMs as well as a possibility to extend the use of agent-based models outside its current niche.

Chapter 4 presents details on the design of the *MDP* survey instrument and why Jamaica was chosen as the case of study. It also provides an overview, including descriptive statistics, of the variables used to calibrate the model of unauthorised migration. To provide the reader with an overview of the ABM and the components of the thesis, the ABM processes and the data feeding into them are presented in Figure 1.1. In this figure, the numbers in parentheses refer to textual description below. The ABM of unauthorised migration is simple and focuses on the effects of immigration policy on migration. Governments control legal migration by imposing a set of channels to categorize and select 'wanted' from 'unwanted' migrants (1). This legal categorization gives different agents different options for migration by heterogeneously reducing agents' perceived *ability* to migrate through legal channels (2), but not necessarily their *desire* to migrate (3). This generates a gap between aspiration and perceived ability (Lee, 1966; Massey et al., 1998; Faist, 1997; Carling, 2002; Sen, 2001; Castles et al., 2013b; De Haas, 2003, 2010). As this gap widens, agents become increasingly likely to adapt by migrating through illegal channels, depending on personal attitudes towards lawbreaking (4) and rational considerations for doing so (5) (Castles, 2004b; Hernández-Carretero and Carling, 2012; Czaika and De Haas, 2013). As immigration policies are notoriously complicated and opaque, individuals are not likely to be perfectly informed of policy changes. Individuals navigate the policy environment through a gradual learning process influenced by their own experience (6) and communication with their networks (Massey et al., 1998; Massey and Zenteno, 1999), and this model focuses on the role of networks in spreading information about migration policies (7). Steps 2 and 3 above are examined empirically in Chapter 5. Step 4 is examined in Chapter 6.

The ABM architecture depicted in Figure 1 can be summarised as follows: Following empirical evidence, policy affects ability to migrate but not aspiration. As such, when policy is restricted, a gap between aspiration and ability is created at the micro-level. Agents' willingness to include an unauthorised strategy into Strategy Set S, indicating their normative preferences, is driven by a dynamically-adjusting ability to migrate on one hand, and a desire to migrate – unaffected by policy – on the other. In the 'Choose Strategy S^*' procedure agents select the strategy they believe they are most able to execute and ignore other choices. Their probability of attempting a migration is driven by the actual probability of success for their chosen strategy. Policy affects agents through local information signals. Agents learn about their environment through first and second-hand experiences (Gigerenzer and Selten, 2002; Epstein, 2003b; Massey et al., 1998; Massey and Zenteno, 1999), as is shown in the relationships coded with red arrows in Figure 1.

Figure 1.1: *System diagram showing agent decisions, feedback processes, and data types used for calibration*



This model addresses the three methodological challenges involved in evaluating the full effects of immigration policy. It allows us to (1) model unobservable populations, (2) attribute changes in migration to (simulated) immigration policy change and, (3) observe migrant flows in the presence of network effects. As shown in Figure 1.1, the model was specified and calibrated using standard survey items as well as two experiments, which directly address the first two points. As mentioned in Section 1.1, drawing causal inferences in empirical evaluations of immigration policy is a challenge: policies are not exogenous (policies might respond to migration flows and vice-versa) and we, generally, cannot disentangle their effects from other processes that may be affecting migration. Chapter 5 examines the effects of receiving information about immigration policy on aspiration and perceived ability to migrate using a simple experiment. In this experiment, individuals were randomly selected to view a 4-minute video focusing on restrictions within the most common visa routes for the top three destination countries for Jamaicans – United States, United Kingdom and Canada – specifically geared towards the Jamaican context. Immediately following this intervention, we elicited their responses on aspiration and perceived ability to migrate. The findings from this experiment showed that, while perceived ability to migrate was affected by immigration policy information, aspiration to migrate was not. Numerical findings from Chapter 5 are used to calibrate a key relationship motivating this chapter: the influence of policy on migrant decision-making (1 in Figure 1.1). The combination of an individual-level information experiment and a macro-level policy simulation can allow us to evaluate policy effects in a manner that is more realistic, much less costly and much more feasible than a large-scale immigration policy evaluation such as the lottery experiment mentioned in Section 1.1.

This thesis also provides a solution to the problem of identifying hidden populations by eliciting several variables that are theorised to play a role in unauthorised migration decisions from the origin country – for instance, support for unauthorised migration. This strategy is, however, also challenging as unauthorised migration is a sensitive topic and may produce bias in measurement when asked directly. These challenges are addressed in Chapter 6. This chapter describes and examines the results of a list experiment, a novel approach to measurement designed to limit the effects of social desirability by protecting individuals' privacy (Glynn, 2013; Kuklinski et al., 1997). This technique is used to generate estimates used in model specification and calibration. The second portion of Chapter 6 examines whether a perceived gap between aspiration and ability is associated with a higher likelihood of supporting unauthorised means of migrating. This is done through further analysis of the list experiments. This analysis lends evidence to model specification and calibration of variables in process (3) in Figure 1.1. Chapter 7 presents the ABM of unauthorised migration, which examines the effects of immigration policy on the volume and legal/ illegal composition of migration. This chapter brings together the work presented in all previous chapters.

As part of the modelling process, the question arises of whether individuals weight information differently depending on whether it is positive or negative, or whether it is based on one's own experience or those of others. Chapter 8 explores this issue further with additional in-silico testing of the ABM of unauthorised migration. The aim of this chapter is to present a basis for further empirical exploration of the manner in which information about immigration policy and odds of migration success is sent, sought out and processed by aspiring migrants.

In chapter 9, I evaluate another form of adaptation: reorientation towards other destinations. This type of reorientation is a theoretical puzzle. According to social network theory, flows tend to be increasingly "siphoned off" to already dominant destinations following the movement of others. Alternative destinations maintain limited appeal despite changes in policy conditions that might make the alternative destination easier to access (De Haas, 2010;

Massey et al., 1993). The question that arises, then, is do policies divert migration flows? Addressing this more precise theoretical question requires a different approach than in previous chapters. I explicitly formalise social network theory as an abstract agent-based model and demonstrate this theory can explain the emergence of both stable, path dependent migration systems as well as systems that adapt and shift in reaction to immigration policy conditions if we consider an oft-neglected aspect of migration – return. This chapter advances migration theory by extending the explanatory power of a highly influential theory of migration (Epstein, 2008). In future work, I will use these theoretical findings to extend the adaptive behaviours of the ABM of unauthorised migration.

This project was funded by a Leverhulme Trust Research Project grant (RPG-2014-271), which I co-authored with my PhD supervisors Prof. Shane D. Johnson and Prof. David Hudson. This grant funded my PhD (in conjunction with the Engineering and Physical Sciences Research Council), employed postdoctoral researcher Dr. Cassilde Schwartz, and funded the *Migration Decisions and Policy* survey (*MDP*). In this grant, I was lead ABM designer and programmer (having the same interactions with my supervisors as would be the case in any other PhD). I also co-designed all experimental and non-experimental portions of the survey and coordinated data collection with a professional survey team in Jamaica together with Dr. Schwartz, project lead for empirics. Although the work presented in this thesis is the result of a close collaborative effort, my thesis focuses on agent-based modelling, the portion of the project that I led.

The empirical work presented in this thesis was also presented in academic papers in an edited form. For transparency, I disclose all relevant academic articles:

Simon, M., Schwartz, C, Hudson, D., and Johnson, S.D. (2018). A data-driven computational model on the effects of government policies on migration flows. *Proceedings of the National Academy of Sciences.*

Simon, M. Path Dependency and Adaptation: The Effects of Policy on Migration Corridor Formation (2018). Invitation to Revise and Resubmit. *Journal of Artificial Societies and Social Simulation.*

Schwartz, C., M. Simon, D. Hudson, and S. D. Johnson (2016). Legality is in the eye of the beholder: Experimental evidence on the criminality and risks of irregular migration. *Presented at the 6th Annual Workshop on Comparative Approaches to Immigration, Ethnicity, and Integration, Yale University*

1.6 Summary

The purpose of this thesis is to examine how migrants adapt to changing immigration policies with the influence of their social networks. This thesis is concerned with the extent to which migrants are driven to adopt illegal routes or alternative spatial corridors when entry into a destination country becomes difficult. No systematic empirical research exists to assess these 'substitution effects' in migration, limiting our understanding of the full impact of immigration policies and hampering their successful implementation (Czaika and De Haas, 2013). I argue that, to understand the full impact of immigration policy, we must: (1) consider the externalities of immigration policy, namely the reorientation of migrants, and (2) we need to adopt an agency-centred approach to migration that connects migration processes occurring at multiple levels of aggregation.

This thesis advances the study of migration and immigration policy on both theoretical and methodological fronts. Students of migration have until recently, paid little attention to the effects of immigration policy on population movements (Massey, 1999). Drawing on existing theories of migration, this thesis develops a systematic theoretical approach to examine the effects of immigration policy on adaptive migration systems. Traditional statistical approaches are unable to examine the reorientation of migrants to other categories or countries or the social process by which specific migration strategies evolve (Czaika and De Haas, 2013). To address this shortcoming, this thesis tailors an original nation-wide survey of Jamaica – a country with a rich emigration history and a source of concern for future unauthorised migration flows into the UK, US and Canada (Thomas-Hope, 2003) – to inform and calibrate an agent-based computational model. Agent-based models (ABMs) allow us to observe how migrant behaviour might give rise to complex migration patterns at an international level and are flexible enough to integrate a wide range of empirical designs. The work presented in this thesis, thus, aims to further develop theories of migration and to examine the impact of policies on migration patterns using a methodological approach that has received only minor attention in the existing literature.

Chapter 2

Theories of Migration, Decision-Making, and the Law

Despite a continuing demand for immigrant labour, major destination countries view migration as a "social and political problem that needs to be managed" (Massey et al., 1998, p. 6). This perspective is borne out of fear that immigration will erode national security, social cohesion and the economy (Weiner, 1995; Schlesinger, 1998; Hainmueller and Hopkins, 2014) and it has lead to – often draconian – policies to restrict legal immigration and heavy enforcement strategies to deter lawbreakers. This is the case in major destination countries, for example, the US (Massey et al., 2016b), Australia (Williams, 2010), and in countries across Europe (Meko and Sharma, 2016) and Asia (Albert, 2018; Williams, 2010).

However, this does not mean that migrants' agency is necessarily thwarted by these policies. Media reports abound with stories of individuals attempting to migrate despite immigration restrictions. A salient example is the

2014 surge in the migration of unaccompanied minors into the United States. Central American families, unable to migrate legally, sent minors across the border unaccompanied, following rumors from family, friends, acquaintances and smugglers, that U.S. law made special provisions for migrant children. At the height of the surge, the Border Patrol apprehended 10,631 minors (Hulse, 2004). North African and Middle-Eastern migrant flows into Europe are equally dexterous and responsive to attempts at restricting entry. The transmission of migrant experiences and rumors facilitate the emergence of "spontaneous" migrant flows and fluid spatial routes (Hagen-Zanker and Mallett, 2016; Katsiafikas and Ruiz Soto, 2016, p. 1-2). These events may seem extraordinary and bounded in time by extreme situations in the origin country. However, the fact that, in 2005, an estimated 200 million migrants around the world did not have regular residency status (GCIM, 2005) indicates the persistence of agency when movement is restricted.

The purpose of this thesis is to examine how migrants adapt to changing immigration policies with the aid of their social networks. In a broader theoretical sense, it is concerned with examining individuals' agency, or the ability to pursue their migration goals under policies that look to restrict their movement. I argue that, a framework that allows us to understand decision-making under policy constraints must consist of the following elements. First, migration must be conceptualised as a multifaceted choice. States' laws and entry classifications create different modes of migration and the decision to migrate should be qualified with the specific conditions of each mode. Even unauthorised migration is a multifaceted choice: there are different forms of unauthorised migration, involving different risks (see

Section 2.3) and individuals may consider migrating under some conditions but not others. Second, immigration policy constraints affect individuals differently depending on their individual characteristics. This diversity is essential to understanding why some individuals succeed and others fail in their migration plans, as I discuss in Section 2.1. Third, to understand what individuals *do* when their options are constrained, as this thesis proposes, it is important to understand how aspiring migrants *perceive* these constraints at both a normative and a rational level (Sections 2.1.2 and 2.3), as well as the process by which these perceptions are formed. As discussed in Section 2.2, individuals are boundedly rational and may display cognitive biases when learning and deciding to migrate under different policies. These biases and cognitive limitations, may lead them to act differently than they would have under assumptions of perfect information and cognition (In Chapter 8, I explore the possible effects of cognitive biases on migration patterns using simulation). Fourth, migration outcomes are not a direct consequence of individual decisions. Social context – the 'crucial meso-level' (Faist, 1997) – can shape and reshape the options individuals consider and the decisions they ultimately take (Sections 2.1.2 and 2.2).

In order to develop this theoretical perspective, it is important to incorporate a range of multidisciplinary literature. In this chapter, I review and synthesise literature on migration. I, then, consider theories of decision-making, focusing in particular on bounded rationality and cognitive biases. I also examine literature on the rule of law, focusing on types of non-compliance in migration as well as normative and rational deterrents to lawbreaking that can be used to understand why individuals migrate through unauthorised means. Finally, I synthesise key concepts into an agency-centred theoretical framework for the study of migration under immigration policy constraints. The framework will guide the remainder of this thesis.

2.1 Migration Theory

Migration theories can be classified according to whether they consider the social structure within which individuals exist or the individuals themselves more worthy of focus when describing the real world. There are three types of migration theories: the historical-structuralist perspective, the functionalist perspective, and more modern agency centred approaches (Castles et al., 2003). The historical-structural perspective, inspired by Marxist political economy, emphasises social structure above the individual decision-maker, while functionalist theories and the more modern agency-centred approaches emphasise the individual decision-maker, albeit in notably different ways.

Historical-structural approaches consider migration to be the outcome of the unequal economic relationship between developed and developing countries and the effects of capitalist penetration (Massey et al., 1998, p. 34-41). Three models of migration are of particular importance to the historical-structural tradition: dual and segmented labour market theory, dependency theory and world systems theory. Dual and segmented labour market theory (Piore, 1979) argues that the structural demand for cheap and flexible labour is the dominant driver of migration. In advanced industrialised countries, there are two types of labour markets. The primary market consists of secure and well-paid jobs for the natives and the secondary labour market consists of low-skilled, risky and badly-paid jobs. The secondary labour market is mainly filled by migrant workers because migrants are easily exploitable – particularly if their legal status is precarious. The secondary labour market is *segmented* to the extent that it can be subdivided into employment subsections according to gender, race or nationality. Labour agents and employers organise the employment of individuals with specific characteristics into certain jobs, and this segmentation is then perpetuated through networks of co-nationals who recruit migrants to join the ethnic enclave economy (Fussell, 2012, p. 28). Dependency theory considers labour migration to be a product of the unequal way in which the developing world has been incorporated into the capitalist economy. Capitalist penetration traps individuals in underdevelopment, forcing them to migrate internally to urban areas or migrate internationally in order to survive (Morawska, 2012, p. 60). Dependency theory has very similar implications to those of world systems approaches (Wallerstein, 1974). These approaches classify countries according to their position within the global market economy. 'Core' nations are the dominant capitalist powers, while the 'periphery' and 'semi-periphery' are countries that are either wholly or partially dependent on the core through asymmetric trade relationships and capital penetration. Similar to dependency theory, world systems theory conceives of capitalist influences as disrupting labour practices, "creating potentially mobile pools of labour available for migration" (King, 2012, p. 18).

As these theories illustrate, the historical-structural approach considers political and economic structures as 'all-determining' (Castles et al., 2003, p. 37) and the movement of people inevitable, as countries go through the motions of a "grand script" (Arango, 2004, p. 27): Migrants are passively recruited into jobs for which there is a structural demand and they are passively dislodged from their traditional economic activities by the global forces of capitalism. While it is certainly true that migrants' actions are shaped by opportunities that often times correlated with "the pathways of capital penetration," (King, 2012, p. 19) migration is still a decision and therefore entails a degree of free choice (Castles et al., 2003, p. 32). Migrants respond to politics and policy and make plans accordingly (Hagen-Zanker and Mallett, 2016), and this process will cause migrants to deviate from expected historical trajectories. Conceptualising individuals as thoughtful and adaptive is essential to understanding changing policy environments can drive changes in migration behaviour. Furthermore, individual heterogeneity is essential to understanding how immigration policy can shape migration because policies themselves disaggregate individuals into categories based on their individual characteristics. Historical-structural approaches leave no room for diversity – in individual characteristics, life-goals or migration outcomes. It is, perhaps, for this reason that these approaches pay little attention to the role of the state in affecting migration flows (King, 2012).

These aspects render historical-structural approaches inappropriate for examining this thesis' research question. To understand, how individuals respond and change paths in tandem with constantly changing policy environments, we need to adopt the perspective of the decision-maker. To understand the effects of immigration policy, we need to expand beyond explanations of labour demand to examine the direct influence of state policies in shaping migration flows; and we need to be able to conceptualise these policies as having heterogeneous effects on *diverse* populations. Therefore, in the remainder of this section, I focus on functionalist and agency-centred approaches. Functionalist approaches consider migration systems to be a collection of interdependent parts (individuals) and seek to explain why it functions the way it does, focusing on individual action within this system. Functionalist perspectives are widely used in the study of migration and, as I show below, are essential to understanding the real or intended effects of immigration policy. However, they have also been criticised for not adequately conceptualising agency (King, 2012). This criticism emerged in the 1980's, in line with a paradigm shift in social theory towards 'structurationism' (Bourdieu, 1977; Giddens, 1984). Scholars argued that functionalism conceived of individuals as atomistic utility maximisers, who execute predictable actions in accordance with their roles within the system.

In the 1980's, new approaches to migration arose, which regarded decision-makers as creative and thoughtful, with actions that cannot be determined by a cost-benefit equation (de Haas, 2014). These theories were part of a paradigm shift in social theory, which considered structure and agency to be part of a single process – "the constitution of society" (Giddens, 1984). Structurationist theories aim to explain how societies are made and remade over time through social interactions. From a structurationist viewpoint, human beings both reproduce and shape the societies they live in through practices they do not fully understand or have complete control over. In Section 2.1.2, I describe this paradigm shift and how the concepts developed by its two most important theorists, Pierre Bourdieu and Anthony Giddens (Inglis and Thorpe, 2012), relate to the study of migration and immigration policies.

In this section, I begin by reviewing classical functionalist theories of migration. I, then, take a step back to discuss the shift in social theory that gives way to more current agency-centred approaches to migration. Throughout this review, I pay specific attention to migration theories' treatment of agency and the obstacles to migration.

2.1.1 Functionalist Theories of Migration

Ravenstein's (1885; 1889) 'laws of migration' are one of the earliest contributions to the study of migration. Among other laws, Ravenstein laid out the predominance of economic motivations; the direction of outward movement – from agricultural to industrial areas; the intrinsic relationship between migration and economic development; and the concept of return migration as a counter-stream to outmigration.[1] He also theorised on the joint importance of distance and population size in determining location choice, laying the foundation for the well-known gravity models of migration – also known as push-pull models.

Push-pull models dominated much of the work on migration until the 1960's, if not later (King, 2012). According to these models, which draw heavily on Newtonian physics, the volume of movement between two locations is directly proportional to the product of their masses (which has been interpreted as population size) and inversely proportional to the square of the distance between them (White and Woods, 1980, p. 39). These simple

[1]The study of two-way migration dynamics – the subject of Chapter 9 of this thesis – was only researched in depth in the 1970s and 1980s and remains an understudied topic today (King, 2012).

models considered migration to be driven by a set of push factors at the origin country, such as poverty, unemployment, political repression, low social status; and pull factors operating from the destination, for example, income, job prospects, better education, political freedom, among other aspects (King, 2012). In the seminal push-pull model by Lee (1966) (1966), he argued that migration decisions were determined by 'plus' and 'minus' factors in areas of origin and destination, obstacles, and personal factors.

Many scholars have discredited push-pull models for being overly deterministic and purely descriptive (Castles et al., 2013b; Carling, 2002; Skeldon et al., 1990). As Skeldon et al. (1990) explains, push-pull models consist of "a list of factors, all of which clearly contribute to migration, but which lack a framework to bring them together in an explanatory system" (pp. 125-126). Even so, Lee (1966) conceptualises the role of immigration policies and other obstacles (physical distance, cost, cultural barriers) in limiting movement, which is not considered enough in more modern literature (Arango, 2000), and the list of factors these models consider is often more wide-ranging than the explanatory models that have succeeded them (e.g. political variables have often been set aside despite their importance (Leblang et al., 2009)). Furthermore, push-pull models are still widely used, particularly in literature on conflict- or climate- driven migration (e.g. Moore and Shellman, 2007; Mayda, 2010) because they distinguish between planned and spontaneous migration (Hein, 1993).

Neo-classical models share some of the same principles as push-pull models – namely the underlying assumption that migrants are rational utility maximisers and the notion that geographical differences in labour supply and wage shape migration flows (King, 2012, p. 13). They are, however, more sophisticated than push-pull models, and remain prominent today. Migration, in neo-classical models, is driven by wage differentials resulting from differences in the supply and demand for labour across regions or countries. Specifically, capital-rich and labour-poor countries have a high equilibrium wage, while labour-rich and capital-poor countries have a low equilibrium wage. These wage differentials drive movement from labour-surplus countries to labour-scarce countries. In parallel, investment capital moves from capital-rich countries to capital-poor countries, as the relative scarcity of capital in the latter yields a high rate of return. With this movement, we see a counterflow of skilled managers, technicians and other skilled labourers.

Neoclassical models tend toward global equilibrium (Castles et al., 2013b). That is, the international movement of workers leads wages to fall in the capital-rich country and rise in the capital-poor country. Hence, wage differentials narrow and may at some point be eliminated, thereby ending the movement of labour (Massey et al., 1993; Harris and Todaro, 1970). The neoclassical economic model considers migration to be a positive phenomenon: it benefits all parties involved and tends towards greater global wealth equality (Castles et al., 2013b, p. 27). From this perspective, state intervention is considered to distort the "immigration market," and limits the benefits it can bring about (Borjas, 1989a). However, according to this theory, immigration control has a decisive and determinative effect on migration flows (Zolberg, 1989, p. 405-406) and, despite its view of unrestricted movement as beneficial, neoclassical theory has been greatly influential in the design of immigration control policies (Massey et al., 1998, p. 19), as will be discussed later.

Corresponding to the macro-level model is the *neoclassical model of individual choice* (Todaro, 1969; Todaro and Maruszko, 1987; Borjas, 1989a). Micro theory focuses on the individual's cost benefit analysis for displacement, where the highest valued location is that which can lead the individual to have the greatest expected discounted net returns over a defined time period – usually an individual's lifetime. Massey et al. (1993) summarises the cost-benefit calculation in the following equation:

$$ER(0) = \int_0^n [P_1(t)P_2(t)Y_d(t) - P_3(t)Y_0(t)]e^{-rt}dt - C(0), \qquad (2.1)$$

where $ER(0)$ is the expected net economic return to migration at time 0; n is the length of the migration trip; $P_1(t)$ is the probability of not being deported if the individual is an illegal migrant; $P_2(t)$ is the probability of obtaining employment at the destination and $Y_d(t)$ is the earnings the individual can expect. Variables $P_3(t)$, $Y_o(t)$ and r relate to home country characteristics. $P_3(t)$ is the probability of obtaining employment, while $Y_o(t)$ represents the earnings received; r is the discount factor reflecting a greater utility of earning money in the present than in the future. The costs of migration $C(O)$ are subtracted from the integrated difference. If $ER(0)$ is positive, a rational individual will migrate.

According to this model governments can control undocumented migration with policies that affect the probability of obtaining employment at the destination, $P_2(t)$, (e.g. sanctions on employers hiring unauthorised migrants) and deportation, $P_1(t)$, (e.g. monitoring and enforcement efforts).

For example, the US Immigration Reform and Control Act of 1986 imposed sanctions on employers who knowingly hire illegal workers. The motivation behind this policy is clearly based on the neoclassical model: "By lowering the odds of employment for undocumented migrants, Congress hoped to reduce the expected value of U.S. wages and, in doing so, to reduce the expected gain from illegal entry" (Massey and Espinosa, 1997, p. 949-959)

This theory also suggests government policy can select legal migrants according to desired characteristics. According to Borjas (1989a, pp. 460-1), when choosing the country of residence that will maximise their economic well-being, potential migrants choose from a set of "offers," and will therefore sort themselves across host countries. Borjas (1989a) describes this concept as *equilibrium sorting* in the immigration market. The notion that countries "compete" for specific skill sets by enacting selective policies, may strike as odd in the current political climate, but the concept of equilibrium sorting is very relevant today. Immigration policies are founded on the premise that a specific configuration of costs and incentives can shape the composition of immigration (Castles, 2004a). The points-based immigration system used in Australia and the UK, is a clear example. As the name suggests, this system allocates points based on desirable attributes. These attributes can be language ability, the capacity to support oneself financially or previous occupation, for example. However, immigration policies may also limit entries of a given characteristic by imposing yearly quotas. For instance, in the 1960s and 1970s, the US sought to reduce immigration from Mexico by reducing the number of visas available. These actions raised the costs of migration by creating lengthy visa backlogs and waiting times, and increasing legal expenses.

Neo-classical theory has been criticised for its overly simplistic treatment of immigration policy – that is, for assuming the state can control immigration effectively and in a straight-forward manner. There are several limits to the effectiveness of state control over immigration. First, the 'supply' of immigration control is subject to compromise between a diverse set of political interests (Money, 1997; Meissner, 1992; Freeman, 1995). Scholars have found that competition between natives and immigrants – economic, cultural or both – drives demand for stricter control (Money, 1997; Meissner, 1992). Ideational, cultural or institutional factors can also affect the policies ultimately implemented (e.g. Haus, 1995; Watts, 2002). For example, restricting family reunification is often politically problematic in Western democracies. This is an important limitation to state capacity for control, as kin members with special entry privileges may, of course, possess the characteristics the state considers undesirable.

Another reason why policies are unable to exert the effects they would like is migrant agency. According to Castles (2004a, p. 858),

> *Two types of belief have been particularly influential in migration policy formation. One is the economic belief in market behaviour based on neo-classical theory, according to which people move to maximise their individual utility (usually through higher income), and cease to move, or return home, if the cost-benefit equation changes. The second is the bureaucratic belief that regulations designed to categorise migrants and to regulate their admission and*

residence effectively shape aggregate behaviour. Together these two beliefs add up to the idea that migration can be turned on and off like a tap by appropriate policy settings.

Here, Castles (2004a) is echoing the structuration theories of Pierre Bourdieu and Anthony Giddens. According to Giddens, actions are not deterministic, as the neoclassical model prescribes and, while autonomy may vary, creativity and thoughtfulness can help individuals act in ways that can transform their social structure (Cohen, 1989, p. 152). Immigration policy, according to Castles (2004a, p. 860), are "opportunity structures" and "migration rules [are] just another barrier to be overcome in order to survive."

2.1.2 Creativity under Constraints

Since the 1980's, a new body of migration literature emerged, which aimed to break out of individual or structural determinism. According to Castles et al. (2003, p. 37), these new theories

> *... highlighted the diversity of migration and stressed the role of migrants' agency by describing the various ways in which migrants try to actively and creatively overcome structural constraints such as immigration restrictions, social exclusion, racism and social insecurity.*

As mentioned earlier in this section, these new theories were influenced by the structurationist theories of Pierre Bourdieu and Anthony Giddens.

Structurationism hinges on two broad concepts: social reproduction – acting in ways that maintain rules from the past and reinforce the social order – and social transformation, the altering of social order through interaction. In this way, structure and agency become one and the same: individual action shapes social structure and social structure shapes individual action. Bourdieu's work focuses on class-based social reproduction, and like the historical-structural approaches to migration discussed earlier, was influenced by Marxism. Giddens, on the other hand, leans more towards social transformation and was, perhaps, more influential in shaping our view of agency in migration.

Still, Bourdieu's concept of 'habitus' and 'capital' were highly influential in these new agency-centred approaches to migration. 'Habitus' consists of ideal and physical 'practices' – or actions that people take without fully reflecting on them – that are particular to the social group to which the individual belongs. This is because the habitus is inculcated into the individual through a process of socialisation, such that the individual adopts values, attitudes and ideas belonging to the group. An important aspect of habitus is that it "adjusts expectations to reality," such that individuals within a particular social class do not expect things which they are unlikely to obtain given the social structure in which they belong (Inglis and Thorpe, 2012, pp. 214-215). Habitus sets the possibilities for action. That is, it creates and changes the social structure and, at the same time, limits the set of actionable alternatives (Reay, 2004). The idea that belonging to a social group can dictate the sort of decisions one may take, is reflected in several of the theories described below. For example, the concept of 'relative deprivation,' which is essential to both the New Economics of Labour Migration and capabilities approaches to migration, considers the importance of local reference groups in shaping aspirations and alternatives for action.

Bourdieu conceived of modern societies as consisting of series of 'fields' or separate social structures within which 'games' are played. In these games, all players seek to dominate others, often in ways that are not entirely conscious. Some players have advantage over others, occupying a higher position in the field. Their position in a field is determined by a specific amount and type of 'capital.' Capital consists of both the resources – the ways in which actors can play a game – and the stakes – or what players are attempting to accumulate by winning the game. There are three types of capital: Economic capital (money); social capital (social connections) and cultural capital (the amount of prestige associated with a person's practices, i.e. how well they speak or how much they know about art). The concept of capital forms the basis of a very influential theory of migration, social capital theory, also known as social network theory, which is discussed later in this section. This theory considers social capital, which may be transformed into economic capital, to be an essential force in perpetuating migration. In this thesis, I take a step further and conceptualise immigration policy as an objective condition that provides necessary advantages only to individuals who possess or have access to a particular type of 'capital' (i.e. social or economic), as I discuss in Section 2.4.

Although, Bourdieu's approach is not deterministic it has been criticised for not considering individuals to be reflexive enough (e.g. Mouzelis, 2008). Giddens conceives of individuals as thoughtful and creative and capable of change. He rejects functionalism (among other theories) because of its "unacceptable downgrading of human agency" (Inglis and Thorpe, 2012, p. 225). Agency for Giddens is captured by the concept of the 'ontology of potentials,' which holds that every agent could have potentially acted in a way that is different than the way they did in a given case. According to Giddens, even individuals in the most constrained social circumstances, such as slavery – have some kind of agency (Cohen, 1989, p. 152). This agency drives individuals to transform a situation in ways the agent may not intend or may not fully understand. Similar to Bourdieu, Giddens considers individuals to be heterogeneous in the set of resources they have at their disposal and how skilled they are at using them. This heterogeneity can help some individuals overcome structural constraints more successfully than others (Inglis and Thorpe, 2012), a concept that is essential to understanding the effects of structural constraints as developed in the capabilities approach to migration and, in particular the work of Carling, which will be discussed below. However, though Giddens emphasises agency and change more than Bourdieu, he also pays due attention to the importance of inheritance from the past. Past practices that are not necessarily one's own but have been inculcated through socialisation are termed 'memory traces' (Inglis and Thorpe, 2012). Memory traces limit the set of actions available and can lead to path dependent behaviour. In other words, individuals tend to repeat or reproduce what individuals before them have done and this limits their capacity to change social structure (Giddens, 1979, p. 5). This path dependency is, once again, very similar to the process of cumulative causation in migration, which is described later in this section.

In the remainder of this section, I describe modern theories of migration, which were influenced by the structuration approach. These theories describe how successful migrants can transform social structures and help others surpass situational constraints of different kinds. These new practices, if successful, can then perpetuate themselves through social reproduction.

New Agency-centred Approaches

The *New Economics of Labour Migration* (Stark and Bloom, 1985) emerged as a critique to functionalist theory – in particular neoclassical models – on two fronts. The first is that migration is a household or community-wide strategy aimed not only at maximising income, but also at mitigating risk. Families or collectives can form joint strategies to minimise the risk of market failure by diversifying labour allocations. If income streams across geographically discrete areas are loosely or negatively correlated, families can have some control over risk of market failure. For example, farm households in developing countries are subject to human or natural events that can substantially lower crop yield. Families have an incentive to send workers abroad, so that these workers can transfer money to the household and insure the household against potential harvest failure. In developed countries, risk of crop failure can often be mitigated with agricultural technology, but in developing countries, these risks pose a significant constraint to well-being that may only be overcome with migration (Massey et al., 1998).

The second key affront to neoclassical theory is the argument that migration does not arise from absolute poverty but relative deprivation (Stark and Bloom, 1985, p. 174). Relative deprivation and inequality are often used in conjunction, but they are not the same. Inequality means a segment of the population is poorer relative to another, but feelings of relative deprivation cannot take place if well-being comparisons within a proximate reference group do not occur. This concept considers want and the ability to move as constructed by one's social environment, rather than abstract macro-level concepts such as poverty.

The concept of relative deprivation has been associated with Amartya Sen's *capabilities approach* to human development. Sen's capabilities approach defines development as a process of expanding freedoms and stresses individuals' ability to lead lives that are subjectively valuable (Sen, 2001). This approach considers factors such as education, health, and different kinds of inequalities as opportunity structures constraining and enabling people's decisions (De Haas, 2011). In this framework, human development includes the capability to decide where to live (De Haas and Rodriguez, 2010), a capability that can be constrained by immigration laws.

Carling's (2002) aspiration/ ability model is a seminal study within the capabilities approach (de Haas, 2014). According to the model, the interplay of aspiration and perceived ability can generate three migratory categories of people: migrants, involuntary non-migrants and voluntary non-migrants. Migrants are individuals whose movements can be observed; involuntary non-migrants are those who wish to migrate but are unable to do so; and voluntary non-migrants are those who stay because "because of a belief that non-migration is preferable to migration" (p. 12).

The aspiration/ ability model and related literature (e.g. Castles, 2004a; Castles et al., 2013b) has been relatively unclear about the effects of restrictive policies on aspiration and ability – that is, whether it produces voluntary or involuntary non-migrants. Immigration policy is likely to reduce people's perceived ability to migrate, but we do not know whether it also decreases their aspirations to do so. This question has significant theoretical and real-life implications. Theoretically, the question sits at the crux of the social reproduction/ social transformation debate. According to Bourdieu, habitus "tends to make a person's 'subjective' mental outlook on life mesh with 'objective' social conditions," such that a person who has little chance of migrating successfully, for example, would never think of doing so. This thought would remain "outside their range of possible thoughts" (Inglis and Thorpe, 2012, p. 214-215). On the other hand, Giddens' 'ontology of potentials' highlights that all individuals have some agency to transform social structure, regardless of objective conditions (Cohen, 1989). This philosophy would contend that individuals will adapt and search for alternative – possibly illegal – ways to migrate. An enduring aspiration to migrate despite objective constraints is a necessary condition for social transformation to occur. I examine this question further in Chapter 5.

One of the most important contributions of the capabilities approach to the study of migration is the concept that immigration policies have different effects on the capabilities of different people (De Haas and Rodriguez, 2010; Ruhs, 2010). Carling's (2002) concept of an 'immigration interface' is a set of legal and irregular migratory channels – each consisting of their own costs and risks. Differing individual characteristics such as age, gender, family network or level of education make individuals heterogeneous in their ability to access any one of the migration modes within the policy interface – as in

Bourdieu's skilled players in a game. This concept is very similar to Borjas's (1989a) "equilibrium sorting," albeit with a different normative tilt. That is, Carling pays greater attention to constraints instead of opportunities or "offers."

The concept of the 'immigration interface' is a step towards understanding migration as a non-binary choice. This concept 'zooms in' on the interaction between the individual would-be migrant – with a set of unique characteristics and resources – and the set of migration options laid out by the state. Although Carling concludes that most individuals do not have the capability to decide where to live – that is, they are 'involuntarily immobile' – he develops a detailed framework that can help us systematically examine individuals' potential choices for migration.

Carling's model also takes seriously the manner in which macro-level structural conditions are processed as perceptions at the individual level. People's desire to emigrate, according to (Carling, 2002, p. 17), "is a result of their own understanding of these problems rather than a straightforward function of unemployment rates and precipitation figures." However, the concept of an 'immigration interface' draws the image of individuals choosing from a clear inventory of legal and illegal options – most of which are inaccessible. In reality,however, individuals continually learn about, assess and reassess migration alternatives and adapt to changing conditions (Simon, 1972; Gigerenzer and Selten, 2002), a point to which I will return later in the chapter in the context of bounded rationality and adaptation (Section 2.2.1). According to Giddens, this thoughtfulness and reflexivity is a key aspect of agency (Beck et al., 1994).

Because learning takes place through one's own experiences as those of family, friends and contacts, and because migration itself can change outcomes for one's relationships and broader community, theoretical conceptualisations of migrant agency and choice cannot be divorced from social context, "migrants are not isolated individuals who react to market stimuli and bureaucratic rules, but social beings who seek to achieve better outcomes for themselves, their families and their communities by actively shaping the migratory process" (Castles, 2004a, p. 860). In other words, we need to be able to understand migration at the *meso* level: the level of social context. *Social network theory* considers migrant agency and creativity in the form of relationships that benefit the migration process.

Migrant networks are sets of interpersonal relationships between migrants, non-migrants and former migrants spanning origin and destination areas. According to social network theory, aspiring migrants can derive several benefits from connections to established immigrants, which can help them achieve their migratory goals. The main expectations from social network theory (SNT) are as follows. First, networks are cost-reducing. Ties abroad provide information and resources that mitigate the costs of the move. Upon arrival, newcomers can draw upon social obligations to provide them with access to lodging, food and employment. In the case of Mexico - U.S. migration, cross-border connections between origin and destination communities are often institutionalised, for instance, through daughter communities in the U.S. or sports clubs. These arrangements promote the frequent sharing of news and information between migrants and non-migrants, and provide a solid base for migration assistance (Massey et al., 1987).

Second, social networks are risk-reducing. According to SNT, migration decisions can be undertaken at the level of the individual or household (Massey et al., 1993). That is, households may send members abroad to diversify labour allocations or individuals may be driven to move by a desire to seek opportunities abroad. Regardless of how the decision is arrived at, SNT emphasises the importance of social relationships and obligations spanning origin and destination. By helping new migrants access employment abroad, networks make migration an attractive strategy to diversify household income. Using data from a 2003 survey, Adams et al. (2005) find that money transfers made by migrants working abroad accounted for 15 percent of per capita household income in rural Mexico. According to Palloni et al. (2011) "Having a tie to someone who has migrated yields social capital that people can draw upon to gain access to an important kind of financial capital, that is, high foreign wages, which offer the possibility of accumulating savings abroad and sending remittances home" (p. 1264).

Third, migration is self-perpetuating and overshadows macro-level conditions, including immigration policy. As people migrate, they become a source for network benefits that future migrants can draw on. This induces further migration which, in turn, reduces costs for a further set of people, increasing their likelihood of migrating. According to SNT, networks will have a larger effect on migration flows than wage differentials, employment rates or immigration policy. Migration can remain an attractive option despite negative employment or policy conditions due to the falling risks and costs of movement stemming from the growth of networks over time (Massey et al., 1993). Massey and Alarcón's (1987) seminal study on the social process of migration from four Mexican communities to the United States finds that, though international migration began through the macro-level dynamics of supply and demand, it has become a mass phenomenon through its intrinsic network dynamics.

However, the benefits brought about by social capital are not endless. Social capital can also be or become exclusionary and networks must eventually decline in strength and extent (King, 2012; Putnam, 2002). Several scholars have pointed out that the same dynamics that further migration also lead to its endogenous decline. Increased labour supply reduces wages and increases competition for jobs. At this point, established migrants may become unwilling to help newcomers, reducing the extent to which social capital can be mobilised (Massey, 1990; Faist, 1997; Massey et al., 1994; De Haas, 2010; Epstein, 2008).

The *theory of cumulative causation*[2] can be considered an extension of social network theory. It focuses on the dynamics of social network formation. In an initial period, networks are considered to increase the incentives and lower the costs of migration. Those who are relatively deprived begin to migrate to take advantage of better opportunities abroad. Once a critical mass of migrants has established itself at the destination, migration through family reunification and other channels quickens, and social capital is spilled over to others who may not be directly connected to the established migrants. Aside from increasing the expected probability of attaining a higher wage through migration, feedback can take the form of changing the distribution of

[2]the concept of cumulative causation was first coined by Myrdal (1958) and applied to economic development.

income through remittance sending, or the distribution of land, as a portion of the labour force moves away (Massey and Espinosa, 1997; Faist, 1997; De Haas, 2010).

Social network theory and the theory of cumulative causation do not aim to explain how migration starts or why it might accumulate in one destination and not another. Rather, these theories concern themselves with the *perpetuation* of movement across an established spatial corridor. According to these theories, migration displays path-dependency. This path-dependency manifests itself spatially in the form of distinct spatial clusters. For example, we can find concentrations of Turkish nationals in Germany, Moroccans in the Netherlands, Italians in Argentina (Epstein, 2008). This clustering pattern can be observed in even within countries. One example is the Indian diaspora in the United Kingdom, which is settled in identifiable areas of London, Birmingham and Leicester (Somerville and Dhudwar, 2010).

Social network theory and the theory of cumulative causation emphasise the internal self-reinforcing dynamics of migration at the detriment of policy effects. Indeed, these theories assume governments will have difficulty controlling migration because the cost and risk reducing effects of networks will counter government policies. However, social network theories' treatment of policy effects is simplistic and relies on several questionable assumptions.

First, the claim that "the process of network formation lies largely outside [government] control and occurs no matter what policy regime is pursued" (Massey et al., 1993, p. 450) may be an oversimplification. Collyer's analysis of (2005) Algerian asylum-seeker migration to France, finds that strict immigration controls increased the burdens on aspiring migrants' social networks.

Immigrant ties, then, began to avoid claims from aspiring migrants on their assistance, leading this corridor to contract.

Second, if movement is path dependent and produces identifiable spatial clusters despite government efforts to restrict movement into a particular destination, we might expect migration flows to be spatially static and largely undocumented. However, spatial reorientation has been observed between countries (Collyer, 2005) and within countries (Ellis et al., 2014; García et al., 2011; Bohn and Pugatch, 2015). This is an important affront to social network theories because it questions one of its most important theoretical predictions: if movement is path dependent and produces identifiable spatial clusters despite government efforts to restrict movement into a particular destination, how can spatial reorientation take place? I tackle this theoretical puzzle explicitly in Chapter 9.

Third, the primary expectation of network theories is that migration begets more migration. However, although the perpetuation of migration is driven by positive feedback, network theories generally do not question whether this information is an accurate reflection of the odds of successful migration. Restrictive entry and enforcement policies in major destination countries have made the odds of success relatively dire for most of the world's population (Carling, 2002). Is there, then, an implicit 'positivity bias' in this theorised feedback process, and if so is the sender or the receiver to blame? What role do migration failures play in decisions to migrate?

Fourth, although network literature emphasises the importance of previous migration experience when considering the likelihood of subsequent trips (Massey, 1986; Piore, 1979), it is unclear about whether personal experiences have a larger or smaller influence than the experiences of friends or family members. I expand on this and the aforementioned point in the context of biases in decision-making later in this chapter. I also explore the possible effect of cognitive biases on migration at the macro level in Chapter 8.

Fifth, as policies have a determinative effect on the overall volume of *legal* migration admitted, the only way in which migration can persist despite government restriction is through illegal means (Massey et al., 1998, p. 45). The assumption that migration will remain, unchanged, despite the new conditions under which it must take place is also simplistic. Even if social networks can mitigate the risks and costs of illegal migration, individuals are likely to face normative barriers when contemplating a migration alternative that is outside the law (Ryo, 2013). This point is discussed further in the context of compliance and decision-making later in the chapter.

Sixth, these theories do not pay sufficient attention to the role of networks in transmitting information that can help potential migrants learn about and navigate the 'immigration interface.' Individuals do not have perfect knowledge about immigration rules, which are obscure and labyrinthine (Fazito and Soares, 2013; Wilson, 2007). Due to the complexity of legal immigration rules and requirements as well as unauthorised migration practices (Spener, 2009), individuals must rely on information from social contacts to *learn* about the immigration environment and how to navigate it (Massey and Zenteno, 1999). Integrating this process in our understanding of social network effects is crucial because of the wide-ranging implications it entails: Migrant networks not only facilitate further migration, as social network theories prescribe; they also play a role in modulating migration flows pertaining to legal and illegal migrant categories by propagating information on policies established at the macro level; an effect that is clearly visible in the examples on Central American child migrants and the European refugee crisis detailed at the beginning of this chapter. Understanding the mechanisms by which individuals acquire and act on policy information requires that we examine psychological theories of decision-making.

2.2 Theories of Decision-Making

In this section, I expand beyond migration theory to examine theories of decision-making. First, I examine theories of bounded rationality, which can help us understand unauthorised migration as an adaptive process. I, then, examine theories on biases in decision-making that may explain migration despite substantial policy-induced risks. Bias in decision-making may be considered under the umbrella of bounded rationality (Gigerenzer and Selten, 2002). However, I consider the two separately because biases may result in maladaptive behaviour – that is, behaviour that runs counter to what is best for individuals' self interest – by distorting the actual situations individuals face.

2.2.1 Boundedly Rational Learning and Adaptation

Bounded rationality can be best described in contrast with the traditional approach to rationality which conceives of the individual as an expected utility maximiser. In the latter perspective, individuals' decision-making process is simple and consists of maximising a goal value (i.e. getting the job with the best salary) and the probability of succeeding in this goal. However, it hinges on several unrealistic assumptions. It assumes that (1) individuals possess all the information available to make a decision and (2) are able to process this information without incurring any costs (Baláž et al., 2014). It also considers (3) behaviour to be always optimising (Selten, 1998), that (4) individuals are able to perfectly assess the value of an attribute or goal and the probability of successfully attaining it and (5) that the subjective weight attached to some probability of succeeding is equal to the objective value (i.e. decision makers value a 50% chance of winning as a 50% chance of winning) (Kahneman and Tversky, 1979).

Bounded rationality is an affront to all these assumptions. Herbert A. Simon's (2000, p. 25) intentionally long-winded description of bounded rationality betrays the complexity of decision-making and how Expected Utility Theory cannot describe the real world:

> *Bounded rationality is simply the idea that the choices people make are determined not only by some consistent overall goal and the properties of the external world, but also by the knowledge that decision makers do and don't have of the world, their ability or inability to evoke that knowledge when it is relevant, to work out the consequences of their actions, to conjure up possible courses of action, to cope with uncertainty (including uncertainty deriving from the possible responses of other actors), and to adjudicate among their many competing wants. Rationality is bounded because these abilities are severely limited.*

The rich body of literature on bounded rationality has associated bounded rationality with adaptation. This research examines how humans make inferences about their environment under the constraints of time, knowledge and cognitive capacities, and use this information to make decisions.

According to Gigerenzer and Selten (2002), individuals' mind is an 'adaptive toolbox' containing a series of heuristics – or mental shortcuts – that are specific both to the cognitive abilities of the individual and to the domain of the problem she is trying to solve. This contrasts with Expected Utility Theory's depiction of the mind, where tools are generalisable to a range of problems and have no limitations. Gigerenzer and Selten (2002, p. 43) liken the boundedly rational mind to a "backwoods mechanic":

> *The backwoods mechanic has no general-purpose tool nor are all spare parts available to him. He must fiddle with various imperfect and short-range tools, a process known as vicarious functioning (Brunswik, 1955). He will have to try one thing, and if it does not work, another one, and with step-by-step adjustments will produce serviceable solutions to almost any problem with just the things at hand.*

Though domain specific, heuristics are composed of more general building blocks, that guide the search for information. Specifically, these building blocks guide search direction and when to stop searching to make a decision. The search itself consists of two dimensions: the search for alternatives – or the construction of a 'choice set' – and cues to evaluate the alternatives.

The aspiration adaptation theory of bounded rationality (Simon, 1957;

Selten, 1999), for example, describes the search for alternatives as an iterative process by which individuals seek new information to construct their choice set, and update their expectations as they learn. Cognitive, emotional and normative heuristics can help reduce the task of constructing the choice set by restricting the range of options evaluated and focusing the individual's attention on specific aspects of the information at hand (Hanoch, 2002). In the case of migration, for example, if an individual is normatively opposed to unauthorised migration, she may focus on other modes of migration in her search.

In aspiration adaptation theory, the stop criterion in the search process is the point where the first decision alternative is found that is as good or better than the aspiration level. The 'cue' is implicit in this comparison between the decision alternative and the aspiration level (Gigerenzer and Selten, 2002). If the individual is unable to find a strategy that matches their aspiration level, they may adjust their aspiration level and continue the search.

At the point of stopping the search, the individual is said to have 'satisficed' – or has opted for a feasible but likely sub-optimal strategy. This stopping rule is less computationally intensive than a rule such as 'stop search when costs outweigh the benefits', which would require a more complex calculation (Gigerenzer and Todd, 1999). However, there are many different stopping rules that may apply to a boundedly rational search processes. In these rules, search is generally stopped as soon as the individual finds the first cue favouring an alternative in their choice set (Gigerenzer and Goldstein, 1999).

Bounded rationality has several adaptive functions. First, when responding to a changing environment, a search strategy that allows for quick decisions is beneficial. The boundedly-rational search process is quick and computationally cheap, allowing individuals to make fast decisions under time constraints, even if the decision itself is not optimal. Second, it conceives of individuals as flexible and creative and, therefore, adaptive. In the aspiration adaptation model, lowering aspiration levels allows individuals to achieve their goals despite objective constraints (Selten, 1998). The implications of such a model for migration are clear. When forming a choice set, a potential migrant might search for several visa options and, if unable to include these in their choice set, they may adjust their aspiration levels and consider suboptimal strategies such as those that forgo the law. These strategies, though not the first choice, may be feasible.

Third, heuristics are adaptive because they exploit the environmental structure. According to Gigerenzer and Selten (2002), "the heuristics in the adaptive toolbox just 'bet' on the environment on the basis of past experience and a little probing, without attempting a complete analysis and subsequent optimisation" (p. 41). The heuristic is considered accurate if it is able to "fit with reality" (Gigerenzer and Todd, 1999, p. 5). Experience and probing in the learning process need not be first-hand. Following the logic of bounded rationality, learning from others' experiences can provide a short-cut and lead to quicker decisions than attempting each strategy personally, particularly if probing the environment is very time consuming (e.g. applying for a visa). For example, migrants may collect information on others' experiences instead of or before attempting migration themselves, as suggested in social network theories. This extension can build a connection between the psychological search process of bounded rationality and Bourdieu's concept of habitus. That is, that individuals are socialised into adopting certain practices which create and recreate the set of actionable alternatives (which Gigerenzer and Selten (2002); Simon (1957); Selten (1998) term 'choice sets'). Fourth, simple heuristics can also easily generalise to new problems, which is particularly important when environments are changing (for example, immigration policy). A complex model with many parameters may fit a given reality much better than a simple one, but if this model is fed new data, it may not function as well. For example, management and decision-making literature often uses the term "analysis paralysis" to describe a situation in which the decision-maker embarks in a complicated decision process with multiple decision alternatives and scenarios. This process increases the length of time until a decision is made and hampers decision-makers' ability to respond to crises or other abrupt changes in the environment (Burke and Miller, 1999; Bonn and Rundle-Thiele, 2007). Simple intuition, on the other hand, can be used to take quick action without much need to learn about the specifics of new changes in the environment.

Cognitive biases can also further migration by distorting the probabilities associated with success and failure. In contrast to bounded rationality as conceived by Gigerenzer, Selten and Simon, biases may lead to behaviour that is not only suboptimal but contrary to individuals' self interest, while reducing the speed with which a feasible alternative is discovered.

2.2.2 Biases in Migrant Decision-Making

There are a multitude of reasons why positive and negative signals about the odds of successful legal migration might be weighted differently. The first culprit may be the sender. Many studies have documented that migrants abroad tend to send positive signals about their migration experience, including the journey and quality of life in the host country, while keeping negative experiences to themselves (Ryo, 2015; Sabates-Wheeler et al., 2009; Reyes et al., 2002; Hernández-Carretero, 2008). Using qualitative data on Ghana, Sabates-Wheeler et al. (2009) demonstrate that return migrants tend to elevate expectations about life abroad by flaunting their wealth or telling stories about the ease of life abroad. This bias in information sharing is also present when migrants speak of the risks involved in making an unauthorised, often dangerous, journey abroad. Reyes et al. (2002) found migrants will generally relate mostly positive experiences. One of their respondents, for example, said: "Nobody talks about the crossing, nobody. The people I heard from always talked about the money, Disneyland . . . ooh, wonderful things. Out of 10, maybe one tells the truth." Hernández-Carretero's 2008 study on West African boat migration to the Spanish Canary Islands, found that unauthorised migrants in destination countries often conceal negative experiences "to maintain a successful image in front of family and friends back home." This bias in information sharing can lead potential migrants – the receivers – to make decisions that go against their own best interest. As Sabates-Wheeler et al. (2009) suggests, "the mingling of reality and aspiration can become problematic for prospective migrants when it leads them to base their search for better life chances on what are, in fact, meta-narratives of success" (p. 753).

In these accounts, geographical distance affords the possibility of hiding information one would rather not share. However, it is not clear whether these findings apply to the full spectrum of migration scenarios. For example, to "maintain a successful image" (Hernández-Carretero, 2008), individuals may hesitate to admit they have been denied a visa. However, applying for a visa is, often, a lengthy and burdensome process. It is, therefore, more difficult to hide – at least from household members or other geographically close ties. As such, distance can play a moderating role in the sharing of information.

A wealth of psychological research on motivated reasoning examines the biases resulting from the active acquisition and processing of information from the perspective of the (future) decision-maker (extensive reviews can be found in Baron (2008) and Hahn and Harris (2014)). This body of research would suggest that individuals who aspire to migrate, will tend to weight positive information about their chances of being able to do so more highly than they would negative information.

Wason's seminal 1960 paper on confirmation bias, "On the failure to eliminate hypotheses in a conceptual task" assigned experimental participants the task of correctly inferring the rule underlying a set of numerical triplets (i.e. 2-4-6). To do so, participants gave the experimenter query-triplets, which the experimenter then confirmed whether or not they conformed to the rule. Wason found that a large proportion of participants sought to obtain positive evidence that confirmed their current hypothesis for the rule, as opposed to evidence that would dis-confirm it.

Similarly Hagen-Zanker and Mallett's (2016) study of recently arrived migrants, refugees and asylum seekers in four European cities (Berlin, London, Madrid and Manchester) found that migration trajectories were influenced more by opportunities inherent in immigration policies, instead of their restrictive aspects: "those we interviewed seemed more influenced by migration policies that made life a little easier (faster asylum-processing procedures are just one example)." At least among the subset of the population that made it to the destination, individuals consistently searched for information that would further their migration goals at the expense of objectivity.

This sort of confirmation bias has also been observed relating to risks induced by immigration enforcement measures. Hernández-Carretero (2008) documents the existence of "tunnel vision" among West African aspiring migrants, whereby information that would go against the hypothesis that migration is possible, is ignored and discarded. Instead, individuals sought positive information from their migrant ties.

> *Maintaining this kind of 'tunnel vision' about the realities of pirogue migration might be a way to protect oneself from having to reconcile the wish to emigrate with the awareness of serious dangers on the chosen route... Sometimes, people who are considering the pirogue journey simply do not enquire about the conditions of the journey to others who have already attempted it* (p. 52).

Individuals may also exhibit bias in the *processing* of information by overweighting positive instances and discrediting negative feedback on the odds of success. This type of bias has been termed “wishful thinking” or “unrealistic optimism” (Hastie, 2001). Several studies document that in judgments of health and medical risks, medical professionals tend to be unrealistically optimistic (Taylor and Brown, 1988; Weinstein, 1980). Similarly, Gilovich (1983) found that gamblers evaluate their losses differently from their gains. Successful outcomes are often considered a reflection of gambling skill, whereas losses are dismissed or discounted. This manner of processing information may result in the perception that one has better odds of succeeding in an enterprise by having skills or certain other qualities another individual does not. In the case of migration, the odds of migrating legally to many major destinations is, in fact, dependent on demographics, social ties or other personal characteristics. As such, a perception that the odds are in one’s favour can be reinforced by immigration systems that categorise and select applicants based on personal characteristics. Some aspiring migrants may also perceive themselves to be more capable of adopting a given illegal strategy, despite the risks involved. For example, in Hernández-Carretero (2008), fishermen considered themselves more capable of taking pirogues due to their experience navigating.

My second question – whether one weights personal opinions higher than those of others – cannot be divorced from the content of that information. A person that seeks confirmatory information, for example, may discard information that does not fit this criteria, regardless of its provenance. However, research on egocentric discounting (Yaniv and Kleinberger, 2000), has found that the source of information (i.e. ones own experience or others’) has an influence in and of itself. This research has found that individuals often discount advice from others in favour of one's personal opinions. It is commonly accepted that the psychological weight associated with a hypothesis or an estimate is correlated with the amount of support that the individual can access for that hypothesis or estimate (e.g., Tversky and Koehler, 1994). Advisees will generally not have access to the basis for the advisers opinions, while they, of course, have access to their own rationale, leading them to weight the latter more heavily. As such, all things being equal, we should expect aspiring migrants to discredit others' assessment of the immigration policy environment in favour of their own. This bias may actually reduce the speed with which a feasible alternative is found. If individuals objectively accumulate knowledge from their networks (given that the information itself is objective), they are more likely to find a feasible alternative without having to try each alternative themselves through trial and error.

However, every social tie is different and may carry a different weight. Individuals' 'weighting policy', Yaniv and Kleinberger (2000) suggest, may also be mediated by the advisees' impressions and perceived reputation of the advisor. Potential migrants might perceive some sources, such as experienced migrants or smugglers, to be more knowledgeable than others (Fazito and Soares, 2013; Gammeltoft-Hansen and Sorensen, 2013b). On the other hand, they may distrust the source or suspect they have an ulterior motive. For example, one of Hernández-Carretero's respondents, Ibrahim (25), explained his reaction to those who tell him that pirogue migration is not worth the risks: "... The way I see it, you are sabotaging me. That's what it is" (p. 52).

Throughout this chapter, I have treated all migration strategies simply as alternatives and have depicted unauthorised migration as simply a sub-optimal strategy (in the context of bounded rationality) or a special instance of migration (in the context of functionalist theories of migration). However migrating illegally is not *one* alternative, it is a grouping of various alternatives that vary in terms of legal compliance, normative acceptability – as well as in terms of risks and costs. This variation in strategies within unauthorised migration is the result of reflexivity and problem-solving and, therefore, reflects aspiring migrants' agency. The next section examines the spectrum of illegality in migration from a theoretical perspective.

2.3 Degrees and Motivations of Non-compliance in Unauthorised Migration

If migrants make decisions through rational calculation, then increasing the costs of non-compliance should reduce unauthorized migration (Cornelius and Rosenblum, 2005; Todaro and Maruszko, 1987). In the context of law-breaking, this is commonly referred to as the deterrence model. However, there is another aspect to compliance, and that is *norms*. Rational and normative deterrents complement each other. Levi's (1989) seminal study of compliance develops the term 'quasi-voluntary compliance' to describe the interplay of norms and enforcement in driving adherence to rules.

Norms can take a variety of shapes. They can be "customs, conventions, conceptions of right and wrong, notions of propriety, and regularities of behaviour" (Young, 2015, p. 361). According to Gibbs (1965, p. 589), a definition of norms that encompasses the various types includes the following three elements:

> *(1) a collective evaluation of behaviour in terms of what it* ***ought*** *to be; (2) a collective expectation as to what behaviour* ***will*** *be; and/or (3) particular reactions to behaviour, including attempts to apply sanctions or otherwise induce a particular kind of conduct.*

That is, norms may define the practices that should be carried out or the ones that are typically carried out, and they are shaped by social context. Additionally, the violation of norms may (or may not) be accompanied by some type of punishment. Mackie et al. (2015) further define the catchment of social influence as a local reference group. That is, norms may exist within a very narrow social context – they are not necessarily widely held. This is important because it permits the existence of norms, bounded in specific social circles, that are atypical or extreme when considered at an aggregate level. This is further discussed in Chapter 6.

While several scholars have examined the effects of rational deterrence in unauthorised migration (e.g. Todaro and Maruszko, 1987; Donato et al., 1992; Espenshade, 1994; Durand et al., 1999; Massey et al., 2016a), comparatively few scholars have examined the role of normative deterrents (e.g. Ryo, 2013, 2015). Ryo's research on unauthorised migrants focuses specifically on two dimensions of norms, personal *morality* and *legitimacy* (Tyler, 2006). Personal morality refers to behaviours an individual perceives to be right and wrong. While morality and legality often intersect, there are laws to prohibit behaviour that many would not consider immoral (Robinson and Darley, 1995). There are also many moral issues that are not protected by law (Krisch, 2002). Relatedly, legitimacy is associated with procedural justice or fairness. Authorities applying laws equally and transparently, for example, are perceived to be more legitimate and, consequently, yield greater legal compliance (Paternoster et al., 1997; Hoffmann, 2005).

Unauthorised migration means breaking the law. Therefore it is highly plausible that normative barriers play a role alongside any cost-benefit calculations, as suggested in the above theory. Omitting this layer from our understanding of migration decisions may lead to erroneous expectations on the levels and types of unauthorised migration (I expand on this point further in Chapter 6). In other words, the interplay between normative and rational considerations has two implications. First, norms can be an additional barrier to migrating illegally despite prevailing risks. Second, norms and risks jointly define the range of different strategies that exist under the legal umbrella of unauthorised migration as well as their prevalence.

2.3.1 Full and Semi-Noncompliance

Within the domain of unauthorised migration, individuals have developed a range of different migration practices, varying in terms of the degree to which aspiring migrants engage, negotiate with, and reject political institutions and laws. Within the actions considered to be illegal in receiving states, individuals perceive some actions to be more illegal than others (Engbersen and Van der Leun, 2001). According to Ruhs and Anderson (2010), unauthorised migrants working in the UK believed they were "less deportable than others" and considered their status as existing within a scale of illegality. For example, even though working on a non-employment visa means breaking the law, individuals believed it was less risky to do so for some types of non-employment visa than for others. Individuals who had, what they perceived to be a 'lower-risk' visa thought of themselves as having greater security of status than other unauthorised migrants committing a very similar crime.

Unauthorised migration may not be the result of a deliberate decision: some immigrants may fall out of status due to carelessness, lack of understanding, or administrative deficiency (Cornelius, 2004; Düvell, 2011). However, some individuals perceive immigration policy as an opportunity structure and actively engage with it (Castles, 2004b, p. 860) and others yet may, deliberately, make no attempts to comply with immigration law. Ruhs and Anderson's study (2010) features individuals who commit very slight violations, such as students in the UK who work more than the hours allowed by their visas and a young woman who is permitted to work as an *au pair* but then takes a cleaning job on the side. These examples contrast with a case in which a Dominican couple married each other's siblings to bring them to the United States, an action termed *matrimonio de favor* (Garrison and Weiss, 1979), and a caseworker who bought a National Insurance Number in order to work (Düvell, 2004).

As these examples illustrate, many irregular migrants exist within a state of "legal ambivalence," where their status consists of both regular and irregular aspects (Düvell, 2011, p. 292). As such, migration scholars have described two principal classes of legal non-compliance: semi-noncompliance and full non-compliance (Düvell, 2006; Ruhs, 2010; Gammeltoft-Hansen and Sorensen, 2013a). Although classification varies, in **?**, we defined fully non-compliant strategies as those operating wholly outside of the law. Clandestine border crossings and forged entry documents, for instance, forgo all legal processes. Here, there is no attempt to engage with immigration law or formal authorities. Semi-noncompliant strategies, on the other hand, comply with *some* aspects of immigration law. For the most part, semi-legal migrants apply for and receive a legal visa, but they violate its conditions. Such strategies may consist of a wide range of permit violations including *matrimonio de favour*, working on a temporary visa, or violating other work restrictions. Regardless of their legal classification, migrants may perceive these strategies as bending rather than breaking immigration law (Ruhs, 2010, p. 205).

The scale of illegality has implications on an individual's normative and rational perspective on a given migration strategy (Schuck, 2000; Ruhs, 2010). Extant evidence suggests that individuals consider semi-noncompliance to be more acceptable than full non-compliance This is clearly shown in Garrison and Weiss's (1979) account of a Dominican family's range of migration strategies. Most family members opposed full non-compliance. Two members, Raul and Virginia, migrated by overstaying their tourist visas – a strategy the family believed to be within the "range of acceptability." On the other hand, another family member, Luz, entered the country with a purchased passport and was considered to be strictly outside this range (Garrison and Weiss, 1979, p.279).

2.4 Theoretical Framework for this Thesis

The goal of this chapter was to critically review classical and actively evolving theories and identify their application to the examination of immigration policy effects. In this section I build on these theories to develop an agent-focused theoretical framework to examine the effects of immigration policy, which will form the backdrop of my thesis. An agency-centered perspective is necessary to understanding migration behaviour under policy constraints. This is because, in order to act within these constraints, individuals must be reflexive, creative and adaptive (Giddens, 1984; Simon, 1972; Gigerenzer and Selten, 2002). This framework will be based on the following premises:

1. *Migration is a non-binary outcome.* States define these migration channels and place barriers and conditions upon them, with the purpose of categorising and selecting 'wanted' from 'unwanted' migrants and also has implications in the realm of unauthorised migration. Individuals may migrate through a series of legal channels – family reunification, or political asylum, for example – or, as described in Section 2.3, they may migrate through a series of channels consisting of legal and illegal components, i.e. illegal and semi-legal migration (Ruhs, 2010; Düvell, 2006). This legal categorisation is not merely a set of labels. It creates very real differences in the conditions of migration – namely, in the degree of security a migrant can expect (Todaro and Maruszko, 1987). The decision to migrate should, therefore, not be divorced from its legal context.

2. *The effects of policy are heterogeneous.* The legal categorisation of mi-

gration gives different individuals different options for migration. As policy barriers are based on factors associated with demographics, monetary resources and social networks, policies have uneven effects on heterogeneous populations (Carling, 2002; Borjas, 1989a). As discussed in Section 2.1.2, by valuing migrants with particular sets of characteristics, immigration policy affects the amount and relative importance of different types of capital needed for migration.

3. *Inequalities between aspiration and perceived ability can drive unauthorised migration.* (a) Individuals may consider migrating through unauthorised channels if policy constraints render them involuntarily immobile. (b) A high aspiration to migrate and a low ability to do so legally can generate involuntary immobility: those who wish to migrate but are unable to do so legally (Carling, 2002). Individuals will not consider unauthorised strategies if they, instead, abandon their migration plans in the face of limited capabilities.

4. *Potential migrants' agency under policy constraints lies in their reflexivity.* The neoclassical model assumes migration ceases when policy-induced costs outweigh benefits (Castles, 2004a, p. 858). Network theorists have made the similarly deterministic assumption that policy restrictions will necessarily divert potential migrants towards illegal channels (Massey et al., 1998, p. 45). However, a migrant's agency lies in their ability to evaluate and choose across the set of options available – legal or not – such that their action could potentially have been different than it was in a given case (Cohen, 1989, p. 152). In

other words, they do not respond to immigration policies in the way these policies intend them to. Individuals also possess beliefs of what is right, wrong and normal among a local reference group, which may be not be correlated with the current law (Mackie et al., 2015), as discussed in Section 2.3. The macro-level implication of this premise is that, while bureaucracies may design policies with the intention of categorising and regulating migrant admission and residence, these rules will not perfectly determine aggregate behaviour (Castles, 2004a).

5. *Individuals' understanding of policy is limited.* Individuals vary in their awareness of legal constraints and will develop different perceptions of opportunities depending on their social context (Bourdieu, 1977). Individuals learn by probing their environment using simple heuristics and will tend to simplify their decision as much as possible through, for example, by accessing norms or emotions (Simon, 1972; Gigerenzer and Selten, 2002). Individuals' need not learn only through their own experiences, however, they can also learn from their social networks (Massey and Zenteno, 1999). Individuals also receive information that may be biased (Sabates-Wheeler et al., 2009; Ryo, 2015) and process information in such a way that confirms their pre-existing views (Wason, 1960). It may also be weighted differently depending on whether the learning experience is personal or second-hand (Yaniv and Kleinberger, 2000). The subject of bias in decision-making is tackled explicitly in Chapter 8.

6. *Potential migrants adapt to policy environments.* Adaptation is a strate-

gic adjustment to conditions that are negatively affecting well-being According to De Haas (2011), restrictive policies may reorient flows to different categories or countries; create time-clusters in migration before policy change; or turn once temporary migrations into permanent ones. These macro-level 'substitution effects' are the result of the boundedly-rational learning and adaptation processes taking place at the micro and meso levels described above. Immigration policies are often described as having 'unintended consequences' or 'externalities' with illegal migration being a prominent example (e.g. Hansen and Papademetriou, 2014). This is due to a poor theoretical understanding of migrant agency under policy constraints. If we conceptualise potential migrants as adaptive, we expand our expectations of possible immigration policy effects. Reorientation, then, becomes an expected consequence of policy change. It is important to note that a necessary and sufficient condition for adaptation to immigration policy restriction is the presence of opportunities – however small they may be. In the real world, it is unlikely that an immigration system, however draconian its entry and enforcement policies, will be devoid of opportunities for migration. These opportunities can be deliberate or due to faults or lack of resources in the implementation process (Hollifield et al., 2014).

7. *Migration is a multi-level process.* Migration theories have, as of yet, failed to integrate processes occurring at multiple levels of aggregation (Brettell and Hollifield, 2000; Massey et al., 1998; Castles, 2010; Haug, 2008).[3] Theoretical integration is important to developing an agency-

[3]The neoclassical model operates on a micro and macro scale, but omits the meso level

centred approach to the study of immigration policy. First, given the level of government interference in global movement, individual decisions to migrate cannot be divorced from their macro-level context. As mentioned in point 1, policies define the modes and conditions of migration. Without legal classification, illegal migration would not exist. Second, the effects of policy at the meso-level are significant, yet have scarcely been theorised (De Haas, 2010, p. 1610-1612). Aside from the effects already described, policy restrictions affect the size, legal composition and geographical distribution of the diaspora abroad, limiting their ability to aid and stimulate further migration. This effect has, to my knowledge, not been explored theoretically, but emerges inductively from the agent-based model presented in Chapter 9.

Building such a multi-level theory of migration and immigration policy, which follows the above premises is facilitated by the use of agent-based models. Agent-based modelling requires us to dig through a wide repertoire of theoretical concepts, find ways to measure those which have been left vague, attempt to straighten out logical inconsistencies, and piece the concepts together, allowing them to guide different parts of the model (Johnson and Groff, 2014).

In the process of constructing the agent-based model of unauthorised migration, several empirical questions were raised relating to the premises above. These three questions were mentioned in Section 2.1.2 and are summarised in Table 2.1. First, while the capabilities approach to migration maintains that immigration policies lower individuals' perceived ability to mi-

connecting the two: social context (Haug, 2008; Faist, 1997).

grate, it is unclear whether they lower aspiration to migrate as well (Question 1). This is important because a gap between aspiration and ability to migrate may drive individuals to consider unauthorised migration (Question 2). Lastly, although premise 5 describes the experiential nature of learning from a decision-theoretic perspective (Gigerenzer and Selten, 2002), there is little theoretical or empirical guidance as to how failures affect future attempts from a migration perspective (Question 3). These questions are examined using novel experimental and non-experimental items from the Migration Decisions and Policy (MDP) survey to inform the design of the agent based model of unauthorised migration presented in Chapter 7.

Table 2.1: *Theoretical Questions for Modelling Choices and Reference Chapter*

Process	**Relevant Literature**	**Data Source**	**Chapter Examined**
Does policy decrease perceived ability only? or also aspiration?	Lee (1966) Massey et al. (1998) Faist (1997) Carling (2002)	Policy experiment, Survey data.	Chapter 5
Does the aspiration/ ability gap drive support for illegal strategies?	Castles (2004b) Czaika and De Haas(2013)	List experiments, Survey data	Chapter 6
Does successful past migration and successful migration of networks increase perceived ability? Do past failures to migrate decrease perceived ability to migrate?	Leblang et al. (2009) Boyd (1989) Massey et al. (1993) Koser and Pinkerton (2002) Hagen-Zanker and Mallett (2016) Massey and Zenteno(1999)	Survey data	Chapter 5

Chapter 9 of this thesis presents an agent-based model which examines another type of adaptation to policy restriction: spatial reorientation. This agent-based model, like the ABM of unauthorised migration, was also motivated by a theoretical puzzle. As mentioned in Section 2.1.2, migration forms spatial clusters of individuals from a given origin country in a certain destination. This is a highly salient feature of both domestic and international migration. The existence of social networks as an important driver in the perpetuation of migration corridors have emerged as the most recognised theoretical explanation for this pattern (Epstein, 2008). Social network theories suggest that migration – driven by risk and cost reducing social capital embedded in social networks – is path-dependent and will persist despite policy restrictions. This means that destinations with a large diaspora of a given origin will continue to attract more migrants from the same origin, regardless of policy conditions. This expectation precludes the idea that aspiring migrants may choose an alternative destination when movement into that destination is restricted. However, spatial reorientation has been observed to take place both across and within destinations (Collyer, 2005; Ellis et al., 2014). This is an outstanding empirical question, which I address in Chapter 8. In this chapter, I formalise the mechanisms underlying social network theory and explore whether this theory could, under certain conditions, predict the spatial reorientation of migration despite the seemingly contradictory expectation that spatial corridors are stable and robust. This theoretical exploration sets the stage for future work integrating various forms of migrant response to immigration policy.

In the next chapters, I describe the state of the art in agent-based modelling of migration and how empirics are used to specify and calibrate model processes. I also describe the MDP survey in its entirety. Chapters 3 and 4 serve as a backdrop to the analyses considered in Table 2.1.

Chapter 3

Use of Empirics in Agent-Based Models of Migration

Agent-based models are often thought of as artificial laboratories where hypotheses are formulated rather than tested. As such, ABMs and their findings are often pidgeonholed in the realm of the artificial; proofs of concept with little substantive impact outside the modelling community. As Boero and Squazzoni (2005) suggest, “ABMs are often conceived as a kind of self-referential autonomous method of doing science, a new promise, something completely different” (par. 1.2).

In recent years, modellers have increasingly incorporated empirical data in an effort to explain or predict processes occurring in the real world (Hassan et al., 2010). The synergy between agent-based modelling and empirical methods is vast and, as of yet, insufficiently explored. ABM is a flexible method, which can integrate information from many types of qualitative or quantitative instruments (Tubaro and Casilli, 2010; Duffy, 2006; Janssen and

Ostrom, 2006). However, ABMs *are* something completely different, and this remains true regardless of whether or not we use data.

Agent-based modelling seeks to explain observed aspects of the real world or predict future scenarios by *generating* the hypothesised underlying mechanisms (Epstein, 1999). This means that results are produced by the model, rather than 'found' in the real world. In a strict sense, ABM outcomes are the result of explicitly defined processes in the source code (Waldherr and Wijermans, 2013, par. 3.10). This is the case regardless of the amount of interactions or stochasticity the model includes. Morton et al. (2010) contrasts computational models such as ABM to empirical research, which extracts "'real' decisions and choices [that] are independent of the researcher" (Morton et al., 2010, p. 55). This quote hints at an important point of scrutiny that arises from the distinction between ABM and empirical research and, likely, contributes to its isolation: computational models are often conceived as "extensions of the researcher's brain" (Morton et al., 2010, p. 55) and, therefore, their results are considered to be dependent on the choices of that researcher.

Admittedly, all scholars, regardless of their method, make choices when constructing a model. Empirical researchers cannot be certain that the relationships they posit are true explanations for the results obtained. The identification of causal relationships, for example, is an important point of contention when evaluating any quantitative model. However, empirical results are obtained directly from real observations. That is, empirical researchers identify relationships in real-world data, which are open to interpretation by other researchers who may, in turn, offer alternative models to explain observational findings. Because results from agent-based models are *generated by the model itself*, they are not open to alternative interpretations.[1] Furthermore, many different models can generate similar results and it is difficult to know for certain whether the model we are testing is the correct one (Axtell and Epstein, 1994). Understandably, this places a greater burden on modellers to justify the choices they make and hampers their efforts to break out of the ABM niche.

The relatively new practice of using empirical evidence to construct and evaluate the quality of a model should increase confidence amongst the academic community that an artificial model can resemble real world data generating processes (Windrum et al., 2007; Berk, 2008). Modellers have developed new and exciting ways to combine computational and empirical methods (Janssen and Ostrom, 2006). However, these efforts at greater data embeddedness have not yet translated ABM findings into broadly citeable evidence. I argue that as migration models – like other areas of study – become more data-driven, we need to return to the question of whether data-driven ABMs are appropriately addressing concerns about arbitrariness and researcher judgement in model construction and evaluation. If so, are they conveying this in their articles? If we want to break out of our self-referential loop; we need to communicate with academics using different techniques, and this requires effectively targetting their concerns about our unique method.[2]

[1] To be clear, I do not mean that the models themselves cannot be evaluated by other researchers. Here, I am referring specifically to ABM results.

[2] Modellers often address concerns about results being driven by the researcher by citing the model's 'emergent behaviour' (Waldherr and Wijermans, 2013). That is, that interactions in the model generate output that the modeller *does not expect* (Railsback and Grimm, 2011). Model emergence helps us make a statement about the added value of an ABM approach over empirical research but it does not address concerns that model

In this chapter, I aim to review the nascent literature using data-driven agent-based modelling to predict or explain migration processes occurring in the real world. This is done in an effort to understand the ways in which migration modellers use and incorporate data into their models, and what lessons may be learned for researchers who wish to broaden their contribution. The present chapter does not consider the extensive benefits of using agent-based modelling in research; these are considered in the introductory chapter of this thesis. Instead, it focuses exclusively on improving empirical embeddedness practices in agent-based models of migration. Drawing on some of the findings of this review, I, then, propose a 'proactive approach to empirical embeddedness' for researchers collecting primary data for their ABMs. The 'proactive' approach relies on the co-evolution of empirical and ABM designs to generate data collection strategies that pre-empt specific challenges in empirical embeddedness before going into the field. This approach guided the manner in which data was collected and used in the agent-based model of unauthorised migration presented in Chapter 7.

Modellers can use data in three main processes: model calibration, validation and specification. In this chapter, I consider all three processes. As mentioned in Chapter 1, model calibration is the use of numerical evidence to set the features of a model component. Modellers may, for instance, set agent characteristics such as age or aspiration to migrate, by inputting values from a survey dataset. They may also employ data more sparingly by

rules may be based on ungrounded assumptions and, therefore, not reflect real-world mechanisms. It is also worth noting that individuals unfamiliar with complexity may not be able to appreciate the value of 'emergent behaviour' and may find it to be purely a curiosity.

using stylised distributions (e.g. a normal or exponential distribution), with measures of centrality and dispersion derived from empirical data to assign numerical values to model characteristics (Gilbert, 2008). Empirical validation is the qualitative or quantitative comparison of computational outputs with empirical patterns (i.e. migration stocks or flows over time) to assess whether the model is sufficient to explain a particular natural process. The highest standard for validation is that the model is able to reproduce multiple empirical patterns and that this comparison be assessed with some goodness-of-fit statistic (Axtell and Epstein, 1994). Using a validation dataset that is independent of the input dataset is an even tougher test. However, an overall comparison of model outcomes with empirical patterns on its own may not be enough to make a convincing case for the model architecture as a whole, as many different sets of agent rules can produce the same output at the macro level. In other words, "mapping from micro-rules to macro- structures may be many-to-one" (Axtell and Epstein, 1994, p. 28). Evidence-based model specification can allow us to substantiate individual rules. Model specification refers to the selection of appropriate model components (e.g. types of agents, micro decision processes) and the relationship between them. This aspect is often guided by theory. However, modellers have used a wide range of quantitative and qualitative data sources (first- or second-hand) to obtain evidence that certain relationships are present in their selected case. Following Boero and Squazzoni (2005, par. 2.6), "to empirically specify the model components it means to use empirical evidences to choose the appropriate model components."

Assisted, in part, by the corpus of literature identified in Klabunde and

Willekens's (2016) review of decision-making models in migration ABMs, I identify agent-based models that are either primarily about migration or, at least, include a migration routine in a suite of behaviours. This provides me with an initial set of 29 studies (two more than those identified in Klabunde and Willekens, 2016). Out of the 27 models captured in Klabunde and Willekens (2016), only 5 are not published in peer reviewed journals or in books. Because fully developing an ABM is a lengthy process and can involve various iterations (Railsback and Grimm, 2011), models published as working papers may not be fully specified or tested and reviewing them may lead to premature conclusions about authors' use of empirics. I, therefore, I omit these models.[3]

In line with the aim of this chapter, I restrict my review to agent-based models which aim to produce evidence about the real world. As a search indicator, I select all models which use data as inputs, even if some parameters are left uncalibrated or 'free.' Some migration ABMs use sensitivity analyses to explore possible values for *all* parameters and may find suitable ranges for these parameters by comparing model outputs to empirical patterns. These models are not falsifiable using standard validation techniques because data is used to set model parameters, not to test the outcomes of the model. As such, these models may be extremely valuable for building theory and asking novel research questions (e.g. Biondo et al., 2013; García-Díaz and Moreno-Monroy, 2012; Ichinose et al., 2013) but do not aim to produce evidence about the real world and, therefore, are not within the remit of this

[3] I also exclude one study, Massey and Zenteno (1999), which is not strictly an agent-based model.

chapter.

Little more than half of all studies captured in Klabunde and Willekens (2016) use empirical data to directly calibrate the model.[4] This leaves me with a set of 12 models, published between 2003 and 2017. It is important to note that not all empirically calibrated models seek to explain or predict something about the real world: The model presented in Chapter 9 of this thesis is an abstract, theoretical model, where calibration serves purely as a way to anchor parameters and minimise modeller discretion. However, I did not find any models that could be considered abstract within the empirically-calibrated sample – in fact, they are all context-driven facsimile models with a heavy use of data (Gilbert, 2008).

An overwhelming majority of the final subset of models primarily deal with climate change-induced migration. Only one model (Suleimenova et al., 2017) examines conflict-driven migration and only one model examines labour migration absent of climate drivers (Heiland, 2003). Out of 12 models, 6 examine migration as part of a set of additional behaviours resulting from adaptation to a changing environment (Naivinit et al., 2010; Berman et al., 2004; Mena et al., 2011; Smajgl and Bohensky, 2013; Naqvi and Rehm, 2014). In my review, I focus specifically on aspects of empirical embeddedness that relate directly to migration decision-making. All models included in the sample are based on a specific case, ranging from a country (Hassani-Mahmooei and Parris, 2012) to a region within a country (e.g. Naivinit et al., 2010; Entwisle et al., 2016; Walsh et al., 2013). Only one article studies and simulates

[4]Out of the 12 models that do not use data as inputs, 5 use sensitivity tests to derive parameter values.

cases in multiple countries (Suleimenova et al., 2017).

I find that one-third of the studies reviewed do not validate their models by comparing simulated to empirical outputs. Most of the ones that do, do not examine more than one pattern, rarely use independent empirical datasets, and use only qualitative measures of comparison. This reflects Janssen and Ostrom's (2006) general evaluation, "although most models have been inspired by observation of real biological and social systems, many of them have not been rigorously tested using empirical data." (p. 37). Furthermore, for some models, authors are unable to calibrate the *components* of their decision models with data that adequately reflects the migration decision model used. Instead, many of the studies reviewed resort to simplified migration decision processes that can be adequately calibrated with existing demographic or socioeconomic surveys, but may be too simple to be realistic. An example could be making migration a simple function of wealth (e.g. Mena et al. (2011)). This indicates the existence of a possible trade-off between priorities: implementing a detailed psychological decision model and the ability to calibrate it to the fullest extent. A simple decision model may, of course, be adequate for the case studied, but it is difficult to tell in the literature reviewed. Some studies cite having accessed an extensive amount of qualitative and quantitative evidence to substantiate decision rules prior to model specification or re-specification. However, these studies are, generally, not transparent about the evidence obtained – aside from its source – and how it was translated into the rules eventually formalised. This is an important omission because it places doubt on the model and, consequently, on the generation of the data itself. Furthermore, it does not allow an independent or critical evaluation of the model.

In the following section I examine the use of data in ABMs of migration. I, then, outline how a proactive approach to data embeddedness may mitigate some of the issues identified. A proactive approach to empirical embeddedness aims to make empirical design, analysis and presentation an intrinsic aspect of the initial stages of the modelling cycle, thereby anticipating the data and empirical analysis that is best suited for specifying, calibrating and validating the ABM.

3.1 The Use of Data in Models of Migration

The models reviewed in this chapter are of two types: case studies and participative approaches such as role playing or companion modelling. In the case-study approach, researchers may use tools such as ethnography or surveys (Tubaro and Casilli, 2010), among many others to calibrate (if data are numeric), specify or validate the model. In role-playing, the researcher develops a game based on the research question at hand, with subjects maintaining their real-life roles. From this game, researchers are able to see how the population of interest behaves in different conditions and can use this information to design their model. Companion modelling involves many kinds of interaction between the subjects and the model or modellers. For example, it may involve workshops where the subjects (which are represented by agents in the ABM) evaluate and provide feedback on the decision model that researchers have designed. This information is then used to refine the ABM architecture. Researchers may also combine any of these approaches to inform, calibrate or validate a model.

Only 2 out of 12 studies use companion modelling or role-playing. These approaches may start off with a theory-driven model, but are distinguished by their inductive nature, where the model is defined and redefined across multiple cycles as researchers learn more about the system. That is, for these models, specification and validation is often indistinguishable. Case-study approaches may also be purely inductive, but theory often takes centre stage in model specification.

3.1.1 Specification and Validation: Case Studies

It is important that modellers use empirical evidence to select model components (specify the model), as well as to validate their model. Specification lends evidence to individual rules, while validation tests whether the combination of rules forming the model architecture resemble the real-life aggregate pattern the model aims to generate. In terms of model specification, we can further subset the ABM case studies reviewed into three types: theory-led, theory- and evidence-led, and purely evidence-led models. Out of the ten models adopting a case study approach, seven use existing theory to specify the migration decision.[5] Most of the models that use theory for specification draw on migration theory to specify their migration decision model – primarily neoclassical and push-pull theories, but also social network theories

[5]Two studies, Kniveton et al. (2011) and Kniveton et al. (2012) examine the same topic and use a the same or a very similar decision model (Klabunde and Willekens, 2016). Kniveton et al. (2012) was published as a letter to the journal *Nature Climate Change*, while Kniveton et al. (2011) was published as an article in the journal *Global Environmental Change*. Therefore it is unclear whether the two papers are based on the same model. However, I am distinguishing them as two separate studies for the purpose of this review.

and the New Economics of Labour Migration – all of which are described in Chapter 2 (Heiland, 2003; Naqvi and Rehm, 2014; Hassani-Mahmooei and Parris, 2012; Entwisle et al., 2016).

Kniveton et al. (2011, 2012) use a general psychological model to guide their migration decisions: the theory of planned behaviour (Ajzen, 1985, 1991). In this theory, individuals' attitudes towards a certain behaviour (evaluations of the behaviour), their subjective norms (relevant others' beliefs that he or she should or should not perform such behaviour) and their perceived behavioural control (perceived ease of personally carrying out the behaviour), all form an individual's behavioural intentions and this, in turn, leads to the behaviour itself. In Kniveton et al.'s application, variations in climate are shown to influence five other drivers of migration through the interaction of agents. For example, communicating about rainfall conditions, a driver of emigration, can affect the later choices of another. Conceptually, a 'behavioural intention' is first developed, composed of the individual's attitude towards a behaviour and a consideration of the opinion of a significant other, as well as their capacity for adaptation (behavioural control). Hence, changes in rainfall or a positive attitude towards migration do not entail displacement; migration is a result of a complex combination of stressors and the opportunities perceived. Smith (2014) is unique among the studies presented here, in that it develops a multi-level conceptual framework, which is then formalised as the ABM architecture. In this study, changes in rainfall affect a range of socio-economic conditions, in turn, affecting household vulnerability, which may or may not result in migration. At the individual level, migration is driven by demographic characteristics: age, gender, migration experience and the social network, variables that are consistent with social network theory.

Simply formalising a theory may not be sufficient to convince readers that the model reflects the real underlying mechanism approximated by the model. While the migration theories cited enjoy decades of accumulated evidence, they both rival and complement each other. A single theory does not explain migration across *all* migration corridors – in fact, evidence pointing to more than one theory is often found to coexist within a single migration context (see, for example, Massey and Espinosa's (1997) analysis of the determinants of migration in Mexican communities, which finds support for indicators corresponding to multiple migration theories). Psychological models have had limited application to migration (however, see Lu, 1998, 1999, for applications of the theory of planned behaviour and Kley, 2011, for an application of Gollwitzer's 1990 Rubicon model, to residential mobility).

Modellers can show case-specific empirical evidence, or test more than one alternative mechanism to substantiate the use of their theory. However, out of the six studies adopting a theoretical approach, only half do (Heiland, 2003; Hassani-Mahmooei and Parris, 2012; Entwisle et al., 2016). Heiland (2003) examines migration flows from five East German states to West Germany from 1989 to 1998. Drawing on the human capital approach in neoclassical theory (Sjaastad, 1962), agents act based on the incentives provided by current and expected unemployment and income differentials between German states, in addition to the cost of moving and job search. The study is able to replicate migration patterns after the fall of the Berlin wall quite closely. Heiland (2003) devotes a section of his chapter to providing qualitative historical evidence of how the human capital approach applies to the German case. Hassani-Mahmooei and Parris (2012) succinctly identify how their model rules – which relate to push, pull and intervening factors in migration, are substantiated by existing micro-level studies on Bangladesh. Entwisle et al. (2016) adopts a unique approach among the studies presented here. The aim is to test different pathways by which climate change may affect migration. To do so, the authors formalise a range of theoretical mechanisms, including push-pull theories, social network theories and the New Economics of Labour Migration. Smith's (2014) article on Tanzania is couched on a local case study and logistic regression analyses used to identify the variables that are significant predictors of migration in Tanzania.

The remaining theory-driven studies cite the wider applicability of the theory but do not provide clear evidence of the applicability of the model to their case. Kniveton et al. (2011, 2012) cite the relevance of the theory of planned behaviour for a range of decisions, but does not cite literature showing how it might apply to migration. The authors do conduct analyses on data from Burkina Faso for the purposes of calibration. However, measures do not always match up nicely with the theory of planned behaviour's nuanced concepts (as I will discuss later). Naqvi and Rehm (2014) models various responses to natural disasters, including migration in the Punjab, a low income region in Pakistan that was hit by floods in 2010. They find that migration to the cities following drought leads to a decline in urban incomes. The study draws on neoclassical theory and the closely associated gravity or push-pull model, which places a greater emphasis on geographical distance (Greenwood, 1975). Specifically, workers' decision to migrate depends on the joint probability distribution of income differentials and distance. The authors do substantiate the rules and assumptions they make using existing literature. However, the authors are not clear whether citations refer to micro-level studies of their region (many of them do not) and, relatedly, whether they lend evidence to the applicability of push-pull theory to their case.

Four of the articles using a case-study approach do not explicitly use a migration or psychological theory to specify the components and relationships of the migration decision (Berman et al., 2004; Walsh et al., 2013; Mena et al., 2011; Suleimenova et al., 2017). To be clear, these studies use discrete choice models, which are rooted in random utility theory, to establish *how* choices are made. However, theory does not explicitly guide the aspects of the decision that are to be included or excluded. Instead, these articles draw on micro-level case studies to specify agent rules. Most of these studies are not primarily about migration. Migration is simply one of many adaptive behaviours, and migration decisions are highly simplified.

Berman et al. (2004) studies the case of arctic communities in the Canadian territory of Yukon, which are adapting their livelihood strategies due to distinct global forces. Climate change is affecting wildlife and fishing, which indigenous communities have relied upon for subsistence, while government retrenchment of the welfare system and changes in the tourism markets are affecting the local cash economy. The model generates projections for eight scenarios, where aspects of the cash and subsistence economy are altered. Migration is one possible outcome, and will take place if no other local subsistence strategy is possible. The model is constructed based on research data and local knowledge from experts in the communities studied, however, it is unclear what evidence informed this specification of the migration decision; or whether the assumption that migration is the least valued of all possible adaptive strategies is empirically founded.

Mena et al. (2011) simulates economic decisions of altering land use on household farms in the Northern Ecuadorian Amazon (NEA). Migration occurs simply if the farm has zero or negative assets. Although the study relies on a longitudinal, socio-economic and demographic survey of colonist households conducted in 1990 and 1999, it is unclear how this data informed the specification of the migration decision. Similarly, Walsh et al. (2013) use a range of data sources collected over two decades of work to inform model rules. Their migration decision may not be considered a decision at all, but a probability based on demographic factors. The process of analysing empirical data, however, helped identify the factors that significantly affect migration and, therefore, which to include or exclude in the model. This strategy is useful to specify a behaviour that may be too complex to model fully, particularly when this behaviour is of minor importance to the article. However, it is unclear whether the researchers relied on existing theory to determine which variables to include in the empirical model. Suleimenova et al. (2017), the only study within this set that examines conflict-driven migration has a more simplistic decision model than the previous three papers (a simple probability set by the authors). This paper does not cite either theory or empirical evidence in their decision model specification.

Out of the ten articles using a case-study approach, 40% did not use any form of qualitative or quantitative measure to validate model outputs (Smith, 2014; Mena et al., 2011; Walsh et al., 2013; Entwisle et al., 2016). The ones that do, do not offer statistical goodness-of-fit measures. These studies do not compare model outputs to more than one empirical pattern and, except for Berman et al. (2004) and Hassani-Mahmooei and Parris (2012), do not use independent datasets for the purposes of comparison. However, some studies compare outputs at multiple time-points to empirical panel data (e.g. Heiland, 2003) – a higher threshold for precision.

3.1.2 Specification and Validation: Role-playing and Companion Modelling

Naivinit et al. (2010) uses both role-playing and companion modelling to continually specify and validate an evolving model. The research was carried out over the span of four years. This study examines the adaptive behaviour of rice farmers in lower Northeastern Thailand (Ban Mak Mai village, in the south of Ubon Ratchathani province) when affected by harsh climactic and soil conditions. The authors examine four adaptive behaviours: i) rice nursery establishment, ii) rice transplanting, iii) rice harvesting, and iv) migration of household members. Their model specification was driven by their careful and extensive qualitative research. In a series of field workshops, the research team probed different components of their research question with stakeholders – in this case, 22 farmers – using a site-specific, spatially-explicit agent-based model.

According to the authors, the modelling process served both the modellers and the stakeholders well. Continuous communication with the participating farmers increased the model's ability to represent their rice farming and migration activities. At the same time, farmers were able to "strengthen their adaptive management ability" (p. 1345). If so, this is a rare example of academic research directly and immediately impacting the subjects of their study, and demonstrates the use of agent-based modelling in economic development activities. However, the lack of a clear, transparent metric for validation (qualitative or quantitative) significantly affects its academic contribution. The authors do not summarise the outcomes of companion modelling and role-playing activities – their only source of validation. As such, readers are forced to take the authors at their word.

Smajgl and Bohensky (2013) examines the effects of fuel price changes on poverty, deforestation and migration to peri-urban areas in East Kalimantan, Indonesia. The model finds that poverty increases in response to fuel price reductions, but this does not trigger a change in migration. This study used a variety of data collection strategies for model specification, following Smajgl et al. (2011). These strategies followed a set sequence of six steps and served different purposes. First, a survey elicited information on household characteristics, which were processed in a cluster analysis in a second step. The resulting household types were, then, presented to experts and stakeholders for confirmation. Behavioural responses were elicited through in-depth interviews asking about hypothetical scenarios, targetting households that represented each of the types identified earlier. This was followed by another 'validation' workshop. The authors then used household-level census data to determine the ratio of agent-types in the total agent population. Unlike Naivinit et al. (2010), the authors did construct a metric based on the final discussion round with stakeholders, which was directly relevant to model outcomes. However, it was conducted prior to model construction and was, then, used to "specify and clarify agent rules" (p. 11). The authors did not provide a separate test of model outcomes using an in- or out-of-sample data source.

In summary, modellers use a range of quantitative and qualitative methods to specify different aspects of a model. However, the amount of description that authors provide regarding how these methods are translated into model rules is inadequate; particularly given the importance of model specification. One-third of the models presented do not use any form of qualitative or quantitative validation. The ones that do, limit themselves to comparing model outputs to only one empirical pattern and, generally, do not use independent empirical datasets.

3.1.3 Calibration

These empirically-calibrated models showcase agent-based modelling's flexibility with data types, allowing modellers to depict multiple scales and dimensions with the aim of achieving a "natural description of a system" (Bonabeau, 2002, p. 7281). Studies use GIS data (e.g. Mena et al., 2011; Suleimenova et al., 2017), measures of rainfall (e.g. Smith, 2014; Entwisle et al., 2016), a range of aggregated data from governments and international organisations (e.g. Naqvi and Rehm, 2014; Suleimenova et al., 2017; Hassani-Mahmooei and Parris, 2012; Naivinit et al., 2010; Heiland, 2003), and even satellite imagery (e.g. Walsh et al., 2013; Mena et al., 2011).

Many scholars use data they have collected themselves in addition to secondary data (Smajgl and Bohensky, 2013; Entwisle et al., 2016; Naivinit et al., 2010; Berman et al., 2004; Walsh et al., 2013). It is unclear whether the primary data was collected for constructing or validating their agent-based model. Others make sole use of available data (Hassani-Mahmooei and Parris, 2012; Heiland, 2003; Kniveton et al., 2011, 2012; Smith, 2014; Suleimenova et al., 2017; Naqvi and Rehm, 2014). It is often difficult to find second hand empirical data that is completely adequate for model calibration (Boero and Squazzoni, 2005, par. 2.20). Some studies, for example, have struggled to obtain data that is sufficiently disaggregated. Hassani-Mahmooei and Parris (2012) examine the migration patterns that result from climate change impacts – particularly droughts, floods and cyclones in Bangladesh. They find that climate change will drive migration towards specific areas of the country, as well as environmentally vulnerable cities. The migration decision is a function of (1) push factors; in this case climate change and socio-economic factors, (2) pull factors; in this case the socio-economic conditions of the destination, and (3) intervening factors; land ownership and employment conditions. The authors employ census data for model calibration. As this data is disaggregated only at the district level, individuals with unique demographic characteristics could not be represented. Instead, the model initiates with 12,317 agents distributed across the 64 districts of Bangladesh, each representing 10,000 members of the total population. According to the authors, this level of abstraction means that all attributes characterising more than 1 percent of the population have one or more agents to represent them in the agent-based model. It is unclear whether this level of abstraction takes into account each unique combination of demographic characteristics present in the population, or whether examining joint distributions is possible given the data. In any case, this method of dealing with aggregated official data sources could prove useful to modellers who wish to depict the migration of large populations.

In other cases, data is obtained at the individual level but may not be perfectly appropriate for the model the researcher looks to build. For example, Kniveton et al. (2011, 2012) construct their decision model by formalising the theory of planned behaviour. To reiterate, in this theory, attitudes, norms and perceived behavioural control, all feed into an individual's behavioural intentions and this, in turn, can result in the behaviour itself. The survey data the authors use is not wholly adequate for calibrating such a model. The attitude towards migration behaviour is represented as the "probability of migration from one model zone to another, based on their personal attributes and according to the rainfall variability they have experienced in the previous three years" (Kniveton et al., 2012, p. 444). Using probability of migration as a proxy for attitudes masks the sequential and nuanced form of the decision model as migration is the expected outcome of the decision model. Smith (2014) encounters a similar problem; this model consists of many parts, not all of which can be parametrised with the data available to the author, rendering it "only as indicative of the potential that future applications may have" (p. 90).

Many of the studies presented here do not use psychological variables. This may be due to the difficulties in finding adequate data, or simply due to disciplinary idiosyncrasies Migration is sometimes considered to be a direct function of demographic or socio-economic characteristics (e.g. Walsh et al., 2013). In other studies, migration is an economic, utility maximising decision, and is therefore easier to calibrate using more readily-available socio-economic data (e.g. Heiland, 2003; Naqvi and Rehm, 2014). Suleimenova et al. (2017) is unique in that it does not use any data to specify the parameters of the decision to migrate aside from geographic location. This study aims to predict refugee flows sparked by three different crises: the 2015–2016 civil war in Burundi, the 2013–2016 conflict in the Central African Republic (CAR), and the Northern Mali conflict in 2012–2013. Each time step, a number of refugees are inserted into the simulation based on the daily increase in the total UNHCR refugee registration count. The probability of movement of refugees from the conflict location to the refugee camps or between refugee camps are set to values determined by the intuition of the authors (p. 10). Through additional robustness checks, the authors find results to be insensitive to these probabilities. However, setting the probability of movement without empirical guidance raises questions of modeller discretion.

Multiple studies do not parametrise the effect of a given migration determinant (e.g. income) on migration or some intermediary factor (e.g. Mena et al., 2011), and the ones that do are unclear about how these coefficients were estimated or obtained (e.g. Berman et al., 2004; Naqvi and Rehm, 2014). Some studies use the coefficients of regression models to parametrise key relationships or variables. Kniveton et al. (2012) regress various demographics and experiences of rainfall variability in the past on the probability of migration to calibrate migration attitudes; in Entwisle et al. (2016), regression coefficients are used in the ABM to calculate individual-specific migration probabilities, based on existing literature. Smith (2014) uses univariate logistic regression models to find the effects of variables relevant to his theory in existing data, and uses these effect sizes to calibrate variables and relationships in his ABM.

However, while traditional quantitative studies devote a significant amount of effort to identifying causal relationships in empirical data, agent-based models of migration do not appear to place the same amount of emphasis on causality. None of these studies mentioned using experiments or quasi-experiments for model calibration (or specification), which would alleviate the threat of omitted variables biasing estimates. Given that several studies already collect primary data for specification or calibration, this may not be a very difficult task. However, some studies use innovative calibration techniques worth noting; even if they are not necessarily related to the migration decision. Smajgl and Bohensky (2013), for example, obtains quantitative metrics for behavioural responses under different "what-if" scenarios through in-depth interviews. Walsh et al.'s (2013) model is used to assess household income in the Nang Rong District in Thailand from several sources: agricultural production of lowland, rain-fed paddy rice and upland field crops as well as remittances from family members working in cities. This study integrates data from widely used software applications, which forecast crop growth – the intermediary variable in this study – under different climate scenarios[6] and a general purpose method to estimate land suitability for growing rice. This allows them to use reliable, direct, estimates of the effects of their primary explanatory variable on an important intermediary variable, and to do

[6]Decision Support for Agrotechnology Transfer, `https://dssat.net/about`

so for a variety of hypothetical scenarios.

In summary, migration studies use a range of data sources to calibrate components of the model. However, calibration is often a struggle, as data that is adequate for the micro-level processes the researcher wishes to depict is often not available. Model relationships – for instance, the effect of income on migration – is not always parametrised. Furthermore, despite the fact that several studies collect primary data, they do not mention using experimental or quasi-experimental methods for calibration or discuss measures taken to remediate common empirical issues such as omitted variable bias. Table 3.1 summarises the use of data in all models reviewed. Please note that these percentages are derived from a small set of studies.

Table 3.1: *Empirical embeddedness across all studies reviewed*

Process	Description	Publications
Specification		
	Theory only	25%
	Theory and evidence	25%
	Evidence only	42%
	Neither	8%
Validation		
	Multiple patterns	0%
	Use statistical tests	0%
	Independent dataset	17%
	No independent dataset	33%
	No validation	50%
Calibration of migration decision		
	Primary data collected	42%
	Used existing data	50%
	No calibration of migration decision (Other aspects were calibrated)	8%

3.2 A Proactive Approach to Empirical Embeddedness

Empirical embeddedness does not only serve to help modellers make their research more applicable to the real world; empirical researchers can also benefit from pairing empirical designs with agent-based models. Researchers studying populations at a micro-level through, for example, a survey are able to observe attitudes and opinions but they are not often able to observe actual *behaviour*. This is often a struggle for migration scholars who can survey return migrants in origin countries or current migrants in destination countries, but are not often able to observe individuals' migratory behaviour.

As I will discuss in Chapter 4, this means micro-level data on migration is often severely affected by selection biases relating to the types of individuals who migrate to a given location and the types of individuals who return home. Researchers may, therefore, find it appealing to combine survey data that targets several aspects of individuals' decision process with an agent-based model. Given an inability to observe behaviour, embedding this data in an ABM decision model can allow us to simulate it. This approach also allows us to consider how our sample may act given alternative scenarios – for example, policy. As mentioned in Chapter 1, ABMs allow us to observe counterfactual scenarios – that is, conditions that are identical, albeit with the addition of the policy or exogenous influence we are interested in. Observing true counterfactuals in the real world is impossible. Therefore, pairing ABMs with carefully designed empirical instruments not only allow us to study behaviour that is difficult to observe at present, but also the effects of various alternative states of the world.

However, as I have argued in this chapter, this symbiotic relationship can only be fully realised if ABMs are considered to provide us with findings that the wider scholarly community can trust to reflect real-life empirical processes. Therefore, the push towards greater credibility must come from the modelling community. In this chapter, I have argued that greater credibility can only be achieved with a more thorough and purposeful use of empirics. This means using empirics to inform all components and relationships described in the model's architecture and to falsify model outcomes.[7] This is a

[7]To be clear, I am referring only to models of the facsimile type, as are the ones reviewed in this chapter.

challenge for modellers because, as Boero and Squazzoni (2005) suggest, it is often impossible to find existing data with sufficient micro-level detail to embed into our unique models. This, perhaps, explains the apparent appetite among migration modellers to use primary data. According to Table 3.1, 42% of empirically-driven models do so. However, collecting original data will not be useful unless the data provides what the model *needs*.

In this section, I propose a practical, systematic process for designing a survey that can be fully utilised to feed into all aspects of data embeddedness identified above: (1) the specification of the model using empirical analyses (e.g. a regression model to identify whether a relationship is likely to exist within our population of interest); (2) the numerical calibration of model components; (3) the validation of model outcomes by comparing them to real, observational patterns of the same or a comparable system. This process leverages the extensive similarities that exist between the conception of an empirical research design and an agent-based model to harmonise the two processes such that they can benefit one another. I focus on survey design, which most often yields quantitative results, as quantitative data is useful for calibration. However, this approach could also be extended to qualitative data collection or a mixed methods approach (see Tubaro and Casilli, 2010 for a explanation of the various applications of qualitative data in ABM research). From the perspective of the modeller, this approach is practical. Acknowledging that it is often impossible to return to the field after we obtain simulation results, the purpose of this process is to *anticipate* data needs. It is labelled proactive because it involves careful, iterative, planning to prepare for the possibility that aspects of the model may change and plan future extensions to the model. For non-modellers, a 'proactive approach' can result in a more thorough and well designed survey instrument and can carry our findings further by allowing us to combine several designs. As I will show, the process of designing an ABM can help us visualise and refine our empirical design by: (1) forcing us to clarify theory and concepts; (2) helping us naturally detect gaps in existing knowledge; (3) increasing our creativity by helping us visualise respondents as thoughtful, creative and able to change their responses and behaviours in different states of the world; and (4) helping us to identify and address challenges in measurement and statistical inference. This approach is beneficial for research groups with an interest in generating traditional empirical work that can stand on its own as well as simulation pieces. This approach can help empirical researchers avoid relying overly on the existing customs of the community studying their research topic, both in terms of research questions and survey design.

The proactive approach to empirical embeddedness involves 4 stages which may be iterated in the manner the researcher considers necessary (i.e. researchers may do full loops or a series of smaller ones). Each step increases in complexity, from conception to practical implementation. The thread connecting all stages is that the overview and details of data collection emerge from and mirror the design of an ABM. That is, the concepts used in the data collection instrument should also be included in the ABM design; the hypotheses informing the questions included and the statistical tests we plan to run should be the same as those informing the relationships eventually formalised as computer algorithms. To allow for data collection to be carried out in one go, I consider the iterations to be focused more intensely around the conceptualisation of the model, not its testing. Careful planning and anticipation are core to the proactive approach.

The proactive approach to empirical embeddedness guided the manner in which data was collected and used in the agent-based model of unauthorised migration presented in Chapter 7 but also includes lessons learned. The empirical and simulated outcomes of this process will be documented in chapters 4 to 8. A preliminary version of this approach was proposed as part of the Leverhulme Trust grant I co-authored with my supervisors, Shane D. Johnson and David Hudson, and substantially refined with the addition of Research Associate Cassilde Schwartz to the project.

3.2.1 Stage 1: Defining the project

The first stage of the process involves defining the scope and components of the research project. It consists of the following steps:

A. *Defining the research question and purpose.* The modelling cycle begins in the same place as any empirical research project. It begins with defining its purpose, usually in the form of a research question. This research question "serves as a primary compass and filter" for designing an ABM (Railsback and Grimm, 2011, p. 8). The research question is usually couched on theory and/ or substantive evidence. As part of the iterative process, the research question may splinter into several more focused questions. I explain how this can happen in point E below.

B. *Finding existing theory and evidence.* The formulation of the research question may be preceded or succeeded by the possible identification of theory, or set of theories, to frame the project. An ABM is often a formalisation of existing theory in the form of computer algorithms (Johnson and Groff, 2014). As such, examining existing theoretical literature can help the researcher identify the concepts that may become part of the ABM in some way or another. These concepts will also be important to the design of the empirical data collection instrument. When choosing theories, it is helpful to find ones that can help the researcher understand the micro-level behaviour of the population of interest, which would be reflected in the behaviour of the artificial agents. As discussed in Chapter 1, agent-based modelling is a bottom-up approach. That is, behaviour is naively and directly represented. Theories that consider relationships between abstract macro-level concepts such macroeconomic indicators or demographic rates will not be as helpful in building the ABM (although they may become useful for forming expectations on macro-level outputs later on) (Railsback and Grimm, 2011). Qualitative evidence is particularly useful for complementing the theory at hand or may even take centre stage if theory is not available. Qualitative research, which may include ethnographic research, focus groups and interviews, aims to identify micro-level processes or mechanisms guiding behaviour, including interactions between individuals and is, like ABM, a bottom-up approach (Johnson and Groff, 2014; Tubaro and Casilli, 2010). It is useful to examine more than one theory, particularly if there are competing theories speaking to our research question, and as much existing micro-level evidence as possible. This will help us form an extensive set of hypotheses and make sure we have our bases covered for data collection. I return to this in point D.

C. *Outlining the model components and the relationships between them.* In this first stage, theoretical concepts need not yet be specified or refined to the point where we are able to measure them. However, it is useful to have a clear inventory of concepts and to be able to connect them in the form of a rough decision model. This can be done as a flow chart or any other simple diagram. In the process, we might formulate a set of directional *hypotheses*. For example, we may have a theory that states that a perception of economic need and perceived opportunity makes individuals more likely to burgle homes. In that case, we could build a very simple decision model connecting these two explanatory concepts to the action of burglary. The formation of hypotheses is as essential to the design of an ABM (Railsback and Grimm, 2011, p. 8) as it is to empirical data collection (Babbie, 2010).

D. *Prepare for getting empirical results that are different to those expected.* Part of the empirical embeddedness process can involve the testing of hypotheses using observational data. This is part of the model specification process, as it indicates whether a hypothesised relationship expressed in the ABM is likely present the population we are examining. Regression coefficients, for example, can also help us set ABM parameters associated with this relationship numerically. When thinking of hypotheses one might wish to test, it is particularly important that the researcher draws an extensive inventory of alternative hypotheses to anticipate the possibility that the data does not tell the story we expected it to and leads us to alter our ABM design. It is important to strike the right balance between precision and flexibility such that we can adapt if the model needs to change. Relatedly, as I will expand on in points E and F, it is important to have a simple core model with separate extensions. This type of model design is more likely to adapt well to the empirical results we obtain. Just like a high-degree polynomial equation may only be able to explain the relationship between a narrow set of data points, a complex model may not fare well when exposed to our original data. The separate extensions that should make the model more complex may or may not be included in the final model, depending on the empirical results we get.

E. *Defining a core and a periphery in our research aims.* Building an ABM requires we simplify as much as we can. Railsback and Grimm (2011, p. 8) explain that "a common mistake of beginners is to throw too much into the first model version – usually arguing that these factors are well known and can't possibly be ignored." Because of the extensive interdependencies and feedbacks that exist between model processes, ABMs can become very complicated very quickly. Over complication has two important implications on the ABM and the data collection that accompanies it. First, overcomplicating the model causes us to lose focus of our aims, which can be costly when that model is guiding our data collection efforts. The second point refers to the ABM itself. Agent-based models are there to help us understand underlying mechanisms and overcomplicating it will hamper our ability to understand why our model is behaving the way it is. Railsback and Grimm (2011) suggest that modellers note ancillary factors in a wish list and check their importance later. In the same vein, I suggest that researchers define a simple core model and peripheral extensions. For example, we may be interested in understanding how a set of factors X leads to a behaviours Y and Z. A simple core model could look at the influence of X on Y, while the influence of X on Z can be relegated to the periphery. The periphery is simply a part of the decision model that will be tackled later.

F. *Develop both core and peripheral hypotheses before the field to increase yield.* As mentioned earlier in this section, it is not often cost-effective to return to the field several times to collect additional data. As such, it is a good idea for researchers to develop hypotheses in the periphery in subsequent iterations of this process before heading to the field. This can allow researchers to produce several models or versions of a model with the same original data source. If the processes are sufficiently related, researchers may find that they are inadvertently better able to tackle peripheral processes if they return to Stage 1 after having finished conceptualising the core model.

3.2.2 Stage 2: Attempting to formalise the decision model

Once we have an outline of the theoretical model process, modellers usually begin to formalise it by translating it into computer algorithms in the software they are intending to use (Gilbert and Troitzsch, 2005). Since we have not yet collected the data, we may not be able to adequately program and test the model. As such, writing the model out in pseudocode (simplified programming notation that is not executed), or as a series of textual descriptions of each model process with its component equations may suffice. Some researchers may find they are able to test some aspects of the hypothesised model before collecting data by, for example, varying loose parameter values across plausible ranges. This process may help researchers detect interesting behaviour for further investigation.

Regardless of how it is done, the process of formalisation accomplishes several aims that are essential to conducting any type of research. They facilitate:

A. *Concept specification.* As Johnson and Groff (2014, p. 514) explain, "theories expressed in natural languages are often vague, ambiguous, and open to interpretation." When putting together an empirical research design, scholars often refine imprecise notions into precise concepts. For example, if we are interested in the idea of compassion, we would want to understand what is meant by compassion, and identify different kinds of compassion that may exist (Babbie, 2010, p. 126 - 128). The process of formalising a theory in computer code or, simply, equations, forces a logical structure on imprecise theoretical constructs. Because the totality of the model should be formalised, this process helps us apply the same rigour to all concepts.

B. *Identifying the micro-components of a decision.* In the case of the ABM of unauthorised migration presented in Chapter 7, the process of putting together a decision sequence that was theorised to result in *actual behaviour* required devoting thought to what might constitute serious intentions for action and what obstacles may lie in the way of actual behaviour. At this point it is useful to return to the micro-level theory and qualitative evidence we examined in Stage 1 and identify the micro-components of a decision, particularly specific drivers and barriers to behaviour. We can then use this information to refine our model rules and make sure we include the appropriate items in our survey questionnaire.

C. *Identification of theoretical gaps that need to be addressed.* As part of formalisation and the development of an agent-based model, we will likely identify parts of the theory that cannot be formalised (Eck and Liu, 2008; Johnson and Groff, 2014). These aspects may require special attention in the data collection process. As mentioned in Chapter 1, the process of formalising the ABMs presented in this thesis identified several questions that were ambiguous in existing theory: Does immigration policy restriction decrease perceived ability only? or also aspiration?; Do past failures to migrate decrease perceived ability to migrate? (examined in Chapter 5); Do individuals consider unauthorised migration when the gap between perceived ability and their aspiration to migrate is large? (examined in Chapter 6); How do individuals weight failures relative to successes and does it affect aggregate outcomes? (examined in Chapter 8); If, according to social network theory, individuals migrate where their network ties are established, how can individuals move to alternative destinations (where their network ties are not established) if policy in the primary destination is restricted? (examined in Chapter 9).

3.2.3 Stage 3: Identifying the dynamic aspects of the decision model

Up to now, we have used theory and evidence to draw a static picture of a decision process and its components. However, adaptive agents, just like real individuals, change their response under different conditions. As such, in preparation for embedding data into our model, we may want our concepts to generalise to situations other than the current state of the world. In other words, we may want to add a dynamic layer to our static decision model. To do so we need to:

A. *Identify key external influences and what components of the decision they affect.* Exogenous factors may constitute scenarios one may wish to examine in an agent-based model by implementing them exogenously as part of an in-silico experiment. In this stage, we identify what these factors are and form expectations about precisely what components of the decision they may affect. Exogenous events can change individuals' decision to support a political party and we may theorise that it does so by targetting individuals' subjective policy priorities. For example, individuals may not prioritise policies relating to global warming until they experience an abnormal rate of flooding in their home town. If we believe that issue priorities will determine people's political behaviour, we may expect that individuals who experience global warming first-hand will be more likely to vote for parties with a strong environmentalist stance. We may also want to treat certain factors as exogenous in order to identify their likely causal effects by using experiments or similar techniques. It is outside the scope of this chapter to describe these techniques but Cook et al. (2002) provides a helpful review. I return to this point in Stage 4.

B. *Identify endogenous feedback mechanisms.* Often the actions of others – or of one's past – may affect future actions. Granovetter's seminal 'Threshold Models of Collective Behaviour' suggests that individuals have different thresholds for a given action, which may be surpassed if they see sufficient others carrying out this action. Potential refugees may leave their home if they see sufficient others fleeing, individuals may join a protest if they see sufficient others protesting. In an ABM these feedback processes are reflected in the spread of information through networks or observation of geographically-close others. As such, if we want to add a dynamic component to our model we might want to also identify how these endogenous factors affect decision components. For example, do individuals follow the actions of others because they learn that the action is feasible? Or simply because they feel protected when being part of a crowd?

C. *Identify how individuals are exposed to influences.* Individuals are often not directly exposed to any particular external influence. For example, individuals are not hit on the head with the results of a referendum; they hear about them from the news or from their network contacts. Similarly, a competitive academic job market is experienced locally by sending out many job applications and receiving few responses in return, or from hearing about others' experiences in online forums. An agent-based model represents this sort of information seeking and sending naively. Agents actually send and receive micro-level information or signals that reflect macro-level conditions. As argued in Chapter 2, this experiential learning process allows agents/ individuals to adapt by learning about new conditions and searching for decision alternatives that may allow them to solve any problems caused by this change (Gigerenzer and Selten, 2002). We can incorporate information relevant to this point into our data collection plan by considering what resources real-life individuals gather information from (e.g. social networks, media).

3.2.4 Stage 4: Measurement

An indicator is an "observation that we choose to consider as a reflection of the variable we want to study" (Babbie, 2010, p. 131) so that we can identify its presence in our data. Stages 2 and 3 will likely have facilitated this process by helping us understand the various meanings and dimensions of a concept. At this point we can start drafting the questionnaire. In doing so, however, we may identify a series of challenges and make some proactive plans for the future.

A. *Identify the appropriate design to measure components of decision as well as various external stimuli.* In the previous steps, we have identified the components of decision, as well as components that are exogenous or that we would like to treat as exogenous We have also identified how individuals are likely to respond to these changes. This lays the groundwork for our choice of empirical design. There is an extensive literature on types of questions and best practices for survey design: how to avoid satisficing (respondents not answering correctly because they are tired), how to make sure the context of the question is properly understood or how to avoid leading the respondent, for example (Pasek and Krosnick, 2010). Similarly, a great deal of methodological research revolves around overcoming threats to causality. It is outside the scope of this chapter to consider this literature. However, it is useful to outline two points that ABM can help with: adaptation and causality. Examining the various forms in which individuals may react to changes in their environment can help us make decisions about whether to present certain items as trade-offs, a ranking of priorities, or like Smajgl and Bohensky (2013), as "what-if scenarios." As mentioned earlier in the chapter, researchers will likely be interested in establishing whether certain effects are causal or simply correlational. Agent-based models allow us to conduct in-silico experimentation that can allow us to attribute changes in behaviour to some exogenous factor. To adequately calibrate this effect, we may, therefore want to conduct a population-based experiment. In this experiment, we may not be able to observe the behaviour of interest. However, we may be able to observe the effect of the variable of interest on some intermediary variable that, we theorised in Stage 2, will lead to the behaviour. The experiment presented in Chapter 5 is an example.

B. *Identify outputs and plan for validation.* The final stage in the proactive process is to identify the observable outputs of the ABM. This could be the aggregate behaviour of agents – for example unauthorised, legal migration and non-migration, violent and non-violent protest, or voting for political party A or party B. After identifying these outputs it is important to search for existing data that may allow us to validate our model by comparing simulated to real outputs. As I have argued in the review, it is not sufficient to test the hypotheses relating to specifics of the model architecture. We also have to evaluate the model as a whole. The more independent data sources we can use to validate our model, the better. However, we can also benefit from collecting our own data to supplement these datasets and conduct within-sample validation. This data cannot be used as part of the inputs of our model and must therefore be set aside expressly for the purpose of validation.

At the end of this process, the researcher will have a plan for one or multiple agent-based models and an accompanying survey instrument targetting all aspects of empirical embeddedness. The ABM design should make data collection more thorough and precise; yet also flexible enough to allow for a change in plans as we learn from our results, and to make inferences about alternative states of the world.

3.3 Summary

In this chapter, I reviewed data-driven models which study migration primarily or as part of a suite of possible agent behaviours, focusing on migration decision-making. Agent-based models are a natural form of modelling which allows us to depict complex processes and relationships. However, we have an important Achilles heel: our results are not interpreted from natural processes; they are generated by the source code of our model. This generates various concerns regarding researcher discretion. Several agent-based models use empirical data and analysis for model specification or embed these data as model inputs, in an effort to lend credence to the model. I argue that, in order to broaden our contribution, we need to develop higher standards for empirical embeddedness.

I find that modellers use a range of quantitative and qualitative methods to specify and calibrate different aspects of a model. However, the process of translating empirical findings into agent rules is often inadequate or obscure. One-third of the models presented do not use any form of qualitative or quantitative validation. If the study does contain a form of empirical validation, it only tests one output and, generally, does not use independent empirical datasets. Calibration is often difficult, as micro-level data for the processes the researcher wishes to model is often not available. Relationships are not always parametrised. When they are, the manner in which these parameters were estimated is not communicated and any measures taken to remediate common empirical issues such as omitted variable bias are not discussed.

I then suggest a proactive approach to data embeddedness for agent-based models for researchers who are looking to collect primary data. This approach consists of designing an abstract agent-based model in conjunction with one or a series of empirical instruments, which can improve our ability to calibrate, specify and validate our models. This approach guided the manner in which data was collected and used in the agent-based model of unauthorised migration presented in Chapter 7.

Chapter 4

Case Selection and Survey Design

This thesis tailors a nationwide survey of Jamaica to inform and calibrate an agent-based model of unauthorised migration, which examines how aspiring migrants adapt to changes in immigration policy by adopting unauthorised migration routes. The combination of empirics and agent-based modelling allows us observe how individual decision-making, elicited empirically at the individual-level, gives rise to complex migration patterns at an international level.

This chapter describes the *Migration Decisions and Policy* survey (*MDP*), which consists of a range of experimental and non-experimental questions. Experimental designs allow us causally identify how micro-level decisions and strategies respond to changes in immigration policy and provide us with reliable measures for sensitive issues.

I was involved in all aspects of the inception, design and execution of the survey: I made contact with a professional survey team through a scoping visit to Jamaica, managed all logistics, as well as contractual and funding aspects, co-wrote all instruments in the questionnaire, trained enumerators, and coordinated the survey in Jamaica.

The survey was designed to fit the needs of the data-driven ABM of unauthorised migration presented in Chapter 7, following the proactive approach to empirical embeddedness. This approach, detailed in Chapter 3, was proposed as part of the Leverhulme Trust grant, which I co-wrote with my supervisors Shane D. Johnson and David Hudson, and refined throughout the project. This the Leverhulme Trust grant funded data collection.

This chapter has the following aims: (1) to describe why Jamaica was selected as the empirical case; (2) to explain how the ABM motivated the design of experimental and non-experimental survey instruments; (3) to provide an overview of the survey, including the wording of questions, their theoretical underpinning, and descriptive statistics. This chapter is structured to address each of these goals in turn.

4.1 Empirical case selection

With the exception of Chapter 9, which considers the case of Mexico-US migration, this thesis uses Jamaica as the empirical case. This case was selected using three criteria that would facilitate the research topic at hand. The case had to be:

1. A migrant source country

2. A country with a large number of aspiring migrants
3. A country where the drivers of migration are largely uniform and of an economic nature
4. A country where unauthorised emigration is a viable and common strategy

I explain the rationale for each of these points in turn relating specifically to the survey.

1. A migrant source country. Eliciting information on migrant decision-making under policy constraints is challenging. While a deep understanding migration decisions requires that we observe individuals who migrate and those who do not, this is very difficult to do in practice (Sana and Conway, 2013). Surveying individuals only at the destination does not allow us to observe barriers to movement. The individuals who migrated are likely the minority who had the capabilities to do so. Those who did not have the ability to migrate legally and have migrated through illegal means tend to remain hidden and are, therefore, often difficult to find or talk to. Given this thesis' focus on undocumented migration, this shortcoming is particularly important.

Surveying individuals in an origin country is not a necessarily a solution as it will yield information only on non-migrants. The Mexican Migration Project, which is described further in Chapter 9, surveys return migrants in the origin country in an attempt to obtain information on individuals with migration experience. However, this strategy is also problematic as the individuals that return are likely a biased subset of those who left. An origin country focus with an empirical strategy that takes seriously aspirations and the individual-level effects of barriers to movement can prove to be a fruitful alternative if paired with agent-based modelling. This alternative does not allow us to observe both migration and non-migration but it does allow us to simulate whether our sample might migrate or stay home. This approach has the added benefit of allowing us to examine the effects of policies that may be implemented in the future on this population, given the sample's responses at the time the survey was implemented. It is possible to compare the outcomes of the ABM to existing estimates from destination country datasets, as was discussed in Chapter 3, to assess whether the information elicited on aspirations and the individual-level effects of barriers to movement is likely to yield credible estimates of future migration when embedded into a simulation model. Another source of validation, which can be implemented in future work, is to follow-up on the sample surveyed during subsequent years to observe whether they migrated or not. This would be an excellent way to directly measure the predictive power of our survey instruments and therefore also further validate the ABM architecture. This could be done by offering a cash incentive to survey respondents for reporting their migratory status, as is done in some experimental studies on migration (McKenzie and Yang, 2010).

2. A country with a large number of aspiring migrants. This case selection criterion has several advantages for the study of migration from an origin country. First, it is likely that a – naturally – large proportion of our sample will have explored opportunities for migration and received information about opportunities and immigration policy constraints. As such, it is not necessary to use snowball sampling or quotas, which threaten the representativeness of the sample, to get at our population of interest. Second, having a large proportion of aspiring migrants provides us with the unique opportunity to observe variation in decision-making amongst aspiring migrants.

Jamaica has a historically high propensity for migration. After becoming a British colony, Jamaicans migrated en masse to Central America to work on construction projects, or Cuba to work on sugar cane production. The United States and the United Kingdom recruited Jamaicans and other Caribbean nationals as part of the World War I and II efforts and post-war reconstruction. Today, its migrant diaspora is concentrated in the United States, Canada and the United Kingdom, but many Jamaicans migrate within the Caribbean to countries such as the Cayman Islands, Bermuda, Bahamas, or Antigua and Barbuda (Thomas-Hope, 1992; Glennie and Chappell, 2010). According to the 2014 LAPOP survey, 58% of Jamaicans intend to move abroad within the next three years (Zechmeister, 2014). This figure compares with 13.7% of Mexicans, the most common case study for migration research. The shortcomings of using an island state as a case study are discussed in the next two points and, in further detail, in Chapter 10.

3. A country where the drivers of migration are largely uniform and of an economic nature. While there are countries with similarly high rates of aspiring migrants, Jamaica is a particularly illustrative case because only a very small proportion of these emigrants qualify as forced migrants. A study of Jamaican migration from 2000 to 2010 found that, despite high rates of emigration, only very small number of Jamaicans were asylum-seekers or refugees. In 2010, only 6% of the Jamaicans who emigrated to the top three destination countries (the US, Canada, and the UK) did so as forced migrants (Thomas-Hope et al., 2012). Individuals who are forced from their homes are likely to make migration decisions under heightened constraints compared to other aspiring migrants. Although there is great value in exploring migrant decisions under different pressure scenarios, it is often difficult, if not impossible, to classify and disaggregate refugee and voluntary migrant populations. Therefore, in order to more clearly delineate the type of migration under study and generalise to other sources of economic migration the survey sample would ideally minimise the number of such highly constrained aspiring migrants.

However, it is important to note that island migration is different from mainland migration in several respects, which places a limit on its generalisability. First, generally islands have dense populations when compared to adjacent mainland areas (King and Connell, 1999), which creates a large pressure to migrate. As prominent geographer Ellen Churchill Semple wrote in (1911), "a small cup soon overflows" (p. 416). Second, out-migration has large effects on the demography of the country. Small islands are particularly prone to large volatility in population due, partly, to emigration (Cleland and Singh, 1980). This not only affects the size of the population but, due to the selectivity of migration flows – favouring the young and highly educated or those whose family has a history of emigrating – it also affects the demographic structure (King and Connell, 1999). This is certainly the case for Jamaica. According to the 2015 Economic and Social Survey of Jamaica, emigration creates the "greatest impact on [Jamaica's] population size and structure," even compared to other basic demographic indicators such as birth and death rates (ESSJ, 2015).

4. A country where unauthorised emigration is a viable and common strategy. Jamaicans' main possibilities for legal migration are seasonal guest worker programs for agricultural harvesting and the hotel industry in the US and Canada. The large Jamaican diaspora abroad makes family reunification another feasible alternative for migration (Thomas-Hope, 2003). According to the US Department of State, 68% of Jamaican applicants for visitor visas were accepted (U.S. Department of State, 2015a). Data for the UK shows a lower acceptance rate of Jamaicans (57%) for that same year (**?**). Jamaicans may be refused a government-issued visa because they cannot convince immigration authorities they will not overstay a tourist visa, because they were deported before, or because they have a criminal conviction – among several other reasons (US Department of State, nd). Therefore, some individuals may only be able to live and work abroad if they do so through irregular channels.

According to Elizabeth Thomas-Hope (2003, p.1), "Under dire circumstances, and as legal channels for entry into potential immigration countries (particularly those in North America and Europe) remain selective on grounds of nationality, education and occupational status, there is likely to be a continuing flow of [Caribbean] migrants trying to circumvent formal channels by resorting to informal ones." According to Thomas-Hope, Jamaicans employ two main irregular migration strategies: entering with a legal visa but violating its conditions and entering with false documentation (Thomas-Hope, 2003, p.9). Unlike the Dominican Republic, Haiti and Cuba, Jamaica is not among the significant sources of irregular boat migration (Thomas-

Hope, 2003). Instead, Jamaican unauthorised migration usually takes place through regular airline routes, with the use of (violated) legal or falsified visas. Another relevant strategy for Caribbean nationals also is crossing a border illegally (Thomas-Hope, 2003). However, in the Caribbean, the only international land border crossing of significance is between Haiti and the Dominican Republic and, therefore, is not relevant to Jamaicans. As such, Jamaica's geography also sets it apart from mainland states in regard to unauthorised migration – not only migration propensity, as discussed in the previous point.

Irregular migration from Jamaica can be a significant proportion of the island's diaspora. The US has the most detailed estimates of the scale of unauthorised migration from Jamaica. According to the augmented American Community Survey (ACS), collected by the US Census Bureau, and the Jamaican census, there were approximately 34.13 Jamaican migrants in the United States for every 100 Jamaican adults living on the island in 2011 (U.S. Census Bureau, 2000; STATIN, 2001).[1] According to the Center for Migration Studies using data from on the augmented ACS (Rosenblum and Ruiz Soto, 2015; Warren, 2014; Center for Migration Studies, 2017), there were approximately 100,000 unauthorised Jamaican migrants in the United States in 2012, or 15% of all Jamaican migrants.[2]

[1]This translates to 680,845 migrants living in the US to 1,995,148 Jamaicans over 15 years old on the island.

[2]These estimates are calculated using the residual method, of subtracting the legal foreign-born population from the total foreign-born population, discussed in more detail in Chapter 1 (Warren, 2014).

4.2 Survey overview

The *Migration Decisions and Policy* survey is a nationally representative survey of Jamaica. Jamaica is geographically subdivided into 14 large administrative units, called parishes. The sample includes all 14 parishes. In total, our sample consists of 1,166 face-to-face interviews with Jamaican adults from across the island. We used a multistage sampling strategy – blocked by parish and clustered by enumeration district. Clusters were proportionally allocated based on the latest (2011) census data and randomly selected.

Table 4.1 shows each parish, the area it occupies (columns 2 and 3), its population and the number of respondents surveyed in each parish (Columns 4 and 5), show the correspondence between the population of that parish and the sample respondents in that parish. Column 3 shows the spatial proportion of the island each parish occupies, which was used to map Jamaica's geography onto the ABM of unauthorised migration's square lattice (see Chapter 1, Section 1.3, for more details on the spatial features of agent-based models)

Table 4.1: *Correspondence between Jamaica's geography and population with the sample surveyed in each geographical subdivision*

Parish	Area (km^2)	Proportion Territory	Population	Agents/ Sample
Clarendon	1,196	0.109	245,103	119
Hanover	450	0.041	69,533	14
Kingston	22	0.002	89,057	40
Manchester	830	0.076	189,797	80
Portland	814	0.074	81,744	35
Saint Andrew	431	0.039	573,369	267
Saint Ann	1,213	0.110	172,362	62
Saint Catherine	1,192	0.108	516,218	217
Saint Elizabeth	1,212	0.110	150,205	70
Saint James	595	0.054	183,811	77
Saint Mary	611	0.056	113,615	47
Saint Thomas	743	0.068	93,902	35
Trelawny	875	0.080	75,164	38
Westmoreland	807	0.073	144,103	65

Source: Statistical Institute of Jamaica, 2011. `http://statinja.gov.jm/`

The fieldwork was carried out by enumerators directly managed by the University of the West Indies in the Kingston Metropolitan Area. I travelled to Kingston, Jamaica in July 2015 to establish contact with the survey contractors and had the opportunity to interview 10 return and deported Jamaicans who had migrated to the United States and the United Kingdom. I also interviewed Professor Elizabeth Thomas-Hope, a prominent expert on Caribbean migration, who has written numerous books, articles and reports for international organisations on the subject (e.g. Thomas-Hope, 1992, 2003, 2005; Thomas-Hope et al., 2009). This allowed me to gain knowledge of the migration context. Before launching the survey, Cassilde Schwartz (the Research Associate on the project) and I consulted with the survey manager, who provided invaluable local knowledge, both on the relevance of the questions we wished to ask, as well as their wording. We also accompanied enumerators while they interviewed 50 respondents in the Kingston Metropolitan Area for the pilot survey between November and December 2015. This allowed us to observe whether questions were effective and easy to understand. We made several revisions to the survey using the knowledge we gained from the pilot, and the final *Migration Decisions and Policy* survey was fielded in April 2016. Data collection continued until June 2016.

4.2.1 The questionnaire

The survey was conducted on tablets using the *Qualtrics* off-line application to allow randomisation and customisation of questions based on previous responses. In this section, I will briefly describe all questions employed in Chapters 5 to 8 of this thesis. Tables 4.2-4.5 provide details on question wording and descriptive statistics on the survey data employed in Chapters 5 to 8. The study employed two experiments embedded in the survey: a video experiment about immigration policy and a list experiment. I provide a full description of the methods and materials used for these experiments in Chapters 5 and 6, respectively.

The questionnaire was designed explicitly for the calibration, specification and validation of an agent-based model of unauthorised migration and follows the proactive approach to empirical embeddedness for ABMs laid out in the last section of Chapter 3. This approach aims build an intrinsic relationship between empirics and modelling from the start of a project by allowing the two aspects to co-evolve. According to this approach, when designing an empirical data collection instrument tailored to inform an agent-based model, we should:

1. Think of respondents as adaptive agents.

2. Consider indicators as part of a sequential decision-making process: This allows us to increase precision in operationalisation.

3. Use relationships defined in the ABM to identify important empirical challenges (e.g. endogeneity problems).

4. Design instruments that can be used for calibration and others that can be set aside for model specification and validation.

5. Use the ABM model specification process to determine which topics to include in the survey.

This process of empirical embeddedness begins with a sketch of an agent-based model describing the system.

The main purpose of the survey was to understand how unauthorised migration may arise. We use the *non-compliance/ semi-noncompliance* typology of unauthorised migration described in Chapter 2 to define two common illustrative cases to be used throughout the survey: entering a foreign country using a false visa and working under the table on a visitor visa. We identified these two cases because, as outlined above, they are quite common and relevant among Jamaicans (Thomas-Hope, 2005). Moreover, our selected cases are also strategies that can be executed immediately upon entry. There are certainly instances where individuals enter legally but then fall out of status – i.e., overstaying one's visa. However, such decisions may be made many months after arriving in the destination country, and eliciting support for these strategies would force respondents to make a cognitive leap and, potentially, lead to incorrect estimates.

Migrating with fraudulent documents is a clear instance of full noncompliance. Through this strategy, individuals move abroad without any consent from immigration authorities. In the United States, it is considered a criminal offense that can be punished with arrest, potentially long prison sentences, civil money penalties, deportation, and a bar on re-admission (8 C.F.R. §270.3(b)(1)(ii)(B), 1270.3(b)(1)(ii)(B); 18 U.S.C. §1546). Much of the literature refers to the case of undocumented border crossing as an illustration of a fully non-compliant strategy (e.g. Espenshade, 1995; Ryo, 2013; Massey and Espinosa, 1997). However, given the geography of the country, Jamaicans would find it difficult to cross a border without presenting documentation (Thomas-Hope, 2005).

Working under the table on a tourist visa is a common semi-legal strategy, containing a "mix of regular and irregular aspects" (Düvell, 2011). There are strict terms associated with these visas, as visitors can only remain in-country for a limited amount of time and are unconditionally prohibited from working. Violating these conditions is certainly against the law (8 U.S. Code §1227, INA §212(a)(9)(B), INA §222(g)), but in **?**, we classify this strategy as semi-legal because a government-issued visa is obtained.

For the purposes of this chapter, I will refer to these cases as *illegal* and *semi-legal* migration.

The questionnaire was organised under the following broad topics:

- *Aspiration and ability.* These set of questions relate to the third theoretical premise outlined in Chapter 2. This premise holds that limiting individuals' ability to migrate will not necessarily drive down their desire to do so. In this manner, restrictive policies can drive a creative search for alternative possibilities for migration (Carling, 2002; Castles, 2004b; Faist, 1997). This set of questions aimed to, independently, capture individuals' real desire to migrate on the one hand and considerations of feasibility and obstacles on the other, into three components: aspiration, seriousness about migrating [3] and ability to migrate. These three components can vary independently as part of a sequential decision process in an agent-based model. Agents in the ABM search for and attempt different strategies. As such, it is important to capture the ability to execute not only the primary strategy (i.e. legal migration), but also secondary strategies that may be considered if the former is not available to the agent. To prepare for this, we include variables on the ability to migrate using an *illegal* and *semi-legal* strategy. These set of questions advance on existing survey instruments which collapse desire and feasibility into one indicator – 'intention' – and are therefore unable to observe their interplay (Carling, 2002).

- *Risks of unauthorised migration.* Adopting an alternative unauthorised strategy is not costless. It is important to take into account the risks of unauthorised migration. However, while the odds of successful legal migration can be estimated using different data sources (see Chapter 7,

[3] Individuals may have a superficial desire to migrate and never attempt to realise this wish. This question aims to mitigate this issue.

Section 7.3.1), data on the odds of successfully migrating illegally are unavailable. We used a "wisdom of the crowds approach" and asked respondents to provide their own estimates using an *illegal* or *semi-legal* strategy. We used the average value to inform the global odds of success in the ABM of unauthorised migration (see Chapter 7). According to Herzog and Hertwig (2009, p. 231),

> *The average quantitative estimate of a group of individuals is consistently more accurate than the typical estimate, and is sometimes even the best estimate. Although individuals' estimates may be riddled with errors, averaging them boosts accuracy because both systematic and random errors tend to cancel out across individuals.*

- *Support for unauthorised migration.* Rational expectations of the risks involved in unauthorised migration are not the only deterrents. Individuals may choose to comply with the law for normative reasons, regardless of risk or punishment (Ryo, 2013; **?**). This set of questions relates to this thesis' fourth theoretical premise, laid out in Chapter 2. Methodologically, this topic presents an empirical challenge for estimation as it is likely to be sensitive and yield biased responses in a face-to-face survey. To mitigate this issue, we employed an instrument that respects respondents' privacy, providing reliable aggregate-level responses (Blair and Imai, 2012). This method – the list experiment – is detailed in Chapter 6. However, briefly, the procedure is as follows: respondents are randomly assigned a treatment or a control list (see

Table 4.3). The only difference between treatment and control lists is a theoretically-relevant sensitive item – in our case, unauthorised migration. The list experiment can be analysed using a difference-in-means test. The coefficient estimate for this test is equal to the proportion of respondents who support the sensitive item. Separate list experiments were used to elicit responses on *illegal* and *semi-legal* strategies. In Chapter 6, I evaluate whether the list experiment worked as intended by comparing results to the proportion of respondents supporting *illegal* and *semi-legal* strategies when questioned directly.

- *Immigration policy.* Aspiration and ability to migrate are theoretically linked to the same factors that drive immigration policy change: past migration. On one hand, networks of family, friends and acquaintances facilitate future migration (Massey et al., 1993; Haug, 2008; Garip and Asad, 2016). On the other hand, migration in a previous time period may signal to policymakers that migration needs to be restricted (Hopkins, 2011). This presents an empirical challenge. To isolate the effects of immigration policy on aspiration and ability to migrate, we used a between-subjects video experiment. Briefly, participants were randomly assigned to view a video about the real policy-induced difficulties Jamaicans may face when attempting to migrate or a control condition. The unique causal effects of policy on Jamaicans' aspiration and perceived ability to migrate were estimated with a simple t-test comparing treatment and control means. This video experiment (the motivation, procedure, the video script and results) are detailed in Chapter 5.

- *Migration history.* We include an extensive battery on migration history in our survey. However, for the purposes of the work done here, we only use one question relating to past legal migration attempts. Specifically, we ask how many times respondents have applied for a visa and been rejected in the past. This question is set aside as one of several patterns by which to validate the agent-based model presented in Chapter 7, following the proactive approach to empirical embeddedness outlined in Chapter 3.

- *Relationships abroad.* As discussed in Chapter 2, social networks are a key facilitator of migration (Massey et al., 1993; Haug, 2008; Garip and Asad, 2016). We used a name generator instrument to elicit ego-centric social network data (Pustejovsky and Spillane, 2009). That is, we asked respondents to first identify relationships abroad and then asked further questions about these contacts. These questions aimed to elicit the following characteristics from individuals' networks: (1) how many of these networks are family members (2) how long ago these family members migrated (3) which of these contacts can be considered a source of support. Respondents were asked to provide first names or aliases of their relations to protect their privacy. Characteristics 1 and 2 were used to determine individuals' eligibility to migrate under different policy conditions, as will be detailed in Chapter 7. Characteristic 3 is the most theoretically-relevant measure of networks (see a description of network theory in Chapter 2) and is, therefore used as a control variable in estimates for model specification and parametrisation presented in Chapters 5 and 6.

- *Life priorities.* To reduce student migration, many governments restrict the work opportunities available to them after graduation (UK Parliament, 2016, p. 12). We included a question on individuals' life priorities to help determine how important having a steady income is for the respondent. This will help us estimate how much they might be affected by this type of policy.

- *Demographics.* We elicited demographic characteristics for three reasons: (1) to serve as control variables in estimates for model specification and parametrisation presented in Chapters 5 and 6, (2) to specify social networks in the ABM, and (3) to determine eligibility for policy conditions, as in *Relationships abroad* and *Life priorities.* The use of these individual-level variables allows us to simulate these individuals' real changes of successful legal migration (as opposed to their perceptions), and allows for immigration restrictions to be heterogeneous. The heterogeneity of legal restrictions is in line with this thesis' second theoretical premise, which follows livelihood or capabilities approach to migration (Carling, 2002; De Haas, 2011; Czaika, 2011; Faist, 1997) outlined in Chapter 2.

Table 4.2: *Survey Data, Part I*

Variable	Description	Question Wording
Aspiration	N = 1,147 $\mu = 5.09$ SD = 2.04 Range = 1-7	Whether or not you think you would be ABLE to move abroad, how much would you LIKE to move to another country? (1) Dislike a great deal (2) Dislike a moderate amount (3) Dislike a little (4) Neither like nor dislike (5) Like a little (6) Like a moderate amount (7) Like a great deal.
Ability	N = 1,102 $\mu = 3.19$ SD = 2.04 Range = 1-7	How easy do you think it would be for you, personally, to move abroad? (1) Extremely difficult (2) Moderately difficult (3) Slightly difficult (4) Neither easy nor difficult (5) Slightly easy (6) Moderately easy (7) Extremely easy.
Ability Illegal	N = 1,058 $\mu = 2.01$ SD = 1.71 Range = 1-7	How easy do you think it would be for you to obtain fake immigration documents? (1) Extremely difficult (2) Moderately difficult (3) Slightly difficult (4) Neither easy nor difficult (5) Slightly easy (6) Moderately easy (7) Extremely easy.
Ability Semi-legal	N = 1,106 $\mu = 3.04$ SD = 1.95 Range = 1-7	How easy do you think it would be for you to FIND A JOB UNDER THE TABLE in a foreign country? (1) Extremely difficult (2) Moderately difficult (3) Slightly difficult (4) Neither easy nor difficult (5) Slightly easy (6) Moderately easy (7) Extremely easy.
Seriousness	N = 1,146 $\mu = 2.38$ SD = 1.21 Range = 1-4	How seriously have you considered moving abroad? (1) Not at all seriously (2) Somewhat seriously (3) Quite seriously (4) Extremely seriously
Semi-legal Risks	N = 1,031 $\mu = 5.27$ SD = 3.27 Range = 0-10	I'm going to give you a small list of countries. For each country, suppose 10 people try to GET A JOB in a foreign country WITHOUT DOCUMENTATION. How many of these 10 do you think will be caught by authorities? Please respond for each of the given countries (mean is computed for responses to US, UK, Canada, Cayman Islands, Sweden. If the respondent indicated previously that they would like to migrate to a country not on this list, that country is also listed and included in the mean):
Illegal Risks	N = 1,017 $\mu = 7.33$ SD = 2.75 Range = 0-10	I'm going to give you a small list of countries. For each country, suppose 10 people try to CROSS THE BORDER without legal documentation. How many of these 10 do you think will be caught by authorities? Please respond for each of the given countries (mean is computed for responses to US, UK, Canada, Cayman Islands, Sweden. If the respondent indicated previously that they would like to migrate to a country not on this list, that country is also listed and included in the mean):

Table 4.3: *Survey Data Pt. II*

Variable	Description	Question Wording
Direct Illegal	N = 1,147 $\pi = 1.85$ SD = 1.21 Range = 1-7	It is OK to ENTER a foreign country without legal documentation (1) Strongly disagree (2) Disagree (3) Somewhat disagree (4) Neither agree nor disagree (5) Somewhat agree (6) Agree (7) Strongly agree
Direct Semi-legal	N = 1149 $\pi = 2.40$ SD = 1.60 Range = 1-7	It is OK to WORK a foreign country without legal documentation (1) Strongly disagree (2) Disagree (3) Somewhat disagree (4) Neither agree nor disagree (5) Somewhat agree (6) Agree (7) Strongly agree
Indirect Illegal List Experiment	N = Control: 569; Treatment: 593 μ = Control: 2.32; Treatment: 2.45 SD = Control: 0.70 Treatment: 0.84 Range = Control: 1-4 Treatment: 1-5	I'm going to give you a list of things that people sometimes do to move permanently to a foreign country: (1) Apply to a university in the new country (2) ask family members abroad to sponsor you (4) be smuggled across the border (5) *For treatment group only:* Obtain a fake visa. Please tell me HOW MANY of the following options you would personally support.
Indirect Semi-legal List Experiment	N = Control: 573; Treatment:581 μ = Control: 2.19; Treatment: 2.33 SD = Control: 0.70 Treatment: 0.87 Range = Control: 1-4 Treatment: 1-5	I'm going to give you a list of things that people sometimes do to work in a foreign country: (1) get an employer to sponsor you (2) build an online profile for recruiters (3) deal drugs (4)*For treatment group only:* Work under the table while on a tourist visa. Please tell me HOW MANY of the following options you would personally support.
Life Priorities	N = 1,166 $\pi = 0.8$ Range = 0-1 *Only used "income", (1)*	I'm going to give you a list of priorities that many people have. Please listen to this list carefully and select THREE items that you consider to be your top priorities. (1) To have a steady income (2) To feel safe from crime (3) To live your life openly without fear of discrimination (4) To study and get qualifications (5) To live in a place where government is transparent and fair (6) To live near your close family (7) To learn useful entrepreneurial skills (8) To be evaluated by merits, not by social class or connections (9) To save money (10) To live in a place without wealth inequality
Visa Rejections	N = 1,158 $\mu = 0.38$ SD = 0.81 Range = 0-6	How many times have you applied for a visa, but had your application rejected? (1) 1 time (2) 2 times (3) 3 times (4) 4 times (5) 5 times (6) 6 times (7) 7 times (8) 8 times (9) 9 times (10) 10 times (11) more than 10 times

Table 4.4: *Survey Data Pt. III*

Variable	Description	Question Wording
Network Name Generator		Now I want you to think about Jamaicans who you have spoken to in the last year and have been living abroad for MORE THAN SIX MONTHS. Could you give me their first names, please? If you feel uncomfortable giving me their names, feel free to make up an alias. The only thing that matters is that you remember which person you're talking about as I ask you a few additional questions.
Network Relationship		Which of the following best describes your relationship with each person? Are they a friend, a family member, an acquaintance, a neighbour, or something else? For people that fit into multiple categories, please select all that apply. (1) Friend (2) A family member (3) An acquaintance, (4) A neighbour (5) Something else
Network Departure		When did they move to [country]? *(only family, year)*
Support Network		Do you think you could count on this person to help you settle into a new country? For example, they could help you find a place to live or find a job?
Networks Frequency	N = 1,166 $\mu = 3.1$ SD = 3.5 Range = 0 - 20	How many Jamaicans do you know currently living in other countries? Please only think about those who you've spoken to IN THE LAST YEAR. Responses were truncated at "More than 20"
Yearly income, USD (Imputed)	N = 1,166 $\mu = 368.55$ SD = 476.92 Range = 0.00 - 2,133 USD	Which of the following income ranges best represents the total monthly income for this entire household? This figure should include income from all sources, including salaries, wages, pensions, dividends, interest, remittances, and all other income (Jamaican Dollars). (1) No income (2) Less than \$6,000 (3) \$6,000-\$9,000 (4) \$9,001-\$12,000 (5) \$12,001-\$18,000 (6) \$18,001-\$22,500 (7)\$22,501-\$27,000 (8) \$27,001-\$31,500 (9) \$31,501-\$36,000 (10) \$36,001-\$45,000 (11) \$45,001-\$54,000 (12) \$54,001-\$72,000 (13) \$72,001-\$90,000 (14) \$90,001-\$126,000 (15) \$126,001-\$162,000 (16) \$162,001-\$216,000 (17) More than \$216,000
Education	N = 1,161 $\mu = 4.56$ SD = 1.22 Range = 1 - 8	What is the highest level of schooling you have achieved? (1) None (2) Pre-Primary (3) Primary school (4) Secondary school (5) Technical school/ Vocational school (6) Associate degree (7) University (8) Graduate school

As often occurs with survey data, household income yielded a high proportion of non-response. More than a quarter of the sample declined to provide this information. We imputed missing values by modeling household income as a function of gender, age, education, marital status, employment status, sector of employment, and household remittances received. The imputation did not substantively influence findings.

Table 4.5: *Survey Data, Pt. IV*

Variable	Description	Question Wording
Religion	N = 1,102 Mode = (4) Range = 1-12	What is your religion? (1) Catholic (2) Protestant (3) Non-Christian Eastern religion (4) Evangelical and Pentecostal (5) Mormon (LDS) (6) Rastafarian (7) Jewish (8) Jehovah's Witness (9) Agnostic, atheist (10) None (believes in a supreme entity, but does not belong to a religion)
Sector	N = 721 Mode = (11) Range = 1-11	In which of these economic sectors are you currently working? (1) Agriculture (2) Industry (3) Banking (4) Retail/ Commerce (5) Crafts (6) Government (7) Construction (8) Transportation (9) Education (10) Information and Technology (11) Other services
Gender	N = 1,166 Male = 558 Female = 608 Range = 0,1	Enumerator observation
Age	N = 1,163 $\mu = 37.32$ SD = 14.37 Range = 18-88	How old are you?
Marital Status	N = 1,162 Mode = (1)	What is your marital status? (1) Single (2) Visiting relationship (3) Married (4) Divorced (5) Common law marriage (living together) (6) Separated (7) Civil union (8) Widowed
Employment Status	N = 1,166 $\pi = 0.57$ Range = 0,1 *Only used "working",(1)*	Which of the following best describes your current employment? Please select all of the following that best identify you: (1) Working (2) Not working, but have a job (seasonal) (3) A student (4) Taking care of the home (5) Retired or disabled (6) Not working but looking for a job (7) Not working and not looking for a job

4.3 Summary

This thesis combines agent-based modelling with a wide range of empirical instruments to understand how aspiring migrants adapt to changes in immigration policy by adopting alternative migration strategies. This chapter introduces the empirics: a nationally-representative sample survey of Jamaica. This short chapter has the following aims: (1) to describe the selected case for empirical data collection (Jamaica); (2) to explain how the ABM motivated the design of experimental and non-experimental survey instruments; (3) To provide an overview of the survey, including the wording of questions and descriptive statistics. The survey was tailored to fit the needs of the ABM of unauthorised migration, following the proactive approach to empirical embeddedness. The next two short chapters analyse the empirical findings corresponding to some of the key junctures of this model.

Chapter 5

The Effects of Immigration Policy at the Micro-Level

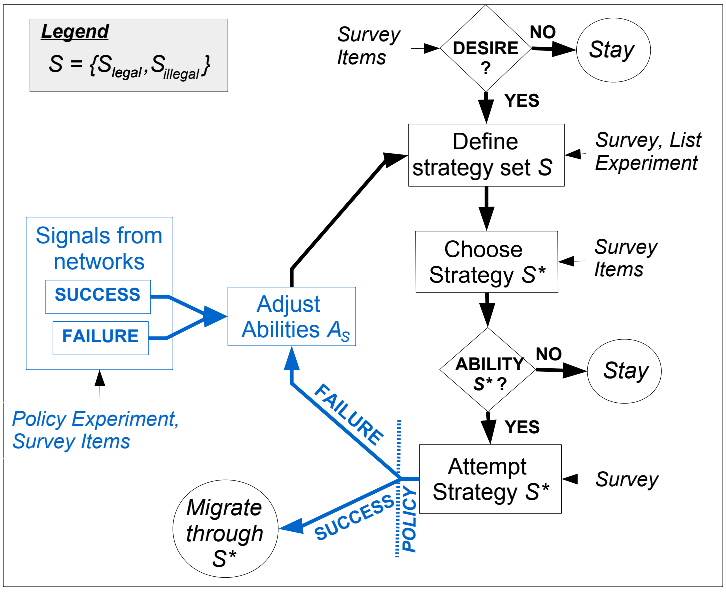
Students of migration have paid little attention to the effects of immigration policy on population movements (Massey, 1999) and much less on how policies exert their effects at the individual level (Hagen-Zanker and Mallett, 2016). Understanding how entry policies influence decision-making is crucial for understanding how they shape migration flows at the macro level. As (Hagen-Zanker and Mallett, 2016, p. 2) suggests, "in order to understand the role that policy may (or may not) play in shaping the dynamics of international migration, it is first important to understand the ways in which individuals process information, think through their options, and select courses of action."

This thesis examines the effects of immigration policy on migration systems by building a multi-level artificial system of potential migrants connected through social ties. Policy change, propagated through these ties, influences agent decision-making and shapes emergent legal and unauthorised migration patterns at the system level. This short chapter and the next zoom in on key processes of this agent-based model and the empirical evidence substantiating their specification. This chapter focuses on the micro-level mechanism by which immigration policy affects individuals' aspirations and perceived ability to migrate.

As examined in Chapter 2, authors have defined the effects of immigration policy at the individual level as an 'intervening obstacle' (Lee, 1966) that thwarts individuals' migration projects (e.g. Carling, 2002; Faist, 1997:247; Massey et al., 1998:12; Castles, 2004a; de Haas, 2010). Policy restrictions can drive a wedge between individuals' aspirations to migrate and their ability to do so, as suggested in this thesis' third theoretical premise. This is important because, as will be examined in the next chapter, 'involuntary immobility' can motivate individuals to seek alternative, often illegal means to migrate. However, the effects of policy on an individual are not so straight forward. As Hagen-Zanker and Mallett (2016) suggest, immigration policy at the micro level consists of a series of information signals, which define the set of options for migration potential migrants perceive themselves to have. As theoretical premise 4 of this thesis suggests, individuals are boundedly rational and learn about policy from their own encounters with it (Carling, 2002; Epstein, 2003a) as well as from their social context (Massey and Zenteno, 1999). Taken together, these premises guide the model relationship in question, which is highlighted in blue on Figure 5.1.

Specifying and calibrating these model processes brought about empirical questions and measurement challenges. Existing literature is clear that

Figure 5.1: *Portions of the ABM Considered in Chapter 5*



immigration policies affect ability to migrate, however it has ambivalent expectations about the effect of immigration policy on aspirations. For example, Castles et al. (2013b) suggest that, beyond a certain level of economic development, "we can expect that migration *aspirations* are likely to decrease... particularly when opportunity gaps with destination countries decrease significantly" (p. 50, emphasis in the original). At the same time, Castles (2004a) suggests that policies affect ability to migrate exclusively: "potential migrants do not cancel migration just because the receiving state says they are not welcome – especially if the labor market tells a different story" (p. 860). Carling (2002) draws a clear relationship between policy constraints and ability to migrate but does not clarify whether destination policies also dampen the desire to migrate, leading to what he calls 'voluntary non-migration', or whether this type of non-migration is independent of policy effects.

Settling this ambiguity is theoretically important and is also essential to the design of the ABM of unauthorised migration, as this programming decision can affect the volume of unauthorised migration that emerges. To explain, if we conceptualise policies as affecting both aspiration and ability in equal measure, we are implying that individuals become content with remaining home when immigration policies thwart their plans for migration. If only perceived ability is affected by immigration policy – or is affected to a higher degree than aspirations – we would conclude that policy creates a large population of individuals who would like to migrate but are unable to do so. Following premise 3(b), we would expect *this* group of individuals – the "involuntary non-migrants" (Carling, 2002) – to consider migrating through unauthorised channels with some, as of yet, undefined probability (however, see Chapter 6).

So, does information about policy restrictions only affect individuals' perceived ability to migrate or does it affect both at the same time? Answering this question is methologically challenging, as aspiration and ability to migrate are theoretically linked to the same factors that may be driving immigration policy change: past migration. Networks of family, friends and acquaintances are a known facilitator of future migration (see Chapter 2) and, by the same token, migration may drive more restrictive policies A salient example of this is Lebanon's January 2015 response to the ongoing Syrian refugee crisis. To limit the influx of Syrian refugees into the country and incentivize repatriation, the Government of Lebanon established restrictive border policies, followed by a freeze on registering refugees (UNHCR, 2017).

To mitigate this endogeneity concern, the effect of policy on aspiration and ability is measured using a between-subjects experiment, in which we randomly assign individuals to receive audiovisual information about immigration policy. Many experimental designs provide information to participants using written cues. We opted for a video cue as the information we needed to convey was both lengthy and complex. Researchers have found that a dual-modality (audio and visual) presentation can increase working memory capacity (Baddeley, 2013; Penney, 1989; Sweller, 2011). An experimental approach helps us identify the causal effects of immigration policy on aspiration and ability to migrate at the micro-level, independent of confounders, allowing us to address this theoretical ambiguity and properly specify this key process in the ABM. The experimental results are also used to set numerical parameters of the ABM relating to the effects of receiving information about immigration policy on decision-making.

A second design question arises from the manner in which policy information is transmitted to agents throughout the system. As specified previously, agents in the ABM receive information about immigration policy through their own experiences and the experiences of their networks (Epstein, 2003a; Massey and Zenteno, 1999). However, this mechanism is only partially examined in existing literature. Studies often find that previous migratory experience and networks abroad are good predictors of migration propensity (Massey, 1986; Piore, 1979; Garip and Asad, 2016; Carrington et al., 1996), but do not often examine the effects of previous, unsuccessful, migration attempts (De Haas, 2010). That is, according to existing work, we may expect that first or second-hand positive experiences may lead to a more positive perception of perceived odds of success, but we have little evidence on whether the opposite is true. Immigration policy exerts its effects by barring the entry of some and not others. Therefore, overlooking migration failures inhibits our understanding of the effects of immigration policy at the micro level. Our original survey questions allow us to examine the effects of personal past experiences – both positive and negative – as well as the number of ego-centric social ties who have successfully migrated abroad, on perceived migration ability. This allows us to more adequately test whether this information diffusion mechanism is likely to be present in our sample, thereby completing the empirical specification of this portion of the model.

This short chapter proceeds as follows. First, I will describe the video experiment procedure, including the script. I, then, describe the analysis and results of two empirical tests: The effects of the video experiment on aspiration and perceived ability to migrate, and a multivariate regression model examining the effects of past migration experiences (positive and negative) and the effect of successful networks on perceived ability to migrate. I then conclude the chapter by discussing specifically how these empirical tests are used in the ABM of unauthorised migration.

5.1 Materials and Methods: The Video Experiment

Participants. The video experiment was embedded into the MDP survey (details on the survey items, the demographics of respondents, and the sampling procedure are detailed in Chapter 4).

After about 40 minutes of standard survey questions on migration, one-third of the 1,166 survey respondents were randomly assigned to a treatment group and one-third were randomly assigned to a control group. The remaining third received a different, independent treatment, which is not part of this thesis.

Materials. The treatment consisted of a 4-minute information video, focusing on restrictions within the most common visa routes for the top three destination countries for Jamaicans – United States, United Kingdom and Canada – specifically geared towards the Jamaican context. The video (script reproduced below) emphasised the strict nature of quotas and requirements. Given the Jamaican context, we believed it would be unethical to present policy information as if it were easy to migrate. The video consisted of illustrated animations we created using the online software Moovly and was narrated by British Broadcast Corporation presenter Nick Ross.

The control group received a short message read by the enumerator, thanking them for their time and telling them the survey will be finished shortly. We decided not to include a control-version of the video for two main reasons. First, a placebo video would have controlled for the extra time it takes the respondent to watch a video. However, we did not believe this would be necessary in our case given the structure of our survey. The treatment took place approximately forty minutes into our survey, and the extra time taken to watch the video would have had a negligible effect. Second, content that is unrelated to migration can inadvertently send messages about a location (Jamaica or any destination) that may encourage the respondent to want to stay in or leave Jamaica, particularly as they were prompted to think about migration throughout the preceding survey questions. Therefore, we did not believe it was worth the risk of introducing a new bias to control for the expected negligible effect of having seen a video.

The video script for the treatment group is reproduced below:

> According to a recent study, almost 60% of all Jamaicans would like to move to a new country in the next three years.
>
> The United States, the United Kingdom and Canada are among the top destinations. But Jamaicans who want to migrate often find their possibilities for entry restricted.
>
> There are VISITOR permits for each of these countries. You might hear these visas referred to as 3, 5, or 10-year visas because they expire after a certain number of years. But they do not let you stay that long. You can stay in the US, UK and Canada for a maximum of 6 months. These permits are for short-term visitors only. What's more, they don't, under any circumstances, allow you to work.
>
> But there are some ways to move to a foreign country, find a job, and create long-term opportunities for you and your family. There are four common legal categories to enter the top destination countries: employment, family ties, lotteries, and asylum. Each of these paths has its own obstacles and restrictions. In fact, only a small fraction of those who would like to migrate to these countries will be able to do so.

Employment

Let's take employment opportunities first. If you want to migrate to earn a better living, one option is to secure an employment-based visa. For high-skilled workers - such as university researchers and high-level business professionals - these visas are very competitive. In fact, a sponsoring employer in that country must demonstrate that no local worker can do the job as well as you, the foreign candidate. That is pretty tough.

For low-skilled workers, it can be nearly impossible to get employment visas. In some countries, like the UK, it is NOT possible to get a permit for low-skilled work. The UK has so many people arriving from European countries that it doesn't recruit low-skilled labour from anywhere else. For the US, there are only 5,000 permanent visas a year for low skilled workers. Those 5,000 visas must be distributed among applicants from all over the world, so you may find yourself on a waiting list for up to 6 years. In Canada, the only programme that accepts low-skilled permanent migrants is the Provincial Nominee Program, where geographic regions nominate migrants who fit their exact needs and qualifications.

Family

Another option is to migrate through family ties. For these visas, you can apply to live in a country where someone in your family has already migrated legally. These visas are also extremely restrictive because the family member living abroad must show that they have an income level high enough to allow them to support the new arrivals. Also, in some cases, family members who use these visas do not have access to government benefits. In the U.S., with millions of family members applying each year, wait times for these visas can last from 6 months to ten years, and there are currently tens of thousands of Jamaicans on the waitlist.

Lotteries

Some countries have immigration lotteries. Jamaicans are not eligible for the US lottery, and many countries - like the UK – do not have lotteries at all.

Refugees

People can sometimes migrate as refugees, but the process is difficult and the burden of proof is extremely high. Refugees must prove that they simply can't remain in their home countries due to life-threatening persecution. Individuals suffering from poverty or difficult economic conditions do NOT qualify as refugees.

Conclusion

So, many Jamaicans look to the rest of the world for opportunities only to find their plans ground to a halt by restrictive policies. The borders erected by foreign governments prevent the ebb and flow of individuals across the world, along with their dreams of a better life.

Design. The experiment used a between-subjects design. The dependent variables were aspiration and ability to migrate. See Chapter 4 for questionnaire wording.

Procedure. Enumerators received a prompt with the random group assignment of the respondent through the Qualtrics offline application on their electronic tablets. If the respondent was assigned to the treatment group, the enumerator showed respondent the 4-minute video on their tablet. The respondent used a headset, which the enumerator disinfected in front of him or her, such that no one but the participant could hear the video. Enumerators were instructed not to let any other individuals view the video when a participant was viewing it. Enumerators were also instructed not to discuss any of the contents of the video with the participant to avoid contaminating the treatment. Immediately after, all respondents were then asked about their aspiration and ability to migrate.

A manipulation check suggests the video was an effective treatment. On a scale of one to seven, where one is strongly agree and seven is strongly disagree, 97% of respondents reported they somewhat agreed, agreed, or strongly agreed that the video was informative. Due to the brevity of the video, treated respondents were read a post-survey disclaimer stating that the information presented in the video represented a brief and stylized account of immigration policies. Respondents were encouraged to seek additional information if they had any intention to migrate.

In the following section, I discuss the analysis and results of this experiment.

5.2 Analysis and Results

I begin by examining whether policy restriction affects perceived ability and aspiration to migrate. Table 5.1 shows the effect of having received information on policy restriction on ability and aspiration to migrate, depicted in models 1 and 2, respectively. *Policy Treatment* is a dichotomous variable indicating that the respondent received the policy treatment. The associated coefficient can be interpreted as a simple difference in the mean value of the dependent variable across treatment and control groups. Each model includes parish fixed effects and clustered standard errors by enumeration district. As mentioned in the previous section, these models only contain 2/3 of the total sample (1,166).

Table 5.1: *Average Treatment Effects: The Effect of Policy Information on Ability and Aspiration to Migrate*

	Ability	Aspiration
	(1)	(2)
Policy Treatment	-0.550^{***}	-0.098
	(0.140)	(0.130)
Constant	3.100^{***}	5.600^{***}
	(0.240)	(0.250)
Fixed Effects	YES	YES
Observations	775	785
R^2	0.080	0.046
Adjusted R^2	0.063	0.029

*p<0.1; **p<0.05; ***p<0.01
Standard errors adjusted for sample design

As shown in Table 5.1, the policy treatment had a substantial effect on perceived ability to migrate. Receiving a negative signal about immigration policy lowers one's perceived ability to migrate by little over half a point on the scale (both perceived ability to migrate and aspiration to migrate are measured on a 7-point scale). This effect is also significant, with a p-value lower than 0.01. Meanwhile, exposure to policy information did not have a significant effect on aspiration to migrate. Methodologically, these results demonstrate the need to conceptualize aspiration and ability as two separate concepts in order to fully understand the effects of immigration policy, as Carling (2002) suggests. The oft used 'intent to migrate' measure conflates these two very distinct concepts. Substantively, they support the hypothesis that immigration policy has an non-ambivalent effect on individuals – it lowers perceived ability to migrate while desire remains unaltered. In other words, restrictive policies appear to create *involuntary*, not voluntary, non-migrants. These findings guide model architecture and the treatment effect of the video experiment on perceived ability to migrate (0.55) is used to calibrate relevant parameters (see the Discussion section of this chapter for details).

In the ABM of unauthorised migration, individuals learn about the policy environment through feedback resulting from personal migratory experiences and the experiences of network ties, will inform expectations about the odds of future success – or the perceived ability to migrate (Massey et al., 1998; Massey and Zenteno, 1999; Leblang et al., 2009; Boyd, 1989; Massey et al., 1993; Massey and Zenteno, 1999). In the analysis that follows, I will show evidence of this mechanism.

Table 5.2 provides some multivariate linear regression models, using our original *MDP* survey. These tests show the association between perceived ability to migrate and the migratory experience of oneself and of one's networks. Table 5.2 includes two variables for personal migration experience: past migration and past visa denial. The first is a dichotomous indicator which equals one when the respondent has successfully migrated in the past (*Past Migration*), and the second is a dichotomous indicator that equals one when the respondent previously applied for a visa but was rejected (*Past Visa Denial*). It also includes a variable, *Network Migration*, for the number of Jamaicans the respondent knows who are living abroad, and a standard set of control variables: gender, age, education and income.

These results show that respondents who have successfully migrated in the past perceive a 0.48 points *higher* ability to migrate, and respondents who have failed to migrate in the past perceive a 0.69 points *lower* ability to migrate. These results suggest that individuals are likely evaluating their odds of success in line with their own migratory history. Individuals also learn from the experiences of their networks. With every additional network contact living abroad, individuals' perceived ability to migrate grows by 0.04 points.

5.3 Discussion

The aim of this chapter was to inform the programming choices made in the agent-based model of unauthorized migration presented in Chapter 7. In this chapter, I have described and analysed the results of a video experiment which treated respondents with information about a restrictive immigration environment. The average treatment effect estimate on perceived ability

Table 5.2: *The effect of migration experiences on ability to migrate*

	Dependent variable: Perceived Ability to Migrate
Male	-0.092
	(0.130)
Age	-0.008^{*}
	(0.005)
Education	0.160^{***}
	(0.058)
Income	0.0005^{***}
	(0.0001)
Network Migration	0.037^{*}
	(0.022)
Past Migration	0.480^{*}
	(0.250)
Past Visa Denial	-0.690^{***}
	(0.150)
Constant	2.700^{***}
	(0.470)
Note:	*p<0.1; **p<0.05; ***p<0.01

shown in Figure 5.1 (0.55) is incorporated into the ABM of unauthorised migration as π – the effect of a signal, from any source, on an individuals' perceived ability to migrate. When the signal is positive, the coefficient's sign is flipped ($\pi = \pm 0.55$). In real life, the effect of a signal about immigration policy on ability may vary depending on the source (Yaniv and Kleinberger, 2000), or whether the information is positive or negative (Hahn and Harris, 2014), among a myriad of different factors. In Chapter 8, I relax the assumption of objectivity by varying the magnitude of π in accordance with theoretical expectations on cognitive bias from Psychology. In other words, I examine migration outcomes when individuals alter their perceived ability to migrate by different amounts depending on the source or valence of the signal.

In the second portion of the analysis, I examined the effects of personal and network migration experiences on perceived ability to migrate. These results showed that, as expected, negative migration experiences lower individuals' perceived ability to migrate, while positive first or second-hand experiences increase it. These tests were not used for model calibration. Instead, they were used to substantiate the assumption that individuals' past experiences – as they relate to immigration policy – transmit signals to potential migrants and that these signals affect individuals' perceived ability to migrate.

The next chapter examines the effect of aspiration and perceived ability on support for unauthorised migration with the aim to specify and calibrate a related model process.

Chapter 6

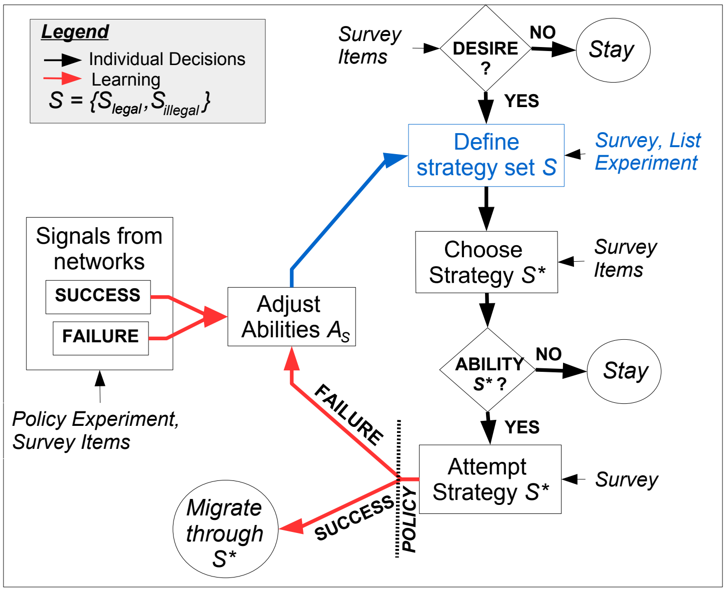
Unauthorised Migration and Norms

Prevailing explanations of migration conceive of aspiring migrants as utility maximisers who will choose undocumented migration strategies if it is cost-beneficial. As argued in Chapter 2, the neo-classical perspective allows migrant decisions to be entirely subsumed to government enforcement policies, which can control the costs and risks of migrating (Massey et al., 1993). Social-network theory takes the opposing view: governments cannot control migration because social networks can mitigate these same factors and allow migration to continue (Massey et al., 1998, p. 45).

This thesis does not dispute that individuals make rational evaluations when choosing a migration strategy; it disputes that migrant decision-making is just that. Unauthorised migration means breaking the law and, beneath any cost-benefit calculations, there is a deeply personal barrier to migrant decision-making that relates to norms – what individuals perceive to be socially acceptable or normal actions within their reference group (Mackie et al. (2015); Gibbs (1965); Cialdini et al. (1991) also see Chapter 2 2.3). Omitting this layer from our models of decision-making may lead to erroneous expectations on the volume of unauthorised migration. If we assume that all aspiring migrants will attempt an unauthorised strategy simply because it is cost-beneficial, we will likely over-estimate the incidence of this type of migration.

This thesis presents a data-driven agent-based model of unauthorised migration, where individuals' beliefs about social expectations are a key feature of its design. This chapter focuses on the model process that defines whether an agent will or will not consider an unauthorised strategy, based on social expectations. As is shown in Figure 6.1, agents define the set of migration strategies they will consider early in their decision-making process. This strategy set, S, will include an unauthorised strategy if the individual is supportive of unauthorised migration. Only after they have included this strategy in strategy set S, will they make a rational judgement on whether to attempt unauthorised migration. Support for unauthorised migration, in this model, is driven by a sense of 'involuntary immobility' – that is, when the desire to migrate is high, but the ability to do so is lowered by prevailing policy conditions (Carling, 2002; Castles, 2004a). We find evidence for this policy effect in the preceding chapter.

Figure 6.1: *Portions of the ABM Considered in Chapter 6*



There are is a significant challenge associated with measuring individuals' support of unauthorised migration and social norms more generally. Norms rely on perceptions of approval or disapproval within a reference group. In a natural, every day environment, individuals may express support for unauthorised migration if they believe their local reference group would also approve of this action. However, the belief that unauthorised migration is OK is not necessarily held outside individuals' reference group and is therefore a sensitive topic for an outsider, such as an enumerator, to enquire about (Mackie et al., 2015). When asked by an enumerator, individuals may downplay their support for unauthorised strategies because they fear being judged. Studies have shown that social desirability bias affects estimates on a wide range of sensitive topics including voting (Silver et al., 1986), racial attitudes (Kuklinski et al., 1997) and anti-semitism (Kane et al., 2004). Similarly, social desirability may lead individuals to under-report support for unauthorised migration and bias our estimates.

To elicit support for unauthorised migration we use list experiments, a novel approach to measurement designed to limit the effects of social desirability by protecting individuals' privacy. Unauthorised migration is defined using the full-noncompliance/ semi-noncompliance typology introduced in Chapter 2. Briefly, full noncompliance includes strategies that circumvent immigration law entirely, (e.g. migrating with no documents or fraudulent documents) and semi-noncompliance comply with some aspect of the law (e.g. strategies where migrants obtain legal documents but violate migratory restrictions). This classification allowed us to define two very distinct, common cases of unauthorised migration, which were used throughout the survey described in Chapter 4 as well as in the list experiments: violating the work conditions of a tourist visa (semi-noncompliance) and obtaining a fake visa (full-noncompliance).

This chapter describes the list experiment and presents results comparing list experiment estimates to responses obtained by direct questions to evaluate the performance of the list experiment in mitigating the effects of social desirability and, therefore, provide sound estimates to be used in calibration. It then examines the relationship between 'involuntary immobility' and support for unauthorised migration through further analysis of the list experiment, lending evidence to this key model relationship. It concludes by outlining how these results guide the specification of the model process in question and the numerical estimates used to calibrate relevant parameters.

6.1 List Experiments

To mitigate issues of social desirability bias, researchers have used aggregation techniques, where respondents are asked how many items from a list they support instead of enquiring about the item of interest directly. The list experiment is one such aggregation technique (Glynn, 2013). The sensitive item of interest is added to a list of non-sensitive items. A control group is randomly assigned to receive a list that consists solely of non-sensitive items while the treatment group is randomly assigned to receive the same list with the sensitive item included. Respondents are instructed to tell the enumerator how many items they would support instead of which ones. This way, respondents do not reveal their personal opinion about the item of interest to the enumerator and their privacy is respected. If there are no systematic differences between treatment and control groups, the difference in average item counts reported between groups provides the overall proportion of support for the sensitive item of interest (Blair and Imai, 2012; Glynn, 2013).

Though the list experiment is conceptually simple, there are certain considerations that must be taken into account when designing it. To obtain accurate results from list experiments, there must be no design effects, ceiling effects, or floor effects (Blair and Imai, 2012). Researchers using list experiments must assume that the only difference between the control list (or the list of purely non-sensitive items) and the treatment list is the inclusion of a sensitive item. However, when design effects are present, respondents are evaluating list items relative to one another and the inclusion of the sensitive item may affect their evaluation of the control items on the list. If this is the case, treatment and control groups cannot be compared because the sensitive item is no longer the only difference between treatment and control lists.

In the presence of ceiling effects, respondents would honestly support all non-sensitive items. This means that treatment respondents do not have the privacy protection needed for the list experiment to work. That is, if a treatment group respondent supports all items on the list, she may expect the enumerator will know she supports the sensitive item. Floor effects occur when the respondent is not likely to support any of the control list items. If respondents perceive that all non-sensitive items have low prevalence, they may be concerned about their preferences being revealed to the enumerator and under-report the number of items they support.

Design effects are difficult to mitigate, although there are ways to correct them at the analysis stage (see Blair and Imai (2012)). However, researchers may follow three pieces of generally accepted design advice to mitigate ceiling and floor effects (Glynn, 2013): First, researchers should avoid including too many high-prevalence items, or items that will likely be supported by all or most respondents (Droitcour et al., 2004). Lists should also not be too short to avoid ceiling effects (Kuklinski et al., 1997). Lastly, researchers should avoid including too many low-prevalence, non-sensitive items to avoid floor effects (Tsuchiya et al., 2007).

List experiments can also fail at the elicitation stage. List experiments protect respondent anonymity insofar as it is impossible for the survey enumerator to know which items the individual supports. In practice, however, improper implementation of list experiments can threaten anonymity. First, respondents may not understand the instructions of the list experiment, particularly if they are used to responding to questions directly. As such, rather than reporting the number of items they would support, they may vocalize which item they support the most. Alternatively, they may respond to each item on the list individually, despite instructions not to do so. This implementation failure is particularly likely if the list experiment is embedded into a survey containing standard questions (as ours was), as respondents may have entered into the habit of responding directly. We observed all of these patterns while conducting pilot tests in Kingston.

To protect respondent privacy at the elicitation stage, we implemented some practical solutions prior to fielding the survey. First, we devoted a substantial portion of enumerator training to the use and purpose of list experiments. We conducted several mock interviews and highlighted which respondent behaviours are incorrect. Second, we explained our instructions in greater detail in the survey instrument and specifically stated that the appropriate response would be a numerical sum. Third, we included a dry-run list experiment in the survey instrument, which walked the respondent through a simple example. Fourth, we used show cards to identify the list items and response options, and we specifically instructed enumerators not to read any of the lists aloud unless the respondent required assistance. If reading items on the list out loud, enumerators may inadvertently intonate the sensitive item differently from the rest, making clear what they believe is the appropriate response. This is likely to make respondents feel uncomfortable and exposed. To mitigate this issue, enumerators read the prompt, presented the show card to the respondent, and the respondents considered the items printed on the show card privately until they gave their answer.

6.1.1 Materials and Methods: The List Experiments

Participants. Our list experiments were embedded into the *MDP* survey. Details on the survey items, the demographics of respondents, and the sampling procedure are detailed in Chapter 4. The survey sample consisted of 1,166 valid respondents. Respondents received three list experiments: a practice list experiment, a list experiment on full noncompliance and a list experiment on semi-noncompliance. All respondents received the same practice list experiment as this was a dry-run intended only to instruct participants on how to respond to this type of instrument. For the remaining two list experiments, half of the respondents were randomly assigned to a treatment group and the other half were assigned to a control group. Randomisation for one list experiment was independent of the randomisation of the other. That is, treatment and control groups did not consist of the same individuals for both list experiments.

Materials. The practice or dry-run 'experiment' consisted of the following list:

> Now I'm going to ask you a new type of question. For this type of question, I'll give you a certain number of options, and I'm going to ask you HOW MANY of these options you like or would support. Please DO NOT tell me if you support each option individually, but only tell me how many options from the list you would support. In other words, your response should be a number. This means we won't know if you like each item, so you are free to report what you truly believe without us knowing.

Before we start the questions, I'm going to walk through an example with you. I'm going to show you 5 possible foods you might like to eat during the week. I want you to tell me HOW MANY of these foods you would like to eat during the week.

- Curry goat
- Mangoes
- Jerk chicken
- Ice cream
- Steak

Now, on your own, think about which options you would choose to eat. You may like curry goat, jerk chicken, and mangoes, but please do NOT tell me that. KEEP THAT INFORMATION TO YOURSELF. Then count the number of answers you support, and tell me the TOTAL NUMBER. So if you would eat curry goat, jerk chicken, and mangoes, then you would tell me the answer is 3.

So tell me, how many choices would you select?

- I would select 0 options
- I would select 1 option
- I would select 2 options
- I would select 3 options
- I would select 4 options

- I would select 5 options
- Don't know
- No response

The unauthorised migration list experiments were designed to measure support for a clear case of semi-noncompliance, and for a clear case of full noncompliance. As specified, for the former, we chose the case of violating the work conditions of a tourist visa and, for the latter, obtaining a fake visa. For each list, the first two items are high-prevalence. The third item is designed to be low-prevalence so that most respondents do not necessarily respond affirmatively to all three control items. This was done to avoid ceiling and floor effects, where participants respond affirmatively to or reject all items.

The experiment on full noncompliance consisted of the following list. The items in bold apply to list assigned to the treatment group.

> I'm going to show you a list of 3/**4** things that people sometimes do to MOVE PERMANENTLY TO a foreign country. Please tell me HOW MANY of the following options you would personally support.
>
> - Apply to a university in the new country
> - **Obtain a fake visa**
> - Ask family members abroad to sponsor you
> - Be smuggled across the border

How many choices would you select?

- I would support 0 options
- I would support 1 option
- I would support 2 options
- I would support 3 options
- **I would support 4 options**
- Don't know
- No response

The experiment on semi-noncompliance consisted of the following list. The items in bold were apply to the list assigned to the treatment group.

I'm going to show you a list of 3/**4** things that people sometimes do to WORK in a foreign country. Please tell me HOW MANY of the following options you would personally support.

- Get an employer to sponsor you
- **Work under the table while on a tourist visa**
- Build an online profile for recruiters
- Deal drugs

How many choices would you select?

- I would support 0 options
- I would support 1 option

- I would support 2 options
- I would support 3 options
- **I would support 4 options**
- Don't know
- No response

Procedure. The practice or dry-run 'experiment' was provided to all respondents approximately 10 minutes into the survey to introduce respondents to the format. Directly after the practice list, half of respondents were randomly assigned to a treatment or control group to receive the experiment on semi-noncompliance. As with the video experiment in the preceding chapter, randomisation was facilitated by the Qualtrics offline survey platform on the enumerator's tablet. The treatment group were shown the same list as the control group, albeit for the inclusion of the sensitive item highlighted in bold above. Enumerators were instructed to provide respondents with the show card containing the list relevant to the respondent's group assignment. Enumerators were told not to read the choices out loud unless the respondent cannot or refuses to read the show card. The enumerator then recorded the number of items the respondent supported.

Immediately after the semi-noncompliance list, respondents were randomly re-assigned to treatment or control groups to receive the full noncompliance list experiment. The same procedure was followed as for the semi-noncompliance list experiment.

6.2 Analysis and Results

In this section, I examine support for the two unauthorized migration strategies by analysing the list experiments. I then compare responses to those elicited through direct questions to evaluate whether list experiments improve upon direct measures of support for unauthorized migration. In the last set of tests, I examine whether, as hypothesised, a gap between aspiration to migrate and perceived ability drives support for unauthorised migration.

However, before presenting the results of the list experiments, I show tests for design effects using the `ict.test` function in the `R` *list* package (Imai, 2011). With a Bonferroni correction for multiple testing, our minimum p-values (1 and 0.95 for full noncompliance and semi-noncompliance list experiments, respectively) fail to reject the null hypothesis of no design effects for both experiments. This suggests that the list experiments were well designed to capture support for unauthorised migration.

Table 6.1 shows the average treatment effects for both list experiments. Differences between the groups – the average treatment effect – may be interpreted as the proportion of respondents who support an unauthorised migration strategy. The models estimate item count as a linear function of group assignment, and we adjust each model to account for the sample design by including fixed effects for parishes and clustering standard errors by enumeration district.

Each model is run for two samples: the full sample and a subsample of aspiring migrants. Results on the full sample – the level at which randomization took place – are included to compare list experiment estimates with direct survey responses and evaluate possible effects of social desirability. However, aspiring migrants are more likely to have deliberated on the migration process or attempted migration and their responses will, therefore, contain less noise than those of individuals who do not wish to migrate. In total, 801 respondents (69% of the total) are included in the aspiring migrant subsample. Aspiration to migrate is based on the 7-point item, "Whether or not you think you would be ABLE to move abroad, how much would you LIKE to move to another country?" Aspiring migrants would like to migrate at least "a little." Because models based on this sample will have unbalanced treatment assignment (as this is not the level at which randomisation took place), control variables gender, age, education, income, networks abroad are included in estimates of average treatment effects. These variables are detailed in Chapter 4.

Table 6.1: *Average Treatment Effects for Illegal and Semi-legal List Experiments, Amongst Full and Aspiring Migrant Sample*

	Illegal		Semi-legal	
	Full Sample	Aspiring Migrants	Full Sample	Aspiring Migrants
	(1)	(2)	(3)	(4)
	0.138	0.162	0.145	0.145
	(0.052)	(0.056)	(0.046)	(0.054)
	$p = 0.008$	$p = 0.004$	$p = 0.002$	$p = 0.008$
FE	Yes	Yes	Yes	Yes
Obs.	1,162	797	1,154	793

Standard errors in parentheses adjusted for sample design

As is shown in Table 6.1, all list experiment treatment effects are statistically significant below an alpha level of 0.05. Models 1 and 3 show that

13.8% of the full sample supports the illegal strategy and 14.5% support the semi-legal strategy. Within the subsample of aspiring migrants (Models 2 and 4), 16.2% of respondents support the illegal strategy, and 14.5% support the semi-legal strategy. This suggests that levels of support are very close for both types of unauthorised migration in both full and aspiring migrant samples.

To evaluate the list experiment, we asked direct questions that were meant to capture support for each strategy with slightly modified question wording. Our direct questions asked how strongly the respondent agreed or disagreed with the following statements: "It is OK to work in a foreign country without legal documentation" and "It is OK to enter a foreign country without legal documentation." In response to these statements, 16% of the full sample (17% of the aspiring migrant subsample) supported working without valid documentation, and 6.3% of the full sample (7.2% of the aspiring migrant subsample) supported entering without documents. The difference between direct and indirect responses for semi-noncompliance is quite small, indicating that this type of unauthorised migration may not be very sensitive compared to full noncompliance. Furthermore, these results indicate that list experiments are an improvement over standard measures of unauthorized migration and imply that, if direct measures of support were used in the ABM of unauthorised migration, we would likely be under-estimating levels of support for full-noncompliance.

But does a gap between aspiration and ability drive support, as expected in literature? In the ABM of unauthorised migration, agents will only evaluate this process if they aspire to migrate. As such, Table 6.2 shows list experiment estimates for both strategies, conditional on the perceived gap between aspiration and ability, among the aspiring migrant subsample. These tests include the same control variables as in the direct effect tests among the aspiring migrant subsample shown above.

Table 6.2: *List experiment treatment effects conditional on the gap between aspiration and ability*

	Full Noncompliance	Semi-noncompliance
	(1)	(2)
Treat	0.020	0.029
	(0.068)	(0.071)
Aspiration/ Ability Gap	0.0004	0.016
	(0.014)	(0.014)
Treat x Aspiration/ Ability Gap	0.051**	0.035*
	(0.020)	(0.020)
Male	−0.123***	0.047
	(0.041)	(0.043)
Age	−0.013***	−0.011***
	(0.002)	(0.002)
Education	−0.046**	−0.064***
	(0.021)	(0.022)
Income	0.0001	−0.00001
	(0.0001)	(0.0001)
Network Migration	0.007	0.014
	(0.008)	(0.009)
Constant	2.120***	2.018***
	(0.166)	(0.153)
Fixed Effects	YES	YES
Observations	1,078	1,071
R^2	0.108	0.125
Adjusted R^2	0.090	0.108

*p<0.1; **p<0.05; ***p<0.01
Standard errors adjusted for sample design

A one-unit increase in the aspiration/ ability gap leads to a 5.1% increase in individuals' support for full non-compliance. This conditional effect is slightly larger than for semi-noncompliance where the a one-unit increase in the aspiration/ ability gap leads to a 3.5% increase in individuals' support for semi-noncompliance. These results indicate that it is appropriate to consider agents' probability of supporting both unauthorised strategies as conditional on the agents' aspiration/ability gap in the ABM of unauthorised migration.

6.3 Discussion

This thesis argues that it is important to consider social norms when it comes to unauthorised migration in our models of migrant decision-making. Omitting this important part of decision-making will lead to erroneous expectations on the incidence of unauthorised migration. This chapter is concerned with the model process that defines whether agents will or will not consider an unauthorised strategy based on beliefs of what is socially expected.

Measuring support of unauthorised migration is a challenge: Individuals will tend to downplay their support for unauthorised strategies because they fear being judged by the questioner. To mitigate issues of social desirability, we used list experiments, which provide individual respondents with the privacy to respond to sensitive questions while yielding reliable estimates at the aggregate level.

Results lend further evidence to the full/ semi-noncompliance typology. It appears that individuals are willing to openly report support for the semi-legal strategy, given the closeness between direct and list experiment estimates, but estimates of the illegal strategy may suffer from social desirability bias. This indicates that disaggregating the spectrum of illegality is important when eliciting information on unauthorised migration as individuals may have had very different responses to the question depending on the type of strategy that comes to mind. These results also lend credence to the list experiment methodology as social desirability bias *does* appear to present a significant challenge when inquiring about unauthorised migration. If support for full noncompliance were asked directly, we would be underestimating support for this type of strategy by about half.

When this evidence is taken together, however, a new question arises. Individuals clearly perceive semi- and full noncompliance to be different types of unauthorised migration, which means it is important to elicit information about these two types of migration separately. However, these differences appear to be driven by factors related to social desirability. Given that the preceding evidence suggests we may effectively overcome this hurdle using list experiments, is the distinction between full and semi-noncompliance worth making in the agent-based model if we use list experiment estimates for calibration? To answer this question, we need to take a broader view of the model. In Chapter 4, we can see that individuals do make distinctions across these two strategies when it comes to perceived ability. This affects the process directly after the one considered in this chapter (Figure 6.1). It is important that this distinction is made throughout all interdependent model processes.

As shown in Figure 6.1, the decision on whether or not to include unauthorised migration strategies in strategy set S is a function of aspiration and perceived ability to migrate, following the third theoretical premise of this thesis. To substantiate this design choice, I examine the effects of the aspiration/ ability gap on support for unauthorised migration. The aspiration/ ability model (Carling, 2002) suggests that a high aspiration to migrate coupled with a low ability to do so may drive individuals to consider unauthorised migration strategies. Results on the conditional effects of the aspiration/ ability gap on support for unauthorised migration show that support is highly contingent on perceptions of involuntary immobility. The conditional effects, 0.051 and 0.035 for full-noncompliance and semi-noncompliance, respectively, are used to calibrate the probability of agents considering each of these strategies in their strategy set, $\beta_{illegal}$ and $\beta_{semi-legal}$. This process is part of the 'Define strategy S' procedure (Figure 6.1). The next chapter presents the ABM of unauthorised migration in its entirety.

Chapter 7

An Agent-based Model of Unauthorised Migration

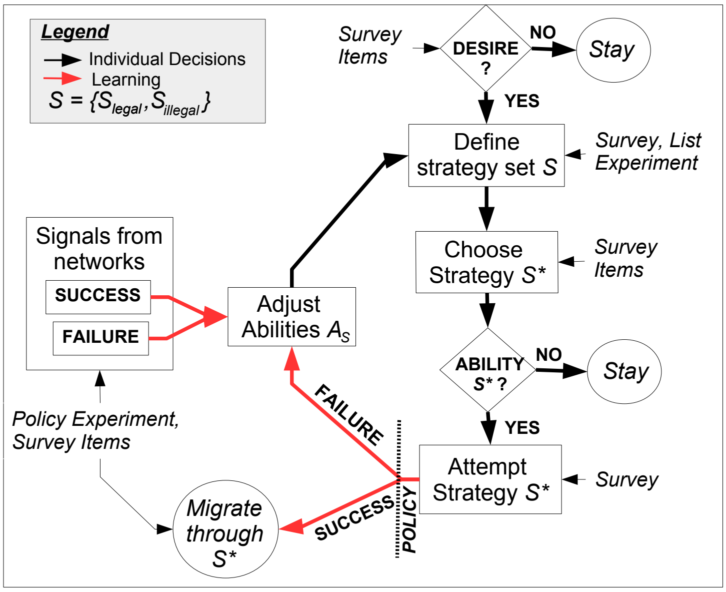
Scholars have suggested that visa restrictions reorient individuals, who would have otherwise migrated legally, toward illegal channels. This expectation is difficult to test empirically for three reasons. First, empirical evaluations of immigration policy are vulnerable to endogeneity and other issues of causal inference. Second, unauthorized migration is often unobservable and, due to its sensitive nature, is likely to yield biased responses in surveys. Third, interpersonal ties between migrants and would-be migrants form a self-perpetuating system, which adapts in ways that are difficult to observe.

This ABM is the outcome of an iterative process of theorization, empirical data collection, in-silico data generation and testing. The first stage of development consisted of the following three steps: (a) building a theoretical framework from existing theory, (b) finding gaps in the literature that needed to be investigated (c) developing a sketch of the ABM. The set of theories that framed the ABM are described in Chapter 2. Theory was transformed into to rules telling the ABM what operations to perform. In the process of formalisation, certain gaps in the literature were highlighted (Johnson and Groff, 2014). Formalisation also identified the parameters in the model that needed to be quantified. To address these modelling needs, an original survey was designed and fielded. This survey is described in Chapter 4. The analyses, described in Chapters 5 and 6, were used to substantiate assumptions and answer empirical questions; and to quantify parameters in model rules and agent characteristics. Once the ABM was finalised and calibrated, it was analysed. Analysis involved running several in-silico experiments examining the effects of different immigration policies where the number and sociodemographic characteristics of migrants admitted into the destination country was examined. These analyses can be found in this chapter.

Preceding chapters have tackled the first two challenges empirically. In Chapter 5, I presented the results of a video experiment, which allowed us to isolate the causal effect of receiving information about immigration policy at the individual level. The results of this experiment showed that restrictive immigration policy create a gap between individuals wish to migrate and their desire to do so. In Chapter 6, I examined how this gap drove support for unauthorised migration using a novel experimental technique to improve the measurement of sensitive issues. This chapter embeds these empirical findings into a dynamic agent-based computational model, which focuses on the effects of immigration policy on decisions to migrate illegally and how these effects are propagated across adaptive social systems.

The architecture of the model, shown in Figure 7.1, is based on the theoretical framework developed in Chapter 2, Section 2.4. This theoretical framework consists of eight premises, drawn from literature across the social and behavioural sciences, regarding the conceptualisation of migration, the effects of policy, the drivers of unauthorised migration as well as individual cognition, learning and decision-making. As shown in Table 7.1, specific model design choices can be traced back to these premises.

Figure 7.1: *System diagram showing agent decisions, feedback processes, and data types used for calibration*



This ABM examines the effect of policy by "naturally" connecting processes occurring at various levels of aggregation (Bonabeau, 2002; Brettell and Hollifield, 2000): The effect of immigration policy trickles down from the macro-level to the decision-maker and her social context. Migration is composed of a wide range of strategies defined by individuals' interaction with the 'immigration interface' (Carling, 2002; Borjas, 1989a). The legal categorization of migration places obstacles in individuals' migration plans, which will vary depending on how their demographic and other characteristics complement the labour or political needs of the receiving state (Lee, 1966; Massey et al., 1998; Faist, 1997; Carling, 2002; Sen, 2001; Castles et al., 2013b; De Haas, 2003, 2010). Receiving state's preferred level of immigration control may be constrained by norms, such as the sanctity of the family unit (Money, 1997; Hollifield and Wong, 2000), but opportunities are generally skewed towards the skilled and wealthy (Thomas-Hope, 2005).

Individuals who do not meet the requirements of the receiving state do not automatically become illegal migrants, however. First, like its legal counterpart, unauthorised migration is an opportunity structure. As discussed in Chapter 2, several studies have shown that individuals perceive unauthorised migration as a continuum; each unauthorised strategy differs depending on the degree to which it bypasses the laws of the receiving state (Ruhs, 2010; Düvell, 2006). As such, individuals may adopt certain unauthorised strategies and not others depending on the risks associated with them or, in other words, their perceived ability to execute it successfully. Second, as discussed in the previous chapter, unauthorised migration carries a normative barrier, leading individuals to reject this form of migration regardless of whether it is cost-beneficial. However, as empirical evidence presented in Chapter 6 suggests, agents *do* become increasingly likely to support migrating through unauthorised channels as the gap between aspiration and ability widens (Carling, 2002; Hernández-Carretero and Carling, 2012).

These relationships can be observed in Figure 7.1, reproduced in previous chapters, which depicts the ABM architecture. Following the evidence presented in Chapter 5, policy affects ability to migrate but not aspiration. As such, when policy is restricted, a gap between aspiration and ability should emerge at the micro-level. Agents' willingness to include an unauthorised strategy into Strategy Set S, indicating their normative preferences, is driven by a dynamically-adjusting ability to migrate on one hand, and a desire to migrate – unaffected by policy – on the other. Agents use simple heuristics in the 'Choose Strategy S^*' procedure: they select the strategy they believe they are most able to execute (i.e. they "take the best" (Goldstein et al., 1996)) and abandon the other choices. Their probability of attempting the strategy is a second simple calculation, driven by the actual probability of success for their chosen strategy. As in real life, policy affects agents through local information signals. Agents learn about their environment through first and second-hand experiences (Gigerenzer and Selten, 2002; Epstein, 2003b; Massey et al., 1998; Massey and Zenteno, 1999), as is shown in the relationships coded with red arrows in Figure 7.1. This process of learning and deciding is adaptive, allowing individuals to quickly understand and generalise to changing policy conditions (Gigerenzer and Selten, 2002; Gigerenzer and Goldstein, 1999).

To evaluate whether the model is a likely candidate for the real-life mechanisms underlying illegal migration, we took a two-stage approach. First, we found empirical support for key theoretically-defined intermediary processes in order to lend credence to agent rules. Some of these intermediary processes also presented empirical questions that needed to be examined in relation to the case at hand – Jamaica. This stage of the validation process is the subject of the two previous chapters. In this chapter, I examine whether the model is able to reproduce key empirical regularities by comparing the simulated output to independent government estimates as well as data from the survey that has not been used to calibrate or specify the model. I, then, present the results of in-silico policy experiments in which I examine the counterfactual impact of restricting four common channels for legal voluntary migration – low-skilled, high-skilled, family-based and student visas – on the legal composition of migration. The reorientation of otherwise legal migrants to unauthorised channels may, of course, be mitigated by border and interior enforcement. Therefore, I also examine the efficiency of increasing the rate of apprehension for all immigration policy scenarios depicted.

Table 7.1: *Theoretical Questions for Modelling Choices and Reference Chapter*

Premise	**Programming Decision**	**Conceptualization (Chapter 2)**
1. Migration is non-binary	(1) Legal migration can consist of four common legal categories: high-skilled, low-skilled, family reunification and student migration (2) This model distinguishes between fully- and semi-noncompliant strategies.	Sections 2.1, 2.3
2. The effects of policy are heterogeneous	Agents with different characteristic profiles have different opportunities for migration	Sections 2.1, 2.3
3a. Policy drives a wedge between aspiration and ability	Receiving a signal about the policy environment affects perceived ability but not desire to migrate	Section 2.1
3b. Aspiration and ability gap drives unauthorised migration	Gap between aspiration and ability makes agents are more likely to include unauthorised migration in strategy set S	Section 2.1
4. Individuals make highly personal choices based on norms and perceptions of ability	Agents consider norms against lawbreaking and perceived ability to migrate when defining S	Section 2.3
5. Individuals' understanding of policy is limited	Agents are boundedly rational and learn from experiences and experiences of others	Section 2.2.1
6. Individuals adapt to changing policies	Agents define feasible alternatives dynamically and move across them when options are constrained.	Section 2.2.1
7. Migration systems are multi-level	Individuals exist and learn how to act within social contexts. Policy effects are propagated through social contexts.	Section 2.2.1

7.1 Model Setup

The model consists of an environment, representing an origin country, autonomous agents connected with each other through network ties, and condition action rules that guide agent behaviour (Railsback and Grimm, 2011). In this section, I describe the elements of the model that are generated at the start of the simulation. The next section will describe the rules guiding agent behaviour throughout a simulation run.

Geography: The island of Jamaica is represented by a grid of 11,881 cells. It is divided into 14 subsections, each representing a Jamaican parish or census administrative unit. To map the size of administrative boundaries onto the grid space, I compute the proportion of the Jamaican territory occupied by that parish. Table 4.1 in Chapter 4, shows how this calculation was carried out as well as the correspondence between the sample and the population. Informed by trends in the literature and our survey finding that over 90% of the *MDP* sample were committed to a single destination country, we depict a single corridor. Given that the model aims to isolate the effects of immigration policy, the destination country is abstract of all characteristics aside from its policy profile.

Agents and their characteristics: Each agent is allocated a profile of characteristics belonging to an individual respondent from the *MDP* survey, including parish of residence. Within this parish, each agent occupies a separate cell. Modelling always involves some trade-offs. Our survey data are cross-sectional, and this model operates under the assumption that agents do not change over time and are not replaced if they migrate. This allows us to maintain the correlation structure of our data, as realistic demographic profiles are essential in determining agent eligibility for specific visa channels.

Social network: Concurrent with extant work (McPherson et al., 2001), social tie formation is modelled as a function of agent similarity (homophily) and geographical distance. No additional assumptions are made on the types of relationships agents have with one another. McPherson et al. (2001) find that individuals connected to one another are generally similar in the following characteristics, in order of importance: Ethnicity, age, religion and education. Because 89% of the *MDP* survey sample is of the same ethnicity (black), we construct a homophily index based on the latter three characteristics.

For religion, agents are considered to be either strictly alike or distinct. Hence, for this characteristic c, we compute an index of similarity, $s^c_{i,j}$, for each pair of agents i and j as follows,

$$s^c_{i,j} = \begin{cases} 0, & \text{if } c_i \neq c_j, \\ 1, & \text{if } c_i = c_j \end{cases} \tag{7.1}$$

As age (range = 18-88) and education (range = 1-8) can be treated as continuous (see Chapter 4 for details), they are constructed differently. For these characteristics, $s^c_{i,j}$ is computed as,

$$s^c_{i,j} = 1 - \frac{|c_i - c_j|}{r_c}, \tag{7.2}$$

where r_c is the full range of the demographic.

Total demographic similarity $s_{i,j}$ is given by computing a weighted sum of values across all demographic characteristics considered.

$$s_{i,j} = \sum_{c=1}^{C} w_c s_{i,j}^c \tag{7.3}$$

The weight, w_c is the relative theoretical importance of a demographic c for tie formation, following McPherson et al. (2001). Age is weighted highest ($w_{age} = \frac{3}{6}$), followed by religion ($w_{religion} = \frac{2}{6}$) and education ($w_{education} = \frac{1}{6}$), such that $\sum_{c=1}^{C} w_c = 1$.

The probability of two agents being connected ($p(i,j)$) is defined as follows:

$$p(i,j) = \frac{s_{i,j}}{exp(\lambda(d_{i,j} - f))}, \tag{7.4}$$

where $d_{i,j}$ is the spatial distance between agent i and agent j, normalised by the maximum distance possible between any agent i and j, and f is the minimum possible distance between two agents in the grid space (as mentioned above, only one agent occupies a given cell). This constant is subtracted from $d_{i,j}$, shifting the function such that $p(i,j) = 1$ only if two agents are at a minimum distance from each other, and are identical on all characteristics as captured by $s_{i,j}$. The rate at which interactions decay with increased distance will generally follow an exponential curve (Taylor, 1983). Parameter λ controls the rate of exponential decay. Ongoing data collection aims to determine the value of λ in the case of Jamaica. In the meantime, due to lack of data, we assume that a person living at the centroid of an average-sized parish has a roughly 0.5 probability of knowing anyone at the edge of the parish adjacent, assuming they are identical on all characteristics captured by $s_{i,j}$.

Time scales and updating. The duration of a migration decision, from an initial desire to migration attempt, is considered to be one year, following theoretical evidence (Rossi, 1955; Lansing and Mueller, 1967) and estimates on immigrant visa processing times (Visa Journey, 2017). As agents' actions are dependent on those of others, agent variables are updated synchronously at the end of a procedure (Railsback and Grimm, 2011). This ensures that the only factor limiting agents' access to information is the boundedness imposed by network structure and not the time at which the agent is called to act (and how much information it was able to accumulate up to this point). This design mimics information seeking in uncertain decision scenarios, of which international migration is an example.

Data embeddedness. Although most aspects of empirical specification and calibration for this model have been examined in previous chapters, there are a few key points worth reiterating briefly. First, we measure aspiration and ability to migrate as distinct indicators and operationalise perceived ability to migrate as strategy-specific. We also measure support for illegal strategies separately from the ability to migrate irregularly, as many individuals would like to move abroad but are unwilling to consider irregular channels (see Chapter 4 for more details). We used a video experiment and a list experiment to estimate the influence of policy on migrant decision-making, and support for unauthorised strategies, respectively. Full details on these analyses and how they inform the model can be found in Chapters 5 and 6. Table 7.2 below shows the types of data collected and Figure 7.1, shown at the beginning of this chapter, illustrates where they feed into the model.

Table 7.2: *Data collected or used to calibrate the model*

Type	**Variable/ Estimate**	**Values**	**Source**
Individual Variables *Vary across agents*	Desire to migrate, $D = L \cap Se$	$1 \leq L \leq 7$ $1 \leq Se \leq 4$	Survey item
	Ability to execute a strategy, A_S $S = \{$Legal Semi-legal, Illegal$\}$	$1 \leq A_S \leq 7$	Survey item, endogenously updated
	Visa eligibility demographics, α_d $d = \{$Education, Sector, Income, Family$\}$	$1 \leq \alpha_e \leq 8$ $\alpha_s = \{0, 1\}$ $0 \leq \alpha_i \leq 2,130$ $0 \leq \alpha_f \leq 20$	Survey items
Aggregate Effects *Fixed*	Effect of receiving policy information (positive/ negative), π	$\pi = \pm 0.55$	Policy experiment
	Effect of gap in aspiration and ability on $\theta_{S_{ill}}$	$\beta_{illegal} = 0.05$ $\beta_{semi} = 0.04$	List experiment
Policy *Varies by model setting*	Prob. avoiding border detection, r	$0 \leq r \leq 1$ Figs. 3-5: $r = 0.3$	Survey item
	Prob. successful semi-legal migration, p	$0 \leq p \leq 1$ Figs. 3-5: $p = 0.32$	US State Dept., Survey item
	Visa quotas, v_q $\{$High Skilled, Student, Low-Skilled, Family$\}$	$0 \leq v_q \leq 1$	DHS Yearbook, Survey items

This table shows policy settings for the validation model. Details on policy values for in-silico experiments can be found in Table 7.4. Income is in US\$. p is a product of visitor visa acceptance rates and internal enforcement. We approximate this probability using two variables: 1) the 2015 acceptance rate for Jamaicans applying for visitor permits to the US (68%) (U.S. Department of State, 2015b), and 2) the mean perceived probability of avoiding apprehension while working in a foreign country with a visitor permit (47%, see Chapter 4, Table 4.2). The product of these two variables results in an overall probability of success of 32%, (68% probability of failure).

7.2 Main Procedures: Individual Decisions

To engage in migration, individuals must both *desire* and *perceive themselves capable* of migrating (Lee, 1966; Massey et al., 1998; Faist, 1997; Carling, 2002).[1] In the *MDP* sample, aspiring migrants are defined as those surveyed who would like to migrate at least "a little," and have considered migrating at least "quite seriously". As such, desire to migrate is defined by the intersect of two variables: L, "like", and S_e, "seriousness" (see Chapter 4 for more details on variable scales). As such, absent the desire to migrate, agents choose to stay home. If they wish to migrate, individuals choose a channel. Most broadly, there are two types of migratory channels: legal and illegal. All strategies or channels are denoted as S, where $\{S_{leg}, S_{ill}\} \subset S$. Legal channels include common visa routes.

This model distinguishes between full non-compliance, or strategies that circumvent immigration law entirely (e.g. migrating with no documents or fraudulent documents) and non-compliance (e.g. strategies where migrants obtain legal documents but violate migratory restrictions). This typology is discussed in Chapter 2.

Agents evaluate their willingness to consider each unauthorised strategy separately because it is possible that they will be willing to consider one, but not the other. Not all migrants will view one or either of these strategies favourably. Individuals are more likely to consider irregular channels as the gap grows between their desire to migrate, D, and their ability to migrate legally, A_{leg} (Massey et al., 1998; Castles, 2004b). Therefore, the probability

[1]This model focuses on voluntary migration.

that agents will be willing to consider each irregular option, $\theta_{S_{ill}}$, is conditional on this gap (see Chapter 6). This process creates the individual's strategy choice set.

Each agent has a different perception of their ability to migrate through a given channel. Agents choose the (legal, semi-legal or fully illegal) strategy they will attempt, S^*, through a weighted random draw, with each strategy weighted by the agent's perceived ability to execute it.[2] The agent will only attempt S^* with a probability $P(Attempt)$ defined by:

$$P(Attempt) = 1/1 + e^{(k(T - A_{S^*}))}, \tag{7.5}$$

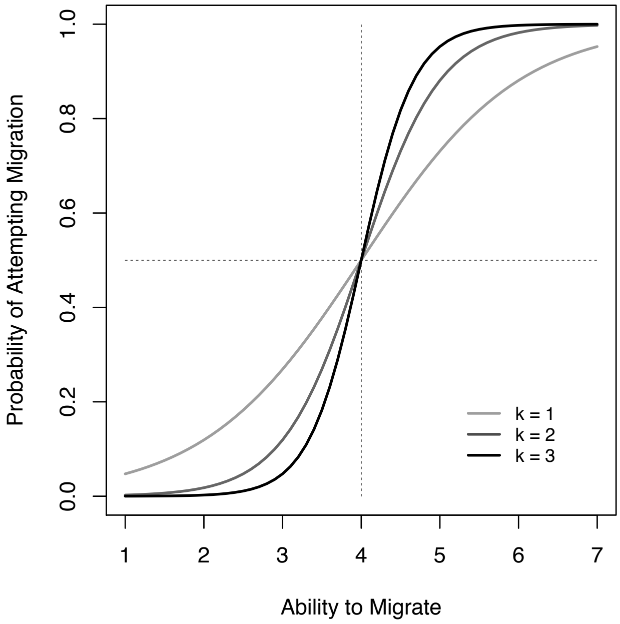
where T is the middle category in the 7-point ability scale[3] and k is the curvature of the logistic function. For the most of this chapter, k is left at 1. I show alternative specifications of k when testing the quality of the model, later in this chapter. I also display alternative results for our main empirical finding in Appendix A.1. We find that, while k affects overall levels of migration, it does not substantially change its legal composition.

An agent's perceived ability to migrate may or may not coincide with current policy conditions. If an individual has chosen to attempt a legal strategy ($S^* = S_{leg}$), they will evaluate their demographics according to the requirements of the receiving state. Common legal migration routes include student, low-skilled, high-skilled and family-based visas. An individual may

[2] Note that the strategy set may be reduced if the agent is unwilling to consider one or both of the irregular strategies.

[3] This question asks: How easy do you think it would be for you, personally, to move abroad? The middle category – " neither easy nor difficult" – is considered the point of indifference, where the probability of attempt is 50/50. More details can be found in Chapter 4.

Figure 7.2: *P(Attempt) with alternative curvatures, k*



be prevented from migrating legally simply because they do not meet the classification criteria for any legal categories (hereafter, baseline eligibility criteria). For instance, an individual with no family abroad cannot migrate through family reunification, regardless of quotas or restrictions. We define the set of legal migration categories for which a given migrant is eligible as V_i, where $V_i \subset S_{leg}$. In addition, a series of requisites and quotas may be placed on each of the channels exogenously, thereby excluding otherwise eligible individuals. This information is summarised in Table 7.4, along with the details of each policy experiment, described in Section 7.4. Agents are assumed to be indifferent about available legal channels. That is, if the individuals' optimal migration strategy is legal migration, they will migrate legally if they are eligible for at least one visa.

For agents whose optimal strategy is an illegal one, the rules are much simpler. The overall probability of success through each of the two illegal strategies is applied uniformly. Individuals will migrate if they successfully avoid enforcement. In real life, undocumented migrants may regularise their status in the destination, or legal migrants may become undocumented after entering legally. As this model focuses exclusively on migrant entry, no assumptions or generalizations are made about shifts in legal status after entry.

In a simulated year, an individual may attempt only one strategy S, legal or otherwise, to account for the time necessary to prepare for migration, possibly through an alternate channel, in the next year. Agents that have migrated are excluded from subsequent model processes, but influence the decisions of their network.

7.2.1 Interaction and Learning

Potential migrants are not immediately or uniformly aware of immigration policies; they learn through interaction with immigration authorities and the experiences of others. In this model, agents update their perceived ability to migrate by aggregating this information. The ability to migrate is dynamic, but aspiration is not. Specifically, individuals accumulate information from their network contacts, η_j, and from their own experiences, η_i. These signals are strategy-specific, and may be positive or negative. For simplicity, all information sources are assumed to affect agents' perceived ability to migrate through any strategy by the same magnitude, π. Tests examining the effects of alternative weights on positive and negative signals, as well as signals obtained directly and indirectly are examined in the next chapter. The impact of omitting network effects is also explicitly examined.

C is defined to be the unique effect of the cumulative information an individual obtains from network contacts, η_j, on their ability to migrate through a given strategy. Each additional signal about the policy environment is assumed to have a decreasing marginal effect on agents' perceived ability to migrate through that strategy. Following established literature on the learning curve (Estes, 1950; Heathcote et al., 2000), we take the natural log of the sum of contacts, $j \in J$, who relay an experience with immigration policy. Agent i computes C separately for positive (C_+) and negative (C_-) information at time t. The only difference is the direction of π.

$$C_{i,\pm}^t = \pm\pi(1 + \log \sum_{j=1}^{J} \eta_j) \tag{7.6}$$

Individuals also learn from personal experiences with immigration policy. These experiences are necessarily negative, as a positive experience would entail a successful migration, after which no learning is necessary. B is defined as the unique effect of an agent's own experience with immigration policy on the ability to migrate through a given strategy. Similar to Equation 7.6, the effect of one additional migration failure, f, for agent i, is considered to be marginally decreasing.

$$B_i^t = -\pi(1 + \log \sum_{f=1}^{F} \eta_{i,f}) \tag{7.7}$$

Finally, each simulated year, agent i updates its ability to migrate for each strategy S as follows:

$$A^t_{i,S} = A^{t-1}_{i,S} + \Delta B_i + \Delta C_{i,+} + \Delta C_{i,-}, \tag{7.8}$$

where $A^t_{i,S}$ is censored to maintain the range of the original survey scale.

To evaluate whether the model architecture described above might approximate the real life mechanism connecting immigration policy to unauthorised migration outcomes, it is important not only to evaluate model rules empirically but also to compare simulated to real world outcomes.

7.3 Comparing the Model to Real World Outcomes

In this section, I demonstrate that our model is fairly accurate in simulating: (i) migrant volume (ii) proportion of migrants who are unauthorised and (iii) number of migration attempts – a measure of the rate of learning about policy across agents. We focus on the case of Jamaica-US migration for these tests because it is possible to obtain independent estimates of US unauthorised migration that are disaggregated at the origin country level. When comparing migrant volume and composition, we use independent data from the Jamaican census and the US Census Bureau. To evaluate migrant learning, we employ survey data not used in model calibration. I will show that, despite data limitations some close comparisons can be drawn between the model output and empirical data.

However, in order to compare model outputs to real world scenarios, we must construct a realistic, artificial legal entry policy. We do this by leveraging agent-based modelling's natural ability to combine data from different sources. As such, before comparing the model output to real-life estimates, I explain how this legal entry policy was constructed and tested.

7.3.1 Constructing a Realistic 'Immigration Interface'

We operationalise immigration policy as consisting of a series of success probabilities associated with each of four visa channels – student, high-skilled work, low-skilled work and family reunification. To construct these probabilities, we need two quantities: (1) applicants for visa v and (2) number of individuals who either succeeded or failed in attaining visa v.

We define subset A_v as consisting of respondents that are likely to apply for v. More specifically, agents/ respondents belonging to the subset A_v must satisfy all of the following conditions: (1) consider migration to be at least "slightly easy" for them (2) they would like to migrate at least "a little" (3) have thought "quite seriously" about migrating and (4) meet the baseline eligibility requirements for a given visa. Details on the baseline eligibility criteria can be found in Table 7.4 below.

Agents can only attempt one migration strategy per year, t. To avoid counting the same respondent in more than one visa applicant pool, A_v, agents randomly select one visa option across those for which they are eligible at the baseline. Specifically, each agent chooses a random number ranging from zero to the length of their set $V_{t=0}$, indexing the selected visa. The agent will then be counted in the applicant pool associated with the selected visa.

Because the *MDP* survey is a random, representative, sample of Jamaica, we assume the proportion of the *MDP* sample belonging to subset A_v is similar to the proportion of adult Jamaican citizens, N, that are likely to apply for a visa. This allows us to estimate a number of applicants that can be paired with official statistics from the U.S. Department of Homeland Security on the yearly number of visas v granted to Jamaican applicants, S_t^v, from 2000 to 2012 (Department of Homeland Security, 2000).

We define the probability of obtaining a visa v in a given year as,

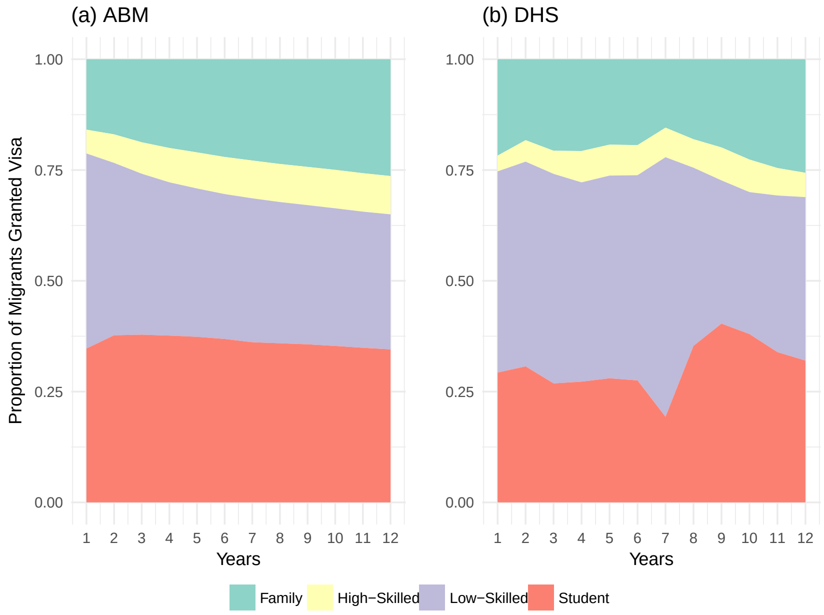
$$P_t^v = \frac{S_t^v}{\left(\frac{A_v}{n}\right) * N}, \tag{7.9}$$

where S_t^v is the raw number of visas given to citizens of Jamaica in year t. We multiply the proportion of the *MDP* sample n belonging to set A_v (or proportion of applicants) by N, the adult population of Jamaica in 2001. Note that while the number of visas granted vary per year, the set of applicants (the denominator) is maintained constant at 2001 levels as the survey data is cross-sectional.

Figure 7.3 verifies that simulated migrant entries for all four visa categories were similar to official data. To take into account differences in scale, I present the relative proportion of entries for each visa category. The left panel shows simulated output and the right panel shows Department of Homeland Security (DHS) data.

The proportions of entries for each visa category are very similar. Students and low-skilled workers receive comparable proportions of visas, and these two channels make up the majority of visas. The smallest visa category

Figure 7.3: *Verification of Artificial Entry Policy using Data From the Department of Homeland Security*



for all years is the high-skilled visa category, which consistently represents approximately 10% of all visas received in both panels. This result indicates that the applicant pool for each visa, A_v, in the *MDP* sample is similar to that in the real Jamaican population. However, the simulated outputs are smoother than their empirical counterparts. This is due to the fact that the probability of success for all visa categories has a constant denominator (see Equation 7.9), which has the effect of smoothing out changes across years.

This policy is used in tests comparing several three simulated outputs to empirical data. In the next section, I present validation results for alternative specifications of the curvature of the logistic function (k) which transforms an individuals' perceived ability to migrate through the chosen strategy into the probability of attempting migration (see Equation 7.5). Figure 7.2, which can be found in Section 7.2, displays the curves resulting from alternative specifications of k.

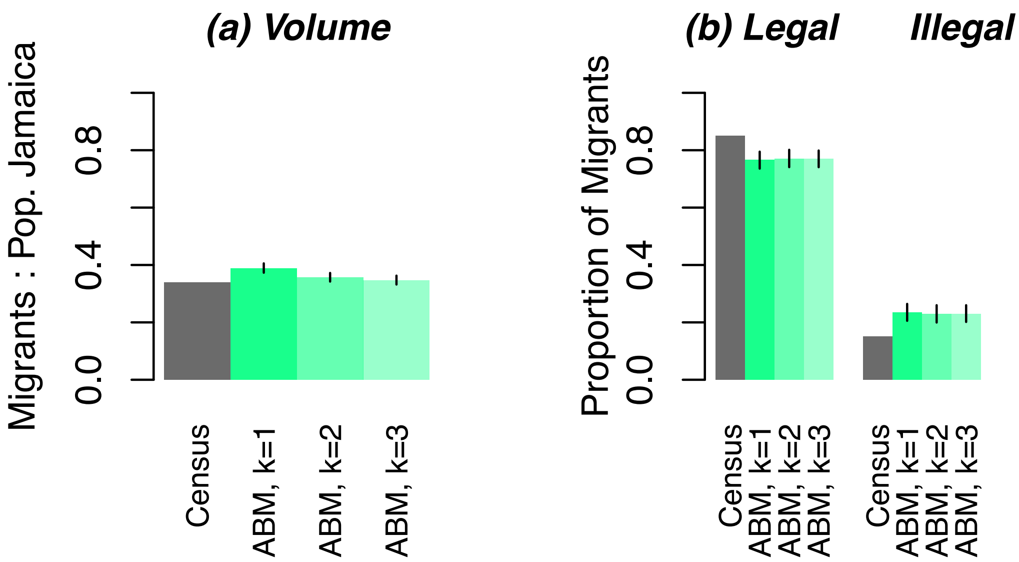
7.3.2 Comparing Volume and Composition To Real World

First, I compare simulated outcomes on migrant volume and legal composition to census estimates. The model is initialised with a proportion of agents abroad equal to the proportion of the Jamaican adult population present in the US in the year 2000. As our survey sample is residing in Jamaica at the start of the simulation (representing potential migrants), the migrants placed abroad at the start of the simulation do not come from the *MDP* sample of 1,166. To construct this proportion, we use data from the US Census Bureau (U.S. Census Bureau, 2000; Warren, 2003) and the Jamaican census (STATIN, 2001). A proportion of these agents is defined as undocumented using estimates from the US Immigration and Naturalization Service (the former office of the DHS) on the illegal Jamaican migrant population in the US (Warren, 2003). The model is run 1,000 times for twelve simulated years.

The results of these validation tests, shown in Figure 7.4, indicate that the model simulates real migrant volume and composition fairly accurately. The left panel presents displays results for volume and the right panel presents results for legal composition. To assess migrant volume, we compare the proportion of agents abroad at the end of 12 simulated years to the proportion of the Jamaican adult population present in the US in the year 2012 (Passel and Cohn, 2014). According to the augmented American Community Survey

(ACS), collected by the US Census Bureau, and the Jamaican census, there were approximately 34.13 Jamaican migrants in the United States for every 100 Jamaican adults living on the island, or 680,845 migrants living in the US to 1,995,148 Jamaicans over 15 years old on the island in 2011. Figure 7.4.a. shows the simulated mean in green and the associated 2.75 and 97.5 percentile error across the 1,000 model runs, next to the census estimates in grey. One thousand simulation runs yielded means of 38.9% ($P_{2.75} = 37.3$, $P_{97.5} = 40.6$), 35.7% ($P_{2.75} = 34.2$, $P_{97.5} = 37.2$) and 34.7% ($P_{2.75} = 33.2$, $P_{97.5} = 36.3$), migrant agents for every 100 Jamaicans on the island, for $k = 1$, $k = 2$ and $k = 3$, respectively. Rates for all three specifications of k are similar to the census-based estimates. However, it is clear that the larger the value of k, the smaller the resulting migrant volume. This difference in volume across settings of k is due to the underlying distribution of the variables in question.

Figure 7.4: *Validating with Census Data: Average Composition and Volume with 2.75 and 97.5 Percentile Error*



As mentioned above, the probability of attempting migration is a function of individuals' perceived ability to migrate using their chosen strategy S^*. As can be seen in Figure 7.2, agents' probability of attempting migration in the left-most half of the figure increases at a higher rate for $k = 1$ than for the functions displaying curvatures of $k = 2$ and $k = 3$. The same relationship can, of course, be observed when comparing $k = 2$ to $k = 3$. This would not have a biasing effect if the sample distribution of ability were symmetrical. However, as shown in Table 4.2, Chapter 4, the sample distribution of the three ability variables is skewed towards lower values, with the mean resting on the "slightly difficult" (legal and semi-legal) or "moderately difficult" (illegal) categories. These categories correspond to '2' and '3' on the 7 point-scale, respectively. Therefore, because the distribution of ability to migrate is not symmetrical, the majority of agents will have a higher probability of attempting migration when the curvature of $P(Attempt)$ is smaller.

Figure 7.4.b. shows comparisons for composition of migrants in terms of their legal status in 2012. Composition is defined as the number of (real/simulated) unauthorised Jamaican migrants in the US divided by the total number of (real/simulated) Jamaican migrants. It is important to note that data on unauthorised migration are limited and often inaccessible. As mentioned, to our knowledge, the US is the only top Jamaican migrant destination, for which estimates of unauthorised migrants can be disaggregated by country of origin.

Figures on the unauthorised Jamaican migrant population in the United States in 2012 used here, were estimated and published by the Centre for Migration Studies using data from on the augmented ACS (Rosenblum and

Ruiz Soto, 2015; Warren, 2014; Center for Migration Studies, 2017). These estimates are calculated using the residual method, where the legal foreign-born population is subtracted from the total foreign-born population(Warren, 2014). These estimates indicated that there were approximately 100,000 unauthorised Jamaican migrants in the United States in 2012, or 15% of all Jamaican migrants. In this computational model, 23.4% ($P_{2.75} = 20.5$, $P_{97.5} = 26.4$), 23% ($P_{2.75} = 20$, $P_{97.5} = 26$) and 23% ($P_{2.75} = 20.1$, $P_{97.5} = 26$) of migrant agents were unauthorised in 2012, for $k = 1$, $k = 2$ and $k = 3$, respectively. The value of k does not meaningfully affect the proportion of migrants who migrated through unauthorised channels.

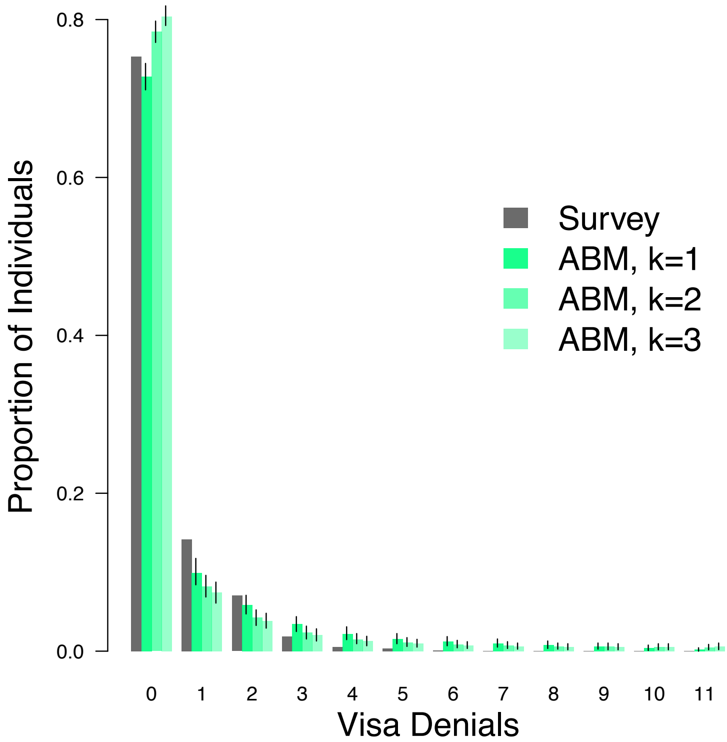
These results indicate that the model produces outputs that are comparable to real world estimates of volume and composition. The value of unknown parameter k, which affects the curvature of agents' probability of attempting migration through their chosen strategy, affects the volume of migration but does not appear to affect its legal composition in a meaningful way. In the next section, I consider an output that is not easily observed in the real world.

7.3.3 Comparing Learning to Real World

Individuals stop attempting to migrate through a given channel once their perceived ability to do so falls below a threshold. If the adaptive process reflects reality, the distribution of unsuccessful visa applications for agents should be comparable to survey estimates on Jamaican visa denials. To assess this, the numbers of unsuccessful visa applications per agent were compared to the actual numbers of failed attempts in securing a visa among the *MDP* survey sample. This data was not used to calibrate the model. These figures include failed applications for all visas, including visitor permits. Whereas the simulation has a defined period (12 years) within which individuals can attempt to migrate, data on the time span within which respondents applied and were denied visas is not available. The *MDP* survey asked respondents how many times they had applied for a visa and been rejected *any* time in the past. Despite these limitations, survey and simulated distributions are qualitatively similar.

Figure 7.5 presents distributions of the empirical and simulated attempts as a proportion of total agents/ respondents. Simulated values are averaged over 1,000 model runs. As is clearly shown, the vast majority of survey respondents and simulated agents are never denied a visa, either because they did not apply or because they were successful on their first attempt.

Figure 7.5: *Visa Denials, Average Distribution with 2.75 and 97.5 percentile error*



In the *MDP* survey, slightly more individuals were never denied a visa, relative to the simulated output for all values of k. On average, survey respondents unsuccessfully attempted to secure a visa 0.38 times, relative to 0.81, 0.7 and 0.67 in the simulation, for $k = 1$, $k = 2$ and $k = 3$, respectively. The median and mode rests at 0 for the survey as well as all simulation settings. Simulated agents are somewhat more persistent than survey respondents, with a small proportion of agents unsuccessfully attempting to secure a visa up to 11 times. However, both the empirical and the average simulated distributions display a clear exponential decay for which the model parameters were similar for the empirical and simulated data.

The distributions were fitted using an exponential function of the form:

$$y = a \times \exp(bx), \tag{7.10}$$

where y is the proportion of failed attempts to obtain a visa, a is the base and b is the decay factor. Table 7.3 shows the empirical and simulated distribution fits (averaged across runs) are similar. As is clearly visible in Figure 7.5, the decay factor amongst the survey sample is smaller than in the simulation, for all values of k. This figure and the parameters for the best fit curve indicate that a curvature of $k = 1$ yields a distribution of migration attempts that is most similar to the empirical distribution.

Table 7.3: *Parameters and 95% Confidence Intervals, Exponential Curve Fitting to Simulated and Survey Data on Failed Attempts to Obtain Visa*

	Simulation		
k	*Base*	*Decay Factor*	R^2
1	4.59 (2.93, 6.25)	-1.84 (-2.19, -1.50)	0.99
2	6.79 (4.46, 9.13)	-2.16 (-2.50, -1.82)	0.99
3	7.99 (5.19, 10.78)	-2.30 (-2.64, -1.95)	0.99
	Survey		
	3.58 (2.48, 4.68)	-1.55 (-1.84, -1.27)	0.99

7.4 Experimenting with Policies

ABMs make it possible for us to isolate components of a policy package and test their interactions, enabling controlled experiments that would be impossible in real life. Our experiments examine restrictions on students, high-skilled and low-skilled workers, as well as individuals who migrate to join family members abroad. Additionally, we examine a policy of free movement and a scenario where all the channels mentioned are restricted.

In this section, I discuss these policies and how they were implemented in the ABM. Table 7.4 at the end of this section, summarises the minimum eligibility criteria for each visa channel as well as the additional quotas and requirements implemented through the various policies we test.

7.4.1 Early Departures for International Students

Student migration has become politically problematic in many countries. To reduce student migration, many governments restrict the opportunities available to them after graduation. For example, one of the 2015 UK General Election commitments was a net reduction in migration to under 100,000, and in 2014, students made up the largest share of the non-EU migrant population (British Future and Universities UK, 2014). The UK closed its post-study work route to new applications from non-EU students in April 2012 (UK Parliament, 2016, p. 12). In this model, agents who intend to work or save money while abroad will no longer be able to migrate if this option is restricted.

7.4.2 Closing Doors to High-Skilled Workers

Although native populations are generally supportive of high-skilled migration relative to low-skilled migration (Hainmueller and Hiscox, 2010), many politicians suggest that high-skilled jobs should prioritise native workers over foreigners. During his campaign, Donald Trump said, "I will end forever the use of the H-1B [high-skilled worker visa] as a cheap labour program, and institute an absolute requirement to hire American workers first ... No exceptions." In the UK, a recent proposal from the immigration minister would introduce a £1,000 levy on employers for each EU skilled worker recruited after Brexit (Warrell and Parker, 2017). Because these penalties are imposed on the employer rather than the potential migrant, high-skilled work restrictions are operationalised as a quota applied uniformly to all agents who meet eligibility conditions for that channel.

7.4.3 Caps on Low-Skilled Workers

To compensate for low-skilled labour shortages without antagonizing domestic workers, many countries implement quotas or caps on the number of low-skilled migrants admitted. Often, these are sector-specific, and employers only recruit for sectors with the greatest domestic need (OECD, 2006). After the UK voted to leave the EU, the immigration minister was quick to propose sector and country caps to regulate and bring down low-skilled migration (Warrell and Parker, 2017). Consequently, quotas are used to restrict eligible agents in in-silico experiments.

7.4.4 Thresholds for Family Reunification

Through family reunification visas, migrants may apply to have their family members join them in the destination country. In the aftermath of Donald Trump's election, Republican senators proposed strict limits on family reunification visas, hoping that migrants would reorient towards employment channels (Kim, 2017). The family reunification channel is often restricted through requirements placed on the resident migrant. In the US, for example, the sponsor must demonstrate that they can financially support their family and the incoming arrival at an annual income 125% above the poverty line (Kandel, 2014). A similar threshold applies in the UK (U.K. Home Office, 2016). Income information about family abroad is not necessarily observable for individuals at the origin country. However, the length of their absence *is* observable and is also a well-established indicator of migrant earnings (e.g. Chiswick, 1978; Borjas, 1989a). Consequently, in-silico experiments vary a required 'years since migration' threshold. To facilitate the interpretation of this proxy, we use 2016 estimates from the US Census Bureau (Ruggles et al., 2017) to show the expected wage for Jamaicans who have been in the United States for a number of years equivalent to the threshold.

7.4.5 Free Movement

In theory, free movement of people represents the absence of migratory channels. Individuals who desire to move abroad would be able to do so without government-imposed restrictions. Free movement of people is one of the main pillars of the European Union. All EU citizens can reside in any country within the Union for up to three months, and may stay for longer if they fulfil basic conditions (EU Directive 2004/38/EC). To shift from a policy of free movement to one with restrictions, a government would likely define and impose migrant channels. The United Kingdom, upon leaving the EU, will find itself in this position.

Table 7.4: *Agent eligibility and thresholds for visa categories*

Visa Category	Baseline Eligibility Conditions	Percent Eligible	Additional Restrictions
Student	Secondary school, 90th percentile household income	16%	Accept only those who do not intend to earn or save money abroad
High-Skilled Work	University degree	10%	Accept a fixed % (quota) eligible for this visa at the baseline (randomly selected)
Low-Skilled Work	Experience in agriculture, construction, or transportation	18%	Accept a fixed % (quota) eligible for this visa at the baseline (randomly selected)
Family Reunification	At least one family member living abroad	58%	Accept only those who have a family member living abroad for a fixed set of years
Closed	None	1.7%	Aggregation of above
Free Movement	None	100%	Accept all

The student channel cannot be entirely closed, as individuals can still migrate as students if they do not intend to earn or save money abroad. This accounts for the small percentage of agents who can migrate in the closed setting.

7.5 Results of Policy Experiments

In the first set of experiments (Figs. 7.7-7.10), I compare migration patterns to a baseline setting. The baseline setting classifies agents into common migrant channels absent of quotas and requirements, which can additionally be imposed by the host government. Classifying potential migrants into these channels has its own effect – limiting migration among individuals who are not eligible (see Table 7.4). Thus, by comparing each policy setting to the baseline, we isolate the unique marginal impact of quotas and restrictions among eligible migrants. In Figure 7.7, we fully restrict one channel at a time. We then focus on the two visa routes that produced the most substantial reorientation in these experiments, to observe the effects of more gradual increases in these policy restrictions. In Figures 7.7- 7.10, we maintain a constant level of enforcement for unauthorised channels (see Table 7.2 on calibration of this value). Therefore, we conclude with experiments that vary levels of enforcement for all immigration policy settings.

For each simulation run, we compute the migrant stock accumulated across all simulated years. All figures present the mean across 1000 runs. I report the results at the end of 20 simulated years, as agent learning about entry policies consistently stabilises around that time. Figure 7.6 shows change in the ability to migrate legally over time. For easier visualization, we take the mean ability to migrate legally across all agents over 61 years and average it over 1000 model runs. We then calculate first differences to better observe change over time. We reach a first difference of approximately 0 at 20-21 simulated years, indicating a point at which we can expect the average ability to migrate legally to remain stable. In other words, we can expect a full adjustment to policy conditions to have taken place at year 20. This is the case for the most liberal policy setting (free movement), the most restrictive policy setting, and the baseline condition.

Each bar in Figure 7.7 shows changes (as a percentage of aspiring migrants) from the baseline conditions in terms of legal migration (blue), unauthorised migration (red) and non-migration (black).[4] In the baseline setting, agents may migrate if they are eligible for any of the four visa channels (see

[4]Unauthorised migration includes illegal and semi-legal categories.

Figure 7.6: *Change in Average Ability to Migrate Legally Over Simulated Years*

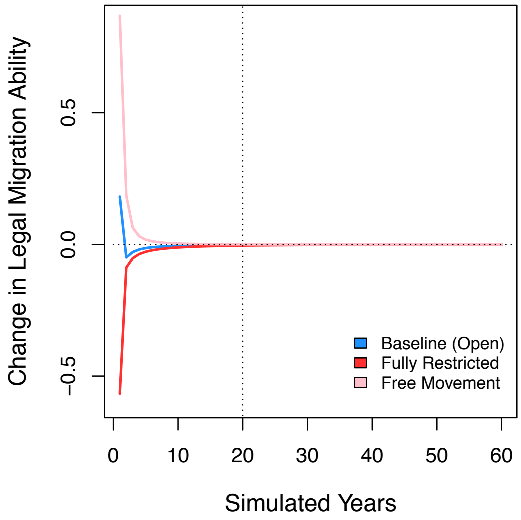
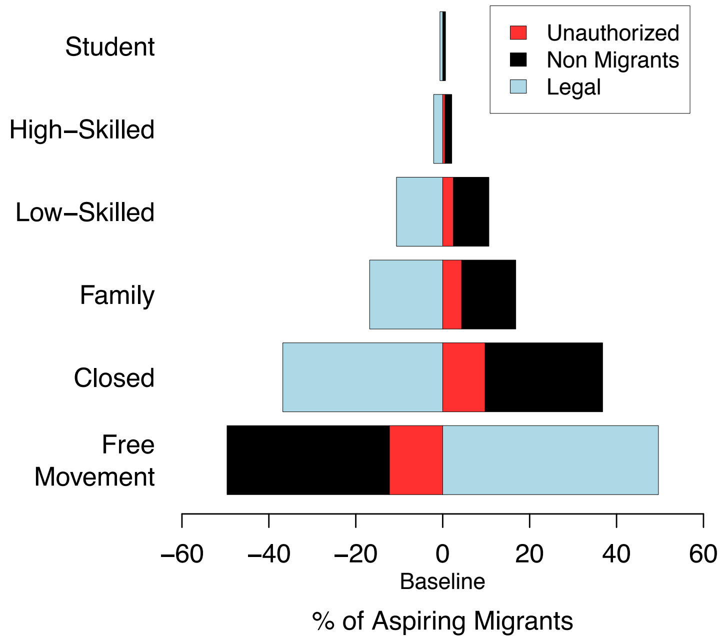


Table 7.4). In this condition, approximately 44% of aspiring migrants migrate through legal channels, 18% migrate through unauthorised channels, and 39% do not migrate. This shows that the mere existence of migratory categories excludes many would-be migrants.

As is shown in the top two bars of Figure 7.7, full restrictions on students or high-skilled workers lead to negligible changes in migration outcomes. Figure 7.7 indicates that full restrictions on student visas lead to 0.64% fewer aspiring migrants entering legally, and a corresponding 0.51% and 0.13% more aspiring migrants opting not to migrate and migrating through unauthorised channels, respectively, compared to the baseline eligibility model. Closing off the high-skilled work channel leads to a very small percentage of aspiring migrants opting for the unauthorised route (0.54%), and a similarly small, 1.54%, increase in non-migration. These findings are rooted in the fact that individuals in many developing countries, like Jamaica, are often not eligible

Figure 7.7: *Mean effects of policy restrictions on migration outcomes relative to the baseline setting (where x=0)*



for these channels even in baseline conditions. Hence, additional quotas or restrictions on these channels will have little to no effect on migration.

Next, we examine full restrictions on low-skilled visas and family-based visas. In Figure 7.7, we see that closing off the low-skilled route would lead to 10.64% fewer aspiring migrants entering legally than would have done in baseline conditions. Instead, 2.50%, or approximately one quarter of these individuals, will opt for unauthorised migration, with the remainder not migrating. Compared to migration levels in the baseline setting, closing off the low-skilled channel leads to a 13.73% growth in unauthorised migration and a 21.23% growth in non-migration.

When the family route is closed, 16.82% fewer agents enter legally, as a percentage of aspiring migrants. This shift corresponds with a 12.46% decrease in migration among aspiring migrants and a 4.36% increase in unauthorised migration. In other words, approximately 26% of the individuals prevented from migrating legally as the family reunification channel is closed, reorient to unauthorised channels. Compared to migration levels at the baseline, closing the family route results in a 32.35% growth in non-migration and a 24.25% growth in unauthorised migration levels. Unauthorised migration in this setting grows at more than double the rate of the low-skilled setting.

Reorientation to unauthorised channels is so high when family reunification channels are restricted because the family-based channel is most easily accessible at the baseline level, as Jamaica's vast diaspora is helpful in continuing migrant flows. This is often the case for countries with a long history of migration. Eligibility for low-skilled work permits generally require prior work experience in a high-demand sector, making this channel less accessible than the family route.

Finally, we consider two opposing scenarios: one in which all legal channels are fully restricted (the *Closed* scenario) and one in which all migratory channels are completely removed (*Free Movement*). In Figure 7.7, we see that, relative to the baseline setting, closing all channels would increase unauthorised migration by 9.76% and non-migration by 27.04%. As a percentage of all aspiring migrants, the *Free Movement* setting decreases unauthorised migration by 12.27% and increases legal migration by 49.64%. If a country removed immigration channels in favour of free movement, total migration would increase substantially, but unauthorised migration would also decrease substantially. It is noteworthy that the removal of migratory channels has the largest influence on migration of all of the policy settings examined. In effect, minimal baseline eligibility conditions are so restrictive that removing them changes the volume and composition of migration far more than even the most draconian policy restrictions, as shown in a comparison of the *Closed* and *Free Movement* settings.

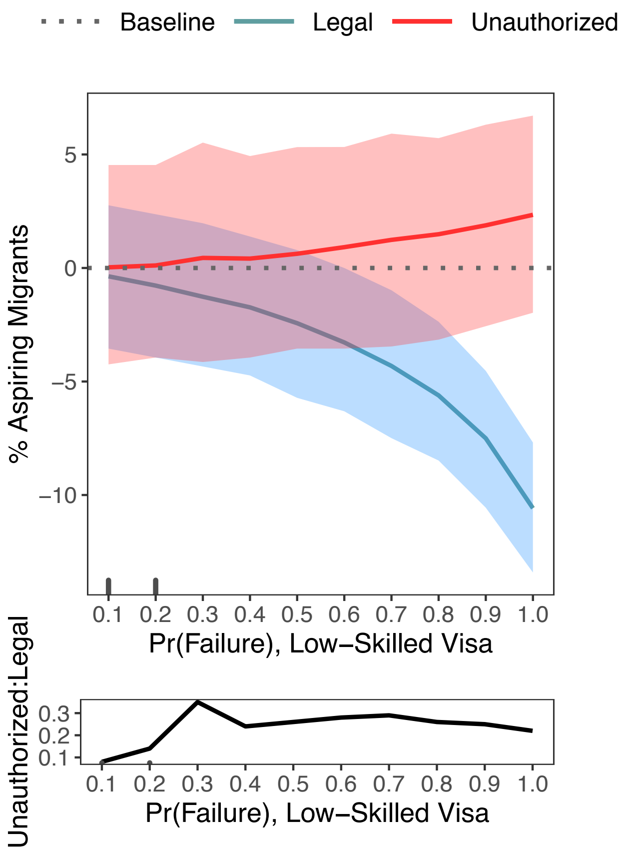
In the figures above, we examined the effects of fully restricting visa routes. Out of all visa channels considered, low-skilled and family restrictions produced the most substantial reorientation towards unauthorised channels. In Figure 7.8 and 7.10 we examine the relationship between policy restriction and reorientation by looking at gradual increases in low-skilled and family restrictions. Both figures present the migrant stock accumulated across all 20 simulated years, averaged across 1000 runs. The error bands in each figure represent the 2.75 and 97.5 percentiles for each level of restriction.

Low-skilled visa restrictions are operationalised as quotas or the probability of failing to receive a visa. In practice, an agent eligible at the baseline draws a number from a random uniform distribution. If this number is larger than, for example, 0.1 (10% quota), the agent is not granted a visa. This amounts to approximately 90% of agents not being able to get a low-skilled work visa in this example.

Figure 7.8 gradually increases the probability of failing to secure a low-skilled work visa, compared to the baseline, at intervals of 0.1. This, in effect, estimates the impact of low-skilled work quotas among eligible agents. As we increase the low-skilled visa quota, the percentage of aspiring migrants migrating legally declines at what appears to be a much steeper rate than illegal migration.

A closer examination shows that for the most part, we see relatively

Figure 7.8: *Mean effects of restricting low-skilled work visas on migration outcomes relative to the baseline with 2.75 and 97.5 percentile error band, ratio of illegal to legal migration, and rug indicating Pr(Failure) settings where illegal migration is not significantly different from illegal migration in the baseline setting.*

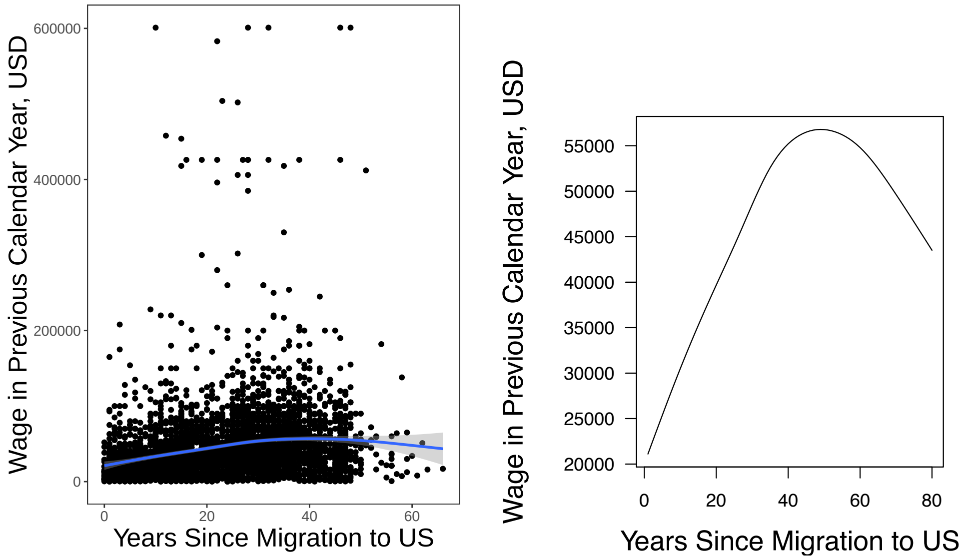


stable levels of illegal migration as a proportion of would-be legal migration – approximately one-third. However, as the quota becomes highly restrictive (*Pr(Failure)* = 0.7), we begin to see the ratio of illegal to would-be legal migration decrease to less than one-quarter (2.34% / 10.58%). In other words, highly restrictive quotas (*Pr(Failure) geq* 0.7) on low-skilled work decrease legal migration at a much greater rate than they increase illegal migration.

As shown in Figure 7.8, average illegal migration for each setting of

Pr(Failure) is not statistically different from the baseline at low levels. This indicates that we do not see significantly greater levels of illegal migration in these settings than in a case where no restrictions are imposed on the low-skilled work channel. A one-sided Mann-Whitney test for each setting of *Pr(Failure)*, considering an alpha value of 0.05, finds significant differences at all levels of *Pr(Failure)* larger than 0.2. In Figure 7.8, insignificant differences are indicated with the presence of a rug line above the x-axis tick. Although legal and illegal migration means across runs are distinct, the error bands spanning the 2.75 and 97.5 percentiles show a large overlap. Significantly higher levels of illegal migration at all intervals of *Pr(Failure)* $\geq$ *0.2* are confirmed by one-sided Mann-Whitney test.

As mentioned above, governments often restrict family migration by placing income requirements on sponsors. Although we cannot vary income requirements, 'years since migration' (*YSM*) is a strong predictor of migrant income. Studies of immigrant labour market adjustment in the US and Canada have shown that, upon arrival, migrants generally earn less than native born citizens, but incomes rise rapidly with labour market experience. These studies have shown that immigrant incomes tend to equal or surpass native counterparts after a period of 10-15 years (Chiswick, 1978; Borjas, 1989b; Meng, 1987). As such, we can approximate a wage level with which each *YSM* requirement corresponds. We use US wages, as this is the primary destination for Jamaicans, but we should expect trends to be generalisable to other destinations as well (e.g. Meng, 1987). Figure 7.9a shows the correlation between time abroad and annual earnings according to the 2016 American Community Survey from the US Census Bureau (Ruggles et al.,



(a) *Scatterplot with Loess Fit and Confidence Intervals*

(b) *Closer View of Loess Fit*

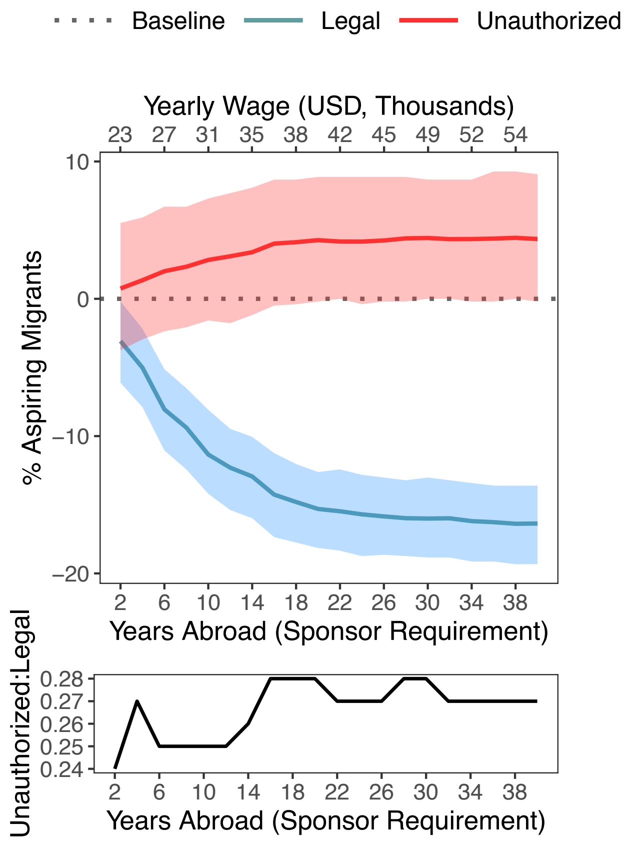
Figure 7.9: *Effects of Years Since Migration on 2015 Yearly Earnings, American Community Survey 2016*

2017). Figure 7.9b shows a closer view of the estimated polynomial fit.

Figure 7.10 shows the effect of restricting the *YSM* requirement for potential family sponsors compared to the baseline. In order to migrate through this channel, an individual must have at least one family member who has lived abroad for a number of years larger than or equal to the *YSM* requirement, as captured by the *MDP* survey data (at the baseline, the *YSM* requirement ≥ 0). The top x-axis represents the wage accumulated in 2015 among American Community Survey respondents born in Jamaica living in the US for the corresponding number of years (Ruggles et al., 2017). These estimates, which correspond to those shown in Figure 7.9, shows wages rising consistently before reaching a peak at *YSM* ≥ 48.

Restricting family sponsorship requirements from 2 to 18 years – which

Figure 7.10: *Mean effects of restricting family reunification channels on migration outcomes relative to the baseline with 2.75 and 97.5 percentile error band and ratio of illegal to legal migration*



corresponds to estimated wage levels between US\$23,000 to US\$38,000 – appears to have the largest effect in reducing legal and driving up illegal migration, compared to baseline conditions. This trend becomes relatively flat with sponsorship thresholds corresponding to yearly wages higher than US\$38,000. At a two-year *YSM* requirement (corresponding to an earnings threshold of ≈ US\$23,000), legal migration as a percentage of aspiring migrants is 3.08% lower compared to the baseline. This corresponds with a 0.75% reorientation of aspiring migrants towards illegal channels. At a

10-year restriction ($\approx$ US\$31,000), almost 3% of aspiring migrants have reoriented towards illegal channels. At an 18-year restriction ($\approx$ US\$38,000), 14.8% of aspiring migrants who would have entered legally under baseline conditions are no longer doing so. Approximately 28% of these individuals are now adopting illegal channels. After this point, further restrictions have only subtle effects on the composition of migrants. Across the full range of settings, relative to the baseline, the ratio of illegal to legal migration oscillates around 0.26, increasing marginally from the lowest setting to larger values (see also Fig. 7.7). A one-sided Mann-Whitney test comparing each setting of *YSM* to baseline conditions finds that levels of illegal migration in all settings are significantly greater than the baseline.

Some might argue that governments could enforce border controls or increase apprehension rates to reduce the threat of undocumented movement. We examine this argument explicitly in the ABM and we find that enforcement may not be a very efficient solution to the problem of unauthorised migration. In the experiment shown in Figure 7.11, the rate of apprehension for both illegal strategies was varied jointly from 10% to 90% to show the percentage of aspiring migrants who migrate irregularly for each policy setting, except for the *Free Movement* setting.[5]

For all policy settings, the percentage of aspiring migrants entering through irregular channels (including full non-compliance and non-compliance) remains quite high even at the very highest levels of enforcement. For instance, when authorities are able to capture seven out of ten irregular migrants, we

[5] We do not include the *Free Movement* setting because it is impossible to migrate illegally in a setting where, strictly speaking, they can cross the border freely.

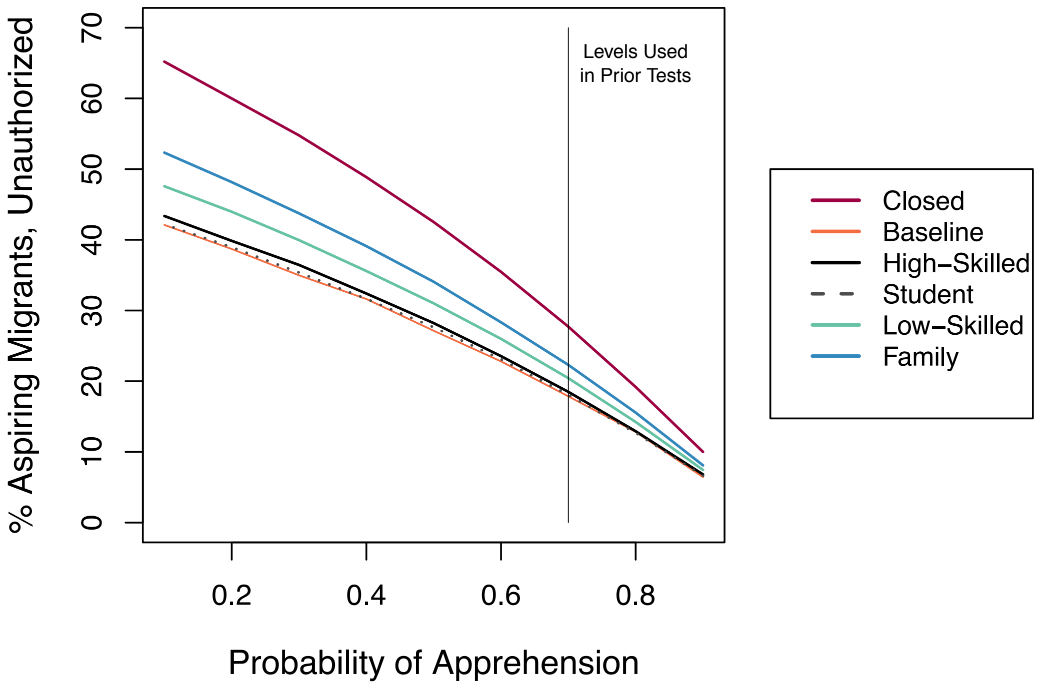


Figure 7.11: *Mean effect of increasing levels of enforcement on illegal migration. Levels of enforcement used in prior tests (Probability of Apprehension = 0.7) indicated by the vertical line*

see approximately 27.71%, 22.30% and 20.43% of aspiring migrants migrating illegally for the *Closed*, *Family* and *Low-Skilled* settings respectively. At lower levels of apprehension, for example *Probability of Apprehension* = 0.5, more than a quarter of all aspiring migrants use irregular channels for all policy settings. When all legal channels are fully restricted (the *Closed* setting), 42.52% of all aspiring migrants enter the destination country through irregular channels.

The effectiveness of apprehension is non-linear. In the baseline setting, increasing the rate of enforcement from *Probability of Apprehension* = 0.1 to 0.5 decreases illegal migration by 14.63%, but increasing the rate of enforcement from *Probability of Apprehension* = 0.5 to 0.9 decreases illegal migration by 20.76%. Similarly, in the *Closed* setting, illegal migration decreases by 22.68% when apprehension increases from 0.1 to 0.5, but decreases by 32.52% when apprehension increases from 0.5 to 0.9. The greatest gains can be made when governments capture more than six in ten irregular migrants, an ambitious figure when one considers the volume of irregular migration and the diverse forms it can take. For example, according to data from the Mexican Migration Project (MMP), the probability of apprehension along the US-Mexico border ranged from 15% to 33% between the years 1960 to 2010 (the MMP dataset is described in Chapter 9). This figure does not include internal enforcement efforts to apprehend unauthorised migrants who may have entered the country with a visa – what we have termed semi-legal migration. Internal enforcement measures are greatly hampered by difficulties in verifying migrants' legal status and eligibility for work (Meissner et al., 2013; Simon, 2010) and errors in their practical implementation can be politically costly. In 2012, the UK implemented interior enforcement policies where access to housing, bank accounts, and even health services, were subject to immigration checks (Kirkup and Winnett, 2012; Elgot, 2018). The public denounced this policy in the 2018 'Windrush' scandal, when elderly legal immigrants were mistakenly deported after having been in the UK for decades (Walshe, 2018).

Figure 7.11 also shows that if enforcement of illegal migration is 80-90%, levels of illegal migration tend to converge across all policy settings. That is, strictly speaking, when levels of enforcement are sufficiently high, the visa policy restrictions have little effect on the rate of illegal migration. This suggests that more than 80% of all illegal migrants would have to be apprehended to account for the increased reorientation of stringent policy restrictions. These results indicate that substantial investment on enforcement would be needed to offset the unintended consequences of restricting legal entry channels.

7.6 Discussion

This chapter presents a theoretically-informed and data-driven agent-based model of migration that simulates the effects of immigration policies, allowing us to observe the reorientation of flows towards illegal channels when legal channels are restricted. This model brings together the work presented in all previous chapters. Based on the theoretical framework developed in Chapter 2, migration is conceptualized as a non-binary outcome, where individuals may either migrate through a series of legal and illegal channels, depending on individual capabilities, attitudes, and the boundedness of their own experiences and the experiences of network ties. Key theoretical relationships embedded in the decision-model were examined using original experiments, with the aim of mitigating several empirical challenges associated with the study of immigration policy and illegal migration. These experiments – their design and results – were presented in Chapters 5 and 6, and the resulting coefficients are used to set effect sizes in this computational model.

Results show that government-imposed restrictions on migrants can decrease total migration, but some restrictions are highly ineffective and others only decrease legal migration at the cost of changing the balance of legal and illegal migrants. The impact of immigration policy depends on the specific restriction imposed. Policies that prevent students or high-skilled workers from migrating legally have little effect because eligible individuals are likely able to migrate through alternative legal categories. Meanwhile, restrictions on family-based visas produce the largest reorientation towards illegal channels. Restricting low-skilled work reduces total migration to a lesser extent than family-reunification restrictions, but the rate of illegal reorientation is also much lower. Results also show that, relative to a system of free movement, the minimal eligibility conditions required to impose migratory channels are highly restrictive on their own.

A further factor that may influence migrant decision-making is the apprehension probability associated with illegal strategies. Results show that illegal migration remains quite high even at the highest rates of apprehension. The effect of changing the rate of apprehension is non-linear, and the most substantial reductions in illegal migration are achieved at very high rates of enforcement. These findings are consistent with recent empirical literature, which has found increases in border enforcement in the United States to be highly ineffective at reducing irregular migration (Massey et al., 2016c). As public spending on enforcement has increased, unauthorized migration to the United States has more than tripled since 1985 (Dixon and Gelatt, 2005; Massey et al., 2016a; Passel et al., 2009; Hoefer et al., 2009). Massey, Durand and Pren (2016a, p. 1558) demonstrate that, “whether measured in terms of personnel, patrol hours, or budget, studies indicate that the surge in border enforcement had little effect in reducing unauthorized migration.”

Findings suggest several avenues for future research. First, although the behavioural rules developed and presented in this chapter are simple and grounded in migration theory, case selection is important. This issue will be discussed further in the concluding chapter of this thesis. Second, this model limited its scope to migrant entries. Future extensions can expand its scope beyond migrant entry, allowing for undocumented migrants to regularize their status in the destination, or for legal migrants to become undocumented after entering legally. Third, while this model focused on how immigration policy information is propagated through social networks, the vast literature on this subject identifies various pathways by which networks may exert their effects. As mentioned in Chapter 2, network effects may involve not only the spread of information, but also material benefits that can help reduce the monetary costs of migration. Future extensions of the model will incorporate the effects of monetary and in-kind transfers (for example, assistance upon arrival).

Finally, I look to extend this model by examining a wider range of adaptive behaviour to immigration policy. As mentioned in Chapter 2, According to De Haas (2011), restrictive policies may reorient flows to different categories or countries; create time-clusters in migration before policy change; or turn migrations that may have been temporary prior to policy change into permanent ones. As I argued in Premise 5, these behaviours are facilitated by boundedly rational learning and heuristics. The following two chapters take steps towards incorporating these extensions by, first, expanding our understanding of boundedly rational decision-making (Chapter 8) and, second, examining another form of migrant adaptation to policy conditions – changing destination countries (Chapter 9).

Chapter 8

Biases in Learning about Immigration Policy

The purpose of this thesis is to examine how migration persists despite restrictive immigration policies. I have argued that to understand the effects of immigration policy, it is necessary to examine the ways in which *individuals* respond to policy change and search for migration alternatives. In the previous chapter, I presented an empirically-calibrated agent-based model where individuals formed expectations about the policy environment, primarily, through feedback from their own experiences and those of their networks (Massey et al., 1998; Massey and Zenteno, 1999). They were boundedly-rational (Simon, 1972) but assumed to be perfectly objective. This chapter builds on the former by relaxing assumptions of objectivity in agent cognition.

As I maintain in theoretical premise 5, aspiring migrants are unlikely to be perfectly objective. Qualitative accounts of refugees and unauthorised migrants (Hagen-Zanker and Mallett, 2016; Hernández-Carretero, 2008; Sabates-Wheeler et al., 2009; Ryo, 2015) suggest that cognitive biases affect the acquisition, processing and sending of information about the odds of succeeding when attempting to migrate. This evidence, shown in Chapter 2, suggests that migrants (1) downweight negative information about their migratory journey in order to maintain a 'successful image', resulting in biased information from the sender's perspective (Hagen-Zanker and Mallett, 2016; Hernández-Carretero, 2008; Sabates-Wheeler et al., 2009; Ryo, 2015). On the receiving side, individuals who wish to migrate or have already embarked on the journey will tend to (2) seek information that confirms the hypothesis that migration is possible (confirmation bias Wason, 1960) and (3) will also display "unrealistic optimism" about their personal chances of succeeding (Hastie, 2001). This literature tends to suggest that individuals who desire to migrate will tend to weight positive information about the odds of migration more heavily than negative information. Aspiring migrants in these qualitative accounts also (4) display a bias favouring their own experiences over those of others – a process termed 'egocentric discounting' (Yaniv and Kleinberger, 2000).

The presence of these biases may have implications on resulting migrant flows. For example, if all individuals consistently weight positive information over negative information in calculating expected odds of success, they will be more likely to attempt migration, regardless of prevailing policy or enforcement levels. Governments' ability to control migration by manipulating probabilities of success is, of course, inhibited if aspiring migrants distort these probabilities when making decisions. However, despite its potential significance and pervasiveness, bias in migrant decision-making has, as of yet, been largely underexplored (Baláž et al., 2014). Although we know, from qualitative accounts, that these biases are likely to exist in migration decisions and the direction they are likely to take, we do not know whether or not they influence migration at a macro level.

This chapter aims to set a basis for future work of this kind by examining whether the presence of these cognitive biases affect the volume and legal composition of migration flows. To answer this question, I present additional results on a slightly modified version of the ABM presented in the previous chapter. Unlike the ABM presented in Chapter 7, agents in this model are prone to bias. For the purposes of a macro-level exploration, it is possible to group these biases according to their broader expectations about the weight agents apply to policy signals. I group 'successful image', 'confirmation bias' and 'unrealistic optimism' under the broader category of 'valence bias,' as they will all result in either positive or negative information weighing more heavily in a potential migrant's decision. To approximate 'valence biases,' I vary the weight agents assign to positive and negative signals. Similarly, to approximate the possible effects of 'egocentric discounting,' I vary the weights agents assign to personal experiences independently from the weights they assign to second-hand migration experiences. I refer to my stylised interpretation of this bias as 'self/network bias.'

I draw the the following expectations for the analyses. First, I expect that weighting positive information about the odds of success more heavily than negative information will have stimulating effect on migration, while weighting negative information more heavily will have a suppressing effect.

However, if immigration policy is restrictive, individuals will need to search for alternative strategies to legal migration in order to migrate. This learning process requires both positive and negative information: Individuals must learn from failures in order to search for other, more successful strategies. As such, I expect that maximum levels of unauthorised migration, and of migration overall, under policy constraints will exist in non-extreme 'valence bias' configurations. That is, where the difference between positive and negative signal weighting is not too large.

Second, as I argue in Chapter 2, individuals who weight the experiences of similar others (as the network configuration described in Chapter 7 ensures), should receive information about the environment more quickly, enabling them to find a feasible alternative more efficiently. For example, if legal migration is difficult in the current policy scenario, an individual who listens to her networks and takes their experiences seriously, is more likely to search for more feasible alternatives rather than wasting their time attempting this strategy. Therefore, I expect that a network bias may stimulate migration. However, its legal composition will be shaped by the policy setting and which type of migration it facilitates or inhibits.

The chapter is organised as follows. First, I briefly reiterate the ABM processes relating to agent learning and show the effects of varying the weights attached to first- and second-hand experiences on relevant equations. I, then, present simulation results examining valence and self/network biases in turn before discussing their implications.

8.1 Background: Learning Equations

The purpose of the following tests is to examine the aggregate migration outcomes that might emerge from a differential weighting on valence and self/network dimensions. In order to more easily understand these results, it is useful to reiterate the process by which individuals receive and process information about immigration policy.

In Chapter 7, agents learned about policy conditions through strategy-specific signals, where the strategy set, S, consists of legal migration, semi-noncompliant migration and fully noncompliant migration. The signal, generated from one's own experience or the experience of network ties, is either positive or negative. That is, a successful attempt generates one positive signal, whereas an unsuccessful attempt generates a negative signal. At the end of the learning process, agents collate all first-hand and second-hand migration experiences (or signals) and re-evaluate their perceived ability to migrate. If signals for a strategy s are overwhelmingly *negative* (assuming positive and negative signals are weighted equally), individuals will *lower* their perceived ability to migrate using strategy s. Conversely, if signals are overwhelmingly positive, agents will elevate their perceived ability to migrate for strategy s.

As the learning process for any given strategy is identical, I present only three equations: the network learning component, Equation 8.1; the personal learning component, Equation 8.2, and the final ability adjustment, Equation 8.3. The final equation, 8.3, simply aggregates all components and uses them to alter agents' current perceived ability to migrate for strategy s. The key variable we consider in this chapter is the weight attached to signals, π, which will be varied to simulate different cognitive biases. This variable is present in equations 8.1 and 8.2 below.

First, we examine the network learning component:

$$C_{i,\pm}^{t} = \pm\pi(1 + \log\sum_{j=1}^{J}\eta_j) \tag{8.1}$$

Variable C is the unique effect of signals accumulated from network contacts, η_j, on their ability to migrate through a given strategy. Agent i computes C separately for positive (C_+) and negative (C_-) information at time t. The only difference is the direction of the weight π. Each additional signal transmitting migration success or failure when attempting a strategy is assumed to have a decreasing marginal effect on agents' perceived ability to migrate through that strategy. As such, I take the natural log of the sum of contacts, $j \in J$, who relay an experience with immigration policy. This functional form is consistent with established literature on the learning curve (Estes, 1950; Heathcote et al., 2000).

Individuals also learn from their own "probing" (Gigerenzer and Selten, 2002) of the policy environment. These experiences form the personal learning component. The learning component is always negative, as a positive experience would entail successful migration and an end to the learning process. B is defined as the unique effect of an agent's accumulated experience with immigration policy on the ability to migrate through a given strategy. The effect of one additional migration failure, f, for agent i, is considered to be marginally decreasing, similar to Equation 8.1.

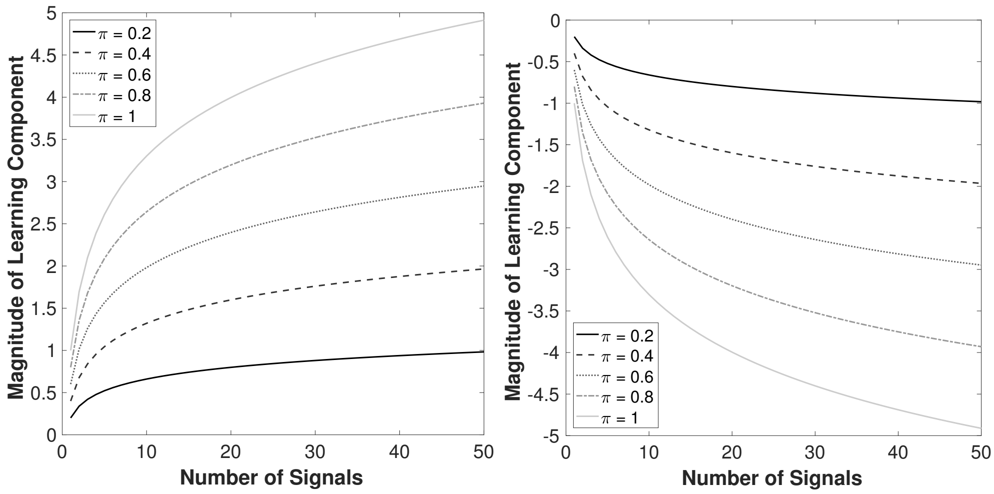
$$B_i^t = -\pi(1 + \log \sum_{f=1}^{F} \eta_{i,f}) \tag{8.2}$$

Finally, each simulated year, agent i updates its ability to migrate for each strategy s as follows:

$$A_{i,s}^t = A_{i,s}^{t-1} + \Delta B_i + \Delta C_{i,+} + \Delta C_{i,-}, \tag{8.3}$$

where $A_{i,s}^t$ is censored to maintain the range of the original survey scale.

The value of the weight π in Chapter 7 is equal to the coefficient of the policy experiment presented in Chapter 5, 0.55. In this chapter, I vary π across its full range (0 - 1) to observe the effects of cognitive biases in learning. To illustrate the effects of altering π on the above equations, Figure 8.1 presents the value of learning components as a function of the cumulative number of signals received, for values of π ranging from 0.2 to 1 at intervals of 0.2 (I do not present $\pi = 0$ as this curve is flat). The left panel refers to component C_+ and the right panel can be applied to components B and C_-. As π is a scaling factor in equations 8.1 and 8.2, the larger the value of π, the larger the magnitude of the learning component and its effect on agents' ability to migrate through any given strategy, as shown in Equation 8.3. As can be seen in Figure 8.1, the first signal received will decrease ability by π. The signals received thereafter will have progressively smaller marginal effects.



(a) *Positive* π (b) *Negative* π

Figure 8.1: *Learning Curves*

8.2 The Effects of Cognitive Biases on Migration

In the these results, I test how alternative values of π would change model outputs. For simplicity, I vary the values of π associated with legal and illegal strategies together. That is, individuals are biased in terms of the valence and the source of the signal but not in terms of strategies. Each parameter combination was run 100 times for 12 years and the average was taken across cumulative values at the end of the run.

In the first set of results, shown in Figures 8.2 and 8.3, I vary the weight agents attach to positive relative to negative signals. For simplicity, I refer to these as π_+ and π_-, respectively. In the second set of results, shown in Figures 8.4 – 8.7, I vary the weight agents attach to their own experiences, π_i,relative to their networks' experiences, π_j. In all tests I present two outcomes: the volume and the legal composition of migrant stock. Observing volume is important as it can give us an overview of the effect of biases. However, in order to observe substitution effects – or the strategic search-and-switch process that potential migrants employ when adapting to immigration policy, it is necessary to disaggregate authorised from unauthorised migrants, as was done in Chapter 7.

The policy settings used in these two sets of experiments are different. In the valence experiments (Figures 8.2 and 8.3), immigration policies are set to the same values as the validation model presented in Chapter 7. This setting is intended to simulate a realistic case – specifically, United States' immigration policy between 2000 to 2012.[1]

In contrast to the valence experiments, where successes and failures are greatly affected by the weight attached to them, agents in the self/network experiments are evaluating migration successes and failures objectively. That is, the bias is placed on the source, not the content of the information and, therefore, the policy setting will play a more important role in driving outcomes. It is easier to disentangle the effects of the self/network bias from the effects of policy when policy is unambivalently restrictive or unambivalently open. Therefore, in Figures 8.4 – 8.7, I employ two extreme policy scenarios: 'Free Movement' and 'Closed' policy conditions. As noted in Chapter 7, the 'Closed' scenario is highly restrictive but not entirely impermeable. Furthermore, a small amount of unauthorised migration may take place in the 'Free

[1]Note, however, that in these validation tests, a proportion of agents abroad equal to the proportion of the Jamaican adult population present in the US in the year 2000 (U.S. Census Bureau, 2000; Warren, 2003) are placed abroad at the start of the simulation run. In this Chapter, I do not do so in order to make the effects of learning easier to observe. Therefore the validation tests is not directly comparable to these figures.

Movement' setting, despite it being unnecessary as some agents (with initial values set to data from the MDP survey) may not have fully adjusted prior expectations on the policy environment. In all experiments, I maintain the level of enforcement or, more specifically, the probability of arrest at 0.7, as in Chapter 7.

For easier visualization of small effects, I reduce stochasticity in these models relative to those presented in Chapter 7. I do so in two ways. First, in the *Choose Strategy* S^* procedure detailed in Chapter 7, agents use probabilities, weighted by perceived ability to carry them out, to select the optimal strategy. For the models presented in this chapter, agents simply choose the strategy associated with the highest perceived ability. Second, in the models presented in this chapter, agents evaluate whether the ability associated with the optimal strategy is higher than a threshold (the midpoint in the ability scale, indicating indifference). Chapter 7 employs a probability function instead.

Valence Bias

In the analyses below, I vary the weight of negative signals on the x-axis and positive signals on the y-axis, from 0 to 1, at intervals of 0.1. I show how the weight attributed to each type of signal influences two outcomes: migrant volume and legal composition. In Figure 8.2, I present the percentage of agents who are abroad in 2012. In Figure 8.3, I examine unauthorised migration in the same year, as a proportion of all agents. Darker hues indicate lower values of migrant volume or unauthorised migration, and lighter hues indicate higher values.

In Figure 8.2, the percentage of agents who migrated varies between 8.1% and 17% across the full range of π_-, π_+ combinations. Overall, when agents assign a larger weight to positive than to negative signals, the volume of migration increases. Conversely, as the value of π increases for negative relative to positive signals, overall migration decreases. This is to be expected as individuals are adjusting abilities upwards more than they are adjusting them downwards when learning about immigration policy.

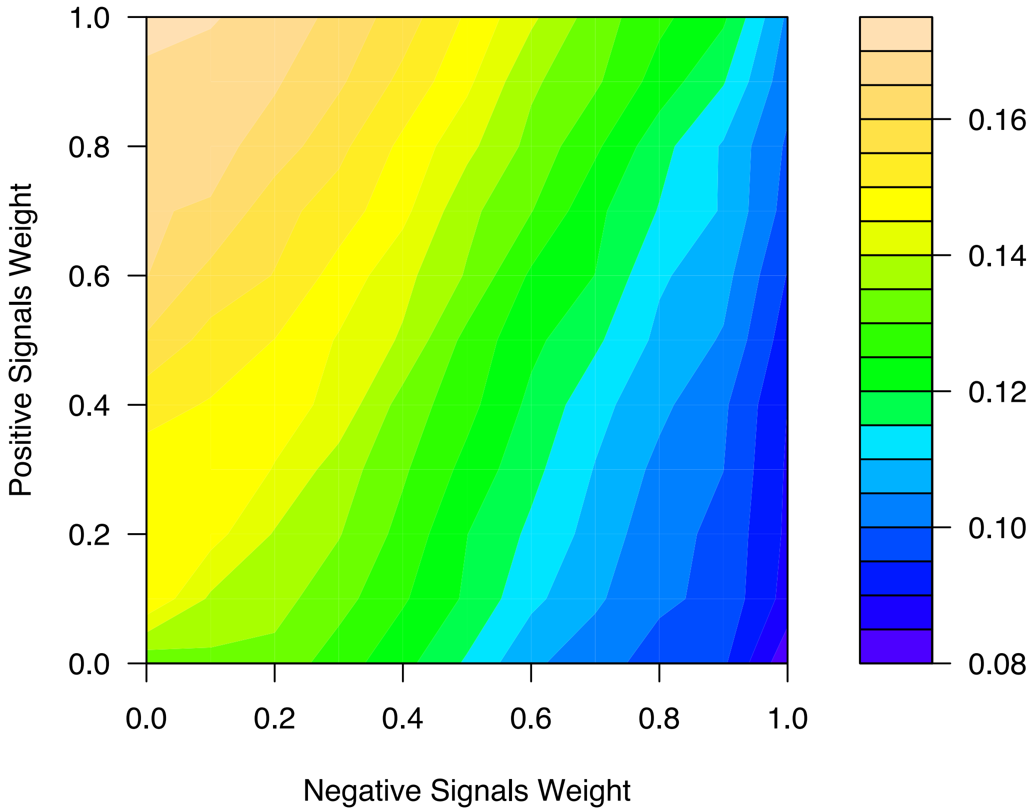


Figure 8.2: *Effects of different weights on negative and positive signals on volume and composition: Proportion of agents migrating*

However, though cognitive biases can distort the real effects of immigration policy, they cannot fully offset them. As mentioned earlier, the policy setting employed in Figures 8.2 and 8.3 reflects the U.S. case, which is restrictive. If an individual were objective, she might perceive her odds of successfully migrating to be dire. An individual who weights positive information more highly than negative information will be more optimistic about her chances. However, the fact remains that, in this policy setting, negative signals will have a numerical advantage over positive signals. As such, changing the weights applied to negative signals will have a larger effect on the system than changing the weights applied to positive signals. This can be observed when we isolate the effects of positive and negative signals in turn. When we move from the lowest to the highest value of π_- and maintain π_+ constant at 0, we can see that migrant stock decreases from 13% to 8.1%, that is, 4.9%. When π_- is set to zero and we move from the lowest to the highest value of π_+, on the other hand, migration increases by a total of 4%. This means that, regardless of positivity bias in cognition, restrictive policies can still shape migration by controlling the frequency of failure.

In Figure 8.3, I examine how the relative weighting of signal valence also affects the proportion of all agents that migrate illegally. In this case, the ratio of illegal migrants to the full sample ranges from 5% to 7.6%, suggesting that changing $\pi_\pm$ would neither eliminate unauthorized migration nor increase it dramatically.

For agents to switch from a legal to an illegal strategy, they must learn that a legal strategy is not feasible (by way of negative signals) and an alternative one is (by way of positive signals). In the unbiased model presented in Chapter 7, agents will, generally, first attempt legal migration. Only as they learn they are not likely to succeed using this strategy, will they adapt

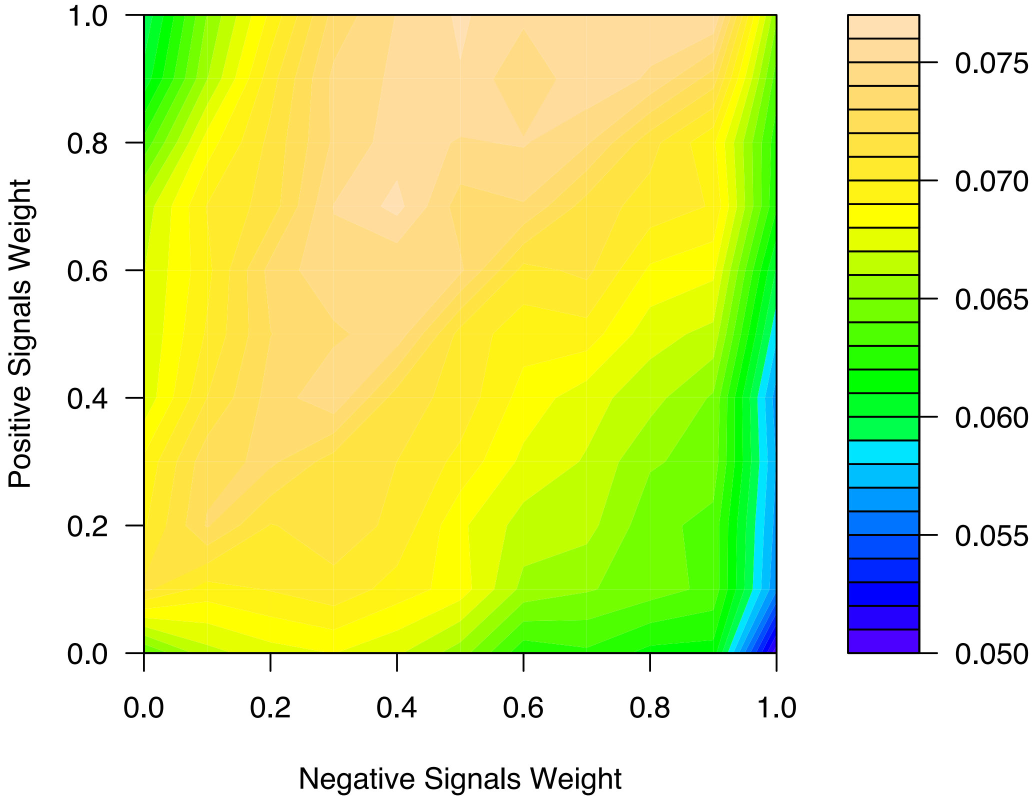


Figure 8.3: *Effects of different weights on negative and positive signals on volume and composition: Proportion of agents migrating illegally*

and attempt illegal migration. This means that, the first signals circulating through the system will be primarily about legal migration. Only later in the simulation will agents learn more about unauthorised strategies. These first signals will also have the largest marginal effects given the shape of the learning curve (See Figure 8.1). As such, when positive signals are weighted heavily, individuals will adjust their ability to migrate legally quite early in the simulation. Only later on in the simulation, will they have the information necessary to adjust their ability to migrate through unauthorised strategies.

This temporal difference will play a role in the legal composition of the resulting migrant stock, particularly when individuals are not processing information in an objective manner. In a restrictive policy scenario such as this one, objective agents would evaluate negative feedback and eventually consider alternative strategies. In a case where positive signals are weighted heavily and there are no negative signals to counterbalance them, agents will attempt and continue to attempt legal migration. Illegal migration, in contrast, will tend to decrease (albeit only by 1.2 percentage points across the full range of π_+, holding π_- at 0). With a restrictive legal entry policy, this is akin to hitting oneself against a wall.

Negative signals are necessary for individuals to pursue alternative strategies. As soon as negative signals are turned on, we can see individuals adopting illegal channels (this can be observed in a large part of the area where $\pi_- \geq 0.4$). However, when agents are more greatly affected by negative rather than positive signals, the proportion of undocumented migrants generally hovers around 6.6%, one percentage point below the maximum value across the parameter space, which is 7.6%. Being overly positive or overly negative does not lead to the greatest levels of reorientation towards unauthorised channels. However, neither does being perfectly objective. The area in the grid displaying the highest proportion of illegal migration is where $\pi_- = 0.4$ and $\pi_+ = 0.7$ – that is, when positive signals are weighted a little less than double the amount of negative signals.

In conclusion, positivity bias leads to higher levels of migration but does not fully offset the effects of restrictive policies because governments can shape the frequency of failure. The level of reorientation to unauthorised channels is also maximised when there is a positivity bias in place. However, this effect is nonlinear. Extreme overconfidence will inhibit rather than aid reorientation to unauthorised channels, because agents are not able to learn from failure.

Self/Network Biases

In the following figures, I vary the weight of personal signals on the x-axis and network signals on the y-axis and show effects on migrant volume and composition. Doing so allows us to explore the effect of effectively 'switching networks off and on': When the value of π applied to networks is zero, individuals do not learn from their networks.

As explained above, the effect of policy manifests itself in the proportions of positive and negative signals agents receive. As such, when varying the weight applied to positive and negative signals, the underlying effects of policy could, effectively, be partially offset by varying the weight of negative relative to positive signals. The question examined in this section is much more dependent on the policy environment because individuals are evaluating migration successes and failures objectively. The bias is now placed on the source, not the content, of the information. As such, to better disentangle the effects of the source from the effects of policy, I employ two policy scenarios: one where signals are overwhelmingly negative – the 'Closed' setting – and one where signals are overwhelmingly positive – the 'Free Movement' setting.

First, I examine the proportion of agents who migrated in the 'Closed' setting. Figure 8.4 shows that varying self/network weights has a smaller effect on volume than does varying valence weights in a less restrictive setting (8.2). Across the parameter space, the lowest value for volume is 10%

of agents and the highest is 14% of agents. This represents only a 4% range. However, these effects are still noteworthy for their implications on our understanding of learning in migration.

Overall, we can see that migration decreases as more weight is applied to agents' own experiences, relative to those gathered from network contacts. This is to be expected: personal signals can only have negative effects on ability to migrate, while networks transmit both positive and negative signals. We can observe the unique effects of π_i by turning networks off. In this scenario, we find that migration decreases 2% across the range of π_i. This is a small number, but its is still notable given the already small range that the volume of migrant stock can take across the parameter space.

If turning networks off reduces migration by 2%, then networks clearly have a stimulating effect on migration when aggregating over all values of π_i. This is to be expected, as networks can have positive effects on perceived ability to migrate by propagating messages of success. However, these positive effects can only be observed where $\pi_j \leq 0.1$. In this area of the grid, increasing network π has a positive or null effect on migration for any given value of π_i. For example if we maintain π_i constant at 0.4 and move along the y-axis from $\pi_j = 0$ to $\pi_j = 0.1$, we can see that the higher the value of π_j the higher the volume of migration.

However, as soon as the weight applied to network signals is above 0.1, we actually see the opposite effect. In this area, increasing the weight of network signals appear to help slightly *reduce* migration in a restrictive policy setting. To see this effect in Figure 8.4, we can choose the same value of π_i as above (0.4) and move vertically along the y-axis, starting at $\pi_j = 0.1$;

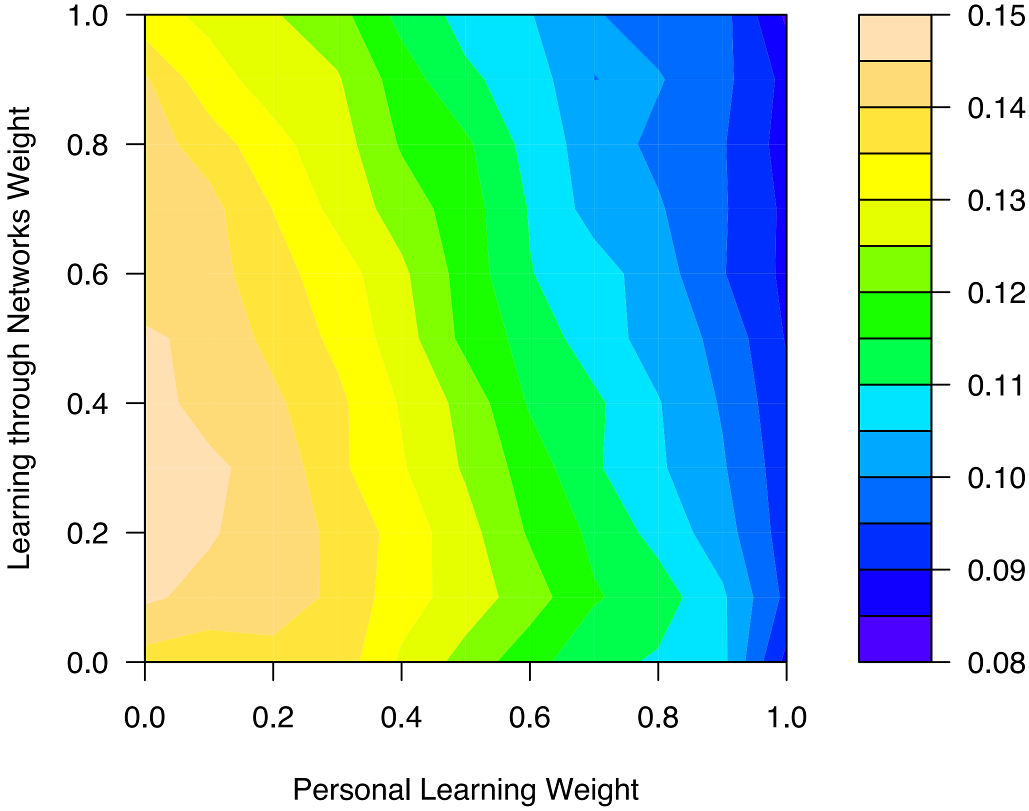


Figure 8.4: *Effects of varying the importance of personal and network feedback on overall volume of migration: Volume, Restrictive Policy*

we can see that, as the value of π_j increases, migration decreases. This takes place because network information in these experiments objectively reflect the policy environment. Therefore, although they have the *potential* to transmit positive stories, they will not do so as much in a restrictive setting. Instead, most stories propagated through the network will be negative.

In the 'Free Movement' setting, Figure 8.5, networks appear to be the single source of signals. In fact, when we compare Figure 8.5 to Figure 8.4 we can see that policy appears to function like a switch, giving one source of information more relevance than the other. That is, when the policy setting is highly restrictive, as in Figure 8.4, (negative) personal experiences play a larger role in driving migration outcomes, whereas in the 'Free Movement' setting (Figure 8.5), personal experiences have no significant effect regardless of how heavily they are weighted. Why does this happen? In a 'Free Movement' scenario, individuals are mostly succeeding in their migration attempts and, therefore, do not need to learn from personal experiences at all. Agents still learn from their networks abroad, which, in this policy scenario, is a consistent source of positive information. These signals, in turn, prompt agents to attempt migration, succeed and send further positive information to their ties back home.

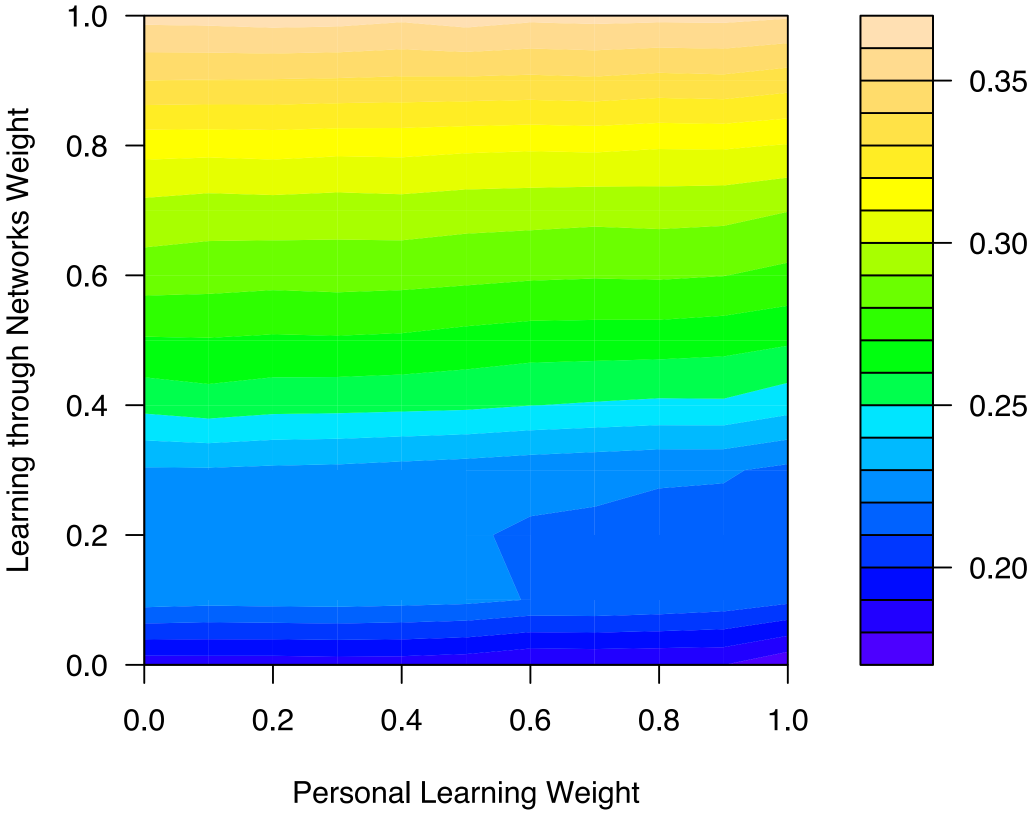


Figure 8.5: *Effects of varying the importance of personal and network feedback on overall volume of migration: Volume, Free Movement*

In the last two figures, I look at undocumented migration – measured as the percentage of all agents who migrated illegally – under the same policy conditions as in the previous two figures. I examine Figure 8.6 first, which depicts the restrictive policy setting. Both the weights applied to personal experiences and those applied to the experiences of others can stimulate unauthorised migration. Reorientation towards illegal channels can function as an escape valve, allowing migration to continue despite legal restrictions. As we observed in the valence experiments, this reorientation is the result of a learning process, by which agents evaluate failures – their own or those of their networks – and the successes of their networks. In this process, they may learn that they are not sufficiently able to carry out their primary alternative (i.e. legal migration) and, if they hear that others are successfully migrating using an alternative strategy (i.e. unauthorised migration), they may attempt this alternative strategy instead. However, in Figure 8.6, we can see that the percentage of agents who migrate illegally is not very sensitive to the weight applied to network or personal signals. The full range of values observed across the parameter space is only 2%. However, out of the two, networks have the strongest effect. When we turn networks off, we see less than half a percentage point change in illegal migration. A larger effect can be seen when we turn personal learning off. Here we can observe 1.1% difference in illegal migration between $\pi_j = 0$ and $\pi_j = 1$. This relationship seems to hold relatively steadily across all vertical lines intersecting π_i, indicating that networks can drive up illegal migration in a restrictive policy environment, while personal learning does not. This is because both positive and negative information is needed for individuals to learn and reorient to alternative channels and networks are the only source of information for potential migrants that is able to provide both.

Of course, in a highly restrictive scenario, not many positive network signals will be circulating through the system. The lack of positive signals partly accounts for the relatively small effects of varying both π_i and π_j on unauthorised migration.

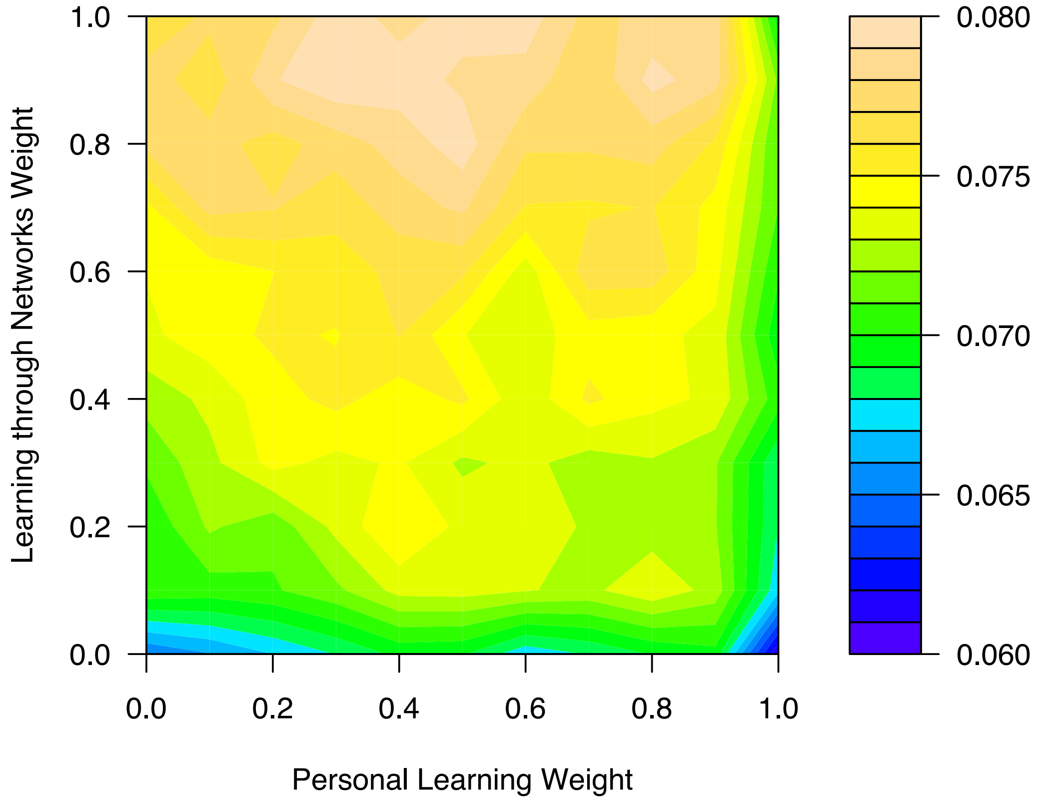


Figure 8.6: *Effects of varying the importance of personal and network feedback on illegal migration: Composition, Restrictive Policy*

Networks are also most important in the free movement setting, shown in Figure 8.7. In this setting, legal migration is the easiest alternative for migrants as the probability of arrest of unauthorised migrants is still high. Therefore adaptive agents will tend to migrate legally. When networks are turned off, personal learning has a negligible effect on illegal migration. At the highest values of π_i, where agents learn rapidly from failed illegal attempts – movement through illegal channels is slightly lower. Meanwhile, more agents tend to migrate legally as we increase the weights of network learning because agents observe their networks migrating successfully through legal channels.

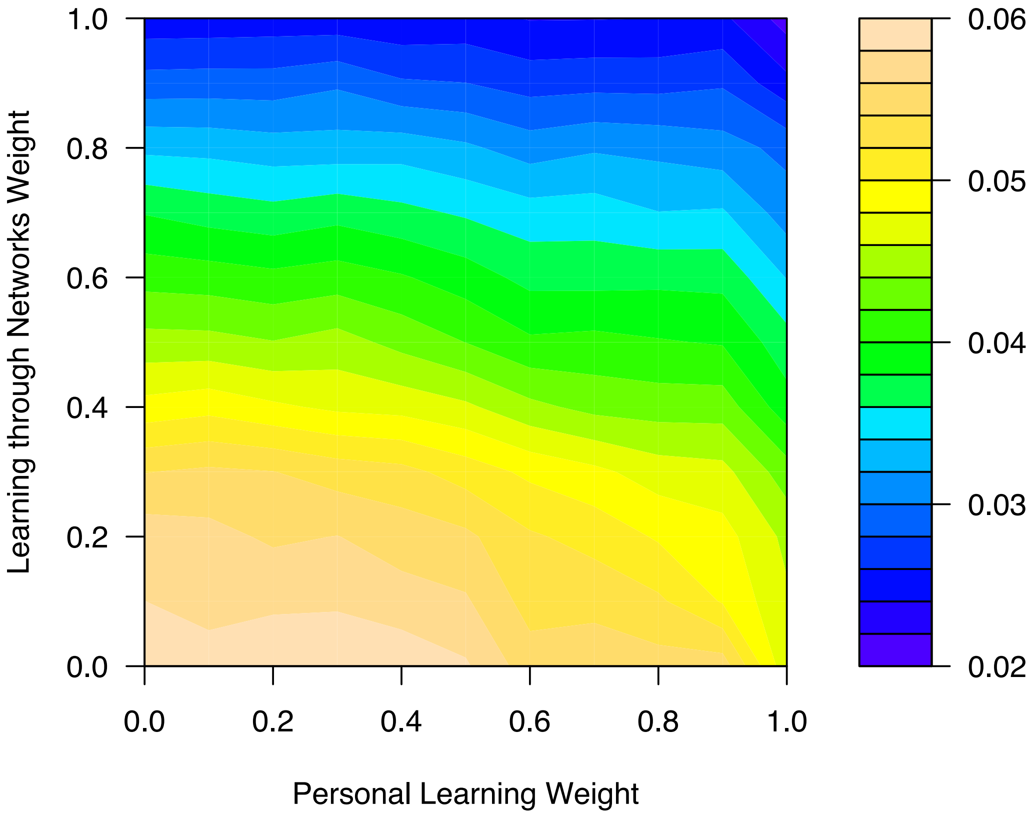


Figure 8.7: *Effects of varying the importance of personal and network feedback on illegal migration:Composition, Free Movement*

In summary, the weight assigned to network or personal experiences does not appear to affect migration volume or composition by a significant amount. However, in restrictive policy environments, we do see minor decreases in the volume of migration as we increase π_i. The value of π_j tends, instead to increase migration slightly overall. However, this effect is highly inconsistent across the parameter space and may, in some instances, help *decrease* migration. This is due to the fact that networks are objectively propagating information about the policy environment. In a 'Free Movement' setting, networks appear to be the sole drivers of migration. This is because individuals are able to migrate easily and, therefore, do not record any personal experiences for future migration attempts. When it comes to driving up unauthorised migration, networks appear to matter the most, regardless of the policy environment, because they are the only source of positive information that can encourage migration attempts.

8.3 Discussion

To understand how individuals respond to changes in immigration policy, it is important to consider humans' cognitive limits. In Chapter 2, I reviewed two theoretical streams of decision-making: bounded rationality and cognitive biases. I integrated the two into premise 5, which guides the limits of agent cognition and learning. The experiments presented in this chapter followed from the theoretical exploration of cognitive biases in Chapter 2. This exploration allowed us to form expectations on the type of biases involved in the decision-making of aspiring migrants. First, it is likely that individuals who aspire to migrate will tend to over-weight information that will support and facilitate this desire, at the expense of objectivity. Second, literature on egocentric discounting suggests that individuals will tend to value their personal experiences more highly than they would others, because they will have more evidence for their own rationale. These hypotheses are supported by existing qualitative evidence on migrant decision-making. The purpose of this chapter was to examine the likely macro-level effects of policy when agents' decision-making is affected by these biases.

Changing decision weights has minor but noteworthy effects on overall model outcomes. First, I examined the effects of differential weighting of positive and negative signals under a realistic policy setting, specifically the U.S. case. In the presence of confirmation bias, we should expect aspiring migrants to weight positive feedback about migration odds higher than they would negative feedback. I find that, overall, when agents assign a larger weight to positive than to negative signals, the volume of migration increases – indicating that confirmation bias may, in fact, facilitate migration. However, a closer look indicates that a dose of negative feedback is necessary for adaptation to strict policy environments. When negative feedback is completely discarded, agents pursue the same unprofitable strategy repeatedly. The highest level of 'strategy-switching' or illegal migration, under the U.S. policy setting, takes place when positive feedback is given a little over double the weight of negative feedback.

Policy has more straight-forward effects when evaluating the biases placed on the source, rather than the content, of the information. In this case, individuals are evaluating migration successes and failures objectively and outcomes are, therefore, more sensitive to changes in migration odds. To better disentangle the effects of source weighting from the effects of policy, I employ two policy scenarios: one where signals are overwhelmingly negative

– the ‘Closed’ setting – and one where signals are overwhelmingly positive – the ‘Free movement’ setting.

Network information, in general, tends to increase the volume of migration across all settings – reflecting the importance of networks in perpetuating migration flows. However a closer look yielded several interesting insights about the nature of network effects. First, networks have the *potential* of circulating positive signals but, they will not always serve a facilitating role. If the policy is restrictive, the balance of negative to positive network signals being sent through the system will reflect this. Furthermore, network signals have a numerical advantage over personal experiences. In a sense, agents are learning about the policy environment by crowd-sourcing experiences. This allows agents to learn about the policy environment more quickly – be it restrictive or lax. As such, even if individuals engage in egocentric discounting and underweight network signals, this source of feedback can still play a significant role.

These results have theoretical as well as real life implications. First, migration literature has focused on the positive, self-perpetuating effect of networks, focusing on the feedback that is sent by successful migrants at the detriment of the negative feedback sent by those who attempted and failed (De Haas, 2010). This theorization ignores the current policy climate. Network feedback is just as likely to be a reflection of policy conditions – albeit imperfect and biased at several points as it travels from sender to receiver. Starting with this premise, we can explicitly investigate the effects of motivated reasoning on information search and processing.

Second, taking cognitive limitations into account is important. Not only because doing so brings us closer to reality (Simon, 2000), but because assuming perfect knowledge and rationality can lead to erroneous expectations about the effects of policy – namely, that governments can perfectly determine aggregate behaviour by changing policy (Castles, 2004a). Individuals who are thoughtful and resourceful will not respond to policy in a straightforward manner: they will seek alternatives and help other aspiring migrants do the same. Theories on bounded rationality and learning help us understand and model this iterative search process. The cognitive biases considered in this chapter are also important, as they will tend to distort individuals' perceptions of their likelihood of succeeding, thereby also distorting the effects of policy at the micro level.

The qualitative studies described in Chapter 2 have suggested the importance of biases in migrant decision-making, however, we have no quantitative measure of their pervasiveness or what factors may make an individual more or less prone to bias. We also know that networks aid migrants overcome restrictive policy environment (Massey et al., 1998) but we do not yet know the mechanisms by which they do so (Hagen-Zanker and Mallett, 2016). Do they aid migration by transmitting useful information that can allow them to learn about the policy environment, thereby bolstering their agency? Or do they, instead, appear to facilitate migration by distorting their experiences with immigration policy and enforcement? These two mechanisms suggest different motivations from the sender's perspective. The first motive is, to an extent, altruistic. The second motive is self-interested and is far from how literature generally describes network effects – as sources of social capital (Garip and Asad, 2016). The lack of work on this front is part of a larger gap in literature on the effects of immigration policy on migration decisions. Future empirical work should seek to disentangle the micro-level mechanisms that underlie the decision-making of aspiring migrants and the various forms of influence that social networks have in this process.

This chapter highlights an important limitation of the ABM of unauthorised migration presented in Chapter 7: the lack of return and repeat migration. Individuals who migrate are assumed to stop learning about immigration policy, but learning should continue if individuals are making several migration trips. This will likely have implications on the effects of policy. In the next chapter, I take a step in this direction by examining a model of return and repeat migration and another form of strategic adjustment to immigration policy: changing destination choice. Although migration is widely considered a social process (Roberts and Morris, 2003; Arango, 2004; Faist, 1997; Haug, 2008; Massey and Espinosa, 1997), network theory has not developed a systematic explanation of why individuals return. Therefore to develop a theoretical framework that can guide future work, I develop an abstract model which formalises network theories of migration and integrates them with existing theories of return migration. In doing so, I also observe the interaction between these two behaviours under different immigration policy scenarios. This model will lay the groundwork for a future extension of the ABM of unauthorised migration, which will incorporate spatial reorientation and repeat migration.

Chapter 9

Social Networks and Spatial Reorientation

At the start of this thesis, I set out to examine how migration systems adapt to changing immigration policies with the aid of their social networks. In previous chapters, I have described how individuals adapt to restriction by learning about policy and illegal migration alternatives from their networks. In this chapter, I examine another observed form of adaptation: reorientation towards other destinations. However, examining this type of reorientation requires a different strategy than previous chapters: Unlike reorientation to unauthorised channels, spatial reorientation presents a theoretical puzzle.

As discussed in Chapter 2, theories on migrant networks and cumulative causation[1] have provided some of the most recognised explanations for the widely-documented concentration of immigrants from one origin in host

[1]Social network theory and the theory of cumulative causation, both detailed in Chapter 2, are complementary theories with very similar expectations on the role of social networks in migration. I refer to them here as social network theories.

destinations. Between 1980 and 1990, Western European countries received immigrants from the same traditional origins: North Africans migrated to France and Turkish and Eastern Europeans migrated to Germany, for example (Collyer, 2005). In 1990, 90 percent of all Hispanics lived in just 10 U.S. states, with 54 percent of all Hispanics concentrated in California and Texas (U.S. Census Bureau, 1993). According to social network theory (SNT), this empirical regularity emerges because the migration-related benefits that social networks can provide are constrained to the specific locations where these contacts reside (Haug, 2008). As such, movement to other destinations is not expected to occur – even in the presence of changes in policy conditions that might make alternative destinations easier to access (De Haas, 2010; Massey et al., 1993).

We know, however, that spatial reorientation *does* take place. Evidence of migrant flows reorienting away from locations where co-ethnics have historically settled is pervasive in literature. In the 1960s, restrictive immigration laws in the United Kingdom reoriented migration from Caribbean countries to the United States and Canada which, at that time, were introducing relatively more favourable skill and education based immigration policies (Glennie and Chappell, 2010). Within the United States, the emergence of new Hispanic destinations has been widely documented (Lichter and Johnson, 2009; Leach and Bean, 2008; Lichter and Johnson, 2006; Terrazas, 2011), with reorientation sometimes being attributed to non federal immigration laws (e.g. Ellis et al. 2014; García et al. 2011; Bohn and Pugatch 2015). Collyer (2005) finds that policy restrictions in France diverted Algerian asylum-seekers with France-based family networks to the United

Kingdom.

The emergence of new migrant destinations for migrants from old source countries presents a challenge to network theories and speaks directly to this thesis' research question: Can the influence of social networks on adaptation to policy extend to 'spatial substitution' – or the choice of alternative destinations promising easier entry? For this to be the case, social network theories need to be able to reconcile the existence of both path-dependency and spatial reorientation found in the real world – two outcomes that appear mutually exclusive. In this chapter, I examine whether they can.

This chapter develops a simple, theory-driven agent-based computational model (ABM) which formalises the expectations of social network theory. As mentioned in Chapter 1, agent-based models are an ideal platform for "complex thought experiments" (Cederman, 1997), allowing us to introduce or relax assumptions and test the boundaries of theoretical expectations (Epstein, 1999). It is also, perhaps, one of the most suitable methods for examining this particular theoretical puzzle. In the real world, migration corridors are formed as a result of a chain of unique historical events, limiting our ability to understand the conditions under which corridors form, break or bifurcate. These dynamics limit our ability to falsify the expectations of social network theories using observational evidence. Agent-based modelling allows us to develop expectations about the real world by simulating how the system might behave under different scenarios, taking into account the effects of random variation that can produce different, path-dependent, migration outcomes.

To examine whether policy can produce spatial reorientation in network migration, I exogenously vary the immigration policies of two destinations:

one with a sizeable diaspora (the traditional destination) and one without (an alternative destination). The model shows that dynamic migration systems can display both path dependency and reorientation – but only in the presence of return migration. Out- and return migration helps the system update itself by allowing networks, and the benefits they bring about, to vary across space. Flows can then adapt to exogenous changes in immigration policy conditions and follow the path of least resistance to a new destination, which may eventually become dominant. This chapter aims to demonstrate that, when we consider return migration, network theories can explain the emergence of path-dependent as well as adaptive migration systems.

Network theories have not developed a systematic explanation of return migration and this process is very often ignored (King, 2012). This chapter develops theoretical expectations on return migration by combining insights from network theories and a complementary approach – the New Economics of Labour Migration (detailed in Chapter 2).

This chapter differs substantially from that Chapter 7 and the supporting work that preceded it. The ABM of unauthorised migration applied a theoretical framework that borrowed from a range of theories across the social and behavioural sciences (this framework was developed in Chapter 2, Section 2.4). In this chapter, I focus on social network theories exclusively. This focus affects model design in substantial ways. As mentioned in Chapter 2, social network theories operate at the meso-level and do not focus on individual decision-making (Massey et al., 1993; Haug, 2008) or the micro-level process by which individuals learn and adapt to changes in immigration policy. As such, agent cognition in this model is simplified; agents are less thoughtful and strategic in the way they interact with immigration policy than they were in Chapter 7. This model also differs in its use of data. While this model is abstract and theoretical and does not aim to produce depictions of realistic policy scenarios, I do use empirics to anchor model parameters to realistic values. As argued in Chapter 3, empirical embeddedness is a good way to reduce researcher arbitrariness and discretion. However, as this model was produced before fieldwork in Jamaica began, I was not able to use the MDP survey for calibration. Instead I employ a widely-used survey of Mexico-U.S. migration: the Mexican Migration Project (MMP). This dataset determined the variables I was able to use and the origin country I was able to depict.

The chapter will proceed as follows. Section 9.1 complements Chapter 2, Section 2.1.2, by deriving expectations on how social networks may matter to the return migration decision. These expectations will guide agent rules, which will be described in Section 9.2, followed by results and discussion.

9.1 Social Network Theories and Return Migration

According to social network theory, each additional individual who migrates provides information and assistance to social ties who will, then, help their own contacts migrate as well. By doing so, networks directly counteract policy measures that increase the risks and costs of migration. The implication of this mechanism is that migration flows will be "siphoned off" to already dominant destinations following the movement of others. Alternative destinations, on the other hand, have limited appeal despite changes in policy conditions that might make the alternative destination easier to access (De Haas, 2010; Massey et al., 1993). Chapter 2, Section 2.1.2 outlined network theories' main expectations. In this section, I draw several assumptions on the likely role of networks on the return migration decision and derive a set of principles to guide agent rules.

First, network theory does not make assumptions about whether individuals intend to migrate permanently or temporarily. A dynamic theory, SNT holds that "acts of migration at one point in time systematically alter the context in which future migration decisions are made" (Massey et al., 1993, p.449). This means that, in contrast to neoclassical economic models of migration, migrants are unlikely to make complex calculations with specific time-horizons (see Chapter 2, Section 2.1.1). Individuals are likely to set off with a particular migration goal in mind, but the location where their social networks are residing at a given point in time will play an important role in inter-temporal decisions to return or remain abroad.

Second, we can expect social networks to serve a similar facilitating function for return as they do for out- migration: Reducing the cost of return and helping migrants secure employment or reintegrate in other ways (Haug, 2008; Massey et al., 1987; Constant and Zimmermann, 2012; Constant and Massey, 2002; De Haas and Fokkema, 2011; Klabunde, 2014). A 2015 Pew Research Centre report indicated that six in ten Mexican return migrants considered reuniting with family at home to be the leading motivator for the decision to end their stay abroad (González-Barrera, 2015). In a recent survey on Mexican return migration conducted in Jalisco, which has the highest return migrant population of the country, networks of family and friends are not only desired but relied upon for reintegration, given a lack of support services from government and other organizations (Mexicans and Americans Thinking Together, 2013). In the case of Italian migrants in Germany, Haug (2008) finds that when migrants' family ties return home, migrants themselves are more likely to return shortly after.

Third, by the same token, networks in the host country will tend to decrease an individual's probability of return (Massey and Espinosa, 1997). Using a nationally representative longitudinal survey of German guest workers from major source countries, Constant and Massey (2002) finds that having a spouse or children in Germany strongly lowers the probability of returning, while having a spouse and children outside of Germany strongly increases it. Similarly, Haug's (2008) single corridor study finds that the more social ties Italian immigrants accumulated in Germany, the less likely they were to return home. In the United States, Massey and Espinosa (1997) find that the migration of wives and children and the birth of children in the United States was associated with a much lower probability of Mexicans returning to their home country.

Though SNT emphasises networks' role in *facilitating* return, it does not offer an explanation of return motivations. When (if at all) and why will a migrant wish to return to the origin country? Neoclassical Economic theory (NE) and the New Economics of Labour Migration (NELM) offer, perhaps, the clearest expectations on motivations for return. Both these theories are discussed in Chapter 2. According to NE, individuals migrate to higher-wage locations in order to maximise expected net lifetime earnings (Sjaastad, 1962). Return migration will happen only if expectations of employment and higher wages have not been met. According to the NELM, on the other hand, people migrate with the intention of returning. Migrants are conceptualised as "target savers," a term which includes personal savings with the prospect of possible investment upon return, and remittances sent home (De Haas and Fokkema, 2011, p. 759). Presumably, remittances will also be sent for savings and investment purposes if migrants are considering eventual return (Amuedo-Dorantes and Mazzolari, 2010). Once migrants meet their 'target savings' they return home where, among other monetary and non-monetary advantages, they can enjoy the higher purchasing power of their foreign earnings (Constant and Massey, 2002; Stark et al., 1997; Dustmann, 2003). According to Boyd (1989), accumulating as much foreign currency as possible in a short period of time, with the aim of return, is a common migrant strategy. Individuals often migrate to save enough money to buy a home or invest in a small business in their home community (Massey et al., 1987). However, quantitative studies have found mixed support for NE and NELM and suggest return motivations are likely heterogeneous (Constant and Massey, 2002; De Haas and Fokkema, 2011).

This chapter does not aim to test motivations for return migration. Instead, it aims to show the effects of return migration on geographical patterns by contrasting a model where migration is temporary to one where it is permanent. I implement NELM's concept of 'target savings' to model return migration because the NELM framework can be considered complementary to social network theory (see, for example, Massey et al., 1993). Remittances

– an essential risk-reducing mechanism within SNT – are an anomaly within NE, which expects that earnings are used to maximise migrant utility in the host country. Within the NELM framework, these private transfers play a key role (Constant and Massey, 2002).

From social network theories' expectations on out- and return migration we can derive several assumptions to define agent rules:

a Agents will value destinations more highly if their networks have migrated there.

  Networks are key sources of information and benefits which reduce the costs and risks of migration to their area.

b Individuals migrate with the intention or goal of earning a foreign wage, saving, and sending remittances home.

c In an individual's out-migration calculus, network benefits overshadow macro-level variables such as immigration policy and wage differentials.

d Agents' return migration calculus will consider both 'target savings' and network benefits.

  Individuals tend to move to or remain in the location where they can draw on the benefits of network membership.

This chapter aims to show that, even though immigration policy is assumed *not* to play a role in an agent's calculus, it does affect decisions by limiting migrant inflow and, by extension, network benefits (assumption *c*). To do this, I simulate and vary a very simple immigration policy barrier, which I explain in more detail in the following section.

9.2 Model Description

Agent-based computer simulation is suitable for developing a more nuanced understanding of the behavioural mechanisms at play in international migration. In this chapter, I develop a conceptually simple, dynamic model, to demonstrate that migrant adaptation to policy change can take place when we consider the effect of return migration on future flows. This behaviour runs counter to network theoretical expectations.

This model is middle range: geographic entities are abstract and the network structure stylised, while agent characteristics are empirically guided (Gilbert, 2008). In this chapter, I opted for this strategy in order to anchor parameters to realistic values while maintaining a simple architecture. I initialise 272 agents, with no two agents occupying a single cell (or grid square) at any given time. This number of agents was chosen to strike a balance between runtime, sample size and the exploration of a large parameter space. It is important to note that equations operating at the macro-level are normalised by number of agents and will, therefore, scale in proportion to this number, mitigating any effects of sample size (more detail is provided below). In Appendix B.1, I display additional results using a larger number of agents (with a smaller number of repetitions and parameter combinations) and, as expected, find that sample size does not significantly affect results. In this chapter, agents can migrate to one of two destinations but the model supports migration to three destinations.

When possible, agent variables are set by randomly drawing values from a distribution with empirical central tendency and dispersion parameters, as well as a shape similar to that shown in data. Input parameters are set using the Mexican Migration Project (MMP) dataset[2] and alternative sources. The MMP survey combines techniques from ethnographic and survey methodology, which obtain a wealth of valuable migration-related information. Communities are surveyed only once and are selected based on diversity in terms of size, ethnic composition and economic development, but not levels of out-migration (Massey and Zenteno, 1999). Approximately 200 households are surveyed for the MMP in December-January each year.

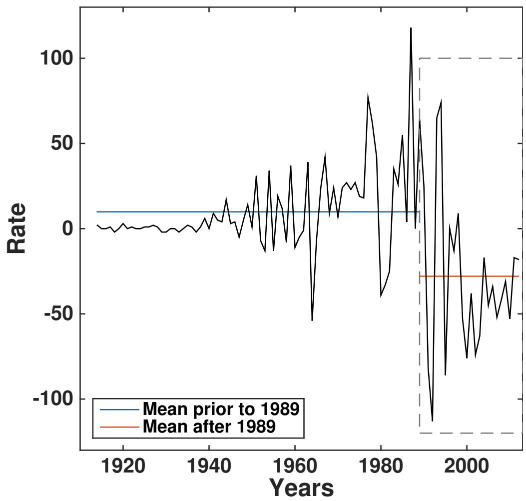


Figure 9.1: *Differences in net migration before and after 1989, MMP, with a square demarcation indicating the period of data used*

The span of data used as inputs to this model is restricted to U.S. entries after the implementation of the sweeping Immigration Reform and Control Act (IRCA) in 1989 and before 2013. Passed in 1986, the IRCA reduced U.S. entries and exits by Mexican migrants and was powerful enough to herald a "new era of Mexican migration" (Durand et al., 1999). As an illustration,

[2]`mmp.opr.princeton.edu`

Figure 9.1 shows yearly differences in net migration[3], from 1982 to 2013. This measure – as opposed to a cumulative measure – more clearly shows the sharp decrease in migration after the 1989 finalization of the IRCA reform roll out.[4] The coloured lines depict the average difference in net migration prior to and post 1989. Given these clear patterns, I consider 1990 a natural starting point for the simulation.

The network structure of Mexican communities is unknown. Therefore I initiate the model using a stylistic small-world network topology (Watts and Strogatz, 1998), following other simulation models of migration (e.g. Klabunde, 2011; Fagiolo and Mastrorillo, 2013). The agent network is specified following Wilensky (2005) which is based, in turn, upon Watts and Strogatz (1998). As in Wilensky (2005), all agents first form a circular lattice of γ nearest neighbours, similar in number to Angelucci et al. (2009). Ties or edges are then rewired with probability π. Specifically, if an edge is selected for rewiring, one of the two agents at its ends will rupture its connection to the other agent and connect with another, randomly selected, agent (never with itself). Though the spatial position of agents changes with migration and return, the network arrangement remains constant throughout a simulation run. Following Rossi (1955), migration decisions are taken within a simulated year. This means that, if an agent has decided to migrate to a destination k and is successful, it must wait until the next year to decide whether to return home. By the same token, if the agent was not successful,

[3] To be clear, net migration in the previous year was subtracted from net migration in the current year.

[4] In this figure, duration of stay was divided by 12 and rounded. This means that trips lasting 5 - 12 months are recorded as one year.

it must wait until the next year to make another migration decision.

The model abstracts the migration decision to be a function of only two variables: network benefits and expected wage (assumptions *a* - *c* in section 9.1). Agents originate from a single location and can migrate to one of two destinations. If they are abroad, they may return to their home. The utility for return is a function of target savings and network benefits (assumption *d*).

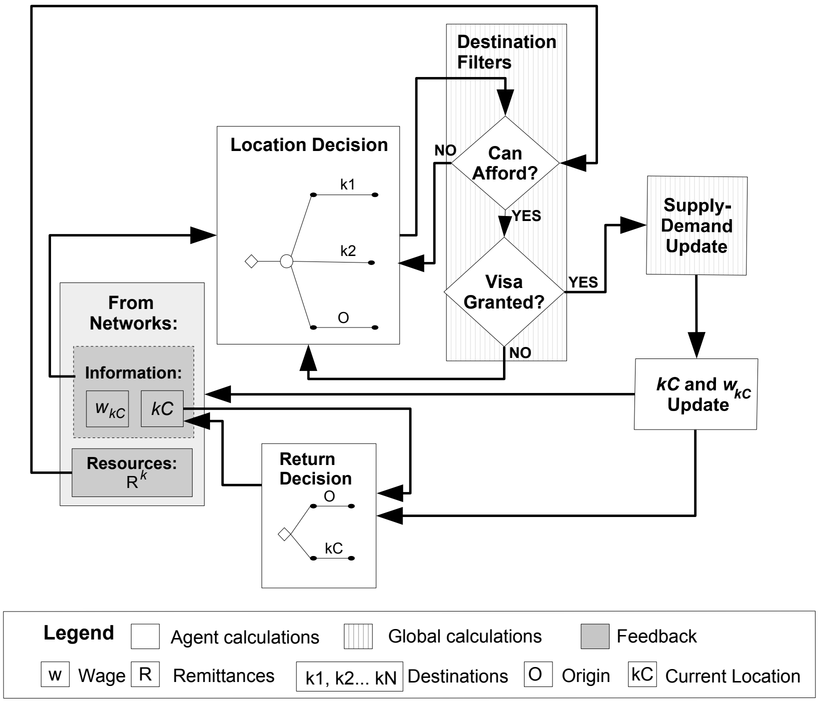


Figure 9.2: Diagram of Interdependencies Across Levels of Aggregation

Though conceptually simple, Figure 9.2 shows the model's extensive macro, meso and micro level interdependencies and feedback. In this figure, agent calculations are distinguished by white boxes, macro-level or global processes are denoted by vertical line hatching, and meso-level feedback (information transmitted through networks), by grey shading. Let us look at out-migration decisions first (starting from "Networks" box). After setting current location and wage variables at the start of the simulation, individuals residing abroad relay information on these variables to network ties at home. This feedback will form the basis of these ties' destination utility calculations (which, as mentioned, is a function of network benefits – or the presence of network members in a given location – and expected wage). Migrants also send remittances to help their home ties counter the costs of out-migration. An agent residing at home may decide not to migrate. If they do decide to migrate to a destination k, the potential migrant is subject to the financial costs of migration as well as the probability of being granted a visa.

Two macro-level variables have direct or indirect effects on individuals' ability to migrate at this stage: Immigration policy and average wage. Governments grant visas to some potential migrants and not others (in this simple model, all agents are equally likely to obtain a visa given a probability or quota). From the perspective of the non-migrant, the more restrictive the policy, the smaller the network living abroad is likely to be. At an aggregate level, restrictive immigration policies limit the stock of migrants in k – or the supply of labour – which, in turn, affects the average wage in this destination[5] (see "Supply-Demand Update" box). A change in the average wage has a number of implications at the agent level. It, primarily, affects the actual wage obtained by individual migrants. However, because migrants send information and monetary resources to their ties at home, it also influences non-migrants' earnings expectations for the destination where their ties are located (and, therefore, their utility for migrating there), as well as

[5]For simplicity, this model assumes perfect employment in all destinations.

the resources they have available to offset the costs of migration.

The decision to return will depend on the interplay of two factors: attaining a 'savings target' and the current location of networks ties, following assumption *d*. As such, return decisions will be informed by network feedback on current location (see "From Networks" and "Return Decision" boxes). Finally, when a *return* migrant updates their location status, they will affect *out-migration* utilities by reducing expected network benefits in the location where the former migrant used to reside. In what follows, I provide further detail on model processes.

9.2.1 Emigration and Destination Choice

The emigration procedures in this model are drawn from Epstein (2008) and follow the theory described in Section 9.1. According to Epstein, an individual's utility function for migrating to a particular location k (U_k) depends on two variables: wage (w_k) and networks present at that location (N_k).[6] Utility increases with respect to wages and with respect to the immigrant stock (for the benefits that networks entail). This is defined by the following partial differential equations:

$$\frac{\partial U_k(w_k, N_k)}{\partial w_k} > 0, \frac{\partial U_k(w_k, N_k)}{\partial N_k} > 0 \tag{9.1}$$

For a given utility, the size of networks and wages are substitutable. In other words, if wages drop, the migrant can be compensated by an increase in network size (Epstein, 2008, p. 570).

[6] Wages are often log transformed but this is not done in Epstein (2008).

$$\frac{dw_k}{dN_k} = -\frac{\frac{\partial U_k(w_k,N_k)}{\partial N_k}}{\frac{\partial U_k(w_k,N_k)}{\partial w_k}} < 0 \tag{9.2}$$

The wage in equilibrium is a function of the stock of immigrants in the country: as the stock of immigrants increases, the equilibrium wage decreases (Epstein, 2008, p.571)[7]. The wages that satisfy the equilibrium constraint are denoted by w_f^*. The full derivative summarizing the utility, as a function of the equilibrium wage and networks, with respect to networks is described as follows:

$$\frac{dU_k(w_f^*, N_k)}{dN_k} = \frac{\partial U_k(w_f^*, N_k)}{\partial N_k} + \frac{\partial U_k(w_f^*, N_k)}{\partial w_f^*}\frac{dw_f^*}{dN_k} \tag{9.3}$$

An increase in the size of the network at the destination has two opposing effects: a positive one through the increase in network benefits and a negative one via the decrease in wages. The first component of the right hand side of the above equation is positive, while the second is negative, reflecting these opposing effects. When (3) equals 0, the additional network benefits from one extra migrant equals the decrease in benefits coming from wages. After this peak is reached, the utility for migrating as a function of networks at the destination begins to decrease: "the probability of an individual migrating to a certain country has an inverse U-shape relationship, with regard to the stock of immigrants already in the host country"[p.573].

Following this description, I define the equilibrium wage for destination k (W_k) as the negative linear function

[7] Though immigrants wages are also a function of native population size as well as immigrant stock, non-immigrant population is assumed to remain constant (Epstein, 2008, p. 571).

$$W_k = -\beta d_k + b \tag{9.4}$$

The y-intercept b is set to the mean U.S. wage from the MMP sample, for years 1990 to 2013. As the stock of immigrants, N_k, increases relative to available jobs, G_k. This ratio is denoted as d_k, wages decrease. The number of available jobs is equal to the total number of grid squares in each destination k. When all available jobs have been occupied, $W_k = 0$.

When agents migrate to a destination, they are assigned an individual wage from a random exponential distribution (w_i^k) with the mean equal to W_k, to approximate the distribution of wages for individuals surveyed by the MMP. That is, individuals are earning, on average, the equilibrium wage given the size of the immigrant labour supply. As the stock of immigrants increases, the equilibrium wage decreases and, thus, migration continues to be beneficial for the host country.

Agents at the origin can only obtain information about host country conditions from the migrants they are connected to through network ties. Let $x_{ij} = 1$ if a tie exists between decision-maker i and agent j, and $x_{ij} = 0$ otherwise. We then define $X_i = \{j \in I | x_{ij} = 1\}$, which is the set of all connections between decision-maker i and persons j from all agents I, and $X_i^k = \{j \in I_k | x_{ij} = 1\}$, which is a subset of X_i including only agents who are in location k. Agents at home construct their expected wage value $E(w_i^k)$ as the average wage of network contacts living in destination k.[8]

[8]For simplicity, networks are not weighted differentially.

$$E(w_i^k) = \frac{\sum_{j \in X_i^k} w_j^k}{|X_i^k|} \tag{9.5}$$

Network benefits form the second component of the emigration utility function. Newcomers can derive benefits from migrants they are connected to through social ties and will therefore be drawn to the location where these migrants reside. By the same token, an individual will have greater home bias when a smaller proportion of his or her network has migrated, consistent with assumptions a and d (Section 9.1). As such, I define the network term N_i^k as the proportion of total network contacts living in destination k as:

$$N_i^k = \frac{|X_i^k|}{|X_i|} \tag{9.6}$$

Having defined its two components, I describe the final emigration utility function, U_i^k, following Epstein (2008).[9]

$$U_i^k = E(w_i^k)c \cdot \log(aN_i^k + 1) \tag{9.7}$$

where c and a are constants, and a affects the curvature of the logarithmic function. The value of U_i^k does not surpass 1. The utility for remaining in the origin country h, relative to moving abroad, is simply the result of subtracting the average utility for all foreign destinations, $k \in K$, from the maximum utility possible:

[9]Epstein (2008) describes the utility for migrating to location k for individual i in terms of its functional form and inputs, but does not describe the shape of the network term, or whether the function is additive or multiplicative. Equation 9.7 is in line with the functional form he describes.

$$U_i^h = 1 - \left(\frac{\sum_{k=1}^{K} U_i^k}{K} \right) \tag{9.8}$$

In conclusion, the decision to migrate consists of three steps. First, the agent will choose to reside in the location with the highest utility, including home. If there is no single winner, agents will select a location by randomly choosing across the highest valued options. Second, having chosen their destination, agents at the origin will migrate if their accumulated wealth in the current year, $\Lambda_{i,t}^h$, is larger than or equal to the cost of migration ζ_m. The costs of migration include one month of destination country income forgone while transitioning into the new labour market,[10] as well as transportation and visa costs. Third, agents will encounter a 'policy filter', whereby they will migrate subject to a probability of attaining a visa.[11]

$\Lambda_{i,t}^h$ is given by adding the savings accumulated in all previous time periods, $s_{i,t}$ to the wages and remittances received in the current time period ($w_{i,t}^h$ and $R_{i,t}^h$, respectively):

$$\Lambda_{i,t}^h = s_{i,t} + w_{i,t}^h + R_{i,t}^h, \tag{9.9}$$

Individuals who have migrated before maintain the wealth they accumulated abroad, $\Lambda_{i,t=n}^k$, and are able to use these savings in addition to any they accumulated at home, s_i^h, to re-migrate. Hence,

[10]Decision-makers must consider the effects of a loss of income relative to the cost of living in the destination.

[11]The cost of migration is an important consideration when migrating. However, I keep costs fixed across destinations to observe the unique effects of varying policy restriction.

$$s_{i,t} = \Lambda^k_{i,t} + \sum_{t=0}^{t=n} s^h_i, \tag{9.10}$$

where $t = 0$ indicates the year they arrived at the destination. According to the 2012 National Survey of Financial Inclusion (INEGI, 2012) 36 per cent of the Mexicans claim to have at least one formal savings product. Thus, 36 percent of agents in the origin are equally likely to be marked as home country savers at initialization. Agents not marked as home country savers, will only accumulate wealth from working abroad (if they migrate).

Once abroad, all agents in destination k spend their yearly (t) wages, $w^k_{i,t}$, on food and lodging (consumption), $C^k_{i,t}$. They may also send remittances $R^k_{i,t}$. Remittances are private transfers generally sent to nuclear or extended family recipients (De Haas, 2007). In this abstract model, agents do not strictly identify connections as family ties, as this would require making assumptions on family dynamics and, possibly, joint migration strategies (Stark and Bloom, 1985). However, agents identify one home country recipient at random, upon migrating, and maintain this recipient throughout the simulation run to approximate the stable relationship an individual would have with family.

The proportion of an agent's wages dedicated to consumption and remittances is equal to the median proportion of yearly destination country wages consumed and remitted, respectively, by MMP respondents across all relevant years.[12] Yearly wages not spent on consumption and remittances (a little more than half the agent's yearly wage) is saved and added to the

[12]Destination country wealth is computed differently than origin country wealth (described above) because, data on Mexican consumption was not available for the latter.

wealth accumulated heretofore (see Table 9.1).

Wealth at the destination, $\Lambda^k_{i,t}$, is given by:

$$\Lambda^k_{i,t} = \left(\sum_{t=0}^{t=n-1} \Lambda^k_i\right) + w^k_{i,t} - (C^k_{i,t} + R^k_{i,t}) \tag{9.11}$$

The accumulation of savings play a part in the length of a migratory trip, as is explained in the following section.

9.2.2 Return Migration

I model return migration utility, U^r_i, as a function of (1) the benefit of an additional network tie residing in the home country and (2) the benefit of approaching savings target η (assumption d). These are the first and second components, respectively, on the right hand side of equation 9.12. As both components are necessary for return, utility is modelled multiplicatively:

$$U^r_i = \frac{\log(aN^h_i + 1)}{\log(a+1)}\left(\frac{2}{1+\exp(-bs^k_i)} - 1\right) \tag{9.12}$$

N^h_i is defined as the proportion of ties to individuals in migrants' home location over their total number of connections. All else equal, the larger N^h_i, the larger the motivation to return. On the other hand, if the number of migrants at home is small, either a large portion of friends and relatives have joined the migrant or moved to other locations and cannot help the migrant to reintegrate. Alternatively, the migrant may have never had a large network at home (e.g. because of young age at the time of migration).

The savings target agents strive towards, η, is obtained from aggregate

MMP data. I construct η by adding return savings and remittances for savings and investment purposes accumulated throughout the length of stay of returned survey respondents, and take the median.[13]

Agents may be satisfied with saving an amount of money that is 'close enough' to the savings target, while not fully reaching it. As such, the utility for approximating η is modelled as a logistic function (scaled and shifted such that the inflection point is at the origin) to reflect the diminishing marginal utility of approaching a concrete savings target. Equally – and consistent with network benefits in the emigration utility equation – the added benefit each additional home-based social tie can bring the agent is also marginally decreasing.

To solve for constants a and b, I hold the second utility component at the savings target, η and find two reasonable values or 'anchor points' for the first utility component – network benefits – in terms of U_i^r. If the amount of savings accumulated equals η, we would expect the utility of returning home, U_i^r to be highest when the proportion of network ties residing at the

[13]The MMP records the amount of savings with which a migrant returns to Mexico as well as the amount of remittances sent and their purpose. In the survey, respondents can select up to 5 purposes for their past remittances from a list of 16 (including an "other" category). Following Massey and Parrado's (1994) handling of the same dataset, I divide the average remittance value reported equally between the purposes reported to determine the amount of remittances used for each purpose. That is, if individuals reported 5 ways in which they intended their remittances to be spent, their reported yearly remittance amount is divided by 5 to obtain how much they sent under each category. The categories of interest are: "Construction and repair of house", "purchase of house or lot", "purchase of vehicle", "purchase of tools", "purchase of livestock", "purchase of agricultural inputs", "start/expand a business", and "savings." As the authors observe, dividing remittances in this way may have the effect of understating the first category mentioned and overstating the latter. I consider both savings and investment remittance purposes because savings may be used for a variety of investment purposes in the home country at any point in the future (e.g. Massey et al. (1987)) and, therefore, it is impossible to distinguish between the two in survey responses.

origin, N_i^h, is also highest. Hence, when $N_i^h = 1$, I set U_i^r to 0.9. When $N_i^h = 0.3$, $U_i^r = 0.6$, slightly above the midpoint. This reflects that, even if target savings have been met, having few network members at home has a discouraging effect. The largest possible value of U_i^r is 1. If able to pay the costs of return, ζ_r, individuals head home subject to the outcome of a Bernoulli trial,

$P(Return) \sim B(1, U_i^r)$.

All parameter settings described above are summarised in Table 9.1 below.

Table 9.1: *Parameter Settings*

	Variables	Values	Equations
Empirical Parameters (fixed)	Wealth	$\Lambda^h_{i,t=1}(s_i, w^h_i, R^h_i)$	9
		$\Lambda^k_{i,t=1}(s^k_i, C^k_i, R^k_i)$	11
	Wage variables	$w^k_i : X \sim Exp(W_k)$, $0 \leq W_k \leq \mu^k$, $\mu^k = 22,075$	4,5
		$w^h_i : X \sim Exp(\mu^h)$, $\mu^h = 4,502$	
	Consumption	$C^k_i = 0.25w^k_i$	11
	Remittances	$R^k_i = 0.19w^k_i$	11
	Savings	$s_i(s^k_i, s^h_i)$, $s^h_i : X \sim \mathcal{N}(\mu_s, \sigma^2)$, $\mu_s = 45$, $\sigma \approx 0.1\mu_s$, $p(s^h_i) = 0.36$ $s^k_i = \Lambda^k_{i,t-1}$	10
	Avg. number of ties	$\gamma = 6$	
Endogenous Variables	Networks (proportion)	$0 \leq N^k_i \leq 1$ $0 \leq N^h_i \leq 1$	6,12
Exogenous Variables	Probability of Forming Random Tie	$\pi = 0.25$	
	Financial Costs of Migration	$\zeta_m : X \sim Exp(\mu_{\zeta_m})$, $\mu_{\zeta_m} = 2,197$	
	Costs of Return	$\zeta_r : X \sim Exp(\mu_{\zeta_r})$, $\mu_{\zeta_r} = 441$	
	Savings Target	$\eta = 2,846$	13
	Pr. Entry	$0 \leq P(Success) \leq 1$	
	Pr. Return	$0 \leq P(Return) \leq 1$	

Notes: μ_s is the average net savings in a year among Mexican bank clients, which is equal for the poorest and best-off third of households in the sample collected by (Peachey, 2008, p. 24). No deviation measures were provided. ζ_m include one month of destination income forgone while transitioning into the new labour market, transportation and visa costs from Klabunde (2011) and U. S. Department of State (2015), respectively. ζ_r include one month of home country income forgone while reintegrating into the home labour market and transportation costs. All other fixed parameters are from MMP. All monetary units are in United States Dollars set using the Consumer Price Index for 2012 as the base (U.S. Bureau of Labor Statistics, 2012) except for time-invariant variables.

9.3 Results

Network theory predicts that, once a critical number of migrants have established themselves in a destination, they help channel future flows to the same destination. At this point, migration corridors will be robust to changes in governments' attempts to influence movement (De Haas, 2010; Massey et al., 1993). I have argued that policy can lead to the reorientation of flows in the presence of return migration. Return migration can aid the system's adaptation, allowing corridors to more easily shift to the destination that offers the greatest possibility for successful entry.

To test this, I present a scenario where a migration corridor has been established between the origin and destination 1, while comparably fewer migrants have settled in destination 2. That is, destination 1 is dominant. Specifically, I place 30 percent of all agents in the traditional destination (destination 1) at initialization, and only 4 percent in the alternative destination (destination 2). I start each simulation run with a specific immigration policy setting and maintain this policy constant throughout 24 simulated years, matching the span of the input data.

Across simulation runs, I vary the probability of a migrant gaining entry to both destinations ($Pr(Success)L1$ and $Pr(Success)L2$) from 0 to 1, at intervals of 0.02 (small enough to observe granularities or non-linear effects that may emerge). I run the model 100 times per unique destination policy combinations and display the average across these runs. All parameter values not discussed in this section are shown in Table 9.1. In this section, I show results on the spatial reorientation of migrants in response to policy conditions in the two destinations. I show patterns at a single point in time – at the end of 24 years – and then examine inter-temporal variations.

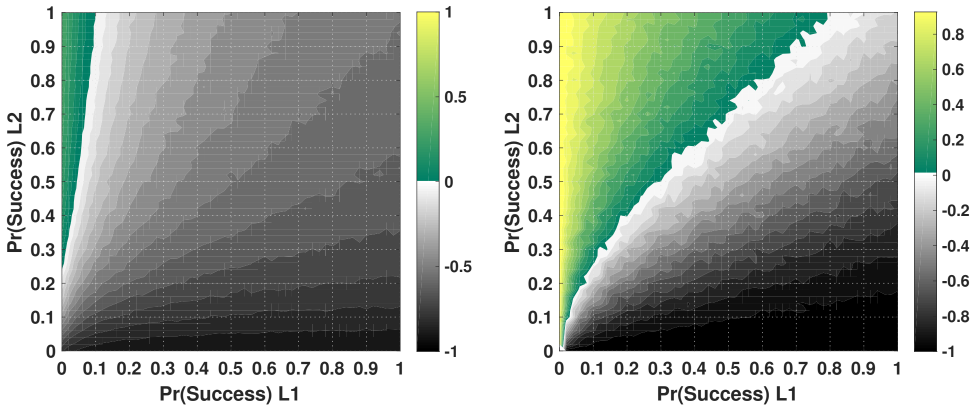
In the first set of results, I compare experiments where return migration is disabled and where it is enabled to show its unique effects on migrant reorientation. At initialization, the traditional destination is dominant. However, if individuals begin to move to an alternative destination, their social ties, drawn by network benefits, may subsequently follow the same path. If more individuals migrate to the alternative destination than to the traditional one, a new dominant destination is established. The relative dominance of a destination S_t is measured by subtracting the proportion of migrants in the alternative destination, N_t^2, from those in the traditional destination, N_t^1, at a given point in time t. It is defined as follows:

$$S_t = \frac{N_t^2 - N_t^1}{\sum\limits_{k=1}^{K} N_t^k} \tag{9.13}$$

Given the initialization settings described above, S_t at the start of a simulation run will equal -0.76. The value of S_t increases as migrants reorient to destination 2 and will be positive if destination 2 becomes dominant.

Reorientation of flows is driven by immigration policy inequality. Specifically, if destination 2 offers the greatest possibility for successful entry, we can expect a larger number of individuals to move there. In the following figures, 9.3a and 9.3b, I examine migrant reorientation at the end of 24 years for different $L1$ and $L2$ immigration policy combinations. I compare the results for unequal policy combinations to the average value of $S_t = 24$ when policies across destinations are equal (the baseline). This is equal to -0.55.

Figure 9.3a displays results where return migration is turned off and Figure 9.3b shows a model where return migration is enabled. For visual clarity, I use grey scale tones to depict values of $S_{t=24}$ that are below zero (that is, the proportion of migrants in the, traditional, destination 1, continues to be larger than in destination 2) and positive values of $S_{t=24}$ (destination 2 has become dominant) are shown in green hues. Within these two colour ranges, lighter shading indicates higher values of $S_{t=24}$, or greater reorientation to destination 2.



(a) Return Migration Turned Off (b) Return Migration Turned On

Figure 9.3: *Spatial reorientation and dominant corridor shifts across available destinations*

For the most part, migrants continue to flow to the traditional destination (L1), regardless of policy, when return migration is turned off – as expected in network theory. In Figure 9.3a, destination 2 becomes dominant only at extreme levels of policy restriction in the traditional destination. Even when the L1 closes its borders completely, the alternative destination must admit a minimum of 1 in 4 migrants to become the new dominant destination. Otherwise, migrants will persist in their attempts to follow their social ties to destination 1.

When policy in destination 1 is most restrictive ($Pr(Success)L1 = 0$) and policy in destination 2 is most liberal ($Pr(Success)L2 = 1$), destination 2 accumulates 33% more migrants than destination 1 at the end of 24 simulated years. However, reorientation from the traditional to the alternative destination decreases sharply as destination 1 relaxes restrictions even slightly. Holding $Pr(Success)L2$ at 1, $S_{t=24}$ drops from 0.33 to 0 when $Pr(Success)L1$ is just 0.08. That is, as soon as destination 1 accepts 8% of all migrants, destination 2 – despite being extremely liberal – loses its dominance.

Figure 9.3b shows that return migration has a significant effect on the reorientation of flows. A cursory look at the grid surface shows a substantial tendency for the alternative destination to replace the traditional one. The upper left triangular of the grid displays values of $S_{t=24}$ that are mostly larger than 0. Where the dominant destination is at its most restrictive and the alternative at its most liberal, L2 effectively replaces L1 as the sole migration corridor ($S_{t=24} = 1$). Once the probability of entry in destination 1 is equal to or surpasses 78%, corridors will not shift regardless of policy in destination 2, but some spatial reorientation still takes place at high values of $Pr(Success)L2$.

To lend further context, it is useful to explain the mechanism by which reorientation takes place. In the simple case where destination 2 is closed, the migrant stock in both destinations varies as agents return and emigrate. Agents will make an average of 5 migration trips in a 24-year simulated period if they are able to enter the traditional destination when they please. As we restrict migrant entry to L1, however, agents are able to return home freely but not necessarily re-migrate. In fact, the average number of migratory trips an agent takes to destination 1 decreases linearly as we restrict the probability of entry.

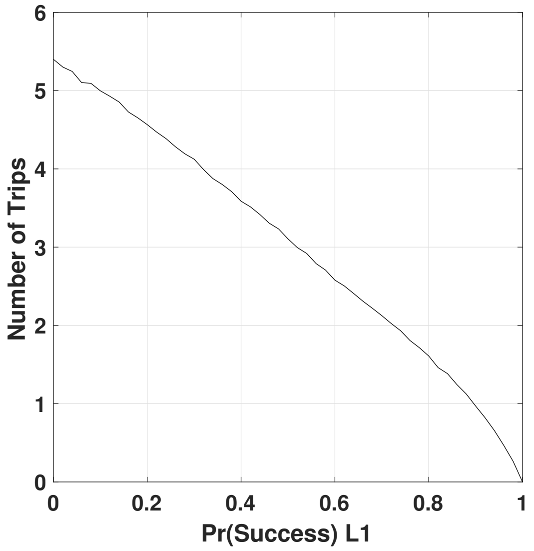


Figure 9.4: *Number of trips to L1 made in a 24-year period when L2 is closed*

As can be seen in Figure 9.4, if half of all applicants are granted a visa, agents will make 3 migration trips to destination 1, on average. When 1 in 10 agents are accepted, agents will only make one migration trip, on average, throughout the 24-year period. This means that, when the probability of being granted a visa to the traditional destination is low, agents will migrate, return, and stay home, reducing the the number of migrants in L1. In this restrictive scenario, new migrants are also unable to replace those returning home. With these two effects taking place, we might expect migration to cease completely. However, as the traditional corridor is contracting, changes are occurring at the micro and meso levels, which will increase the migrant population in L2. Return migration affects the locational composition of *some* agents' networks and may tip these agents' decisions in favour of the alternative destination. These individuals, in turn, may spur network migration towards the alternative destination. Through this process, the system can adapt and corridors can shift in response to hostile policy conditions.

However, a more restrictive policy does not always lead to greater spatial reorientation. Figure 9.3b shows that the relationship between policy restrictiveness in the traditional destination and the value of $Pr(Success)L2$ required to make the alternative location dominant is non-linear. Specifically, the alternative destination will have more difficulty becoming dominant when immigration policy in the traditional destination is extremely restrictive. However, if the traditional destination loosens its entry policy by a only small amount, becoming dominant becomes much easier for L2. When the probability of entry in destination 1 is just 2%, destination 2 must be willing to admit approximately 5 times more migrants to become dominant. By comparison, when $Pr(Success)L1 = 10\%$, destination 2 needs to admit 2.5 times more migrants than destination 1 to become dominant and, when $Pr(Success)L1 = 20\%$, it needs to admit only double that of destination 1. This finding is counter-intuitive as it should be easier for the alternative destination to become dominant when destination 1 is extremely restrictive.

Further exploration on this finding uncovers an interesting avenue for future research: the pre-existence of a corridor – and the financial benefits this entails – may, in fact, be conducive to the establishment of an alternative one. As mentioned, spatial reorientation takes place because aspiring migrants have networks with different locational compositions. For example, at the start of the simulation, one agent may have one-sixth of their migrant network living in the alternative destination and a second agent may have none. As these agents' network contacts return home from the dominant destination, where most migrants were located at the start of the simulation, the composition their migrant networks will change. The first agent may find that her only migrant contact is now in destination 2 and may now wish to migrate there instead. However, migration is costly and having monetary resources is a necessary condition for migration into *any* destination. If prevailing policy in destination 1 does not allow aspiring migrants to enter, they cannot reap the financial benefits of migration to re-migrate or help other aspiring migrants mitigate the costs of movement through remittances. As such, agents who may have wished to migrate to an alternative destination and facilitate the establishment of a new corridor are unable to do so.

In real life, several factors may inhibit our observation of spatial reorientation. First, we may not be able to observe extreme differences in policy across major labour importing countries (Hollifield et al., 2014). As an illustration, let us consider the case where country 1 grants a visa to 8 percent of applicants (the probability of a Mexican applicant obtaining a U.S. green card in 2012 was 7 percent, according to MMP data). According to simulation results, in order for country 2 to become dominant, it must grant a visa to 24 percent of applicants *from this origin country* in a given year – more than 3 times the percent admitted in country 1. In real life, this scenario may be unlikely. If the alternative destination is desirable for migrants and the demand for labour is relatively similar to that of destination 1, destination 2 may also employ tough policy restrictions to curtail otherwise large immigration flows.

Second, the policy impacts we observe will be dependent on the point in time at which we look. The following set of results examine fluctuations in destination dominance over time. Figures 9.5 and 9.6 focus in on the patterns displayed in Figure 9.3b. Figure 9.5 displays the average number of times, within a 24-year run, where differences between the stock of migrants in destination 1 and destination 2 cross zero. Lighter hues signify a larger number of crossovers, or number of times dominance fluctuates from one location to the other.

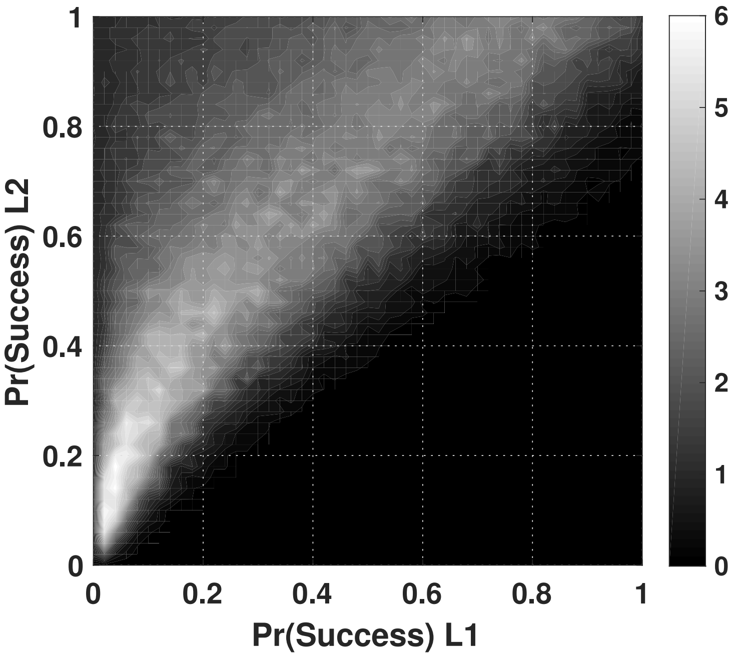


Figure 9.5: *Average number of fluctuations in destination dominance*

The average number of crossovers in the parameter space delimited by $Pr(Success)L1 \leq Pr(Success)L2$ is 2.7, with the highest activity concentrated at low values of $Pr(Success)L1$ and $Pr(Success)L2$, where there may be up to 6 crossovers. Most fluctuation in this area takes place where entry policies are similar, as it is in these cases that migrant stock may tend to become equal across destinations over time. This convergence, in turn, generates more indifferent potential migrants choosing destinations at random. In the area where $Pr(Success)L2$ is decisively larger than $Pr(Success)L1$, the number of crossovers decreases substantially. The remaining parameter space (the bottom-right triangular of the grid) is very stable (0.16 crossovers on average), indicating that agents are continually flowing to destination 1, where a majority of migrants were placed at initialization.

Agents have networks with different locational compositions and are affected by random migration events which can generate distinct path-dependent outcomes. As such, new corridors to destinations with lower immigration restrictions may not always establish themselves or may display a high degree of instability over time. Figure 9.6 displays a range of migration patterns that emerge over time when policy in destination 1 is set to an 8% probability of successful entry and set at 80% success in destination 2. Figure 9.6a shows the case of a simple crossover, while 9.6b shows some instability before a new corridor establishes itself after year 7. Figure 9.6c shows a case where the proportion of migrants in both locations is equal at three points in time but destination 2 never becomes dominant. Figure 9.6d displays a case of where instability remains high across time. Future work will examine how these patterns may be affected by network size. A larger network may result in agents' destination utility being less sensitive to the movement of few individuals.

In this model, agents take short trips, which likely enhances the rate at which the system is able to adapt and corridors can shift. Averaged over

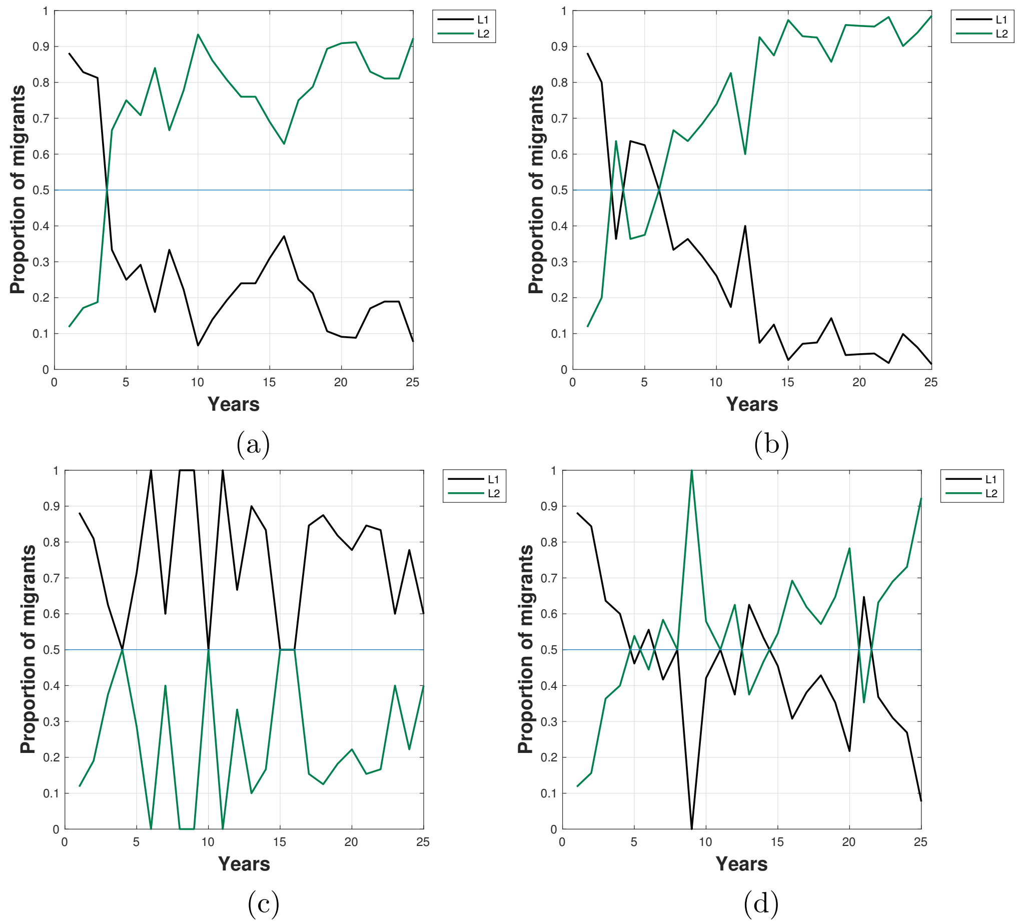


Figure 9.6: *Proportion of migrants in each destination,* $P(Success)L1 = 0.08$ *and* $P(Success)L2 = 0.8$

100 model runs, approximately 56% of migrants remain abroad for one year, 12% of migrants remain abroad for two years and 3.4% remain abroad for three years. For simplicity, these calculations are based on a setting where probability of successful entry to both destinations is 0.8, but length of stay is not directly affected by entry policy setting. These results are similar to the length of stay distribution for the MMP sample used. Pooled across the full timespan of the data, 52% of the sample remain abroad for one year, 18% remain abroad for two years and 9.6% remain abroad for three years

(see Appendix B.2). However, it is important to note that US-Mexico return migration patterns have changed throughout the 1989 to 2013 time period and short-term migration has, for many, given way to longer stays abroad. This trend, which cannot be observed in this stylised model, is discussed in further detail below. We can expect the dynamic effects of return migration on the adaptation of flows to be reduced with prolonged migration trips.

9.4 Discussion

This thesis seeks to understand how individuals adapt to changes in immigration policy with the aid of their social networks. In this chapter, I examine a particular form of adaptation: spatial reorientation. Unlike unauthorised migration – the focus of previous chapters – the role of social networks in spatial reorientation is unclear. Network theory holds that once a migration corridor has been established, flows will not reorient to an alternative destination when immigration policy becomes restrictive (De Haas, 2010). However, empirical studies have shown that spatial reorientation *does* take place. I formalise social network theory as an agent-based computational model to examine whether these, seemingly mutually exclusive, outcomes can coexist.

This chapter integrates literature explaining emigration and return, which is often dissociated. It also extends the explanatory power of network theories by showing that the same behavioural rules that predict geographical clustering can also predict the reorientation of flows under conditions of policy inequality across destination options. However, this only happens when we consider return migration.

Results show that, if return migration is not enabled, spatial reorientation takes place only at extreme levels of policy restriction in traditional destination. The presence of return migration has a significant effect. In contrast to the no return model, even minor differences between policy settings in the traditional and the alternative destination (where the former is more restrictive) leads to the alternative destination replacing the dominant one. I also examine the behaviour of corridors over time. These results show that new corridors are not always stable and may contract and reform at various points over time, depending on the policy environment. An new corridor's hold is likely to be particularly weak when policies are strict across destination options. These results indicate that immigration policy restriction can, in fact, have an important effect on network migration, despite theoretical explanations. Policies can lead corridors to contract and re-form. Moreover, this effect can be explained by social network theories when we take return migration into account.

This chapter contributes to literature seeking to understand the wide-ranging effects of immigration policy and does so from the perspective of network theory, which has, to date, provided one of the most recognized explanations for why migrants from a given origin form geographical clusters in host countries or regions (Epstein, 2008). This simple model will lay the foundation for future work exploring individuals' complex interactions with immigration policy. Spatial reorientation is just one of a wide range of 'substitution effects' resulting from trade-offs in decision-making when faced with tough entry laws. As I will discuss in the next and final chapter, individuals faced with policy restrictions may adapt by changing the date of departure in expectation of a policy shift ('intertemporal substitution'), migrating through other (il)legal channels ('categorical substitution'), and extending the duration of their stay abroad ('reverse-flow substitution') – in addition to choosing an alternative destination ('spatial substitution') (De Haas, 2011).

Reverse-flow substitution, has been widely documented in Mexico-US migration. Several studies have observed that migrants first consider whether they will be able to re-enter the U.S. in the future before they decide to return. The circular movement that characterised migration prior to IRCA has given way to prolonged or permanent stays abroad (e.g. Durand et al., 1999, Massey and Pren, 2012, De Haas, 2011). In the light of the results presented in this chapter, reverse-flow substitution is likely to reduce spatial reorientation. Additionally, undocumented migration can allow geographical clustering to continue, defying visa restrictions. As such, unauthorised migration can also reduce spatial reorientation. Future extensions of this simulation model will seek to factor policy tightening into return intentions and undocumented movement, and observe the extent to which these effects interact with spatial reorientation.

By focusing on only two forms of adaptation – unauthorised migration and spatial substitution – the work covered in this thesis has only scratched the surface. Next chapter concludes this thesis and describes plans for future work, including extensions to the model that can incorporate a wider range of adaptive behaviour and help us understand how they interact with one another.

Chapter 10

Summary and Discussion

The aim of this thesis was to examine how migration flows adapt to changing immigration policies with the help of their social networks, specifically by adopting illegal routes or alternative destinations. Despite a widespread consensus that immigration cannot be "turned off like a tap" by restricting entry (Castles, 2004a), no systematic empirical research exists to assess what migrants *do* when their options for migration are limited (De Haas, 2011). I have argued that the study of migration needs to take seriously the role of individual agency when movement is restricted and must also explicitly examine the network-based feedback processes that help migrants adapt. This perspective can allow us to understand the full impact of immigration policies by expanding our scope of expected migrant behaviours.

My thesis develops a new agency-centred, multi-level theoretical framework for the study of migration decisions under immigration policy constraints, drawing from literature across the social and behavioural sciences. Methodologically, it presents a new approach to: (1) observe clandestine populations, (2) examine policy targets' adaptive responses while overcoming challenges in causal identification, (3) capture the complex outcomes that emerge at the macro-level when policy information is spread across networks, and (4) bridge migratory processes occurring at macro- meso and micro levels. Specifically, I use agent-based computational modeling (ABM) to naturally integrate a series of individual-level empirical designs targeting key parts of migrants' decision-making process. This combination of methods allows us to examine the effects of potential policy scenarios and their counterfactuals, which are impossible or impractical to observe in real life. From a policy standpoint, these capabilities can be very useful as they can help policymakers anticipate the outcomes of policies before implementing them, and it can also help us improve policy design by identifying numerical thresholds or parameter ranges (e.g. level of enforcement or visa quotas) that will yield the desired effects. In short, this approach can help governments make better informed cost-benefit decisions and substantially aid the policy design process. This work sets the stage for a new research agenda that uses simulation models as both a guide and a thread that ties together a set of targetted empirical designs. Future work will both (a) expand the purview of my research questions and (b) refine data collection and design techniques.

The chapters of this thesis are organised around the design, implementation and results of an agent-based model of unauthorised migration. Chapters 2 to 4 provide a general background of the model, Chapters 5 and 6 refer to the empirical specification and calibration of specific portions of the model. Chapters 7 and 8 present the results of the agent-based model of unauthorised migration, integrating all the work shown in previous chapters. The last chapter of my thesis, Chapter 9, expands beyond unauthorised migration to examine another form adaptation: the reorientation of migrants to alternative destinations.

Specifically, Chapter 2 builds the theoretical framework that guides the ABM of unauthorised migration and some aspects of Chapter 9. I critically review interdisciplinary literature on migration, decision-making and the rule of law with a particular focus on their treatment of individual agency and their implications on our study of the effects of immigration policy. Drawing from this literature, I develop eight premises:

1. *Migration is non-binary.* States' laws and entry classifications define different migration modes, spanning legal and illegal forms of migration. The decision to migrate cannot be understood without considering the different situation individuals find themselves in within each mode.

2. *The effects of policy are heterogeneous.* The legal categorisation of migration gives individuals with different demographic profiles and relationships abroad different opportunities (Carling, 2002; Borjas, 1989a).

3. *Inequalities between aspiration and perceived ability drive unauthorised migration.* (a) Individuals may consider migrating through unauthorised channels if policy constraints make it difficult or impossible for them to migrate legally (Carling, 2002; Castles, 2004a). However, (b) a continued aspiration to migrate is a necessary pre-condition for unauthorised migration.

4. *Potential migrants' agency under policy constraints lies in their re-*

flexivity. Individuals are not atomistic utility maximisers. They are reflexive and creative, and may not respond in predictable ways to immigration policy. This definition follows Giddens' 'ontology of potentials' (Cohen, 1989).

5. *Individuals' understanding of policy is limited.* Individuals learn by probing their environment and learning from others and use simple heuristics for decision-making (Simon, 1972; Gigerenzer and Selten, 2002). This is one of, possibly multiple, observable behaviours stemming from the conception of agency described above. Individuals also send and receive information that may be biased (Sabates-Wheeler et al., 2009; Ryo, 2015; Wason, 1960; Yaniv and Kleinberger, 2000).

6. *Potential migrants adapt to policy environments.* Migrants adjust to conditions that are negatively affecting their well-being by actively searching for opportunities within objective conditions. It is highly likely that such opportunities will exist in within the 'immigration interface' (Carling, 2002; Hollifield et al., 2014).

7. *Migration is a multi-level process.* The effect of immigration policy trickles down from the macro-level to the decision-maker and her social context (Hagen-Zanker and Mallett, 2016).

Chapter 3 reviews literature using data-driven agent-based modelling to study migration. I focus specifically on strategies for incorporating empirics in ABMs. Based on this analysis, I propose a proactive approach to empirical embeddedness, which integrates the design, analysis and presentation of empirical pieces with the computational modelling process. This approach sets the stage for a description of the *Migration, Decisions and Policy* survey in Chapter 4. This survey was designed specifically to inform and calibrate the ABM of unauthorised migration. Chapter 4 also provides details on case selection, as well as an overview, including descriptive statistics, of the variables used in or to inform the model.

Chapters 5 and 6 address key ABM design choices and empirical questions that arose when specifying the ABM of unauthorised migration: (1) Does policy decrease perceived ability only? or also aspiration? (2) Does the aspiration/ ability gap drive support for illegal strategies? (3) Does successful past migration and successful migration of network ties increase perceived ability to migrate? Do past failures to migrate decrease perceived ability to migrate? These questions represented key elements of model design and therefore required empirical testing to evaluate whether these theoretical relationships were present in the data used to calibrate the ABM of unauthorised migration, as argued in Chapter 3. Answering these questions is also important for theoretical development. First, we know that immigration policy is likely to reduce people's perceived ability to migrate, but migration scholars have provided contradictory expectations on whether aspirations are affected as well (e.g. Carling, 2002; Castles, 2004a). This question also sits at the crux of an important social theory debate: Do individuals' adapt their expected life choices to objective conditions, as Bourdieu's concept of habitus might suggest (Inglis and Thorpe, 2012, p. 214-215), or do they search for opportunities within these conditions in order to further their goals? (Cohen, 1989). These two underlying mechanisms would, in practice, give way to two very different types of behavioural outcomes: non-migration or a range of creative alternatives, including unauthorised migration strategies, respectively – addressing our second question. The third question, which regards learning and feedback has been explored by few researchers (Ryo, 2015; Sabates-Wheeler et al., 2009; Reyes et al., 2002; Hernández-Carretero, 2008). As such, there is little theoretical or empirical guidance as to how failures affect future attempts from a migration perspective.

These questions were examined using novel experimental and non-experimental items from the *MDP* survey to inform the design of the ABM of unauthorised migration. Chapter 5 tackles the first and third questions by examining the effects of receiving information about immigration policy on aspiration and perceived ability to migrate. The effects of immigration policy are difficult to isolate from other factors limiting migration using observational data. Immigration policy is also not exogenous: policies might respond to migration flows and vice-versa and we, generally, cannot observe the outcomes that might have occurred in the absence of policy change. These threats to causal identification are mitigated through an experimental design. Chapter 5 examines the effects of receiving information about immigration policy on aspiration and perceived ability to migrate by randomly assigning individuals to view a short video about immigration policy. Findings showed that, while perceived ability to migrate was affected by information about immigration policy, aspiration to migrate was not. These findings were complemented with a multiple regression analysis that leveraged novel network and migration history items in the *MDP* survey. These analyses showed that past migration experiences negatively affected individuals' perceived ability to migrate and that network ties' successful migration experiences positively affected individuals' perceived ability to migrate. Numerical findings from Chapter 5 are used to calibrate a key variables of the ABM of unauthorised migration, relating to the influence of policy on migrant decision-making.

Answering the second question – whether involuntary immobility drives unauthorised migration – is not straight-forward. As this topic is sensitive, social desirability bias may affect measurement (Glynn, 2013; Kuklinski et al., 1997). Chapter 6 describes and examines the results of a list experiment, a novel approach to measurement that protects individuals' privacy and thereby limits these effects. Experimental results show that a perceived gap between aspiration and ability *is* associated with a higher likelihood of supporting two types of unauthorised strategies: full-noncompliance and semi-noncompliance (defined in Chapter 2). This analysis lends evidence to the specification and calibration of the relationship between involuntary immobility and unauthorised migration in the model. Chapter 7 presents the ABM of unauthorised migration, bringing together the work presented in all previous chapters. The results of this model show that barriers to family and low-skilled migration have the largest effects on migrant reorientation towards unauthorised channels and that border enforcement is ineffective.

In the ABM of unauthorised migration agents were assumed to objectively evaluate information about immigration policy. However, it is likely that individuals weight information differently, depending on whether it is positive or negative, or whether it is based on one's own experience or those of others. Following literature on cognitive biases reviewed in Chapter 2 (e.g. Wason, 1960; Yaniv and Kleinberger, 2000), Chapter 8 examines whether the manner in which individuals weight feedback can have effects on macro level migration patterns. This is done through further experimentation on the ABM of unauthorised migration.

In chapter 9, I evaluate another form of adaptation: reorientation towards other destinations. This type of reorientation is a theoretical puzzle: We know that spatial reorientation takes place (e.g. Ellis et al., 2014; Collyer, 2005) and we know that networks are essential in perpetuating migration flows. However, network theories cannot explain how reorientation takes place. Because network benefits are location-specific, theory expects migration to emerge in robust spatially clustered patterns that will not shift when policy is restricted. I use agent-based modelling as a "complex thought experiment" (Cederman, 1997) to examine the conditions under which spatial reorientation may emerge in a networked system. I find that an oft-neglected aspect of migration – return – helps the spatial distribution of migration update periodically, allowing corridors to shift in space.

10.1 Future Work

Several avenues of future research were identified in previous chapters. I develop them further in this section and point to additional paths that may be taken.

10.1.1 Substitution Effects and Interdependencies

In this thesis, I have examined two forms of reorientation to immigration policy restriction: unauthorised migration and movement to other destination countries. However, as mentioned in the previous chapter, these behaviours only scratch the surface of a lengthy research agenda. As part of this research agenda, I intend to implement and further develop the theoretical framework presented in this thesis to examine other types of adaptive behaviours and their interdependencies. When adopting an agency-centred perspective, it is possible to conceptualise migrant decision-making as consisting of a wide range of creative options. De Haas' (2011) 'substitution effects' (see Chapter 2) are a good starting point.

Categorical Substitution

Categorical substitution refers individuals' choice to shift across legally defined categories. In chapters 5 to 8 of this thesis, I have focused on one type of categorical substitution: the movement from any legal category to an illegal category. I have assumed that individuals are indifferent across the various legal categories available to them and will choose randomly across them. However, aspiring migrants are likely to have distinct preferences across legal categories. Visas such as family reunification may give individuals the opportunity to migrate abroad permanently, whereas a low-skilled guest worker permit will not; some visas are attached to particular forms of employment, which may restrict migrants' career mobility. The exchange visitor visa in the US, for example, is attached to employment for the visa sponsor (US Department of State, 2018). Future fieldwork will gather evidence on whether individuals follow an ordered set of preferences when shifting across the visa categories available to them.

Spatial Substitution

In Chapter 9, I have examined the reorientation of individuals to countries with laxer policy measures with the aim of understanding the mechanism underlying this sort of reorientation in a networked system. However, for some empirical cases it may be interesting to conceptualise spatial reorientation as continuous and more closely tied to physical and monetary impediments and facilitators as well as location-specific border policing. For example, since the 1990's crossings along the US border are constantly shifting in response to Border Patrol crack downs on specific sections. In 2013, illegal border crossings shifted from Arizona to Rio Grande Valley of South Texas – leading to a very different type of crossing. According to the *New York Times*, this shift entailed "makeshift rafts crossing the river in increasing numbers, high-speed car chases occurring along rural roads and a growing number of dead bodies turning up on ranchers' land" (Lipton and Preston, 2013). The effect of physical distance may also make treks more difficult and payment to smugglers more onerous (Kulish, 2018). These physical factors likely play a part in shaping the spatial shifts that take place.

Inter-temporal Substitution

Anticipation of changing policy can trigger 'now or never' migration. This sort of behaviour can affect measurement. A pre-policy surge in flows may create an artificially high baseline, affecting our comparison with post-policy measures (Czaika and De Haas, 2013). This sort of 'now or never' migration was documented in 2016 in response to US President Donald Trump's plans to build a border wall (Dart, 2016). The UK, similarly, saw a pre- EU referendum inflow of 284,000 EU citizens leading the country to reach a record level of immigration (650,000 people) (Travis, 2016). Ongoing research on refugees displaced in the Mediterranean has found that migrants respond to signals from political rhetoric before a policy is even implemented (Jakli et al., 2018).

Reverse-flow Substitution

As mentioned in Chapter 9, restrictive policies can discourage return migration for fear of a difficult re-entry, if it were to be needed. Massey (2005) shows that increased enforcement unintentionally encourages illegal migrants to remain in the United States by driving up the cost of border crossing.

Viewed from the perspective of the decision-maker, these adaptive mechanisms can be conceived as trade-offs. One may not wish to migrate irregularly and, therefore, chooses to move to a more liberal destination instead. Strategies may also be conceptualised as multifaceted. In many of the examples above, individuals adopt unauthorised routes in addition to shifting their entry point into a country, or choosing to remain abroad longer than they would have. This interdependence is important because considering various forms of substitution simultaneously, may change our expectations on the incidence of any given adaptive behaviour on its own. In the long-term, I aim to build an agent-based model where all these adaptive behaviours are in place and migrants can shift across them depending on their personal preferences and characteristics, as well as the characteristics of the alternative itself.

A further question that future ABM research might seek to address is whether policy effects on the above behaviours are asymmetric (Czaika and de Haas, 2016). For example, Is the magnitude of effect observed when transitioning from a more restrictive-policy scenario A to a more liberal-policy scenario B equivalent to the transition from scenario B to A, or does the size of the effect depend on the direction of the change? Answering this question would require restricting or liberalising policies at different points within a simulation run.

10.1.2 Migration Contexts

In this thesis I have focused mainly on migration from Jamaica. I have used data from Mexico to inform parameters in the theoretical model presented in Chapter 9, but I did not do so with the intention of examining the Mexican case in particular. The use of data in this case was simply to anchor parameters to realistic values.

Future work will seek to extend beyond the case of Jamaica to various other migration contexts. I have identified two types of contexts that are particularly useful to extend the explanatory power of the ABM of unauthorised migration: (1) different demographies and migration histories, and (2) different types and magnitudes of migration pressures.

Demographic and Historical Contexts

Jamaica differs from other source countries because of the migration related characteristics of its citizens as well as its migration history. As mentioned in Chapter 4, Jamaica has a long history of emigration and a large diaspora abroad (Thomas-Hope, 1992; Glennie and Chappell, 2010). This is a characteristic feature of islands. Islanders often look abroad to escape harsh living conditions, as well as relative seclusion compared to the mainland in terms of resources, employment and other opportunities (Burholt et al., 2013; Thomas-Hope, 1992). Emigration drives further emigration because of its developmental impacts (e.g. brain drain (Glennie and Chappell, 2010)) and because it becomes ingrained in the culture and traditions of the island. That is, migration is part of an islander's set of alternatives simply because it has been practised throughout history (Bourdieu, 1977). As such, Jamaican migration may differ, specifically, from mainland emigration in important respects.

Results will also vary when compared to countries where fewer individuals aspire to move abroad or have greater access to additional legal channels. The complexity of this phenomenon makes it difficult to form expectations, attesting to the need for a model that identifies the various dynamic aspects that can feed into the decision-making and behaviour of migrants. We could consider the case of Mexico, for example. Mexican citizens tend to have much lower intentions to live or work abroad than Jamaicans (Zechmeister, 2014), but are also generally wealthier – with a GDP per capita almost double that of Jamaica (World Bank, 2016) and therefore will likely have a relatively higher ability to migrate legally. At the same time, the well established tradition of *coyotaje*, or the hiring of smugglers, in Mexico may also make illegal migration easier and more accessible to this population (Spener, 2009). Likewise, we could examine Indian migrants, who represented the highest proportion of high-skilled (H-1B) visas and the second highest proportion of student visas to the US in 2016. Indian nationals accounted for 74 percent of the 345,000 H-1B petitions approved by the U.S. Citizenship and Immigration Services (USCIS) that year, and 16 percent of the 1 million international students (Zong and Batalova, 2017). These circumstances are notably distinct from those of Jamaican migrants, for whom high-skilled and student visas are largely inaccessible.

Pressure Contexts

In this thesis, I have examined cases of voluntary migration. However, migrants flee to escape conflict, environmental change, persecution, as well as extreme poverty. These drivers often intertwine to form unique pressure scenarios. According to a 2011 UK Government report, environmental change will become an increasingly important factor driving migration decisions in the next decades, around the world. While 17 million individuals around the world were displaced by natural hazards in 2009, this figure rose to 42 million in 2010. Compared to 2000, there may be between 114 and 192 million additional people in urban areas of Africa and Asia whose homes will be in floodplains by 2060 (Foresight, 2011).

Environmental change is interlinked with other drivers of migration, such as poverty and conflict. In 2004-2006, for example, temporary labour migration among Kenyan households that were farming land with high quality soil was 67% lower than in households using poor soils. Increased levels of drought due to climate change is, therefore, expected to increase migration pressures (Black et al., 2011). El Salvador is another example of a country facing interlinked migration pressures. El Salvador is part of Central America's 'Dry Corridor' and, according to a 2016 FAO report, is suffering from one of the worst droughts in recent history, with 3.5 million in need of humanitarian assistance (FAO, 2016). Large-scale violence perpetrated by armed criminal gangs at the origin and in transit areas simultaneously drives individuals to flee and endangers their journey into and through Mexico (Amnesty International, 2017).

Migrants fleeing from extreme pressure are likely to make decisions in a very different way than the voluntary migrants depicted in this thesis: Flows are likely to have different characteristics and the role of the receiving state will also be different. Hein (1993) describes several characteristics that make refugee flows different from voluntary migration. First, although refugees organise migration through social networks, similar to voluntary migrants, the demographic composition of network migration is different. Social networks for voluntary migration are selective – networks abroad help others that are like them (Faist, 1997). However "refugee populations include many persons who would not leave home on a voluntary basis" (Gold, 1992, p. 17). Refugee migrations are also more often composed of families than individuals. This is due to the need to leave an area of danger, but also due to admissions systems that facilitate group migration (Hein, 1993, p. 50). Second, refugee crises will produce distinct migration waves with similar dates of departure, while voluntary migration may not take place in such distinct temporal clusters. Third, refugee migration seeks protection of the receiving state and, therefore, the state is more involved in the adaptation of the migrant to the host country.

A model similar to the ABM of unauthorised migration applied to these distinct migration contexts can generate interesting differences worth examining in detail.

10.1.3 Other Barriers to Migration

In this thesis, I have concentrated on isolating the effects of immigration policy on migration flows. According to Carling (2002, p. 26), "today, a person wishing to migrate from a poor country to a wealthy country is likely to find that the greatest barriers are connected to the destination country's immigration policies." This is because social contacts can, in theory, help mitigate many of the financial difficulties involved in voluntary migration by providing credit for the journey. A visa, on the other hand, cannot be negotiated.

However, not all individuals are able surpass non-policy barriers to migration. Bryan et al. (2011) test the effects of providing a small monetary incentive on internal migration rates during famine season in Bangladesh. Individuals from 100 Bangladeshi villages were randomly allocated to one of three treatment conditions (cash, loan and information treatment) or a control group. The cash and loan treatments consisted of providing $8.50 - the cost of a round-trip ticket - either upfront, or in the form of a zero-interest loan with limited liability. The third treatment group were provided with information about jobs at the destination. Researchers monitored actual migration flows carefully and added an extra incentive of $3.00 for households reporting having migrated to the destination. The authors found a 22 percent increase in movement at the household level for treatment groups, relative to the control group. Moreover, the migration rate was 10 percentage points higher in treatment areas a year later, and 8 percentage points higher three years later after the incentive was removed. This study showed that seemingly small barriers to migration can have substantial effects on migration rates. As alluded to above, any study that considers the financial barriers to migration must also take into account the importance of financial transfers across networks, as was done in Chapter 9. Future extensions of the ABM of unauthorised migration will incorporate these aspects.

This stream of future work can also be tied to research on other pressure contexts. Many migration pressures can also function as barriers, such that the pressure is "equally likely to make migration less possible as more probable" (Foresight, 2011, p. 9). Individuals experiencing conflict or violence may face a great deal of danger when attempting to escape, as mentioned in the context of El Salvador (Amnesty International, 2017). Similarly, individuals driven to poverty by climate change or any other factors will have the most need and as well as the greatest difficulty in migrating (De Haas, 2007).

10.1.4 Developing a Better Understanding of Migrant Decisions

To identify agents' rules for behaviour, this thesis used quantitative, statistical methods to find support for the presence or absence as well as the magnitude of relationships within a theoretical decision model. This approach is useful because it allows us to find numerical parameters necessary for calibrating an ABM and it also allows us to infer whether relationships are likely to be present beyond our limited sample.

However, relative to qualitative methods, this approach has two important shortcomings. First, finding support for indicators of a theory in a quantitative sense does not mean the theoretical *mechanism* is present in the data. That is, we can find support for a set of rules but not for the way these rules hang together in a decision process. Second, statistical inference relies on observations being independent of one another. This hampers our ability to observe and find evidence for the interaction processes depicted in the model.

Qualitative techniques can help mitigate both concerns and may be used in conjunction with quantitative approaches. As mentioned in Chapter 3, modellers have used a range of different qualitative techniques such as 'role playing' or 'companion modelling.' In these techniques, the subjects represented in the model provide the researcher with direct information about model rules. Modellers usually present participants with a representation of the model in a workshop, for example, which sets the stage for a focused discussion that can help modellers refine its rules (Janssen and Ostrom, 2006; Naivinit et al., 2010).[1]

Regardless of whether or not we use the model as an elicitation technique, the use of qualitative evidence can improve our understanding of the decision process (Tubaro and Casilli, 2010). Qualitative strategies can include in-depth interviews, focus groups (where subjects are asked to discuss top-

[1]However, having a model in place can potentially also 'lead' participants to confirm the current model rather than alter it.

ics of interest in small groups), ethnography (where researchers observe, or observe and participate, in the life of the subjects of interest) and a variety of other methods (Berg, 2009). Modellers may use a combination of these techniques to obtain answers to different questions prompted by the modelling process. For example, interviews can be useful for gaining in-depth information about decision-making unaffected by group dynamics. Focus groups and ethnographies, on the other hand, allow us observe the effects of social context and can be useful for developing rules for agent interaction (I expand on this point below). Focus groups also lend themselves to depicting hypothetical scenarios or conducting experiments, much in the same way as an ABM. In future work, I plan to incorporate qualitative methods in the first stages of the model design, as suggested in the 'Proactive Approach to Empirical Embeddedness' developed in Chapter 3.

10.1.5 Developing a Better Understanding of Network Structures

There is a lack of evidence on the structural characteristics of migrant networks (Fazito and Soares, 2013). This is, in part, due to the costs involved in collecting information on full networks, as required when building a networked system of agents in a computational model. Random sampling provides a way to generate inferences about a population without surveying everyone in it, which significantly reduces the costs of data collection. However, when collecting social network data, we want to observe interdependencies and, therefore, we must survey the whole population of interest. Due to budget constraints, this thesis used existing theory to generate social networks in the ABM rather than collecting full network data. However, the process of combining ABM with empirics helped illuminate some cost-effective strategies to develop a better understanding of network structures in future work. These strategies involve identifying the *rules* for network formation empirically and then growing the network in the ABM.

Focus groups provide a suitable method for extracting the rules for network formation because they allow interaction to take place in a controlled setting. The formation of social networks can be observed through the analysis of a focus group transcript and may be further facilitated through the use of a private survey conducted after the discussion takes place. For example, using social network name generators, we can elicit information about how focus group participants perceived one another (e.g. a survey question might read: "Please indicate the ID letters of participants with which you agreed" or "Please indicate the ID letters of participants you found most informative"). Using this information, correlated with relevant characteristics of focus group participants, we can construct network matrices on several dimensions of interest. For example, we may be interested in knowing: To what extent do experts (return migrants or individuals with substantial knowledge of immigration policies) become key nodes of influence? Is optimism a significant attractor of migration preferences, as suggested in qualitative migration literature (e.g. Hernández-Carretero and Carling, 2012)?

These types of questions can help us develop rules for growing a network in an ABM. Once we have grown the network, we can, then ask several further questions of the ABM such as, in which cases do individuals converge on an extreme preference (Amblard and Deffuant, 2004), for example an unauthorised migration strategy, and which structural characteristics of the network facilitate this outcome?

10.2 Summary

In summary, this thesis set out to examine how migration systems adapt to changing immigration policies. Specifically, it examined the extent to which migrants adopt unauthorised routes or seek alternative destinations when policies impede entry into the chosen destination. This thesis advances the study of migration and immigration policy on both theoretical and methodological fronts. Drawing on existing theories of migration, this thesis develops a new theoretical approach to examine the effects of immigration policy on adaptive migration systems. It formalises this theory as an ABM informed by and calibrated with an original nation-wide survey of Jamaica. This combination of methods allows us to examine the effects of potential policy scenarios and their counterfactuals. This approach can help governments be better informed about the costs and benefits involved in implementing a policy – regardless of the policy area – and can help design smarter ones. In this chapter, I identified several areas for future work that (a) expand the purview of my research questions and (b) refine data collection and design techniques. These avenues for future work demonstrate how this thesis initiates a promising, long-term research agenda.

Appendices

Appendix A

Chapter 7

A.1 Varying Specification of Attempt Probability on In-Silico Experiment Results

Figure A.1 shows results for alternative values of k, the curvature of the logistic function outputting the probability of attempting migration (see Chapter 7). For each experiment in Figure A.1, I fully restrict one channel at a time, while holding all others to their baseline conditions. As in the main text, all models were run for a duration of 20 years. For each simulation run, I compute the migrant stock accumulated across all simulated years. I then compute the mean of this value across 700 runs.[1] Each bar in Figure A.1 shows changes (as a proportion of aspiring migrants) from the baseline conditions in terms of legal (blue) and illegal (red) migration and non-migration (black).

[1] Results for $k = 1$ displayed in Chapter 7 did not change significantly between 700 to 1000 runs

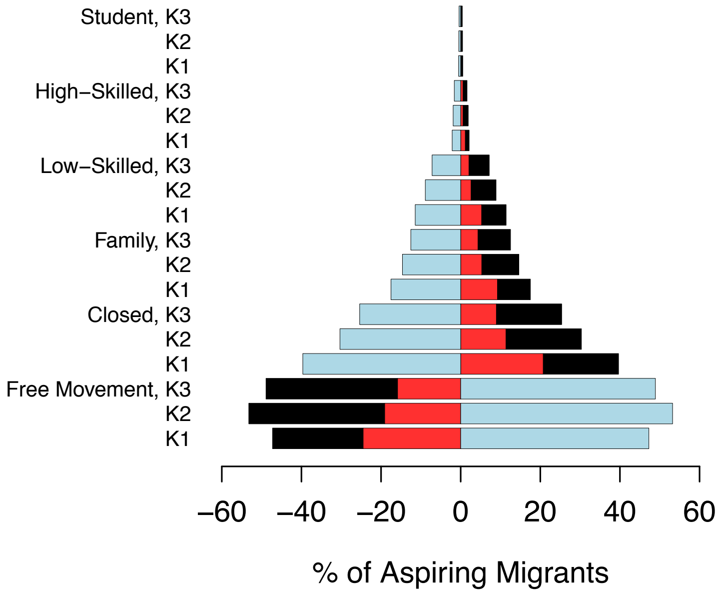


Figure A.1: *Mean effects of policy scenarios on migration outcomes relative to the baseline, alternative ks*

I compare results for $k = 2$ and $k = 3$ to the results reproduced in Chapter 7, where k is set to 1. In general, overall levels of migration increase at lower values of k. This is due to the fact that the initial (survey) distribution of ability values for all three strategies is skewed towards values below the midpoint (see Table 4.2). As such, altering the curvature of the function results in more individuals attempting migration initially, despite low perceived abilities. However, legal, illegal and non-migration ratios remain relatively constant across settings.

A.2 Changing Preferences over Lifecycle

Individuals' preference for migrating may change in tandem with their biographical situation. In this article, we have assumed preferences remain constant over time. Here, we evaluate how sensitive our results are to relaxing this assumption.

There are several lifecycle events that may lead an individuals' aspiration to migrate to change. As Kley (2011, p. 473) suggests, "anticipating life-course events may trigger considering migration by scattering peoples' daily routines and therefore opening their minds for a broader view of possible actions." Several key changes happen in early adulthood: leaving the parental home, starting higher education, beginning one's first job, or entering a partnership or marriage. These life events can trigger a desire to migrate (Mulder and Wagner, 1993; Mulder, 1993). Additionally, the birth of a child has been shown to be a significant driver of domestic migration (Kulu and Milewski, 2007), as couples may seek more spacious dwellings (though evidence is mixed, see Clark and Huang, 2003). Anticipating the birth of a child may also lead couples to seek alternative sources of income through international migration.

These events are "framed by institutions" (Kley, 2011, p. 473) and, as such, we can observe clear aggregate patterns for lifecycle events for different age ranges. Table A.1 shows descriptive statistics from our cross-national survey of Jamaica. As expected, we can see that most individuals pursue higher education between the ages of 18-24. Many individuals start obtaining their first permanent or seasonal job around these ages. However, there is a large spike in the percentage of people working between ages 25-34, indicating that at least as many individuals are obtaining their first job between their mid-twenties and mid-thirties. Most of our respondents had at least one child, but this percentage appears to be higher among respondents who were at least 25 years old (59%-98%). Co-habiting appears to be more common later on in life, with 59% of respondents between 35-44 years of age indicating they had a partner or spouse, in contrast with 30.4% in the 25-34 age range.

Table A.1: *Descriptive Statistics from MDP survey on Lifecycle Events by Age*

Age / Life Cycle Event	Studying	Job	Co-habiting	Child
18-24	32%	30%	6.7%	26.0%
25-34	5.9%	70%	30.4%	59.0%
35-44	1.6%	80%	59.0%	90.0%
45-54	0.1%	77%	55.9%	93.0%
55-64	0.1%	72%	62.9%	98.0%
65+	0%	34%	43.4%	98.0%

As expected, age does have a significant effect on aspiration to migrate, as shown in Table A.2. In fact, aside from prior migration, age is the only significant predictor for aspiration to migrate. The coefficients for age and age squared are, however very small.

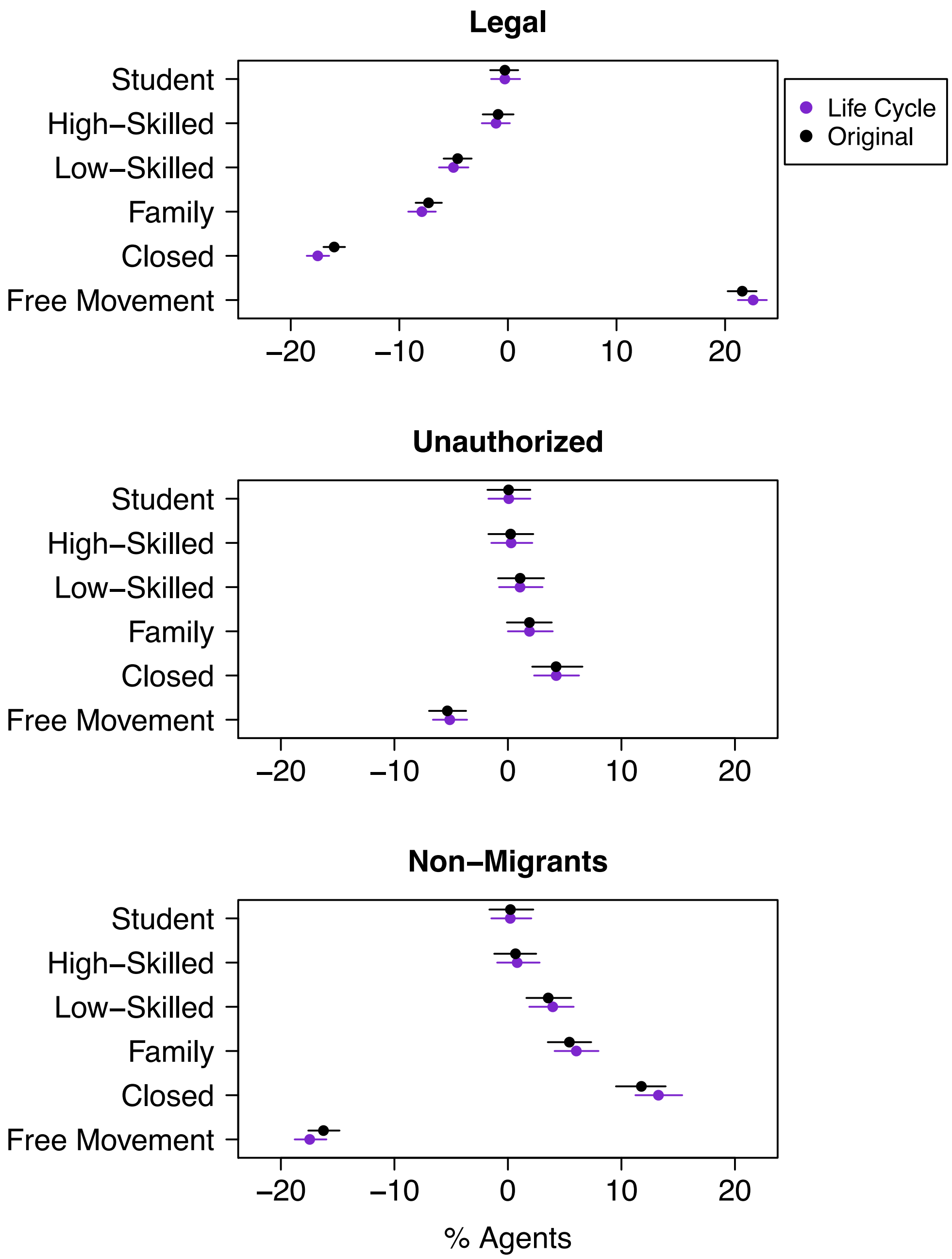
Table A.2: *Effects of Age on Aspiration to Migrate*

	Dependent variable:
	Aspiration to Migrate
Male	−0.073
	(0.110)
Age	0.057***
	(0.020)
Age^2	−0.001***
	(0.0002)
Education	−0.047
	(0.051)
Income	−0.0001
	(0.0001)
Prior Migration (=1)	0.310*
	(0.190)
Family Abroad	0.010
	(0.022)
Constant	5.400***
	(0.460)
Observations	1,128
R^2	0.170
Adjusted R^2	0.160
Note:	*p<0.1; **p<0.05; ***p<0.01

For our in-silico sensitivity tests, aspiration was modelled as a linear function of age. To incorporate stochasticity, equation parameters were allowed to vary randomly across a normal distribution centered around the point estimates described in Table A.2. Specifically, as agents age a year, they update their aspiration to migrate by inputting their new age into a linear function. As coefficients vary randomly across their confidence intervals, the parameters of the function are slightly different each time any agent updated their aspiration to migrate.

Figure A.2 shows the ABM results for this sensitivity test. As aspiration to migrate – the denominator in the main text – is not comparable across the 'Original' (black) and 'Life Cycle' (purple) models, we show outcomes over *number of agents* instead. In all other aspects, Figure A.2 is comparable to Figure 7.7 in Chapter 7: to distinguish the effects of policy, we subtract results from the baseline eligibility model, and each model setting represents the effects of closing a migratory channel completely (except for the Free Movement setting, where channels are removed). As in Chapter 7, Figure A.2 shows averages over 1000 model runs, but also includes the 2.75 and 97.5 percentile error band. As we can see in Figure A.2, there is no significant difference between model outcomes when we model aspiration as a function of age. This is due to the small (though highly significant) effect of age on aspirations shown in Table A.2.

Figure A.2: *Comparison of Models: Changing Aspiration Over Lifecycle and Original*



Appendix B

Chapter 9

B.1 Results With Larger Sample Size

These results, using 8,930 agents, should be compared to Figure 9.3b. The seemingly odd sample size is due to difficulties sizing and dividing the lattice, but results will not differ from a model where 9,000 agents are used, for example. $Pr(Success)L1$ and $Pr(Success)L2$ ranges from 0 to 1 at intervals of 0.2 (in Figure 9.3b intervals are 0.02) and the number of repetitions per parameter combination are 10. Due to the large intervals, the area where no migration takes place due to extreme policy restrictiveness in both locations (bottom-left corner), appears larger than in Figure 9.3b. As can be observed in this figure, results are not significantly affected by number of agents.

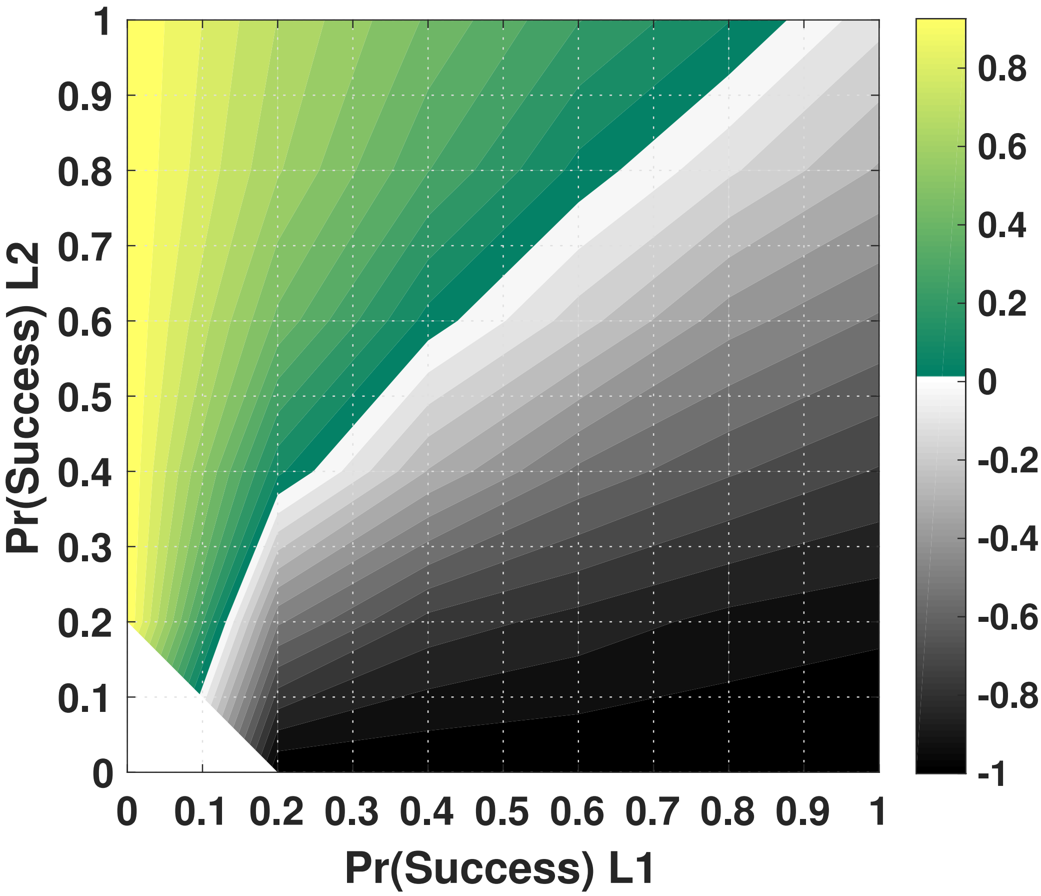
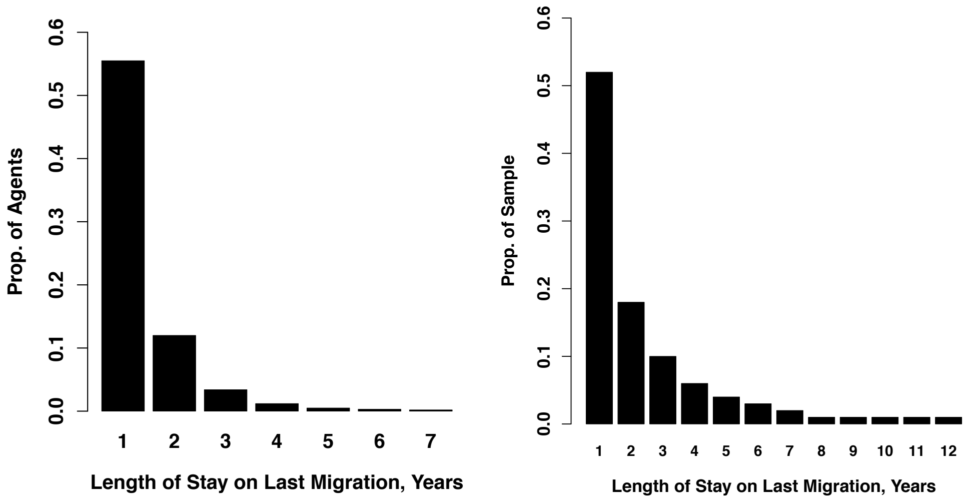


Figure B.1: *Spatial reorientation and dominant corridor shifts across available destinations, return migration turned on*

B.2 Length of Stay Distributions



(a) Proportion of migrant agents by trip duration, ABM

(b) Proportion of MMP (1989-2013) migrant sample by trip duration

Figure B.2: *Distribution of trip durations among migrants*

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