Traveling for happiness, moving to adapt:

An agent-based perspective on population mobility

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September 2017

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Traveling for happiness, moving to adapt:
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Stefano Balbi *

Tourism and human migration research are gradually converging towards agent-based simulations as a methodology for exploring the complex feedbacks between human and natural components within social-ecological systems. Growing attention is given to the causes and effects of global environmental change and the study of social phenomena, as identity, lifestyle and attribution of value, in conjunction with sustainability analysis. Both tourism and migration are related to population mobility, relational values and to the pursuit of happiness, at the individual or at the household scale. Both are deeply affected by the globalization process, which increasingly blurs the distinction between the various classes of spatial-temporal movements. This article attempts to consider tourism and human migration under a unitary research framework, more compatible with the analysis of adaptation to shifting opportunities and social conflict prevention. We touch on the main methodological and thematic elements that indicate the mutual benefits of a combined agent-based perspective.

Keywords: agent-based modeling, population mobility, global environmental change, adaptation, tourism, migration.

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1. Introduction

Moving has always been a fundamental component of human behavior. Traveling—here intended as the generic movement of people in space and time—is a both a direct and indirect strategy to pursuing happiness: be it for leisure, business or other reasons. Happiness can be experienced directly by visiting unknown amusing places, but it also can be approached with increased economic resources generated by commuting to work. At the end of the day, traveling is but one way to increase our wellbeing (or utility for some) as a direct experience in its own right (e.g. leisure, tourism and recreation, volunteering) or as a way to improve our means of existence (e.g. business traveling, commuting, migrating).

Indeed, various classes of spatial-temporal movements exist: most notably, travel and tourism, commuting, seasonal migration, circular migration, temporary migration, nomadism and permanent migration among the others. In the globalized and hyper-connected (virtual and physical) world(s) the distinctions among those classes can become subtle and evolve over time. Take the well-studied example of tourism that later becomes seasonal retirement and finally relocation (Gustafson, 2002; Haug et al., 2007). In other cases the distinction between work and leisure is blurred, for example:

- − a one year work and travel permit (so called "working holiday visa") in Australia after college;

- − a six month to one year Erasmus project (i.e. European Community university exchange program);

- − a winter-sports passionate seasonal worker for an Alpine resort;

- − a sabbatical period for a research professor;

- − a volunteering experience in the developing world, etc.

In this article we discuss a unitary research framework compatible to all the above mentioned classes of population mobility, from travel to permanent change of residence, which considers population mobility in the context of globalization and socio-environmental transformation.

On the one hand globalization has facilitated the movement of people (presumably) and goods (certainly), on the other hand Information & Communication Technology (ICT) development has also increased the flow of information between people and regions, so that it has become much easier to connect to or simply be aware of other "situations" around the world.

Not only tourism destinations compete among each other in the global tourism market place, but also regions compete to attract foreign investments. In the same way people, more and more frequently, decide to move to find better living conditions.

While population mobility in the form of tourism has always had a positive connotation, in the globalization debate, migration has long been neglected or considered an unintended consequence, but it is now moving to a central position comparable to that of trade and investment, due to the ongoing and expected humanitarian crises. On the contrary, it must be recognized that, far from being a purely benign phenomenon, tourism has contributed and contributes significantly to global environmental change (Gössling and Peeters, 2015) and that this change has huge implications on global population mobility. Views on migration are much diversified in the current public debate and according to the different perspectives migration can be addressed as something to avoid and prevent or a legitimate mode of adaptation in the face of global environmental change (Scheffran et al., 2012).

The latter—moving as a strategy to adapt—is increasingly gaining acceptance in the research and climate policy arena since the beginning of the current decade.

Indeed, environmentally induced migration is a fact. Many countries are already experiencing some form of migration associated with environmental and climate change (Ionesco et al., 2016). Human migration is driven by a multitude of factors and almost never by a single cause. At the same time, environmental factors will increasingly influence migration (Black et al., 2011) by affecting the economic, social and political drivers, and in particular by threatening people's livelihoods that depend on a healthy environment. For example, in Bangladesh, moving to cities has become a popular strategy to avoid continuous flooding (Penning-Rowsell et al., 2011). People from Carteret Islands in Papua New Guinea are relocating in response to coastal erosion (Barnett and Webber, 2010). In Kenya, diminished soil quality has led people to travel to diversify their income (Gray, 2011).

It is reasonable to expect more of these cases in the future. The biggest losses in suitable cropland area due to climate change are likely to be in Africa and the continent will contribute 40−50% of the total 90−1,320 million people in developing countries anticipated to be at risk of hunger by 2080 (Schmidhuber and Tubiello, 2007). By 2050, climate change is expected to push hundreds of millions of people—up to 1 billion, by some estimates—to leave their homes seeking better land, jobs and other resources (Tacoli, 2009). This has huge implications for the current international governance of migration that has been sorely tested with "just" 5 millions of Syrian refugees since 2011.

Given the ongoing globalization process and the expected environmental changes, the necessity to have a fresh look at how population mobility could evolve in the next years at the global level emerges clearly. Simulation modeling of social-ecological systems is particularly well-suited to advance the understanding of interdependencies among human and environmental processes factors, including impacts and responses to environmental change (Balbi and Giupponi, 2010), especially in cases where the potential for experimentation is limited. Model-based computational experiments can be of great use to explore possible futures talking into account uncertainty (Kwakkeland and Pruyt, 2013). Among the different simulation and modeling paradigms, *agent-based modeling (ABM)* has proven to be a powerful framework for research on issues related to population mobility (see the reviews on migration: Klabunde and Willekens, 2016; and on tourism: Nichols et al., 2016) and more in general on the behavior of social-ecological systems (Balbi et al., 2010; Filatova et al., 2013).

This article elaborates on the insights of considering the modeling of population mobility from two different angles. In the methodological section we adopt an ABM perspective, touching on the main methodological features that are considered to be useful for both tourism and migration research. As envisioned by O'Sullivan (2008), ABM is here used as a unifying metaphor to describe the interdisciplinary modeling of complex social-ecological systems. In the discussion section we highlight the common challenges that need to be prioritized and the potential of a combined perspective. Finally, we outline the attributes of a comprehensive research framework and summarize the main available tools that, to our experience, can methodologically support it.

2.   Methods: ABM key features in tourism and migration research

From a methodological point of view, both tourism and human migration research are gradually converging on the use of ABM as an appropriate computational tool to explore future dynamics of complex social-ecological systems (Klabunde and Willekens, 2016; Nichols et al., 2016). This is partly a consequence of the need for system thinking and interdisciplinarity in both research fields (for tourism: Amelung et al., 2016; for migration: Ionesco et al., 2016, 12−14). Both research fields are

also becoming increasingly concerned about the implications of climate change, and more in general of global environmental change (e.g. for tourism: Balbi et al., 2013; for migration: Kniveton et al., 2012). A more or less simultaneous uptake of the methodology is also happening in the two fields, which are facing similar challenges (see Johnson et al., 2016 for a brief summary about tourism research), but there has been little integration among the two modeling communities.

Indeed, ABM is more than a modeling approach, it is also a unifying and complexity-embracing metaphor to combine interdisciplinary modeling concepts for the purpose of describing community behavior, stemming from micro-level decision making. Applied to population mobility (be it for tourism or migration) at the global level, the flows of people, both explicit in spatial and temporal scales, emerge as a consequence of the interactions at the individual level. Just like flocks of birds appear like moving, shifting objects in the sky, though they are clearly also interactions of the birds themselves.

2.1   Heterogeneity

Typical ABM studies consist of computationally intense, detailed dynamic simulations where many heterogeneous human and natural agents interact at multiple temporal and spatial scales. Heterogeneity is a key word here. Indeed, one of the main advantages of ABM is that it can avoid a coarse representation of the system's components. Human agents can vary for demographic characteristics, location, own endowment, individual abilities, perception of the world, attitudes and behavior. Natural agents can also vary both in terms of spatial and temporal attributes.

The literature on migration modeling is rich, beginning with the "gravity model" (Ravenstein, 1885). This quite seasoned approach uses locations as the aggregated unit of analysis, while migration is and individual's decision. The advent of ABM applied to social-ecological systems has made modeling of environmental migration from the perspective of an individual migrant possible. A parallel consideration holds for modeling in tourism research where, for example, Butler's (1980) Tourism Area Life Cycle (TALC) model portrays the destination's trajectory at the aggregate level. ABM makes it possible to look into the details of these trajectories by connecting individuals' actions to macro-level phenomena (Nichols et al., 2016).

In addition ABM allows to explore the heterogeneity of agents' profiles. For example, tourists' profiles that flock to the same destination (as in Balbi et al., 2013), can be based on marketing analysis or experts' opinion in a situation of data scarcity. Available secondary data and ad-hoc collected primary data can be mined to unpack representative profiles. When data is available, multivariate statistics (e.g. cluster analysis) and machine learning methods (Witten et al., 2011) become convenient tools[1]. For instance, a migratory profile can be considered as a migrant behavioral type characterized by a certain typology of socio-economic profile and livelihood behavior, sending location, migratory behavior (e.g. voluntary vs. forced, proactive vs. reactive, short- vs. long- term), transit trajectory, and preferred destination.

Clearly, the amount of heterogeneity captured is connected to the level of detail of the model and it is a primary driver of increased model complicatedness (Sun et al., 2016). Thus, both tourism and migration modelers need to assess the trade-offs underlying fundamental choices as the desired level of empiricism, the risk of over-parametrization and over-fitting, and the validation strategies among the others.

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[1] See Smajgl et al. (2011) for a review on methods to characterize agents.

2.2 Internal complexity

While most natural agents can be simple (they just have to react to the world around them), human agents are more complex to simulate, mainly because they execute deliberative processes (i.e. take autonomous decisions). Behavioral complexity derives from the agents' internal world, their mental models (Lynam et al., 2012) or architectures, which include their cognition ability and learning capacity. There exists an abundance of theories in social sciences—beyond the rational agent (Simon, 1978)—about how human agents behave in various contexts, which can capture how people actually make decisions, also taking into account emotions, motivations and perceptions (Schluter et al., 2017). ABM allows to explore this whole set of decision making theories including the agents' capacity of learning from past experiences (An, 2012).

In tourism research theories regarding motivations play a crucial part, for example, in destination choice modeling. ABM offers a precious tool to explore such theories and test their implications (Nichols et al., 2016). The same applies to migration research where it has proven hard to disentangle environmental from economic, social and political drivers (Black et al., 2011)

The demographic "push-pull-mooring" theory (Moon, 1995) provides a mechanism to interpret possible decisions about shifts in livelihood strategies. In migration modeling push factors can include the loss of reliable income. Pull factors can include the knowledge of better opportunities elsewhere, or perhaps household members or community that has already left. These same social factors can act as moorings, much as can assets like houses or a piece of land, to maintain or protect. Similar push-pull and mooring factors can be identified in tourism behavior as, for example, in the general model of traveler leisure destination awareness and choice (Woodside and Lysonsky, 1989). This model could also be considered as a tourism specific precursor of the theory of planned behavior (Ajzen, 1991), recently identified as one of the most promising decision making theory for human migration modeling (Klabunde and Willekens, 2016). The traveler variables (e.g. income, age, etc.) match Ajzen's attitude towards the behavior, the marketing variables (e.g. pricing, promotion, etc.) are equivalent to Ajzen's subjective norm, and the traveler's destination preferences are somehow comparable to what Ajzen (1991) calls perceived behavioral control.

Decision making theories can be quantitatively formalized into Bayesian Belief Networks: probabilistic models that express the decision structure in form of direct acyclic graphs linking the underlying factors, as demonstrated in Sun and Muller (2013) who combine them into a unitary ABM framework. Experiments with stakeholders (e.g. choice experiments) can also be used to inform the decision making module under scarce secondary data availability while improving stakeholders' integration into the modeling process (Bishop et al., 2009).

Hence, ABM potentially enables a more realistic modeling of human decision making. However, to produce credible agent-based simulations, both in tourism and in migration modeling, requires new models that are able to capture the critical elements of livelihoods and consider embedded choices in life course events. Indeed, traveling and migrating are strategies to get access to valued opportunities among an agent's geography of opportunities (and challenges) over a certain period of time.

2.3 Interactions

Not only most human agents are deliberative, but they are also *social*: they communicate with other agents. This aspect is fundamental to capture dynamics like clustering (or kinship), imitation, learning and diffusion processes. ABM lend itself to *graph and network analysis* allowing to represent the topology of the network of information between social agents, and the relative importance of such

agents within the network. This is a crucial modeling feature for both tourism and migration modeling in that agent's interactions, and in particular informal relationships and opinion dynamics (e.g. word of mouth), can really shape the patterns of mobility.

Travelers tend to ponder advises from their more similar peers when choosing their next destination. In the same way, migrants consider migrating opportunities based on what their social ties are communicating. More importantly, migrants are highly influenced by the presence of relatives, peers, compatriots or other forms of safety networks at the destination location. Network analysis can be applied to study social dynamics, like segregation, for the purpose of preventing social tensions and conflicts, which are increasingly topical challenges in tourism and migration research, as we discuss in the next section.

Building a network for an empirical model often requires hardly available fine grained data about endpoints, direction and frequency of the main interactions. When such data is not available theoretical models can be assumed and tested. A very popular one is the small world model by Watts and Strogatz (1998), where most nodes can be reached through a small number of edges, which has been applied to natural resource management issues in rural communities (e.g. Sun and Muller, 2013). Both tourism and migration research have only scratched the surface of the potential of using network data and models to explore individuals' behavior.

2.4   Organization and structure

Interactions are greatly related to the emergence of an organizational structure. This is because most complex systems can be described as networks of interacting elements and these interactions may lead to global behaviors that are not observable at the level of the single elements (Baggio, 2008).

As mentioned above, human agents are deliberative and social, but they are also *organizational*: they can form into social and organizational structures. Cooperation and coordination or competition can be a consequence of the original system structure (e.g. Lansing and Kremer, 1993). At the same time different norms and institutions can direct individuals to act in the benefit or detriment of the collective.

For tourism research the organizational features within ABM are of particular interest to study destinations as complex organizations emerging from the interactions between different agent classes belonging to four main dimensions (Amelung et al., 2016, Fig. 1):

1. Governance (e.g. local authorities, resident population, etc.);

2. Natural resources (e.g. natural amenities, biodiversity, etc.);

3. Commerce (e.g. tourism facilities, tour operators, etc.);

4. Transport (e.g. road network, airport network, etc.).

All of these dimensions can be generalized to a unitary population mobility perspective. The latter, in particular, is a major theme for the broad travel research arena. The accessibility of the destination as a consequence of changes in the transportation network and traveling routes is a crucial theme for both tourism and migration. The main difference when considering migration is that informal transit patterns play a fundamental role, the trajectory might be fragmented into stages, and connectivity and openness are controlled and constrained rather than promoted by political will, at least in this phase of human history.

Both research fields could greatly benefit from ABM that allows exploring the consequences of introducing structural changes, including new norms and institutions. For tourism one modeling

priority is the study of the costs and benefits of the increased connectivity among the world regions, in particular taking into account the environmental effects at the global (e.g. carbon emissions) and at the local level (e.g. water-food-energy consumption). For migration it seems more urgent to start modeling and testing policy scenarios of protectionism and increased border filtering (e.g. "building walls") against, for example, the implementation of human corridors, to substantiate current political claims that seem more driven by ideological positions rather than facts.

Indeed, ABM is a flexible but computationally intensive methodology that has the power to encapsulate all the above mentioned modeling features: (1) the heterogeneity of the modeled components, (2) their behavioral complexity, (3) the multilevel interdependencies among them, and (4) their organizational capabilities.

In this section we showed that ABM is increasingly adopted for tourism and migration modeling for a wide set of valuable reasons. At the same time ABM may happen to become too complicated to be useful and there are various trade-offs to be considered between simple and complicated models depending on the model's purpose, the modeler's perspective and the stakeholders' perspective (see Sun et al., 2016). In the next section we discuss possible thematic spillovers between tourism and migration research.

3. Discussion: current problematics in population mobility

Even though both tourism and migration study spatially explicit opportunities (and challenges) to humans, population mobility and relational values[2] (here intended as the values relative to the meaningfulness of a relationship between human individuals or with a place or its components) there has been little cross-pollination between the two research fields. In this section we emphasize some of the current common issues, whose research would benefit from a unitary ABM approach, with the hope of inspiring further collaboration.

3.1 Stakeholders' perception

Both tourism and migration can be perceived as beneficial and detrimental phenomena by the local community. Until recently tourism has had a predominantly positive connotation, but things have changed radically with "the great acceleration of humankind" (Amelung et al., 2016) and with mass tourism, for example, in historic European tourism destinations.

In Venice (Italy), locals are increasingly dissenting to the daily flood of tourists: at present, the tourists to residents' ratio (no matter if child or elder) is one for at least 8 months per year (Tattara, 2013). In particular, cruise ship tourism is producing the bulk of the protests due to its environmental implications for a delicate social-ecological system like the Venice Lagoon (Tattara, 2013). A very little part of the tourism benefits is returned to the locals, compared to the majority of social and environmental externalities. As a consequence, outmigration has grown steadily since after the Second World War—from 175,000 inhabitants in 1951 to 56,000 in 2015—. Local businesses shut down and are substituted with tourist oriented products and services and the city becomes progressively similar to a thematic park. Less extreme, but similar experiences are shared by Barcelona (Spain) and Berlin (Germany), in Europe, and in other tourist cities outside Europe (Colomb and Novy, 2016).

The opposite change in perception is gradually happening to migration: long seen as an unintended consequence of globalization, now increasingly seen as a legitimate mode of adaptation to global environmental change (Scheffran et al., 2012), at least by the academics. At origin, out-

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[2]. See Pascual et al. (2016) for a discussion on different types of values that nature contributes to people.

migration can help communities find new income sources and become more resilient. At the destination, immigration may provide the needed labor force, especially for the rapidly ageing western societies. However, migrants might also stretch the capacity of existing infrastructure, especially in low income countries, and new arrivals are frequently vulnerable (Black et al., 2011). The latter is due to the fact that, in absence of a good assimilation and integration process, migrants can be perceived as competitors for job positions and access to public services.

It seems that in both cases, to avoid negative consequences, the competition between locals and the newcomers has to be lowered down. This might include access to income sources, public services, and a healthy environment in its broad sense. The assimilation process of tourists and migrants has to be managed to avoid the "sense of invasion". In this view the study of the city/destination as a complex adaptive system to promote cooperative rather than competitive behavior seems particularly relevant. It is also probable that only studies that focus on cultural change, including social integration and (mobility) behavior, can achieve sensible results on the ground.

3.2   Identity and culture

Both tourism and migration involve the movement of people to different geographical locations and the establishment of social relations between people who would otherwise not meet. Cultural encounters and clashes can take place as a result of differences in cultures, ethnic and religious groups, values, lifestyles, languages and levels of prosperity. More or less dormant cultural frictions may appear in different forms of ordinary societal phenomena that can range from *gentrification* to *segregation*. The latter has been the matter of one of the major seminal studies on ABM applied to social dynamics (Schelling, 1971). However, cultural richness is a primary factor of attraction for the modern travelers (Richards, 2014) and definitely a desirable element for a migrant.

The case of Berlin is particularly telling of both the positive and negative sides of cultural integration for both tourism and migration research. Since the fall of the Berlin wall, the German capital has become a social laboratory of integration: first, the encounter between the capitalist and the communist cultures, then, the colonization of working-class neighborhoods by immigrants (a great majority of Turkish heritage), finally the invasion of *hipsters*. The first phase created a bipolar city, a mixture of rich and poor. With the second phase neighborhoods wedged against the west side of the wall became populated with legions of kebab shops, now a gastronomic trademark for the whole city. Finally, the same areas become a magnet for the international crowd of creatives (and "wannabes") attracted by the relaxed atmosphere, cheap prices and hedonistic party scene. Since 2013, affluent expats and tourists mainly from Italy, Spain and the UK are being blamed for the city's rapid gentrification. This has mutated into physical attacks and abusive graffiti directed to tourists and comparatively well-off immigrants, making no distinction between them (Stallwood, 2012).

As European cities like Berlin, Barcelona and Venice struggle with increasing visitation caused by mass tourism, some others like Copenhagen seek alternative solutions in which tourism can provide a net benefit to locals and visitors alike. Funny enough, in this quest, the Destination Management Organization (DMO) of Copenhagen proclaimed the end of tourism (as an isolated industry bubble of culture and leisure experts) and the beginning of "localhood" (as a way to think of visitors as temporary residents, instead of as tourists) (Wonderful Copenhagen, 2017). Hence, some innovative tour operators have also recognized the blurred boundaries between population mobility classes and the tenet of culture as the ultimate traveling experience—"locals become the destination".

In the globalized word, culture is increasingly a primary factor of attraction and a possible source of conflict, especially if identity is not preserved adequately. Tourism can turn local culture into commodities when religious traditions, local customs and festivals are reduced or standardized to

conform to tourist expectations. In the same way immigration can be perceived as a threat to the existence of the local identity when newcomers are felt very distant from the main social norms and values.

The preservation of identity in a way that recognizes both its stabilizing (people are rooted on certain values and thus do not feel lost) and dynamic nature (norms evolve as a result of integration, e.g. "the *Berliner* kebab") is a cross-cutting issue for tourism and migration research, where both can mutually learn from the other.

Two elements for further discussion seem of particular relevance to this overarching theme:

1. The utilization of *virtual spaces* to preserve cultural identities and improve their access. The explosive development of ICT and social media has empowered and connected individuals locally and across the world, with massive implications for the accounting of cultural exchanges. On the one other hand ICT and augmented reality offer the possibility of consuming a virtual version of a destination without having to travel. On the other hand, cultural institutes do not have to be located in the location of origin, and more in general, do not have to be physically located any more. This offers the opportunity to safely archive, monitor and share culture on the internet without the risk of losing any part it due to, for instance, a cultural colonization process. Even though we have not witnessed yet something as ambitious as this, similar indications have come from recent technological experiences. For example, it has been argued that the Estonian virtual residency is a response to the need for a safe (technological) space to differentiate Estonian identity from the neighboring countries (Kotka et al., 2015). Here, the added value of using ABM is that ABM allows the creation of synthetic societies that can be used as virtual laboratories to flexibly test scenarios that could not otherwise be put in place in the real world.

2. The *role of food* as a mediating factor to facilitate cultural integration. Several experiences (e.g. Vallianatos and Raine, 2008) suggest that food is one of the best ways of preserving and promoting cultural identities. More than this, food is a basic need that anybody can relate to. It is an immediate vehicle of empathy to understand the different. While food has been treated just like any other industrial commodity by mass tourism, food, in its broader cultural connotation, has also been embraced by gastronomic tourism, which has put it at the center of the visiting experience. Here, we suggest that migration research could expand more on this mechanism in particular for analyzing how real and authentic food can be put at the center of a workflow for integration and conflict prevention. We think of (virtual or not) gastronomic workshops between locals and newcomers or, more precisely from an ABM perspective, to scientifically directed *role-playing games* (see Barreteau et al., 2003) where the ultimate outcome is a better understanding of others' perspective. In companion modeling (Barreteau et al., 2003) role-playing games have proven successful in involving stakeholders during the ABM development while testing model results with empirical observations.

3.3   Economic sustainability and globalization

In the above we touched on the social aspects of sustainability while the whole triple bottom line of sustainability has to be considered.

At the economic level tourism has long be seen as a totally benevolent sector producing consistent benefits without significant economic caveats nor environmental or social externalities. Typically, in a young tourism destination, tourism sector short-term growth is never questioned with

regards to its long term consequences. However, research has studied many cases where tourism has started slowly and gradually crowded-out the destinations' economy hindering the long term economic sustainability (e.g. van der Borg et al., 1996). This is the typical case of tourism monocultures gradually replacing diversified economies driven by the differential in revenues. Locals prefer to rent out their properties and move away from the hot spots while the local economy becomes totally dependent on tourism demand. Although this might not be an issue *per se* in an interconnected globalized world, where every region supplies goods and services according to its comparative advantages, it exposes the local system to external and uncontrollable shocks (e.g. preference changes, food, water and energy supply, etc.)

Migration is also a consequence of globalization as it can provide cheap and/or skilled labor in economies where population levels are stable and ageing (Harper, 2012). On the one hand, migrants often take jobs that locals are unwilling to take (e.g. children and elderly care), on the other hand migrants might compete against the locals for other categories of jobs, by dragging down the salary level (i.e. price competition), or by providing locally unavailable skills. These ordinary economic dynamics might have huge impacts at the social level. In the current political debate there seems to prevail a double moral that blames the migrants for the negative aspects of those economic adjustments while timidly recognizing the positive contribution of external talents in certain sectors (e.g. Research & Development).

One sustainability related concept consistently applied in tourism research is that of *carrying capacity*: the capacity to absorb tourism by a certain destination. Under an economic perspective that would be the dimension of tourism flows that provide net benefits to the receiving system in the short and in the long term. As a local scale solution, carrying capacity has a long research tradition, especially among geographers studying tourism and recreation (Saarinen, 2006). It is, however, a multifaceted concept with multiple interpretations according to the different angles of analysis. For example, Getz (1983) has divided the concept into six subtypes: physical, economic, perceptual, social, ecological, and political. While the search for a magical absolute and objective calculation of the maximum acceptable number of tourists at a destination has failed (Saarinen, 2006), it remains a valuable concept to explore planning scenarios, if human values and changing perceptions are also considered. For the same reasons, the concept of carrying capacity could be applied to explore *ex-ante* the sustainability implications of immigration. The receiving systems can be modeled including the local job market, access to public services and considering the main liming factors and key agents' behavior for a sustainable assimilation process. The ideal use is not to set a maximum threshold of hosting capacity, but to negotiate the locals' and the newcomers' perspectives into and ideologically unbiased assessment process, which can utilize a *multi-criteria assessment* approach to combine different value functions (e.g. Bonzanigo et al., 2016).

In the current analysis of economic sustainability, an up-to-date unitary research framework on population mobility should not neglect what is commonly referred to as the rise of the "sharing economy". For example, in Amelung et al. (2016) we referred to the multiplication of the number of stakeholders active on the tourism supply side (e.g. Airbnb and Uber). However, the issue is much broader and is connected to the possibility of capturing the network of informal social exchanges which, in both legal and illegal forms, are becoming commonplace under the pressure of economic crises and hampered by the exponential growth of ICT.

In tourism research the rise of Airbnb has recently become a textbook case (Guttentag, 2015) to explain how informal networks can outcompete the ordinary tourism industry (and trick the regulatory framework) with positive and negative implications. On the positive side, this phenomenon is totally aligned to the convergence of culture and tourism (Richards, 2014) explained before, as it

allows the possibility of living a more authentic experience—"living like a local". On the negative side, the multiplication of suppliers can promote economic speculations and exacerbate the monoculture of tourism while circumventing the regulations. The case of Barcelona has set a milestone in the process of gradual normalization of such a disruptive innovation for the tourism systems (Sans and Quaglieri, 2016).

The role of informal social networks is also key throughout the whole migration process (Boyd, 1989). At origin, potential migrants consider possible destinations on the basis of information provided by their peers under the constraint of their individual's resources (assets, capabilities, including earlier migration experiences). Networks also shape the traveling patterns by means of legal and illegal transportation opportunities, facilitators (e.g. migration agents/brokers), information provided by formal and informal channels on costs, regulations, documents required, physical barriers, language barriers, etc. Finally, at destination, informal social networks often provide the primary interface and safety net to newcomers.

The issue of how to account for informal networks in the analysis of economic sustainability is therefore of paramount importance for both tourism and migration research. Despite increases in individual operosity and creativity due to improved access to information, traditional economic governance studies still seem unable to include the effects of informal individual initiative in the assessment of wellbeing. Virtual simulation studies of social-ecological systems, incorporating formal and informal networks, could help asses these dynamics by accounting for crucial flows between social agents.

3.4   Global environmental change

At the environmental level sustainability must consider the ongoing global environmental change (GEC), most notably climate change, and its disrupting effects on social-ecological systems. The multiple ways in which GEC is likely to affect population mobility can be distilled into the initial and the final stages of a generic spatial-temporal movement:

1. At origin, increasingly inhospitable environments and the lack of capacity to adapt locally may push travelers to leave (temporary, seasonally, or permanently) while, at the same time, mooring their ability to do so;

2. At destination, attractiveness (or pulling factors) may change positively or negatively due to changes in environmental conditions.

The first stage, "what happens at origin", is currently more relevant for migration, but it may become an progressively more relevant tourism research theme, further closing the gap between the two research approaches. In fact, the conditions at origin affect the tourism demand in fundamental ways, including the tourists' spending capacity.

In migration studies, the idea of "moving with the climate" is well documented long before climate change started unfolding. Temporary and circular mobility has been a traditional way to adapt to seasons in many communities worldwide: herders, for example, have traditionally engaged in seasonal transhumance, moving their livestock between pastures. These patterns have been gradually modified by climate change mainly through its effect on rainfall. Frequent droughts have forced pastoralists to find new routes, and travel further or for longer periods and sometime led to permanent migration to places with better environmental conditions (e.g. water and grazing land) (Ionesco et al., 2016, 22). Here we can recognize two main modalities of migration: the first related to slow-onset environmental degradation (e.g. desertification) and the second related to major natural hazards and sudden displacement. A hybrid modality is that related to small scale recurrent natural hazards.

In tourism, research on how GEC will alter geographically and seasonally the pushing and mooring factors of mobility is quite unexplored. For example, it make sense to assume that, in the context of mountain tourism, the increase in probability of heat waves in metropolitan areas will likely push more tourists to the mountains in the attempt to escape from them (e.g. as happened for the European Alps in summer 2003: Balbi, 2012). Until now tourism research has focused on seasonal and geographical tourists' preferences (e.g. Amelung et al., 2007), which are more related to what happens at the destination (i.e. pulling factors). The effect of GEC on "what happens between origin and destination" is also a potential relevant research theme for tourism. Scott et al. (2008, 116−118) assumed that increased travel cost and environmental concern over tourism travel would have impacted long-haul and air travel. However, ten years later, it is reasonable to say that travel cost has generally decreased and that aviation is not among the top concerns of current climate change global governance.

Conversely the second stage, "what happens at destination", is a well explored theme in tourism research and a recognized one in migration studies (e.g. on amenity migration). The most exposed destinations are probably the mountain and the coastal regions and those endowed with a rich natural and cultural heritage (Scott et al., 2008, 68−80). In this case the environment is a pulling factor and global environmental change can negatively impact traditionally amenable destinations while creating opportunities for new destinations. Here, the public perception of destination impacts will play a central role in travel decision making.

One useful conceptual framework to model human wellbeing dependency on the environment is that of *ecosystem services* (e.g. Villa et al., 2014). Different service typologies can match the multiple ways in which environmental conditions can affect population mobility: for example, provisioning services (e.g. water-food-energy availability) vs. livelihoods, regulatory services (e.g. flood prevention) vs. security, and cultural services (e.g. heritage, recreation) vs. amenity (or place utility as in Adams and Adger, 2013).

Because the responses to GEC, in terms of mitigation and of adaptation have to be found in humans' behavior, it is recommendable to explore the evolution of social-ecological systems with a methodology that can analyze complex systems starting from the behavior and the interactions of the individual agents composing them, as is ABM (Balbi and Giupponi, 2010).

4.   Concluding remarks

This article has considered tourism and migration research under the same ABM lenses and demonstrated that there are sufficient methodological and thematic issues in common to argue for a comprehensive research field on population mobility. Such a research field is characterized by:

1. The analysis of spatial-temporal movement of human agents from an origin to a destination (and often return);

2. The heterogeneity of movement modalities and underlying causes with an increasing overlapping between visit and (temporary) relocation;

3. Movement as one behavioral option to improve/adapt wellbeing among others depending on livelihoods, securities and amenities;

4. The role of social interactions in shaping movement patterns and the disruptive effect of ICT;

5. The role of (legal and illegal) transportation infrastructure, connectivity and costs in determining transit trajectories;

6. The changing geography of opportunities (and challenges) of such movements as a consequence of globalization and global environmental change;

7. The subjectivity of human values nested into cultural identities that affect moving (and hosting) decisions, their perception and the risk of social conflicts;

8. The possibility of exploring possible futures with computational methods to support more sustainable human societies, particularly at the urban scale;

9. The need for realism, robustness and transdisciplinarity to deliver credible results to the stakeholders.

We thoroughly discussed why ABM is at present the most promising modeling methodology for this overarching research field, but it has to become more robust and realistic for addressing real world problems. Current ABM of population mobility are mainly stylized models, not well suited for a predictive approach. There is a significant margin to improve the state of the art to quantitatively explore future scenarios depending on the considered assumptions and on the uncertainty related to them. In this regard, a quite unexplored option is to produce ensemble simulations of the social-ecological system through Monte Carlo-like techniques (as for weather forecasting: Gneiting and Raftery, 2005).

Indeed, one of the main advantages is that ABM can be used as a modeling framework to incorporate complementary methods. In this article we touched on those methods and in the following table (Table 1) we summarize them, stressing the main reasons for their use from a modeler's and a stakeholder's perspective.

Table 1. Useful tools in agent-based modeling of population mobility

Role in ABM development	Value for the stakeholders	Candidate tools
*Model agent's characterization	Create representative synthetic populations capturing the heterogeneity of behavioral types	Multivariate statistics; Machine learning
Model geographical dependency on natural resources	Understand the relationship between livelihoods, security, amenity, and the environment	Ecosystem Services
*Model agents' decision making	Realistic representation of livelihood strategies, the decisions to move and the destination choice	Push-pull-mooring theory; Theory of Planned Behavior; Bayesian Belief Networks
Model traveling patterns	Understand routing possibilities and cost functions	Graph theory and Network Analysis
Model social interactions (market and non-market)	Understand the role of formal and informal exchanges (information, services, help, etc.)	Social Network Analysis
*Verify agents' behavior	Make sure the model is empirically grounded and facilitate mutual understanding between different stakeholders' categories	Choice Experiments; Role Playing Games

Results exploration and ensemble modeling	More robust communication of possible future outcomes avoiding a purely predictive approach	Exploratory Modeling and Analysis; Monte Carlo Simulation
Assess sustainability levels and/or combine indicators with heterogeneous values	Minimize possible frictions that may lead to conflicts and mediate different perspectives	Carrying Capacity Multi Criteria Analysis

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